RECLAMATION
Managing Water in the West

Arkansas Valley Conduit and Long-Term Excess Capacity Master Contract

DRAFT ENVIRONMENTAL IMPACT STATEMENT

DES12-39

APPENDICES: VOLUME 1

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

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

August 2012

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Appendices - Volume 1

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Appendix A.1 – Participant Supply and Demand

Introduction

This appendix presents existing and future water demand, supplies and operations for each AVC and Master Contract participant. Participants are grouped by AVC and non-AVC participant, and then presented in order generally from upstream to downstream participant.

AVC Participants

This appendix describes the purpose of and need for the AVC by participant. Larger participants (i.e. participation level in AVC exceeds 100 ac-ft per year) and participants with identified non-Project supplies are discussed individually. The remaining participants are discussed as a group. Appendix A.2 contains a list of water rights that are proposed for use in the AVC and AVC participant Master Contract storage space. These are the only water rights that would be included in the proposed federal actions.

The locally funded portion of the AVC would be repaid to the federal government over a period of 50 years. Assuming the AVC is constructed by 2020, purpose and need for AVC participants was evaluated based on their projected 2070 water demand and ability to meet those projected demands with existing water supplies. Water supply information was gathered from each Master Contract participant, the STAG Final Report (Black & Veatch 2010), and a yield analysis of the project (Appendix D.1).

Future water demands were evaluated based on population projections, current per capita use, and water conservation, calculated as:

> Population Projection*Current Per Capita Water Use *(1-Future Water Conservation Percentage)

Future population was estimated using historical population trends and future population projections provided by the Colorado State Demography Office and the Colorado Water Conservation Board (Reclamation 2010). The AVC participants are expected to experience population growth of up to 1 percent per year and will need the AVC and other supplies to meet future water demands associated with population growth.

Current per capita use was calculated using 2010 population and demand. 2010 population values were provided by the Colorado State Demography Office or individual participants. 2010 demand values were obtained from the STAG Final Report or from individual participants.

Future conservation values, as described in Chapter 1, were obtained from participant water conservation plans or forecasted passive conservation savings (Great Western Institute 2010).

Deliveries in the AVC were determined based on future water demand, Fry-Ark allocations, and existing and future water supplies, as documented in Appendix D.1. Participant water deliveries were calculated based on participants' delivery preferences noted in Table 3-7 of Black & Veatch (2010). The delivery preferences are summarized as follows:

- Only Fry-Ark allocation water deliveries in the AVC
- Fry-Ark allocation water plus additional supplies in the AVC to meet 100 percent of demand
- Fry-Ark allocation water plus additional supplies in the AVC to meet partial demand; remaining demand met with existing supplies
- 50/50 blending of AVC deliveries with current sources

Fry-Ark supplies reported in this section include Fry-Ark allocations (or the portion of the "Entities East of Pueblo" 12 percent allocation of Fry-Ark yields) and "Not Previously Allocated Non-Irrigation Water" (NPANIW), which accounts for an additional 2.8 percent of Fry-Ark Project supply that may be allocated to the AVC participants (Appendix D.1). NPANIW is a percentage of Project water that was previously allocated to agriculture, but the water rights being supplemented were sold to municipal entities, the agricultural land dried up, and thus are no longer eligible for Fry-Ark Project water. Fry-Ark return flows are surface water flows that can be captured and reused. See Appendix D.1 for calculation of Fry-Ark return flows.

Throughout this section, existing surface water and groundwater supplies for participants are identified. These supplies are as reported by the participant and confirmed with other information where available (primarily Black & Veatch 2010). However, it should be noted that in cases where surface water supplies are used to augment surface water depletions caused by groundwater pumping, these supplies are mutually exclusive. In these cases, the surface water supplies could not be used for another purpose without also reducing the amount of well pumping by the same amount. Therefore, throughout this section, surface water supplies and groundwater supplies for individual entities are not summed to provide total supply.

Reported annual yield for each participant is generally believed to be the average yield, which is the amount of water available in an average year or the average amount of water available over a period of years. For those participants who have previously done more comprehensive analyses of their systems, firm yield is also reported. Firm yield is the amount of water available in a dry year, and is less than or equal to the average yield. Firm yield analyses have not been done by any of the AVC participants and many of the Master Contract participants. Yields reported by the participants are primarily based on experiences with their water rights and delivery systems rather than quantitative analyses. The reported annual yields are water supplies currently available to the participants.

Some participants with yields greater than projected demand plan to lease excess supplies, whereas other participants that currently lack sufficient supplies for projected demand plan to acquire additional water rights. These additional water rights, where known, are discussed in the text for each participant. If known current and future supplies are less than projected demand, it is assumed that Lower Arkansas Valley Conservancy District leases from their Master Contract storage space would fill the gap. Decrees for change in use and exchanges of all water rights are listed in the tables for each participant, though it should be noted that most AVC participants' non-Project supplies would be exchanged under Southeastern Colorado Water Conservancy District's pending 06CW8 decree.

The AVC would deliver about 10,300 ac-ft per year (Chapter 1). Water supplies for AVC would deliver a mixture of Fry-Ark allocations, the AVC participants' usable existing supplies, and future water supplies that are assumed to be obtained from agricultural water rights. AVC will be designed to deliver peak-day flows. Further information regarding AVC design is in Chapter 2 of the EIS.

Throughout this section, use of Fry-Ark allocations are identified as a water source for AVC, and Fry-Ark Return Flows are identified as a water source for both AVC and the Master Contract. Water rights for the Fry-Ark Project and Fry-Ark return flows are described in several water rights cases, and are not repeated for each entity. Table 1 summarizes Fry-Ark water rights.

Table 1. Fry-Ark Project Water Rights Decrees

West Slope Decrees	East Slope Decrees	Reuse and Exchange Decrees
District Court, Chaffee County, Civil Action No. 4613	District Court, Chaffee County, Civil Action No. 5141	District Court, Pueblo County, Civil Action No. B-42135
Div. 5, W-829-76	District Court, Pueblo County, Civil Action No. B-42135	Div. 2, 01CW151 (Pending)
Div. 5, 83CW352	Div. 2, 80CW6	

96 Pipeline Company

96 Pipeline Company	
AVC Annual Delivery:	27 ac-ft
Master Contract Request:	25 ac-ft

96 Pipeline Company (Co.) serves a portion of unincorporated Crowley County. 96 Pipeline Co. currently uses disinfected alluvial groundwater provided by Crowley County to fulfill its demand and augments this water with its Colorado Canal Companies shares and Fry-Ark allocation. Table 2 presents the current and future water demands for 96 Pipeline Co., while Table 3 presents 96 Pipeline Co.'s water supplies. Water demand in 2070 is projected to be 85 ac-ft. Current reported supply of alluvial groundwater is 51 ac-ft, while augmentation supply from surface water sources is 34 ac-ft. 96 Pipeline Co. uses Crowley County Board of Commissioners delivery systems. 96 Pipeline Co. has a high per capita water usage rate due to leaks in service lines to individuals, and because they serve several stock watering meters.

Table 2. Current and Future Water Demand for 96 Pipeline Company

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	160	311	56
2070	254	299	85

Table 3. Current and Future Water Supplies for 96 Pipeline Company

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Wells [(1)]		51	0
Surface Water			
Colorado Canal Companies [(2)(3)]	Div. 2, 84CW62, 63, & 64	3	3
Fry-Ark Project	See Table 1.	27	27
Fry-Ark Project Return Flow [(4)]	See Table 1.	4	4
Total Surface Water Supplies		**34**	**34**

Notes:
(1) From STAG AVC survey and Master Contract questionnaire. Groundwater provided by Crowley County.
(2) Share information from Master Contract questionnaire.
(3) From STAG, Twin Lakes Yield = 0.78 ac-ft/share for augmentation; Colorado Canal/Lake Meredith yields = 0.684 ac-ft per share for augmentation purposes.
(4) Return Flow estimates assume full use of Fry-Ark Project allocation

Annual AVC deliveries to 96 Pipeline Co. are estimated to be 27 ac-ft per year, which is about 32 percent of 2070 demand. Of this amount, 27 ac-ft would be Fry-Ark allocations and NPANIW supplies, while the remaining 7 ac-ft would come from Fry-Ark return flows and non-Fry-Ark Project sources. The remaining 17 ac-ft of 2070 demand not delivered by the AVC would be met through blending with existing groundwater supplies. 96 Pipeline Co. is requesting 25 ac-ft of Master Contract storage space to store Fry-Ark return flows and non-Fry-Ark Project water that would be delivered through the AVC. Non-Fry-Ark Project water sources include existing Colorado Canal Companies shares.

96 Pipeline Co. is requesting participation in AVC and the Master Contract to meet future demand via delivery of their surface water supplies. 96 Pipeline Co. will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract and used in AVC would service growth within Crowley County.

Avondale

Avondale	
AVC Annual Delivery:	164 ac-ft
Master Contract Request:	0 ac-ft

Avondale is located in the lower Arkansas River Basin in Pueblo County. Avondale currently uses filtered and disinfected alluvial groundwater to meet water demands. Table 4 presents the current and future water demands for Avondale, while Table 5 presents Avondale's water supplies. Municipal and industrial water demand in 2070 is projected to be 238 ac-ft. Current reported supply of alluvial groundwater is 160 ac-ft, while supply from surface water sources is 267 ac-ft.

Table 4. Current and Future Water Demand for Avondale

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	2,000	71	160
2070	3,570	60	238

Table 5. Current and Future Water Supplies for Avondale

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial wells [(1)]		160	0
Surface Water			
Fry-Ark Project	See Table 1	164	164
Fry-Ark Return Flows [(2)]	See Table 1	103	0
Total Surface Water Supplies		**267**	**164**

Notes:
(1) From STAG, Table 5-3.
(2) Return Flow estimates assume full use of Fry-Ark Project allocation

Annual AVC deliveries to Avondale are estimated to be 164 ac-ft per year, which is about 69 percent of 2070 demand. All AVC deliveries would be Fry-Ark allocations and NPANIW supplies. The remaining 2070 demand not delivered by the AVC would be met through blending with 74 ac-ft of existing groundwater supplies. Avondale is not requesting Master Contract storage space, and will not exchange Fry-Ark return flows for AVC delivery.

Avondale is requesting participation in AVC to replace poor quality supplies (Black & Veatch 2010). In addition, Avondale seeks to more efficiently use existing supplies by reducing or eliminating transit losses that are currently assessed on deliveries from Pueblo Reservoir to Avondale via the Arkansas River. For those alternatives that divert directly from Pueblo Dam or the Joint Use Pipeline, no transit loss would be assessed to AVC participants. The River South alternative would continue to incur a transit loss assessment from Pueblo Dam to the river intake, but at a reduced rate from existing deliveries. Water quality constituents of concern include residual levels of trinitrotoluene; the U.S. Army assists with treatment of Avondale's water due to contamination.

Avondale will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070.

Crowley County Water Association

Crowley County Water Association	
AVC Annual Delivery:	617 ac-ft
Master Contract Request:	1,000 ac-ft

Crowley County Water Association serves a portion of unincorporated Crowley County. Crowley County Water Association currently uses disinfected alluvial groundwater to fulfill its demand and augments this water with its Twin Lakes shares. Table 6 presents the current and future water demands for Crowley County Water Association, while Table 7 presents Crowley County Water Association's water supplies. Water demand in 2070 is projected to be 883 ac-ft. Current reported supply of alluvial groundwater is 320 ac-ft, while supply from surface water sources is 993 ac-ft. Crowley County Water Association owns water rights and uses Crowley County Board of Commissioners delivery systems. Crowley County Water Association has a high per capita water usage rate due to leaks in the service lines to individuals, and because they serve several stock watering meters.

Table 6. Current and Future Water Demand for Crowley County Water Association

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	3,130	165	580
2070	4,965	159	883

Table 7. Current and Future Water Supplies for Crowley County Water Association

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Groundwater (1)		320	0
Surface Water			
Twin Lakes Reservoir and Canal Company Decrees (2) (3)	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	8	8
Colorado Canal Companies (2) (3)	Div. 2, 84CW62, 63, & 64	176	176
Fry-Ark Project	See Table 1.	497	497
Fry-Ark Project Return Flow (4)	See Table 1.	312	312
Total Surface Water Supplies		**993**	**993**

Notes:
(1) From Southeastern Colorado Water Conservancy District (2011).
(2) Share information from STAG survey, raw water supply.
(3) From STAG, Twin Lakes Yield = 0.78 ac-ft/share for augmentation; Colorado Canal/Lake Meredith yields = 0.684 ac-ft per share for augmentation purposes.
(4) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual AVC deliveries to Crowley County Water Association are estimated to be 617 ac-ft per year, which is about 70 percent of 2070 demand. Of this amount, 497 ac-ft would be Fry-Ark allocations and NPANIW supplies, while the remaining 120 ac-ft would come from Fry-Ark Return flows and non-Fry-Ark Project sources, including Twin Lakes or Colorado Canal/Lake

Meredith shares. The remaining 266 ac-ft of 2070 demand not delivered by the AVC would be met through blending with existing groundwater supplies. Crowley County Water Association is requesting 1,000 ac-ft of Master Contract storage space to store Fry-Ark return flows and non-Fry-Ark Project water that would be delivered through the AVC. Non Fry-Ark Project water sources include existing and future Twin Lakes Reservoir and Canal Company shares, Colorado Canal/Lake Meredith shares, and other consumptive use water within the basin that would be leased on a short-term or long-term basis.

Crowley County Water Association is requesting participation in AVC and the Master Contract to improve water quality. The primary water quality issue with current supplies, as identified by the participant, is hardness (Black & Veatch 2010). No specific water quality data was provided by the participant or collected as part of the EIS process.

Crowley County Water Association will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract and used in AVC would service growth within Crowley County.

Eads

Eads	
AVC Annual Delivery:	116 ac-ft
Master Contract Request:	50 ac-ft

Eads is in Kiowa County, about 30 miles north of the Arkansas River. Eads currently uses alluvial groundwater tributary to Rush Creek and Kiowa Creek to meet water demands. Water is chlorinated and blended with phosphates to protect against corrosion. Table 8 presents the current and future water demands for Eads, while Table 9 presents Eads' water supplies. Water demand in 2070 is projected to be 232 ac-ft. Current alluvial well yields are 266 ac-ft. Sources of surface water include Fry-Ark allocations, NPANIW supplies, and Fry-Ark return flows, which total 171 ac-ft. Reclamation has determined that given the historical trend of negative growth in the area, future growth is unlikely and Eads' population will remain unchanged. Conservation (as discussed below) accounts for the expected decrease in water demand between 2010 and 2070. Eads' higher than typical per capita water use is attributed to industrial livestock watering, large commercial users, and a bulk water station used by summer residents and campers.

Table 8. Current and Future Water Demand for Eads

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	626	357	250
2070	625	331	232

Table 9. Current and Future Water Supplies for Eads

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Wells [1]		266	0
Surface Water			
Lower Arkansas Valley Water Conservancy District lease		Conditional on AVC and/or Augmentation Demand Gap	
Fry-Ark Project	See Table 1.	105	105
Fry-Ark Project Return Flow [2]	See Table 1.	66	0
Total Surface Water Supplies		**171**	**105**

Notes:
(1) From STAG, Appendix 5.
(2) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual AVC deliveries to Eads are estimated to be 116 ac-ft per year, which will meet 50 percent of 2070 demand. These deliveries will consist of 105 ac-ft per year of existing Fry-Ark allocations and NPANIW supplies, and 11 ac-ft of non-project water leased from the Lower Arkansas Valley Water Conservancy District. Fry-Ark return flows are not available to use in AVC, because Eads' return flows accrue to the Arkansas River downstream from John Martin Reservoir and cannot be exchanged upstream. The remaining 2070 demand not delivered by the AVC would be met through blending with existing groundwater supplies. Eads is requesting 50 ac-ft of Master Contract storage space, and would store non Fry-Ark Project water supplies and make releases for AVC use.

The primary use of AVC is to replace poor quality supplies and to improve overall water quality. The specific contaminants of concern are alkalinity, hardness, and total dissolved solids. In particular, total dissolved solids are reported at 1,550 mg/l, which exceeds secondary drinking water quality standards. Eads would blend half of its existing supply with water from the AVC to improve water quality.

Eads will be covered under a regional water conservation plan being prepared by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract would service demand within Eads' service area.

Fowler

Fowler
AVC Annual Delivery: 220 ac-ft
Master Contract Request: 50 ac-ft

Fowler is located south of the Arkansas River in Otero County. Fowler currently uses alluvial groundwater treated in a conventional water treatment plant to meet water demands. Table 10 presents the current and future water demands for Fowler, while Table 11 presents Fowler's water supplies. Annual municipal and industrial water demand in 2070 is projected to be 223 ac-ft. Current reported potable supply of alluvial groundwater (including springs) is 210 ac-ft, while supply from surface water sources is 311 ac-ft. Fowler currently has another 121 ac-ft of non-potable irrigation water demands. Fowler is also a member of the Colorado Water Protective and Development Association, which provides additional well augmentation.

Table 10. Current and Future Water Demand for Fowler

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	1,700	110	210
2070	2,183	91	223

Table 11. Current and Future Water Supplies for Fowler

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial wells (potable only) [(1)]		210	0
Surface Water			
Oxford Farmers Ditch (used for non-potable supply) [(2)]		36	36
Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	Conditional on AVC and/or Augmentation Demand Gap	
Fry-Ark Project	See Table 1	169	169
Fry-Ark Return Flows [(3)]	See Table 1	106	106
Total Surface Water Supplies		**311**	**311**

Notes:
(1) From STAG, Table 5-3.
(2) Yield from STAG, Appendix 5.
(3) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual AVC deliveries to Fowler are estimated to be 220 ac-ft per year, which is about 99 percent of 2070 demands. These deliveries will consist of existing Fry-Ark allocations, NPANIW supplies, and Fry-Ark return flows. Additional potable water needed by Fowler to meet 2070 demands will be provided by existing alluvial wells. Non-potable water needed by Fowler will be provided by existing water supplies, including Oxford Farmers Ditch shares and alluvial wells. Fowler is requesting 50 ac-ft of Master Contract storage space to store Fry-Ark Project return flows. This water would be delivered to Fowler in the AVC or as augmentation water to offset depletions for existing wells.

Fowler is requesting participation in AVC and the Master Contract to improve water quality. The primary water quality issue with current supplies is selenium (Black & Veatch 2010). No specific data water quality data was provided by the participant or collected as part of the EIS process.

Fowler will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern has assumed water conservation can be achieved through passive water conservation through 2070.

La Junta

La Junta	
AVC Annual Delivery:	2,299 ac-ft
Master Contract Request:	2,000 ac-ft

La Junta is located south of the Arkansas River in Otero County. La Junta currently uses alluvial groundwater treated in a reverse osmosis water treatment plant to meet water demands. Table 12 presents the current and future water demands for La Junta, while Table 13 presents La Junta's water supplies. Water demand in 2070 is projected to be 2,421 ac-ft. Current reported supply of alluvial groundwater is 2,040 ac-ft, while supply from surface water sources is about 2,500 ac-ft. The town currently operates augmentation releases under the Colorado Water Protective and Development Association. La Junta's higher than typical per capita water use is attributed to outdoor irrigation, backwashing of the reverse osmosis filters at the water treatment plant, and large commercial users.

Table 12. Current and Future Water Demand for La Junta

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	7,102	256	2,040
2070	9,120	237	2,421

Table 13. Current and Future Water Supplies for La Junta

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Wells (1)		2,040	0
Surface Water			
Holbrook Ditch (2)		800	800
Fry-Ark Project	See Table 1.	1,059	1,059
Fry-Ark Project Return Flow (3)	See Table 1.	664	664
Total Surface Water Supplies		**2,523**	**2,523**

Notes:
(1) Average yield from STAG, Table 5-3. Firm yield from Master Contract questionnaire.
(2) Yield from participant.
(3) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual AVC deliveries to La Junta are estimated to be 2,299 ac-ft per year, which is about 95 percent of 2070 demand. These deliveries will consist of 1,059 ac-ft per year of existing Fry-Ark allocations and NPANIW supplies, while the remaining 1,240 ac-ft would come from Fry-Ark return flows and non-Fry-Ark Project sources, including existing shares of Holbrook Mutual Canal. The remaining 122 ac-ft of 2070 demand not delivered by the AVC would be met through blending with existing groundwater supplies. La Junta is requesting 2,000 ac-ft of Master Contract storage space, and would store Fry-Ark return flows and non-Fry-Ark Project water supplies, and make releases for AVC and well augmentation uses.

The AVC's primary use is to meet projected growth in demand and to improve water quality. Specific contaminants of concern are selenium, uranium, sulfate and radium. The STAG survey reported that pre-treatment total dissolved solids levels are currently about 1,400 mg/l, which is greater than the secondary total dissolved solids standard of 500 mg/l that is discussed in Chapter 1. La Junta plans on using both AVC and the existing reverse osmosis water treatment plant in the future. The exact blending of these two sources has not been determined at this time. La Junta could provide base-load supply from AVC, then supplement and blend water from the reverse osmosis system, or use AVC for one pressure zone in their distribution system, and use the reverse osmosis water for the other pressure zone. La Junta has also identified a specific need for additional storage tied to AVC, which would be met by the Master Contract.

La Junta is in the process of developing a water conservation plan. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract would service growth within La Junta's service area.

Lamar

Lamar	
AVC Annual Delivery:	1,241 ac-ft
Master Contract Request:	0 ac-ft

Lamar is located south of the Arkansas River in Prowers County, downstream from John Martin Reservoir. Lamar currently uses alluvial groundwater that is treated in a conventional water treatment plant where it is chlorinated and fluoridated. Table 14 presents the current and future water demands for Lamar, while Table 15 presents Lamar's water supplies. Water demand in 2070 is projected to be 2,157ac-ft. Current reported supply of alluvial groundwater is 2,400 ac-ft, while average supply from known surface water sources is 2,019 ac-ft. Average yield from non-Fry-Ark Project water sources are unknown. Lamar's higher than typical per capita water use is attributed to outdoor irrigation and large commercial users. Reductions in water demand are anticipated due to the water conservation program (see following paragraphs).

Table 14. Current and Future Water Demand for Lamar

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	8,171	262	2,400
2070	9,500	203	2,157

Table 15. Current and Future Water Supplies for Lamar

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Wells (1)		2,400	0
Surface Water			
Fort Bent Ditch (currently used for non-potable use, augmentation and recharge) (2)		--	0
Lamar Canal (currently used for non-potable use, augmentation and recharge) (2)		--	0
Fry-Ark Project	See Table 1	1,241	1,241
Fry-Ark Project Return Flow (3)	See Table 1	778	0
Total Surface Water Supplies		**2,019**	**1,241**

Notes:
(1) Average yield from STAG, Table 5-3.
(2) From STAG AVC survey.
(3) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual 2070 AVC deliveries to Lamar are estimated to be 1,241 ac-ft per year, which will meet about 58 percent of future demand. These deliveries will consist entirely of Fry-Ark allocations and NPANIW supplies. Fry-Ark return flows cannot be exchange due to accruals below John Martin Reservoir. The remaining 2070 demand not delivered by the AVC would be met through blending with existing groundwater supplies. Lamar is not requesting storage as part of the Master Contract.

The primary use of AVC is to replace poor quality supplies, and to improve overall water quality. The specific contaminant of concern is total dissolved solids. Lamar's total dissolved solids can range from 825 mg/l to about 1,500 mg/l, which is greater than the secondary total dissolved solids standard of 500 mg/l discussed in Chapter 1.

Lamar completed a water conservation plan that was approved by the Southeastern Colorado Water Conservation Board in October 28, 2010 (The Engineering Company 2010). The short-term goal in the water conservation plan is to decrease water use by one percent each year over a ten-year period to 2019. Long-term goals are to decrease overall water use such that a 0.3 percent increase in population over a 20-year period will not increase water use, and to increase the use of non-potable water to irrigate parks, open spaces and landscaping over a 20-year period. This will be accomplished through irrigation water conservation, residential indoor improvements, industrial and commercial efficiency improvements, water rate increases and distribution system maintenance and repair. Based on values in the water conservation plan, per capita use would be reduced by about 23 percent over the planning horizon. Because these measures are anticipated to be mostly complete by 2029, additional reductions beyond the 2029 per capita use rate were not assumed to occur.

Las Animas

Las Animas	
AVC Annual Delivery:	602 ac-ft
Master Contract Request:	300 ac-ft

Las Animas is located south of the Arkansas River in Bent County. Las Animas currently uses alluvial groundwater treated in a reverse osmosis water treatment plant to meet water demands. Table 16 presents the current and future water demands for Las Animas, while Table 17 presents Las Animas' water supplies. Water demand in 2070 is projected to be 602 ac-ft. Current reported supply of alluvial groundwater is 570 ac-ft, while average supply from known surface water sources is 862 ac-ft.

Table 16. Current and Future Water Demand for Las Animas

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	4,405	116	570
2070	5,488	98	602

Table 17. Current and Future Water Supplies for Las Animas

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Wells [(1)]		570	0
Surface Water			
Las Animas Consolidated Canal		50	50
Fry-Ark Project	See Table 1	499	499
Fry-Ark Project Return Flow [(2)]	See Table 1	313	313
Total Surface Water Supplies		**862**	**862**

Notes:
(1) Average yield from STAG, Table 5-3.
(2) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual 2070 AVC deliveries to Las Animas are estimated to be 602 ac-ft per year, which meet the entire future demand. Deliveries will consist of 499 ac-ft per year of existing Fry-Ark allocations and NPANIW supplies, while the remaining 103 ac-ft would come from Fry-Ark return flows and non-Fry-Ark Project sources, including existing shares of Las Animas Consolidated Canal. Las Animas is requesting 300 ac-ft of Master Contract storage space, and would store Fry-Ark return flows and non-Fry-Ark Project water supplies for AVC use.

The primary use of AVC is to replace poor quality water supplies and to meet future discharge requirements for brine disposal. Specific contaminants of concern were not mentioned, but are likely similar to those for La Junta. Las Animas will discontinue use of its existing reverse osmosis system, except for any disinfection requirements for AVC water.

Las Animas will be covered under a regional water conservation plan being prepared by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract would service growth within Las Animas' service area.

Manzanola

Manzanola	
AVC Annual Delivery:	50 ac-ft
Master Contract Request:	60 ac-ft

Manzanola is located south of the Arkansas River in Otero County. Manzanola uses blended supplies that include 75 percent alluvial groundwater and 25 percent deep groundwater. Table 18 presents the current and future water demands for Manzanola, while Table 19 presents Manzanola's water supplies. Water demand in 2070 is projected to be 50 ac-ft. Current reported groundwater supply is 39 ac-ft, while supply from surface water sources is 181 ac-ft.

Table 18. Current and Future Water Demand for Manzanola

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	476	73	39
2070	610	73	50

Table 19. Current and Future Water Supplies for Manzanola

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Deep Wells [(1)]		10	0
Alluvial Wells [(1)]		29	0
Surface Water			
Catlin Canal		26	26
Rocky Ford Highline Canal		74	74
Fry-Ark Project	See Table 1	50	50
Fry-Ark Return Flows [(2)]	See Table 1	31	31
Total Surface Water Supplies		**181**	**181**

Notes:
(1) From Master Contract Questionnaire.
(2) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual AVC deliveries to Manzanola are estimated to be 50 ac-ft per year, which is 100 percent of 2070 demands. These deliveries will consist of 50 ac-ft per year of existing Fry-Ark allocations and NPANIW supplies, or a combination of Fry-Ark supplies and non-Project supplies. Manzanola is requesting 60 ac-ft of Master Contract storage space for drought protection and to provide for future demand. Manzanola would store existing Catlin Canal and Rocky Ford Highline canal shares, and potentially return flow credits, and make releases for AVC uses.

The primary use of AVC is to meet projected growth in demand and to improve water quality. Manzanola has reported radionuclide contaminants in their deep wells, though state enforcement actions have not been required. No specific data water quality data was collected as part of the EIS process.

Manzanola will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070.

May Valley

May Valley	
AVC Annual Delivery:	222 ac-ft
Master Contract Request:	300 ac-ft

May Valley is north of Lamar and the Arkansas River. May Valley currently uses tributary and non-tributary deep bedrock groundwater, which is treated in a conventional water treatment plant. Of May Valley's ten existing wells, seven are under an enforcement action for radionuclides, leaving three wells capable of producing water that meets primary drinking water standards. Table 20 presents the current and future water demands for May Valley, while Table 21 presents May Valley's water supplies. Water demand in 2070 is projected to be 435 ac-ft. Current wells in compliance for radionuclides have a yield of 231 ac-ft. Sources of surface water include Fry-Ark allocations, NPANIW supplies, and Fry-Ark return flows, which total 311 ac-ft. May Valley is a member of the Colorado Water Protective and Development Association, which provides well augmentation. May Valley's high per capita water use is attributed to industrial livestock watering and leaks in the distribution system.

Table 20. Current and Future Water Demand for May Valley

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	1,500	244	410
2070	1,740	223	435

Table 21. Current and Future Water Supplies for May Valley

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Wells not under enforcement actions [(1)]		231	0
Surface Water			
Lower Arkansas Valley Water Conservancy District lease		Conditional on AVC and/or Augmentation Demand Gap	
Fry-Ark Project	See Table 1	191	191
Fry-Ark Project Return Flow [(2)]	See Table 1	120	0
Total Surface Water Supplies		**311**	**191**

Notes:
(1) From STAG, Appendix 5
(2) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual AVC deliveries to May Valley are estimated to be 222 ac-ft per year, which will meet about 51 percent of 2070 demand. These deliveries will consist of 191 ac-ft per year of existing Fry-Ark allocations and NPANIW supplies, and 31 ac-ft of non-Project water. May Valley has not identified a source of non-Fry-Ark Project AVC water supplies. Fry-Ark return flows are not available to use in AVC, because May Valley's return flows accrue to the Arkansas River downstream from John Martin Reservoir; thus, they cannot be exchanged upstream. The remaining 2070 demand not delivered by the AVC would be met through blending with existing groundwater supplies in compliance with State water quality regulations. May Valley is requesting 300 ac-ft of Master Contract storage space, and would store non-Fry-Ark Project water supplies and make releases for AVC use during periods when sufficient Fry-Ark supplies are unavailable.

The primary use of AVC is to replace poor quality supplies and to improve water quality. The specific contaminants of concern are combined radium 226/228 and gross alpha particle activity, which are not in compliance with primary drinking water standards. May Valley would abandon existing wells that are out of compliance for radionuclides, leaving three compliant production wells for blending with AVC.

May Valley will be covered under a regional water conservation plan being prepared by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract would service growth within May Valley's service area.

Olney Springs

Olney Springs	
AVC Annual Delivery:	59 ac-ft
Master Contract Request:	125 ac-ft

Olney Springs is located in the lower Arkansas River Basin in Crowley County. Olney Springs currently uses disinfected alluvial groundwater and augments this water with its Fry-Ark allocation, and Colorado Canal Companies and Twin Lakes shares. Table 22 presents the current and future water demands for Olney Springs, while Table 23 presents Olney Springs' water supplies. Water demand in 2070 is projected to be 59 ac-ft. Current reported supply of alluvial groundwater is 226 ac-ft, while augmentation supply from surface water sources is 210 ac-ft.

Table 22. Current and Future Water Demand for Olney Springs

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	390	92	40
2070	619	86	59

Table 23. Current and Future Water Supplies for Olney Springs

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Wells (1)		226	0
Surface Water			
Twin Lakes Reservoir and Canal Company Decrees (2)(3)	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	100	100
Colorado Canal Companies (2)(3)	Div. 2, 84CW62, 63, & 64	56	56
Fry-Ark Project	See Table 1	54	54
Fry-Ark Project Return Flow	See Table 1	0	0
Total Surface Water Supplies		**210**	**210**

Notes:
(1) From STAG AVC survey and Master Contract questionnaire.
(2) Share information from STAG survey, raw water supply.
(3) From STAG, Twin Lakes Yield = 0.78 ac-ft/share for augmentation; Colorado Canal/Lake Meredith yields = 0.684 ac-ft per share for augmentation purposes.

Annual AVC deliveries to Olney Springs are estimated to be 59 ac-ft per year, which meets 100 percent of 2070 demand. Of this amount, 54 ac-ft would be Fry-Ark allocations and NPANIW supplies, while the remaining 5 ac-ft would come from non-Fry-Ark Project sources. Olney Springs is requesting 125 ac-ft of Master Contract storage space to store non-Fry-Ark Project water that would be delivered through the AVC. Non-Fry-Ark Project water sources include existing Colorado Canal Companies and Twin Lakes shares. Olney Springs does not have any Fry-Ark return flows because they use evaporation ponds for their wastewater treatment.

Olney Springs is requesting participation in AVC and the Master Contract to replace poor quality groundwater supplies and to enable leasing of their excess surface water supplies to surrounding areas. Olney Springs has reported substantial manganese issues with their current groundwater supplies.

Olney Springs will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract and used in AVC would service growth within Crowley County.

Ordway

Ordway	
AVC Annual Delivery:	366 ac-ft
Master Contract Request:	750 ac-ft

Ordway is located in the lower Arkansas River Basin in Crowley County. Ordway currently serves customers through disinfected non-tributary groundwater. Table 24 presents the current and future water demands for Ordway, while Table 25 presents Ordway's water supplies. Annual municipal and industrial water demand in 2070 is projected to be 366 ac-ft. Current reported supply of alluvial groundwater is 125 ac-ft, while supply from surface water sources is 760 ac-ft.

Table 24. Current and Future Water Demand for Ordway

Year	Population	Per Capita Water Use (gpcd)	Potable Water Demand (ac-ft)
2010	1,270	169	240
2070	2,015	162	366

Table 25. Current and Future Water Supplies for Ordway

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Faw Wells (non-tributary) (1)		125	0
Surface Water			
Twin Lakes Reservoir and Canal Company Decrees (1)	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	450	450
Colorado Canal Companies (1)	Div. 2, 84CW62, 63, & 64	135	135
Fry-Ark Project	See Table 1	175	175
Fry-Ark Project Return Flow	See Table 1	0	0
Total Surface Water Supplies		**760**	**760**

Notes:
(1) From STAG AVC survey and Master Contract questionnaire. The number of shares owned was not identified.

Annual 2070 AVC deliveries to Ordway are estimated to be 366 ac-ft per year, which is 100 percent of 2070 demand. Fry-Ark allocations and NPANIW supplies would provide 175 ac-ft of AVC delivery, while the remaining 191 ac-ft would come from non-Fry-Ark Project sources, such as Twin Lakes and Colorado Canal/Lake Meredith shares. The Town of Ordway does not have any Fry-Ark return flows, because it uses evaporation ponds for its wastewater treatment. Ordway is requesting 750 ac-ft of Master Contract storage space to store non-Fry-Ark Project water, including existing and future Twin Lakes Reservoir and Canal Company shares, and Colorado Canal/Lake Meredith shares. Ordway plans to lease its Twin Lakes water stored under the Master Contract to other municipalities within Southeastern Colorado Water Conservancy District's boundaries.

Ordway is requesting participation in AVC and the Master Contract to provide a more reliable and efficient means for meeting future supplies and to replace poor quality supplies (Black & Veatch 2010). As with other participants, Ordway incurs transit losses on water delivered from Pueblo Reservoir. These losses would not be incurred in the AVC. No information was supplied on particular constituents that may be the source of water quality issues. However, these constituents are likely similar to other participants in the area using similar water supply sources.

Ordway uses non-potable surface water to irrigate public areas and school grounds and uses drip irrigation on their baseball fields. Ordway will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract would service growth within Ordway's service area and within Southeastern Colorado Water Conservancy District's boundaries through lease of water stored under the Master Contract.

Rocky Ford

Rocky Ford
AVC Annual Delivery: 576 ac-ft
Master Contract Request: 1,200 ac-ft

Rocky Ford is located south of the Arkansas River in Otero County. Rocky Ford currently uses alluvial groundwater treated in a conventional water treatment plant to meet water demands. Table 26 presents the current and future water demands for Rocky Ford, while Table 27 presents Rocky Ford's water supplies. Water demand in 2070 is projected to be 1,031 ac-ft. Current reported supply of alluvial groundwater is 1,122 ac-ft, while supply from surface water sources is 1,507 ac-ft.

Table 26. Current and Future Water Demand for Rocky Ford

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	3,994	199	890
2070	5,130	179	1,031

Table 27. Current and Future Water Supplies for Rocky Ford

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Wells [(1)]		1,122	0
Surface Water			
Catlin Canal [(1)] [(2)]	Div. 2, 06CW49	406	406
Rocky Ford Ditch [(1)] [(2)]	Div. 2, 06CW49	151	151
Fry-Ark Water	See Table 1	584	584
Fry-Ark Project Return Flow [(3)]	See Table 1	366	366
Total Surface Water Supplies		**1,507**	**1,507**

Notes:
(1) Groundwater and ditch share information from Master Contract questionnaire.
(2) From STAG Appendix 5, Catlin Canal yield = 0.984 ac-ft/share; Rocky Ford Canal yield = 17.3 ac-ft per share.
(3) Return Flow estimates assume full use of Fry-Ark Project allocation.

Annual AVC deliveries to Rocky Ford are estimated to be 576 ac-ft per year, which is 56 percent of 2070 demands. These deliveries will consist of existing Fry-Ark allocations and NPANIW supplies. The remaining 2070 demand not delivered by the AVC would be met through blending with existing groundwater supplies. Rocky Ford is requesting 1,200 ac-ft of Master Contract storage space. Rocky Ford would store existing Catlin Canal, Rocky Ford Ditch shares, and potentially return flow credits, and make releases for well augmentation uses.

Rocky Ford recently purchased the Hancock water system and will be adding it to their system shortly (Hancock is discussed separately). No specific water quality issues were reported by Rocky Ford and no specific data water quality data was collected as part of the EIS process.

Rocky Ford will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070.

Sugar City

Sugar City
AVC Annual Delivery: 127 ac-ft
Master Contract Request: 0 ac-ft

Sugar City is located in the lower Arkansas River Basin in Crowley County. Sugar City currently uses disinfected alluvial groundwater to meet demands. Table 28 presents the current and future water demands for Sugar City, while Table 29 presents Sugar City's water supplies. Municipal and industrial water demand in 2070 is projected to be 127 ac-ft. Current reported supply of alluvial groundwater is 82 ac-ft, while supply from surface water sources is 174 ac-ft. Sugar City is also a member of the Colorado Water Protective and Development Association, which provides additional well augmentation. Sugar City's higher than typical per capita water use is due to several livestock watering operations within its service area.

Table 28. Current and Future Water Demand for Sugar City

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	280	261	82
2070	444	255	127

Table 29. Current and Future Water Supplies for Sugar City

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial Groundwater (1)		82	0
Surface Water			
Twin Lakes Reservoir and Canal Company Decrees (2) (3)	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	62	62
Colorado Canal Companies (2) (3)	Div. 2, 84CW62, 63, & 64	55	0
Twin Lakes Reservoir and Canal Company lease (4)	Div. 2, 10CW2 and 06CW8	Conditional on AVC Demand Gap	
Fry-Ark Project	See Table 1	57	57
Fry-Ark Return Flows	See Table 1	0	0
Total Surface Water Supplies		**174**	**119**

Notes:
(1) From STAG, Table 5-3.
(2) Share information from STAG AVC survey, raw water supply.
(3) From STAG, Appendix 3, Twin Lakes Yield = 0.78 ac-ft/share for augmentation; No yield for Colorado Canal/Lake Henry is provided. For purposes of this table, assumed to be equal to Colorado Canal/Lake Meredith yields = 0.684 ac-ft per share for augmentation purposes.
(4) Twin Lakes Reservoir and Canal Company lease from other Crowley County entities.

Annual AVC deliveries to Sugar City are estimated to be 127 ac-ft per year, which is 100 percent of 2070 demand. Of this amount, 57 ac-ft would be Fry-Ark allocations and NPANIW supplies, while the remaining 70 ac-ft would come from non-Fry-Ark Project sources. Non-Fry-Ark Project water sources include existing Twin Lakes Reservoir and Canal Company shares, and Twin Lakes Reservoir and Canal Company shares leased from other Crowley County entities, such as Ordway. Sugar City is not requesting Master Contract storage space, and therefore is unable to use Colorado Canal shares and Fry-Ark return flows in the AVC.

Sugar City is requesting participation in AVC to replace poor quality water supplies (Black & Veatch 2010). As with other participants, Sugar City incurs transit losses on water delivered from Pueblo Reservoir. These losses would not be incurred in the AVC. No information was supplied on particular constituents that may be the source of water quality issues. However, these constituents are likely similar to other participants in the area using similar water supply sources.

Sugar City will be covered under a regional water conservation plan currently in preparation by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070.

St. Charles Mesa Water District

St. Charles Mesa	
AVC Annual Delivery:	2,651 ac-ft
Master Contract Request:	2,000 ac-ft

St. Charles Mesa Water District (St. Charles Mesa) is located east of Pueblo and south of the Arkansas River. St. Charles Mesa currently uses surface water from the Arkansas River treated in a conventional water treatment plant to fulfill its demand. This water is generally delivered from Pueblo Reservoir to the water treatment plant via the Bessemer Ditch during summer months and through an Arkansas River pump station and pipeline during the winter months. Table 30 presents the current and future water demands for St. Charles Mesa, while Table 31 presents St. Charles Mesa's water supplies. Water demand in 2070 is projected to be 2,651 ac-ft. Current reported supply of alluvial groundwater is 200 ac-ft, while supply from surface water sources is 8,680 ac-ft, although some existing surface supplies have limitations that make them unavailable for use in AVC (see below).

Table 30. Current and Future Water Demand for St. Charles Mesa Water District

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	10,937	135	1,660
2070	19,540	121	2,651

Table 31. Current and Future Water Supplies for St. Charles Mesa Water District

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage and/or AVC Delivery (ac-ft/yr)
Groundwater			
Alluvial wells (1)		200	0
Surface Water			
Bessemer Irrigation Ditch (2)	Div. 2, 04CW08 & 09CW91	4,665	4,665
Zoeller Ditch (3)	Div. 2, 80CW164	620	620
Cottonwood Irrigating Ditch (3)	Div. 2, W-4411	1,040	1,040
Velasquez Rights (3)	Div. 2, W-4791 & W-0228	238	238
Fry-Ark Project	See Table 1	1,301	1,301
Fry-Ark Return Flows (4)	See Table 1	816	816
Total Surface Water Supplies		**8,680**	**8,680**

Notes:
(1) From STAG, Table 5-3.
(2) From Master Contract questionnaire. Due to decree limitations that required conveyance of Bessemer Ditch shares in the Bessemer Ditch, these shares cannot be used in AVC, but can be stored in Master Contract storage space.
(3) From Master Contract questionnaire.
(4) Return Flow estimates assume full use of Fry-Ark Project allocation.

In 2070, annual AVC deliveries to St. Charles Mesa are expected to be 2,651 ac-ft per year and would serve their entire demand. St. Charles Mesa would deliver 1,301 ac-ft of Fry-Ark water, and 1,350 ac-ft of existing Fry-Ark return flows and non-Fry-Ark Project supplies in AVC. St. Charles Mesa is also requesting 2,000 ac-ft of Master Contract storage space. This storage space would be used to store Fry-Ark return flow and non-Fry-Ark Project supplies, including shares of the Bessemer Ditch (decreed and pending water rights). Native Arkansas River water rights, including Cottonwood Irrigating Ditch, Zoeller Ditch, and Velasquez water rights, would be exchanged to or routed through excess capacity space for delivery through AVC. Due to limitations in decrees, the Bessemer Ditch water could not be used in AVC and would be used for other as yet undetermined uses.

St. Charles Mesa is requesting participation in AVC and the Master Contract in order to improve water quality. The primary water quality concern is non-point source pollution and potential spills of toxic material into source water systems, including both the Bessemer Ditch and the Arkansas River, as these systems flow through the City of Pueblo. No specific water quality data was provided by the participant or collected as part of the EIS process.

St. Charles Mesa is also requesting participation in AVC and the Master Contract to more efficiently use existing supplies by eliminating transit losses currently assessed on deliveries from Pueblo Reservoir to the water treatment plant through surface water conveyance (either in the Arkansas River or Bessemer Ditch). For those alternatives that divert directly from Pueblo Dam or the Joint Use Pipeline, no transit loss would be assessed to AVC participants. The River South alternative would continue to incur a transit loss assessment from Pueblo Dam to the river intake.

St. Charles Mesa has a water conservation plan that includes a water conservation goal of 0.4 percent per year through the year 2030 (Young Technology Group 2010). Existing supply side measures in place are an increasing block rate structure for water usage and revised rates and tap fees on a geographic basis to better reflect costs. Demand side efforts include alternative landscape practices and materials to reduce water use and providing lawn irrigation cost information to all customers. Based on values in the water conservation plan, a reduction of 13 percent in per capita use was anticipated between 2007 and 2027. Some of the measures in the plan have already been implemented. Using a constant reduction of per capita use in the conservation plan planning horizon, it is anticipated that an additional 10.6 percent conservation could be achieved from existing 2010 per capita use. Because most conservation measures are expected to be enacted within the planning horizon, additional reductions in per capita use beyond the conservation plan planning horizon were not assumed.

Water stored in the Master Contract would service growth within St. Charles Mesa’s service area. St. Charles Mesa would take delivery of water stored in the Master Contract via its existing diversion on the Arkansas River until the proposed AVC is available. At that time, except for Bessemer Ditch supplies, St. Charles Mesa would take deliveries of the Master Contract water through the AVC. Bessemer Ditch supplies would continue to be delivered using the Bessemer Ditch.

Smaller AVC Participants

Smaller AVC Participants
AVC Annual Delivery: 919 ac-ft
Master Contract Request: 378 ac-ft

The remaining 25 AVC participants are those participants with average annual deliveries in AVC of less than 100 ac-ft per year (less than about 100,000 gallons per day), and who have not identified non-Project water supplies for their Master Contract storage space or do not have Master Contract storage space. A summary of the requested AVC annual delivery and Master Contract storage request is shown in Table 32. The AVC total annual delivery for these entities is 919 ac-ft, which is about 9 percent of the total AVC annual delivery. The Master Contract storage request is 378 ac-ft, which is about one percent of the total Master Contract storage request.

Table 32. AVC Participation and Master Contract Request for Smaller AVC Participants

County	Participant	AVC Participation (ac-ft)	Master Contract Request (ac-ft)
Pueblo	Boone	94	0
Crowley	Crowley	51	0
	Beehive Water Association	10	18
	Bents Fort Water Co.	81	10
	Cheraw	30	0
	East End Water Association	13	0
	Eureka Water Co.	86	0
	Fayette Water Association	14	16
	Hancock Inc.	18	0
	Hilltop Water Co.	40	35
	Holbrook Center Soft Water	22	12
	Homestead Improvement Association	9	6
	Newdale-Grand Valley Water Co.	60	50
	North Holbrook Water	8	0
	Patterson Valley	17	40
	South Side Water Association	5	8
	South Swink Water Co.	92	80
	Swink	49	0
	Valley Water Co.	39	47
	Vroman	37	41
	West Grand Valley Water Inc.	15	15
Otero	West Holbrook Water	9	0
	Hasty Water Company	33	0
Bent	McClave Water Association	59	0
Prowers	Wiley	28	0
Total		**919**	**378**

Table 33 presents current and future water demands and per capita use rates for these participants. Overall, 2010 population is about 12 percent of total population for all AVC participants, while 2010 annual demand is about 8 percent of total annual demand. In 2070, population for these participants is expected to be 11 percent of total population, while demand is expected to be 8 percent of total demand. Per capita use for these participants varies from 43 to over 500 gpcd, with an average of 115 gpcd. Of the 25 participants in this group, five of the participants have existing per capita use rates greater than 200 gpcd. As stated in Chapter 1, the primary reasons for these higher per capita use rates is livestock watering and leaking distribution systems.

Table 33. Current and Future Water Demands for Smaller AVC Participants

County	Participant	2010			2070		
		Popu-lation	Per Capita Water Use (gpcd)	Water Demand (ac-ft)	Popu-lation	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
Pueblo	Boone	324	182	66	580	171	111
Crowley	Crowley	200	151	34	317	145	51
	Beehive Water Assn	165	43	8	210	43	10
	Bents Fort Water Co.	900	62	63	1,160	62	81
	Cheraw	193	222	48	250	204	57
	East End Water Assn.	75	131	11	100	113	13
	Eureka Water Co.	330	200	74	425	181	86
	Fayette Water Assn.	60	179	12	80	156	14
	Hancock Inc.	150	101	17	195	83	18
	Hilltop Water Co.	284	141	45	365	122	50
	Holbrook Center Soft Water	50	321	18	65	307	22
	Homestead Improvement Assn.	67	93	7	85	93	9
	Newdale-Grand Valley Water Co.	463	110	57	595	90	60
	North Holbrook Water	40	156	7	50	139	8
	Patterson Valley	96	139	15	125	125	17
	South Side Water Assn.	48	130	7	60	101	7
	South Swink Water Co.	610	126	86	780	105	92
	Swink	664	51	38	850	51	49
	Valley Water Co.	325	104	38	415	85	39
	Vroman	150	190	32	195	168	37
	West Grand Valley Water Inc.	84	266	25	110	242	30
Otero	West Holbrook Water	23	543	14	30	494	17
	Hasty Water Company	285	100	32	355	83	33
Bent	McClave Water Assn.	440	114	56	550	114	70
Prowers	Wiley	434	49	24	505	49	28
Total		**6,460**	**115**	**834**	**8,452**	**107**	**1009**

Table 34 presents existing water supplies. All small Pueblo and Crowley county participants currently use alluvial groundwater supplies to meet demands, while all small Otero, Bent and Prowers County participants use mostly deep groundwater to meet demands. The entities shown in the table make up 59 percent of the deep groundwater supplies used in the AVC service area. The total Fry-Ark supplies for these entities are about 1,180 ac-ft, which is about 15 percent of total Fry-Ark supply for AVC entities.

Table 34. Current Available Water Supplies for Smaller AVC Participants

County	Participant	Current Available Annual Supply (ac-ft)			
		Alluvial Wells (ac-ft)	Deep Wells (ac-ft)	Fry-Ark Project (ac-ft)(1)	Total
Pueblo	Boone	66		80	146
Crowley (2) (3)	Crowley			26	26
	Beehive Water Assn.		8	16	24
	Bents Fort Water Co.	30	35	132	197
	Cheraw		48	30	78
	East End Water Assn.		11	16	27
	Eureka Water Co.		74	91	165
	Fayette Water Assn.		12	15	27
	Hancock Inc.		7	29	36
	Hilltop Water Co.		45	65	110
	Holbrook Center Soft Water		18	10	28
	Homestead Improvement Assn.		7	15	22
	Newdale-Grand Valley Water Co.		57	98	155
	North Holbrook Water		7	13	20
	Patterson Valley		15	21	36
	South Side Water Assoc.		7	8	15
	South Swink Water Co.		86	133	219
	Swink		38	80	118
	Valley Water Co.		38	60	98
	Vroman		32	33	65
	West Grand Valley Water Inc.		25	20	45
Otero	West Holbrook Water		14	3	17
	Hasty Water Company		32	54	86
Bent	McClave Water Assoc.		56	96	152
Prowers	Wiley		24	46	70
Total		**96**	**696**	**1,188**	**1,980**

Notes:
(1) Total Fry-Ark allocation includes first use Fry-Ark water, not previously allocated non-irrigation water (NPANIW), and Fry-Ark Return Flows, where applicable.
(2) Crowley County participants also own various shares in Colorado Canal and Twin Lake Reservoir and Canal Co.
(3) 96 Pipeline Co. and Crowley currently purchase supplies from Crowley County Commissioners.

Table 35 lists current and future non-project supplies that could be used for Master Contract storage, augmentation, and/or AVC delivery for smaller AVC participants. Participants that have requested Master Contract storage space, but have not identified a non-project source, could store Fry-Ark return flows and Lower Arkansas Valley Water Conservancy District leases in their excess capacity account. The needs for Master Contract storage space for participants listed in Table 35 include drought protection and future demand growth.

Table 35. Current and Future Water Non-Project Supplies for Smaller AVC Participants with Master Contract Storage Space

Participant	Source	Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage or AVC Delivery (ac-ft/yr)
Beehive Water Assn.	Fry-Ark Project Return Flow	See Table 1	6	6
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Bents Fort Water Co.	Fry-Ark Project Return Flow	See Table 1	51	51
	Twin Lakes Reservoir and Canal Company Decrees	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	2	2
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Fayette Water Assn.	Fry-Ark Project Return Flow	See Table 1	6	6
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Hilltop Water Co.	Fry-Ark Project Return Flow	See Table 1	25	25
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Holbrook Center Soft Water	Fry-Ark Project Return Flow	See Table 1	4	4
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Homestead Improvement Assn.	Fry-Ark Project Return Flow	See Table 1	6	6
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Newdale-Grand Valley Water Co.	Fry-Ark Project Return Flow	See Table 1	38	38
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Patterson Valley	Fry-Ark Project Return Flow	See Table 1	8	8
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
South Side Water Assn.	Fry-Ark Project Return Flow	See Table 1	3	3
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
South Swink Water Co.	Fry-Ark Project Return Flow	See Table 1	51	51
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Valley Water Co.	Fry-Ark Project Return Flow	See Table 1	23	23
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Vroman	Fry-Ark Project Return Flow	See Table 1	13	13
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
West Grand Valley Water Inc.	Fry-Ark Project Return Flow	See Table 1	8	8
	Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	(1)	(1)
Total			**243**	**243**

Notes.
(1) Amounts Conditional on AVC and/or Augmentation Demand Gap

Table 36 presents a summary of estimated 2070 demands, 2070 deliveries through AVC, the percent of 2070 deliveries that are taken through AVC, and water supply system operations for the smaller AVC participants. Overall, 91 percent of 2070 demands will be served from AVC, and 18 of the 25 (72 percent) participants will serve their entire 2070 demands from AVC. The remaining participants plan to blend AVC water with existing alluvial and deep wells. One participant, Cheraw, plans to blend AVC supplies with deep well water that is currently under enforcement actions.

Table 37 presents a summary of the needs identified for the AVC. Of the 25 participants shown in the table, 14 of the participants (56 percent) currently have enforcement actions for existing deep groundwater well supplies. An additional three participants have elevated levels of radionuclides in their groundwater supplies, but do not currently have enforcement actions against these supplies. Water quality has specifically been identified as a need for the AVC for 21 of the 25 participants (84 percent), either because of the enforcement actions, or through identified needs by the participants to replace poor quality supplies or to improve water quality by blending. Although only six of the entities specifically identified current or projected future shortfalls in water supplies as a need for the project, comparison of existing well yields with projected future demand shows that all participants require additional supplies to meet future demands.

All of these participants will be covered under a regional water conservation plan being prepared by Southeastern Colorado Water Conservancy District. Because the water conservation plan has not been finalized, Southeastern Colorado Water Conservancy District has assumed water conservation can be achieved through passive water conservation through 2070. Water stored in the Master Contract would service growth within the participants' service area.

Table 36. Summary of 2070 AVC Operations for Smaller AVC Participants

County	Participant	2070 Demands (ac-ft)	AVC Partici-pation (ac-ft)	Percent of 2070 Demands From AVC	2070 AVC Operations
Pueblo	Boone	111	94	85	Blend AVC with existing alluvial wells
Crowley	Crowley	51	51	100	AVC to serve all demands
Otero	Beehive Water Assn	10	10	100	AVC to serve all demands
	Bents Fort Water Co.	81	81	100	AVC to serve all demands
	Cheraw	57	30	53	Blend AVC with existing deep wells (enforcement actions on existing wells)
	East End Water Assn.	13	13	100	AVC to serve all demands
	Eureka Water Co.	86	86	100	AVC to serve all demands
	Fayette Water Assn.	14	14	100	AVC to serve all demands
	Hancock Inc.	18	18	100	AVC to serve all demands
	Hilltop Water Co.	50	40	80	Blend AVC with future supplies from Crowley County or Lower Arkansas Valley Water Conservancy District
	Holbrook Center Soft Water	22	22	100	AVC to serve all demands
	Homestead Improvement Assn.	9	9	100	AVC to serve all demands
	Newdale-Grand Valley Water Co.	60	60	100	AVC to serve all demands
	North Holbrook Water	8	8	100	AVC to serve all demands
	Patterson Valley	17	17	100	AVC to serve all demands
	South Side Water Assn.	7	5	71	Blend AVC with existing deep wells
	South Swink Water Co.	92	92	100	AVC to serve all demands
	Swink	49	49	100	AVC to serve all demands
	Valley Water Co.	39	39	100	AVC to serve all demands
	Vroman	37	37	100	AVC to serve all demands
	West Grand Valley Water Inc.	30	15	50	Blend AVC with existing deep wells
	West Holbrook Water	17	9	53	Blend AVC with existing deep wells
Bent	Hasty Water Company	33	33	100	Blend AVC with existing deep wells
	McClave Water Assn.	70	59	84	Blend AVC with existing deep wells without enforcement actions
Prowers	Wiley	28	28	100	AVC to serve all demands
Total		**1009**	**919**	**91**	

Table 37. Use of AVC by Smaller AVC Participants

County	Participant	Current Enforcement Action	Need Identified in STAG Survey: Meet Shortfall in Current Supply	Need Identified in STAG Survey: Meet Projected Growth in Demand	Need Identified in STAG Survey: Replace Current, Poor-Quality Supplies	Need Identified in STAG Survey: Improve Water Quality (Through Blending)	Current Treatment: Disinfection Only	Current Treatment: Filtration and Disinfection	Notes
Pueblo	Boone						X		No need specified
Crowley	Crowley, Town of				X		X		Purchased from Crowley County
	Beehive Water Assn			X					Treatment unknown
	Bents Fort Water Co.		X	X	X		X		
	Cheraw	X				X		X	
	East End Water Assn.	X			X		X		
	Eureka Water Co.	X			X	X		X	
	Fayette Water Assn.	X			X	X		X	
	Hancock Inc.	X		X				X	
	Hilltop Water Co.				X	X		X	High radionuclide levels but no enforcement actions
	Holbrook Center Soft Water	X			X	X	X		
	Homestead Improvement Assn.	X [1]			X			X	Current supply from La Junta
	Newdale-Grand Valley Water Co.				X			X	High radionuclide levels but no enforcement actions
	North Holbrook Water					X			Treatment unknown
	Patterson Valley	X			X	X	X		
	South Side Water Assoc.								No need specified, treatment unknown
	South Swink Water Co.	X		X	X			X	
	Swink	X				X	X		
	Valley Water Co.	X				X		X	
	Vroman	X			X			X	Currently looking at RO-at-tap system
	West Grand Valley Water Inc.		X		X	X		X	
Otero	West Holbrook Water		X						Treatment unknown
	Hasty Water Company					X	X		
Bent	McClave Water Assn.	X				X	X		
Prowers	Wiley	X					X		No need specified.
	Count	**14**	**3**	**4**	**13**	**12**	**10**	**11**	

Notes:
[1] Homestead Improvement Association enforcement action has been satisfied by purchasing water from La Junta.

Master Contract Participants

Reclamation is proposing to enter into a 40-year contract with Southeastern Colorado Water Conservancy District for storage of non-Fry-Ark Project water in Pueblo Reservoir. Assuming the AVC is constructed by 2022, Master Contract participants were evaluated based on their projected 2060 water demand and ability to meet those projected demands with existing water supplies. The methodology for calculating water demand is explained in Chapter 1 and is summarized in the "AVC Participants" section of this appendix. The planning horizon for the Master Contract (2060) differs from AVC (2070), because of the difference in the length of the contract with Reclamation. This information was gathered from each Master Contract participant.

Generally, the Master Contract participants would use the requested storage space to exchange and store transferred agricultural water, or capture return flows for augmentation, reuse, or exchange. Decrees for change in use and exchanges are listed in the tables for each participant, though it should be noted that many Master Contract participants' non-Project supplies would be exchanged under Southeastern Colorado Water Conservancy District's pending 06CW7 decree. Appendix A.3 contains a list of water rights proposed for use in Master Contract storage space (excluding AVC participants). These are the only water rights that would be included in the proposed federal actions.

The Lower Arkansas Valley Water Conservancy District is a wholesale water supplier that is requesting Master Contract storage space in order to lease agricultural water under the Super Ditch to those municipal and agricultural entities that do not have enough water supplies to meet future demand.

Cañon City

Cañon City
Master Contract Request: 1,000 ac-ft

Cañon City is on the Arkansas River, upstream from Pueblo Reservoir in Fremont County. Table 38 presents the current and future water demands for Cañon City, while Table 39 presents Cañon City's water supplies. Water demand in 2060 is projected to be 11,070 ac-ft, while reported annual supply is 28,196 ac-ft.

Table 38. Current and Future Water Demand for Cañon City

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	25,300	198	5,600
2060	54,838	180	11,070

Table 39. Current and Future Water Supplies for Cañon City

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)[(1)]	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater			
Alluvial Pumping		0	0
Surface Water			
Cañon City Water Works	Div. 2, W-4034	Unknown	162[(2)]
Cañon City Hydraulic Ditch & Irrigating Co.		Unknown	Unknown
Frank Mayol Ditch		360	0
Fry-Ark Project	See Table 1.	1,000	0
Fry-Ark Project Return Flow [(3)]	See Table 1.	643	643
Total Surface Water Supplies		**28,196**	**805**

Notes:
(1) Cañon City's reported total annual supply is 28,196 ac-ft. Cañon City has not provided annual supplies for some of their water rights.
(2) Value provided by Cañon City.
(3) Return Flow estimates assume full use of Fry-Ark Project allocation.

Cañon City is requesting 1,000 ac-ft of Master Contract storage space to store Fry-Ark return flows and non-Project supplies to provide drought protection and meet peak demands. Although Cañon City has senior water rights typically sufficient to meet future projected demand on an annual basis, Cañon City has only direct flow rights and minimal storage for emergencies that may not meet demands at all times of the year. Cañon City projects these direct flow rights will not sustain demand during drought. Generally, Cañon City pumps water from the Arkansas River to a 46 million gallon settling pond. This allows time for settling suspended solids before treatment. The settling pond also can provide a few days of raw water during an emergency when Arkansas River diversions are unavailable.

Without Master Contract storage, Cañon City would not have the opportunity to store water for use during drought conditions, or when existing direct flow rights will not sustain demand. No additional facilities would be required to transport water stored under the Master Contract.

Cañon City completed a water conservation plan in 1996 (City of Cañon City 1996) that includes the following measures: low water use fixtures and appliances; efficient landscape irrigation; commercial water conservation; leak detection and repair; customer education; block rate structures; city ordinances; and rebates. Meters, water efficient plumbing fixtures (as mandated by the 1992 Energy Policy Act) and education were already in place at the time of the plan. The water conservation plan does not contain a target demand reduction percentage. Based on data in the 1996 water conservation plan and data provided by the participant, Cañon City has reduced demand by 16 percent since the water conservation plan was enacted. Even with this reduction, existing per capita use (198 gpcd) is higher than the statewide average (see Chapter 1). Therefore, it is assumed that continued passive water conservation would reduce per capita water use by an additional 8.8 percent from now through 2060.

Water stored in the Master Contract would service growth within Cañon City's service area.

Florence

Florence
Master Contract Request: 2,250 ac-ft

Florence is on the Arkansas River, upstream from Pueblo Reservoir in Fremont County. Table 40 presents the current and future water demands for Florence, while Table 41 presents Florence's water supplies. Water demand in 2060 is projected to be 2,975 ac-ft, while reported firm annual supply is 4,147 ac-ft. Florence's most recent water demand projections were prepared in 2002 as part of the Master Plan Update for the Florence Regional Water System (The Engineering Company 2002). The 2002 Master Plan Update projected 2010 water demand to be nearly double the actual 2010 water use, due to overestimation of the actual growth rate. Therefore, Reclamation's water demand projections are less than what Florence originally projected in 2002.

Table 40. Current and Future Water Demands for Florence

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	8,090	160	1,450
2060	18,202	146	2,975

Table 41. Current and Future Water Supplies for Florence

Source	Surface Water Decree No.	Reported Firm Annual Water Supply (ac-ft/yr)	Reported Average Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater				
Alluvial Pumping		Unknown	Unknown	0
Surface Water				
Adobe/Mineral Creek	Div. 2, 80CW93	0	216	216
Newlin Creek	Div. 2, 80CW93	0	372	372
Coal Creek Pipe	Div. 2, 80CW93	0	90	90
Williamsburg Pipe	Div. 2, 80CW93	0	36	36
Union Ditch	Div. 2, 80CW93, 99CW149, 10CW63 (pending)	3,803	4,126	4,126
Florence Treatment Plant Diversion Works		0	84	0
Augmented Florence Treatment Plant Diversion Works		344	479	0
Fry-Ark Project	See Table 1	Unknown	327	0
Fry-Ark Return Flows [(1)]	See Table 1	Unknown	210	210
Total Surface Water Supplies		**4,147**	**5,940**	**5,050**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation.

Florence has sufficient water rights to satisfy future demand on an annual basis. An engineering report on the Master Plan Update for the Florence Regional Water System discusses the benefits of water storage for Florence (Martin and Wood Water Consultants, Inc. 2002). The primary benefit is diversion of direct flow water rights during peak runoff and irrigation seasons to storage until later times of the year when they can be delivered. The storage would also be used to “firm” some existing supplies by storing this water during wet years and making it available during dry years. Florence is requesting 2,250 ac-ft of Master Contract storage space to store Fry-Ark return flows and non-Project supplies to meet municipal and other beneficial use demand.

A water conservation plan has been developed that includes conservation recommendations for normal conditions, as well as increasing rates depending on the conditions of reduced availability. It is assumed that 9 percent water conservation can be achieved through passive water conservation through 2060 (Great Western Institute 2010). Water stored in the Master Contract would service growth within Florence’s service area. Delivery of water stored under the Master Contract would be via diversion from the Arkansas River at Minnequa Canal. No additional facilities would be required to transport water stored under the Master Contract.

Fountain

Fountain
Master Contract Request: 1,000 ac-ft

Fountain is located in El Paso County south of Colorado Springs in the Fountain Creek watershed basin. Fountain currently serves customers through the Fountain Valley Authority pipeline and the Fountain Creek Alluvial Wellfield. Fountain is also a participant in the Southern Delivery System project. Table 42 presents current and future water demands for Fountain, while Table 43 lists Fountain's water supplies. Water demand in 2060 is projected to be 13,156 ac-ft, while Fountain's reported firm annual surface water supply is 3,040 ac-ft.

Table 42. Current and Future Water Demands for Fountain

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	26,000	150	4,369
2060	87,000	135	13,156

Table 43. Current and Future Water Supplies for Fountain

Source	Surface Water Decree No.	Reported Firm Annual Water Supply (ac-ft/yr)	Reported Average Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater				
Fountain Creek Aquifer Wells, including Stubbs and Miller Water Rights (requires augmentation)		1,560	1,560	0
Widefield Aquifer Wells (requires augmentation)		130	1,125	0
Additional 10 percent Widefield Aquifer Allocation (requires augmentation)		0	113	0
Surface Water				
Fry-Ark Project Water	See Table 1	950	1,900	0
Fry-Ark Project Return Flows[(1)(2)]	See Table 1	661	1,322	1,322
Fountain Mutual Irrigation Company[(2)]	Div. 2, W-4396, W-4559, 85CW110	179	251	251
Fountain Mutual Irrigation Company[(2)]	01CW146 (pending), and future water court filings for 98 shares	128	179	179
Little Fountain Pipeline (Keeton Res.)		100	160	0
Colorado Canal[(2)]	Div. 2, 84CW62, 63, & 64	0	208	208
Miller Ditch	Div. 2, 03CW59	285	285	285
Crabb Ditch		35	35	0
Chilcott Ditch	Div. 2, 06CW119	102	572	572
FMIC - Priority 4 & 17	Water Court Action Needed	600	850	850
Bell Ditch Water Rights	Div. 2, 08CW47 (pending)	0	240	240
Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	2,000	2,000	2,000
Total Surface Water Supplies		**3,040**	**8,002**	**5,907**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation.
(2) Water rights also proposed for storage in Southern Delivery System excess capacity account.

Fountain is requesting 1,000 ac-ft of Master Contract storage space to meet municipal, industrial, augmentation, and replacement needs. As part of the Southern Delivery System, Fountain will be contracting for 2,500 ac-ft of excess capacity storage in Pueblo Reservoir. Those water rights that can also be stored in Fountain's Southern Delivery System excess capacity account are noted in Table 43. Some water rights in Fountain's current water rights portfolio cannot be stored in the Southern Delivery System storage space. The Master Contract storage space would allow storage of Fountain's entire current water rights portfolio that is decreed for storage in Pueblo Reservoir.

Fountain would take delivery of water stored in the Master Contract through the Fountain Valley Authority pipeline, proposed Southern Delivery System, or by release of the stored water to the confluence of Fountain Creek and the Arkansas River. No additional water delivery facilities are proposed for water stored under the Master Contract.

Fountain adopted a water conservation plan in 2001 (City of Fountain 2001) which included typical indoor and outdoor water use conservation, non-potable use, distribution system leak repair, consumer education, and an inclining block rate structure. In 2009, Fountain prepared an update to the conservation plan (W.W. Wheeler 2009). The update stated that since the original conservation plan was adopted, Fountain has reduced its system-wide demand by about 12 percent. Additionally, the water conservation plan update provided metrics, current status, savings and monitoring of water conservation plan goals. Based on information supplied by Fountain (Thompson 2010), it is anticipated that an additional 10 percent reduction in per capita use will be realized between 2010 and 2070.

Water stored in the Master Contract would service growth within Fountain's service area.

Lower Arkansas Valley Water Conservancy District

Lower Arkansas Valley Water Conservancy District
Master Contract Request: 5,000 ac-ft

The Lower Arkansas Valley Water Conservancy District (Lower Ark District) encompasses Pueblo, Crowley, Otero, Bent and Prowers counties. The Lower Ark District is requesting 5,000 ac-ft of Master Contract storage space to beneficially use all of its water resources to serve municipal, industrial, and commercial demands. Water supplies would originate from Lower Ark District supplies and a temporary rotational fallowing program called the "Super Ditch," which has been incorporated as part of the Lower Arkansas Valley Super Ditch Company. Table 44 presents a summary of the proposed water supplies.

Table 44. Current and Future Water Supplies for Lower Arkansas Valley Water Conservancy District

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Owned Supplies			
Bessemer Ditch		44	44
Holbrook Mutual Canal		76	76
Rocky Ford Ditch		Unknown	Unknown
Las Animas Consolidated Canal		1	1
Rock Ford Highline Canal		3	3
Larkspur Ditch		500	500
Super Ditch Supplies			
Bessemer Ditch	Div. 2, 10CW4	Amounts dependent on annual participation rates, fallowing rates, and exchange potential	Amounts dependent on annual participation rates, fallowing rates, and exchange potential
Rocky Ford High Line Canal	Div. 2, 10CW4		
Oxford Farmers Ditch	Div. 2, 10CW4		
Otero Canal	Div. 2, 10CW4		
Catlin Canal	Div. 2, 10CW4		
Holbrook Mutual Canal	Div. 2, 10CW4		
Fort Lyon Storage Canal	Div. 2, 10CW4		
Fort Lyon Canal	Div. 2, 10CW4		

The Lower Ark District would lease water stored in the Master Contract to the following customers for use within Southeastern Colorado Water Conservancy District's boundaries:

- Fountain Valley Authority, including Fountain, Security, Widefield, and Stratmoor Hills
- AVC Participants
- Irrigators participating in "Rule 10 Plans" to replace out-of-priority depletions pursuant to "Compact Rules Governing Improvements To Surface Water Irrigation Systems in the Arkansas River Basin in Colorado"
- Irrigators with out-of-priority seep ditch diversions

Estimates of deliveries to these potential Lower Ark District Master Contract customers are shown in Table 45.

Table 45. Lower Arkansas Valley Water Conservancy District Deliveries

Water User	Projected Future Delivery (ac-ft/yr)
Fountain Valley Authority	
Stratmoor Hills	1,250
Widefield	1,000
Security	1,000
Fountain	2,000
Arkansas Valley Conduit	Conditional on AVC and/or Augmentation Demand Gap
Rule 10 and Seep Ditch Actions	2,000

The Lower Arkansas Valley Super Ditch Company was formed in 2008 by shareholders of six irrigation districts as an agent to facilitate temporary leases and transfers of irrigation water between the Company and other water users, primarily municipal water users throughout the Arkansas Basin. Super Ditch supplies are being considered by several AVC and Master Contract participants.

This EIS considers and evaluates the effects of Super Ditch transfers to the entities described above. Additional NEPA likely would be required for transfers to other entities, as storage of this water in Pueblo Reservoir would require an additional contract with Reclamation.

With the Master Contract, the Lower Ark District would exchange water to and from major canal systems in the lower Arkansas Basin. Intermediate storage locations would also be used to facilitate exchanges of Super Ditch supplies into Pueblo Reservoir. These intermediate locations include Holbrook Reservoir, Dye Reservoir, and Lake Meredith, and are described in Super Ditch's 10CW4 application. No additional facilities would be required to transport water stored under the Master Contract.

Water conservation measures have not been developed, since the Lower Ark District is not a retail water supplier. Water stored in the Master Contract would service the entities described above; none of the municipal entities described above have indicated that this water would be used to serve growth outside of their established service area. The lease of the water is intended to help agricultural communities within the Lower Ark District financially by ensuring that water is not permanently transferred from agricultural uses.

Penrose

Penrose
Master Contract Request: 900 ac-ft

Penrose is on the Arkansas River, upstream from Pueblo Reservoir in Fremont County. Table 46 presents Penrose's current and future water demand while Table 47 presents Penrose's water supplies. Water demand in 2060 is projected to be 1,679 ac-ft. Penrose currently leases water from Beaver Park Water, Inc. and recently acquired water rights that would be stored in Master Contract storage space. The water demand presented in Table 46 reflects municipal demand and does not include demand for water to satisfy winter return flow obligations for their changed Pleasant Valley Ditch and Alexander Ditch water rights.

Table 46. Current and Future Water Demand for Penrose

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	3,300	138	510
2060	7,385	203	1,679

Table 47. Current and Future Water Supplies for Penrose

Source	Surface Water Decree No.	Reported Firm Annual Water Supply (ac-ft/yr)	Reported Average Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater				
Alluvial Pumping		0	0	0
Surface Water				
Beaver Park Water Inc. lease		Unknown	Unknown	0
Pleasant Valley Ditch/Alexander Ditch	Div. 2, 06CW12	151	334	334
Pleasant Valley Ditch/Alexander Ditch Return Flows	Water Court Action Needed	92	204	204
Fry-Ark Project	See Table 1	Unknown	115	0
Fry-Ark Return Flows (1)	See Table 1	Unknown	74	74
Total Surface Water Supplies		**243**	**727**	**612**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation

Penrose is requesting 900 ac-ft of Master Contract storage space to store Fry-Ark return flows and non-Project supplies to meet municipal demand and to maintain winter returns. Penrose expects land use within their service area to change, resulting in higher per capita water use in the future because Penrose serves a largely agrarian community. Penrose serves a relatively large percentage of underutilized taps that are primarily used to provide stock water on an intermittent basis. The majority of these taps are committed to properties zoned for single family homes and Penrose assumes that these property owners will construct homes, which will increase average per capita water use in the future. Penrose calculated water demand based on historical demand, number of taps on system, number of active taps, and U.S. Census data. Demand projections were calculated using a linear growth calculation based on historical populations and water use (1969-2009 data).

Penrose anticipates construction of a point of diversion along the Arkansas River for delivery of water stored in the Master Contract. This structure will be built regardless of Penrose's participation in the Master Contract. Planning for this structure has commenced, though a location has not been determined.

A "Conservation Rate Structure and Use" policy is in place that discourages high usage and allows its board to define allowable uses of water in a short-supply condition. Water stored in the Master Contract would service growth within Penrose's service area.

Poncha Springs

Poncha Springs is located west of Salida in Chaffee County. Poncha Springs currently delivers water to customers from alluvial wells that are tributary to the South Arkansas River.

Poncha Springs
Master Contract Request: 200 ac-ft

Table 48 presents the current and future water demands for Poncha Springs, while Table 49 presents Poncha Springs' water supplies. Reclamation has projected water demand in 2060 to be 360 ac-ft, while Poncha Springs' reported annual supply is 527 ac-ft. Reclamation assumed that population would grow much slower than Poncha Springs has estimated. As a point of comparison, Poncha Springs projects to reach a population of 2,769 at build-out within its existing boundaries by 2030, whereas Reclamation estimates 2060 population at 1,883.

Table 48. Current and Future Water Demands for Poncha Springs

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	701	187	147
2060	1,883	171	360

Table 49. Current and Future Replacement Water Supplies for Poncha Springs

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater			
Alluvial Pumping		Unknown	0
Surface Water			
McPherson Ditch	Div. 2, 99CW183, 01CW148	35	35
Harrington Ditch		30	0
Friend Ranch Rights	Div. 2, 07CW111 (pending)	302	302
Upper Arkansas Water Conservancy District Augmentation Certificate		22	0
Fry-Ark Project Water	See Table 1	100	0
Fry-Ark Project Return Flow (1)	See Table 1	38	38
Total Surface Water Supplies		**527**	**376**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation

The firm annual water supply is estimated at about 350 acre feet, reflecting the above reported amount with the Friend Ranch Water Rights reduced from an average 302.3 acre feet, as claimed in the Water Court application, to a dry year yield of 124.8 acre feet. Poncha Springs is requesting 200 ac-ft of Master Contract storage space to store Fry-Ark return flows and non-Project water to meet augmentation and replacement requirements of stream depletions associated with Poncha Springs' municipal well diversions. Water stored in the Master Contract would also provide drought protection by increasing Poncha Springs' firm annual water supply.

Water deliveries would include exchanges of water stored in Fry-Ark reservoirs to the locations of the well depletions or to other storage facilities available to Poncha Springs. Water deliveries would also include releases of water from Fry-Ark reservoirs for augmentation. No additional facilities would be required to transport water stored under the Master Contract.

Water conservation measures include lawn watering restrictions and individually metered wells; It is assumed that nine percent water conservation can be achieved through passive water conservation through 2060 (Great Western Institute 2010). This is reflected in the reduced per capita water use for 2060 in Table 48.

Pueblo West

> **Pueblo West**
> Master Contract Request: 6,000 ac-ft

Pueblo West is near the Arkansas River, generally north of Pueblo Reservoir and west of the City of Pueblo. Table 50 presents the current and future water demands for Pueblo West, while Table 51 presents Pueblo West's water supplies. Water demand in 2060 is projected to be 10,000 ac-ft, while reported firm annual supply is 8,400 ac-ft. Pueblo West expects to reach build-out before 2060 and is also a participant in the Southern Delivery System.

Table 50. Current and Future Water Demands for Pueblo West

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	31,036	198	6,877
2060	50,000	179	10,000

Table 51. Current and Future Water Supplies for Pueblo West

Source	Surface Water Decree No.	Reported Firm Annual Water Supply (ac-ft/yr)	Reported Average Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater				
Alluvial Pumping		0	0	0
Surface Water				
Colorado Canal Companies (1)	Div. 2, 86CW118A; 84CW62, 63, & 64	0	120	120
Twin Lakes Reservoir and Canal Company Decrees (1)	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	2,380	5,423	5,423
Wheel Ranch Ditch (1)	Div. 2, 81CW0056	0	30	30
Reuse & Exchange – Part A & Part B (1)	Div. 2, 85CW134A, 85CW134B	1,200	2,880	2,880
Hill Ranch	Div. 2... 01CW152	1,080	1,976	1,976
Carry-Over Storage in Twin Lakes Reservoir		0	Unknown	Unknown
Carry-Over Storage in Pueblo Reservoir (2)		3,740	Unknown	Unknown
Non-Tributary Wells (3)	Div. 2, 80CW160, 80CW171	0	0	0
Fry-Ark Project	See Table 1.	Unknown		0
Fry-Ark Return Flows (4)	See Table 1.	Unknown		
Total Surface Water Supplies		**8,400**	**10,429**	**10,429**

Notes:

(1) Water rights also proposed for storage in Southern Delivery System excess capacity account.
(2) Based on Pueblo West's current storage capacity at Twin Lakes and Pueblo Reservoir of about 15,300 ac-ft, all shown in Pueblo Reservoir.
(3) Due to water quality and depletion issues, these non-tributary wells are not currently used for water supply, but are maintained as an emergency back-up water supply.
(4) Return Flow estimates assume full use of Fry-Ark Project allocation.

Pueblo West is requesting 6,000 ac-ft of Master Contract storage space to store non-Project supplies to meet municipal and industrial demands. As part of the Southern Delivery System, Pueblo West will be contracting for 10,000 ac-ft of excess capacity storage in Pueblo Reservoir. Those water rights that can also be stored in Pueblo West's Southern Delivery System excess capacity account are noted in Table 51. However, some water rights in Pueblo West's current water rights portfolio cannot be stored in the Southern Delivery System storage space. The Master Contract storage space would allow storage of Pueblo West's entire current water rights portfolio that is decreed for storage in Pueblo Reservoir.

Pueblo West anticipates using the Southern Delivery System pipeline for delivery of water stored under the Master Contract. No additional facilities would be required to transport water stored under the Master Contract.

In 1999, Pueblo West adopted a Community Plan that outlined qualitative conservation plan (Pueblo West Metropolitan District 1999). Water conservation efforts enacted include a tiered water rate structure and a xeriscape demonstration garden that includes utilizing local landscapers to conduct free seminars, demonstration and counseling. Pueblo West also has a water conservation and drought contingency plan. The overall water conservation effort aims to achieve ten percent water conservation through 2060.

Water stored in the Master Contract would service growth within Pueblo West's service area.

Salida

Salida
Master Contract Request: 2,000 ac-ft

Salida is on the Arkansas River, upstream from Pueblo Reservoir in Chaffee County. Table 52 presents the current and future water demands for Salida, while Table 53 presents Salida's water supplies. Water demand in 2060 is projected to be 3,418 ac-ft. Absolute decreed diversion rates for individual water rights were provided, however, average or firm water supply available from these rights was not.

Table 52. Current and Future Water Demand for Salida

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	5,600	224	1,406
2060	15,043	203	3,418

Table 53. Current and Future Water Supplies for Salida

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater			
Alluvial Pumping		Unknown	0
Surface Water			
Harrington Ditch/Champ Ditch	Div. 2, 84CW158	701	701
Tenassee Ditch	Div. 2, 04CW125	361	361
Fry-Ark Project	See Table 1.	146	0
Fry-Ark Return Flows (1)	See Table 1.	94	94
Total Surface Water Supplies		**1,302**	**1,156**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation.

Salida is requesting 2,000 ac-ft of Master Contract storage space to store non-Project supplies to meet municipal demand and winter augmentation requirements. Salida has not requested Fry-Ark return flows to be stored in Master Contract storage space. Although average annual water supply is typically sufficient to meet demand on an annual basis, Salida has concerns about meeting water demand year round without storage due to seasonal fluctuations in its water supplies. Without Master Contract storage, Salida is unable to store some water rights during peak runoff times for augmentation obligations during the winter months.

Salida would take delivery of water stored in the Master Contract through existing facilities. No additional facilities would be required to transport water stored under the Master Contract.

Salida completed a water conservation plan in 2008 (Clear Water Solutions 2008). Existing water conservation measures include even/odd day restrictions on outside watering, and outside watering restrictions between 10:00 A.M. and 4:00 P.M. daily. The water conservation plan goal is to reduce water use by 13 percent over the ten-year planning horizon of the plan through utility based programs to reduce system losses, passive conservation programs, changes to inclining block rate structures, and xeriscaping in parks. The water conservation plan reports that average population between 2003 and 2007 was 5,353, with an average per capita use of 233 gpcd.

Assuming a linear reduction in demand between 2008 and 2017, 2010 per capita water use was reduced by 3.9 percent from the 2003-2007 value for use in the 2010 projections (224 mgd), and assumed as the full 13 percent for 2060 projections (203 mgd).

Water stored in the Master Contract would service growth within Salida's service area.

Security

Security
Master Contract Request: 1,500 ac-ft

Security is located in El Paso County just south of Colorado Springs in the Fountain Creek watershed basin. Security currently serves customers through the Fountain Valley Authority pipeline and wells in the Widefield aquifer. Table 54 presents the current and future water demands for Security, while Table 55 presents Security's water supplies. Water demand in 2060 is projected to be 4,930 ac-ft, while reported firm annual surface water supply is 1,729 ac-ft. Security expects to reach build-out before 2060 and is also a participant in the Southern Delivery System.

Table 54. Current and Future Water Demand for Security

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	18,200	179	3,653
2060	27,000	163	4,930

Table 55. Current and Future Water Supplies for Security

Source	Surface Water Decree No.	Reported Firm Annual Water Supply (ac-ft/yr)	Reported Average Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater				
Widefield Aquifer Wells (requires augmentation)		2,577	2,577	0
Windmill Gulch Wells (requires augmentation)		240	240	0
Additional 10 percent Widefield Aquifer Allocation (tributary)		0	258	0
Clear Spring Ranch Wells (lease expires in 2012)		0	600	0
Surface Water				
Fry-Ark Project Water	See Table 1	782	1,564	0
Fry-Ark Project Return Flows[(1)(2)]	See Table 1	420	840	840
Fountain Mutual Irrigation Company	Div. 2, 90CW28, 01CW149 (pending), & 07CW51 (pending)	264	370	370
Fountain Mutual Irrigation Company	Water Court Action Needed	54	76	76
Lock Ditch Water Rights	Div. 2, 06CW117	164	164	164
Chilcott Ditch	Div. 2, 06CW119	45	252	252
Union Ditch	Water Court Action Needed	0	300	300
Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	0	1,000	1,000
Total Surface Water Supplies		**1,729**	**4,566**	**3,002**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation.
(2) Water rights also proposed for storage in Southern Delivery System excess capacity account.

Security is requesting 1,500 ac-ft of Master Contract storage space to meet municipal, industrial, agricultural, and replacement needs. Those water rights that can also be stored in Security's Southern Delivery System excess capacity account are noted in Table 55. However, some water rights in Security's current water rights portfolio cannot be stored in the Southern Delivery System storage space. The Master Contract storage space would allow storage of Security's entire current water rights portfolio that is decreed for storage in Pueblo Reservoir.

Fry-Ark return flows are used for two purposes in the Security water system. First, Fry-Ark return flows are used to provide replacement water in a decreed augmentation plan to allow well diversions from the Widefield Aquifer and Windmill Gulch Aquifer well fields. Second, Fry-Ark return flows are delivered into storage in an existing short-term excess capacity account in Pueblo Reservoir by exchange or by contract exchanges with other water users for use as augmentation or for reuse by direct municipal water deliveries. Security is seeking to store some or all of its augmentation water rights under the Master Contract, including Fry-Ark return flows.

Water stored in the Master Contract would be delivered through the Fountain Valley Authority at times when Fry-Ark project yield is below average or through the Southern Delivery System. Storage of this water under the Master Contract would provide additional firm yield delivered through the Fountain Valley Authority and provide a water supply for delivery through the Southern Delivery System. The Master Contract would supplement the 1,500 ac-ft of storage that will be contracted for as part of the Southern Delivery System, and allow additional water rights to be stored. Water stored in the Master Contract would service growth within Security's service area.

A water conservation plan was initially developed by Security in 2004 (Security Water District / Enterprise 2004). The plan included the use of water-efficient fixtures and appliances, installation of low water use landscapes and efficient irrigation, and development of water-efficient industrial and commercial processes. Security also implemented in tiered rate structure in 2004. Security updated and expanded its water conservation plan in 2011 (Water Matters 2011). The update reports a water conservation savings of about 19 percent between 2004 and 2009, which it attributes to changing attitudes towards water use, implementation of water meters and the Security's efforts to encourage conservation. The water conservation plan update expands indoor water conservation efforts, expands public education, and implements water audits and incentives. Security is investigating water reuse systems for both potable and non-potable uses. A distribution system leak repair protocol is already being used, as is the dissemination of water use efficiency information. The water conservation plan update identifies an additional four percent reduction in demand through next 20 years. Based on long-term demand projections provided by Security (Thompson 2010), a nine percent reduction in demand is anticipated between 2010 and 2060.

Stratmoor Hills

Stratmoor Hills
Master Contract Request: 200 ac-ft

Stratmoor Hills is located in El Paso County just south of Colorado Springs in the Fountain Creek watershed basin. Stratmoor Hills currently serves customers through the Fountain Valley Authority pipeline (part of the Fry-Ark Project) and Widefield Aquifer. Table 56 presents the current and future water demands for Stratmoor Hills, while Table 57 presents Stratmoor Hill's water supplies. Water demand in 2060 is projected to be 750 ac-ft, while reported firm annual supply is 486 ac-ft.

Table 56. Current and Future Water Demand for Stratmoor Hills

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	5,500	104	640
2060	6,000	112	750

Table 57. Current and Future Water Supplies for Stratmoor Hills

Source	Surface Water Decree No.	Reported Firm Annual Water Supply (ac-ft/yr)	Reported Average Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater				
Widefield Aquifer Wells (requires augmentation)		770	770	0
Surface Water				
Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	0	1,250	1,250
Fry-Ark Project	See Table 1	285	571	0
Fry-Ark Project Return Flows [(1)]	See Table 1	201	403	403
Total Surface Water Supplies		**486**	**2,224**	**1,653**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation.

Stratmoor Hills is requesting 200 ac-ft of Master Contract storage space to store Fry-Ark return flows to meet municipal, industrial, agricultural, and replacement needs. Fry-Ark return flows are used for two purposes in the Stratmoor Hills water system. First, Fry-Ark return flows are used to provide replacement water in a decreed augmentation plan to allow well diversions from the Widefield Aquifer well field. Second, Fry-Ark return flows are delivered into storage in an existing short-term excess capacity account in Pueblo Reservoir by exchange. This water is then delivered through the Fountain Valley Authority at times when Fry-Ark project yield is below average. Storage of the Fry-Ark return flows in the Master Contract would be a long-term excess capacity account and is needed for additional firm yield of the overall water supply of the Fountain Valley Authority.

Although no conservation plan is in place, newsletters and public meetings are used to help encourage customers to actively conserve. Stratmoor Hills expects to reach build-out before

2060. Of the land left for build-out, about 85 percent of it is zoned commercial use, which would likely increase per capita water use. Because of this and Stratmoor Hills' existing lower than average per capita water use rate, no additional conservation was assumed. Water stored in the Master Contract would service growth within Stratmoor Hills's service area.

Upper Arkansas Water Conservancy District

Upper Arkansas Water Conservancy District
Master Contract Request: 1,000 ac-ft

The Upper Arkansas Water Conservancy District is located along the Arkansas River, upstream from Pueblo Reservoir and south of Leadville, generally in Chaffee, Fremont and Custer counties, but also in smaller portions of neighboring counties including parts of El Paso and Saguache counties. No retail water deliveries are made by Upper Arkansas Valley Water Conservancy District. The Upper Arkansas Water Conservancy District administers an umbrella augmentation plan within its boundaries. When water users within its district need to replace out-of-priority depletions resulting from use of wells, on-stream or off- stream reservoir/pond or surface diversion they can purchase water augmentation through the District, represented by a certificate. The Upper Arkansas Water Conservancy District then provides replacement water from one of its replacement water supplies to offset the depletion of the water user's well. Most water users participating in the Upper Arkansas Water Conservancy District's plans for augmentation are individuals or small businesses not serviceable by a municipal water provider. Larger public water providers typically have their own separate augmentation plan. Upper Arkansas Water Conservancy District operates several tributary reservoirs and exchanges between these vessels and excess capacity storage are vital to meeting needed water supplies in the Upper Arkansas River Basin.

Table 58 presents the current and future water demands for Upper Arkansas Water Conservancy District, while Table 59 presents Upper Arkansas Water Conservancy District's water supplies. Water demand in 2060 is projected to be 960 ac-ft, while reported annual supply is 991 ac-ft. Reclamation was not able to perform an independent estimate of Upper Arkansas Water Conservancy District's projected demands. However, the demands prepared by Upper Arkansas Water Conservancy District are consistent with the demand trends of other Master Contract participants in the Upper Arkansas River Basin.

Table 58. Current and Future Water Demand for Upper Arkansas Water Conservancy District

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	39,125	(1)	602
2060	90,331	(1)	960

Notes:
(1) Because Upper Arkansas Water Conservancy District water is used for well augmentation, per capita water use is not a useful metric.

The Upper Arkansas Water Conservancy District is requesting 1,000 ac-ft of Master Contract storage space to store Fry-Ark return flows and non-Project supplies, which will serve agricultural, municipal, industrial, commercial, recreation, stock watering, fish and wildlife protection uses. The excess capacity storage will be used to store water that is diverted during peak runoff periods until it is needed during later times of the year, and to make releases during winter months when ice causes problems releasing from other existing high elevation facilities.

Table 59. Current and Future Water Supplies for Upper Arkansas Water Conservancy District

Source	Surface Water Decree No.	Reported Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater			
Alluvial Pumping		Unknown	0
Surface Water			
Twin Lakes Reservoir and Canal Company Decrees (owned)	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	111	111
Twin Lakes Reservoir and Canal Company Decrees (leased)	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	32	32
Pueblo Board of Water Works Twin Lakes Reservoir and Canal Company Decrees Lease	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	202	202
White Ditch	Div. 2, 91CW19	26	26
North Fork Reservoir	Div. 2, 82CW204, 83CW141	Unknown	Unknown
O'Haver Reservoir	Div. 2, 82CW205	Unknown	Unknown
Boss Lake	Colorado Session Laws 1897, 1935, 1953, 1963, 1981, & CRS37-88-208	Unknown	Unknown
Thompson Ditch (Cottonwood Lake, Rainbow Lake)	Div. 2, 94CW5, 95CW208	23	23
A. Katzenstein Ditch No. 1 (Conquistador Reservoir No. 1)	Div. 2, 10CW30 (pending)	86	86
Lester Attebury	Div. 2, 93CW31	28	28
Cameron Ditch		130	0
Fry-Ark Project	See Table 1	215	0
Fry-Ark Project Return Flow (1)	See Table 1	138	138
Total Surface Water Supplies		**991**	**646**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation.

The Upper Arkansas Water Conservancy District typically has sufficient water supply to meet future demand on an annual basis. However, there are times during the year when their direct flow right cannot meet demands. Without Master Contract storage, the Upper Arkansas Water Conservancy District would not have storage during low water supply winter months.

No additional facilities would be required to transport water stored under the Master Contract. Lake and Teller counties have discussed with Upper Arkansas Water Conservancy District officials possible inclusion of these counties into the Upper Arkansas Water Conservancy District. However, Master Contract deliveries are limited to those lands that are within Southeastern Colorado Water Conservancy District's boundaries. Therefore, deliveries could not be made from the Master Contract account for use Lake and Teller counties, as well as Saguache County and those portions of El Paso County that are not within Southeastern Colorado Water Conservancy District's boundaries.

The Upper Arkansas Water Conservancy District does not have a formal conservation plan, because it is not a "retail water provider" covered under Colorado Water Conservation Board requirements. However, the Upper Arkansas Water Conservancy District does recommend water savings and tools to calculate water use from outdoor irrigation. It is assumed that nine percent water conservation may be achieved through passive water conservation through 2060

(Great Western Institute 2010). Water stored in the Master Contract would service growth within Upper Arkansas Water Conservancy District's service area.

Widefield

Widefield
Master Contract Request: 650 ac-ft

Widefield is located just south of Colorado Springs in the Fountain Creek watershed basin. Widefield currently serves customers through the Fountain Valley Authority pipeline and the Widefield Aquifer. Table 60 presents the current and future water demands for Widefield, while Table 61 presents Widefield's water supplies. Water demand in 2060 is projected to be 5,195 ac-ft, while firm annual surface water supply is 3,848 ac-ft.

Table 60. Current and Future Water Demand for Widefield

Year	Population	Per Capita Water Use (gpcd)	Water Demand (ac-ft)
2010	16,000	139	2,491
2060	35,123	132	5,195

Table 61. Current and Future Water Supplies for Widefield.

Source	Surface Water Decree No.	Reported Firm Annual Water Supply (ac-ft/yr)	Reported Average Annual Water Supply (ac-ft/yr)	Supplies Available for Master Contract Storage (ac-ft/yr)
Groundwater				
Widefield Aquifer Wells (requires augmentation)		3,145	3,145	0
Jimmy Camp Aquifer Wells (requires augmentation)		650	650	0
Additional 10 percent Widefield Aquifer Allocation (tributary)		0	315	0
Surface Water				
Fry-Ark Project Water	See Table 1	710	1,425	0
Fry-Ark Project Return Flows (1)	See Table 1	450	900	900
Fountain Mutual Irrigation Company	Div. 2, 81CW229	286	400	400
Fountain Mutual Irrigation Company	Water Court Action Needed	108	151	151
Colorado Springs Fry-Ark Return Flows		1,021	1,021	1,021
Bell Ditch Water Rights	Div. 2, 08CW47 (pending)	0	240	240
Owen and Hall Ditch Water Rights	Water Court Action Needed	111	111	111
Laughlin Ditch Water Rights	Water Court Action Needed	456	456	456
Reclamation Water Rights	Water Court Action Needed	706	706	706
Lower Arkansas Valley Water Conservancy District lease	Div. 2, 10CW2 and 06CW8	0	1,000	1,000
Total Surface Water Supplies		**3,848**	**6,410**	**4,985**

Notes:
(1) Return Flow estimates assume full use of Fry-Ark Project allocation.

Widefield is requesting 650 ac-ft of Master Contract storage space to meet municipal, industrial, and agricultural demands. Fry-Ark return flows are used for two purposes in the Widefield water system. First, Fry-Ark return flows are used to provide replacement water in a decreed augmentation plan to allow well diversions from the Widefield Aquifer and Jimmy Camp

Aquifer well fields. Second, Fry-Ark return flows are delivered into storage in an existing short-term excess capacity account into Pueblo Reservoir by exchange or by contract exchanges with other water users. Widefield is seeking to store some or all of its augmentation water rights under the Master Contract. This water would be delivered through the Fountain Valley Authority at times when Fry-Ark project yield is otherwise below average. Storage of the water under the Master Contract is needed to increase the firm yield of the overall water supply delivered through the Fountain Valley Authority. In addition, water released from the Master Contract would be used to replace depletions associated with out-of-priority depletions by Widefield's wells and surface diversions near Widefield, or the water would be exchanged upstream along Fountain Creek to those wells and surface diversions.

Widefield completed a water conservation plan in 2009 (Widefield Water & Sanitation District 2009). Conservation measured utilized by Widefield include increasing block rate structure, education and outreach, low water use fixtures, water loss accounting, customer contact for high water usage, water audits, and water use profiling. New conservation measures to be implemented include landscaping recommendations to new customers, additional fixture retrofitting, and pricing incentives. The water conservation plan indicates that current incentives provide an annual five to six percent water savings, and new water conservation measures will provide an additional savings to an additional 4.8 percent. Water stored in the Master Contract would service growth within Widefield's service area.

Interconnect Participants

The third proposed federal action to be analyzed in this EIS is entering into a conveyance contract for use of the Interconnect that could be constructed as part of the AVC. The Interconnect would be a pipeline between Pueblo Dam north and south outlet works, and would provide water delivery flexibility if either outlet were to be temporarily shut down. Because the Interconnect would be an engineering feature of the AVC, it would only be constructed and operated if the AVC was constructed, but the AVC could be constructed without the Interconnect.

Four Interconnect participants, Colorado Springs Utilities, Fountain, Security, and Pueblo West, are taking part in the future Southern Delivery System. The Southern Delivery System is currently under construction and will include a new north outlet at Pueblo Reservoir. The need for the Interconnect for Colorado Springs Utilities is presented within this subsection. Pueblo West also takes delivery of water from the existing south outlet works at Pueblo Reservoir, and therefore will take deliveries from both outlet works at Pueblo Reservoir in the future. Pueblo West's needs for the Interconnect are discussed independently below. Colorado Springs, Fountain, and Security also take delivery of water from the Fountain Valley Authority Pipeline. The Interconnect needs for Fountain and Security are discussed under the Fountain Valley Authority subsection. A matrix showing Interconnect participants and associated operating groups is shown in Table 62.

Table 62. Interconnect Participants and Operating Groups

Individual Entity	Operating Group			
	Individual	AVC	Fountain Valley Authority	Southern Delivery System
AVC		X		
Board of Water Works of Pueblo	X			
Colorado Division of Parks and Wildlife - Pueblo Fish Hatchery	X			
Colorado Springs Utilities			X	X
City of Fountain				
Pueblo West Metropolitan District	X			X
Security Water and Sanitation Districts			X	X
Stratmoor Hills Water and Sanitation District			X	
Widefield Water and Sanitation District			X	

AVC

Current water supplies and water demands for the AVC participants are described by participant in earlier portions of this appendix. The AVC could withdraw water from the south outlet works at Pueblo Reservoir. The AVC would have two storage tanks along the pipeline that could provide about one day of water at peak demands.

Without the Interconnect, in the event of a shutdown of south outlet works at Pueblo Reservoir, the AVC participants would rely on storage tanks along the AVC and other existing supplies. For those AVC participants that are planning to blend AVC water with existing sources, those existing sources would be maximized in the event of an outage at Pueblo Reservoir. Some participants, however, have requested that their entire water demand be served by the AVC, and they would have no alternate sources of water.

How the Interconnect would operate during an outage would be determined during operations planning. It is anticipated that the Interconnect would continue to serve water demands of the AVC participants if the south outlet works at Pueblo Reservoir was not functioning. If the Interconnect were not built, each of the AVC participants would manage their systems to minimize disruptions as much as possible.

Board of Water Works of Pueblo

About 67 percent of Board of Water Works of Pueblo's water supplies originate at Pueblo Reservoir, which are taken through the south outlet works. About 278.5 cfs of water can be taken from the south outlet works. Two emergency intakes are located on the Arkansas River downstream from Pueblo Reservoir. The Northside emergency intake has a capacity of 82 cfs, and the Southside emergency intake has a capacity of 54.2 cfs. Additionally, for short periods of time, the Northside emergency intake could supply an additional 39 cfs (124 cfs total). In 2010, Board of Water Works of Pueblo used 27,713 ac-ft of water, and projects to need 61,200 ac-ft by 2070. A draft water conservation plan has been prepared, which includes conservation measures such as its Wise Use program, metering, leak detection, main replacement program, outdoor irrigation program, and regulatory measures. Board of Water Works of Pueblo uses Pueblo Reservoir as a terminal storage facility. It has no terminal storage other than Pueblo Reservoir.

Without the Interconnect, in the event of a shutdown of south outlet works at Pueblo Reservoir, Board of Water Works of Pueblo would activate their two emergency intakes off the Arkansas River that can provide up to 136 cfs with an additional pumped supply that could provide an additional 39 cfs.

If the Interconnect were in place, the Board of Water Works of Pueblo would begin using it immediately in the event of interrupted water service from Pueblo Reservoir. As long as capacity is available from the north outlet works, they would use the Interconnect exclusively to supply water and would not activate the emergency intakes off the Arkansas River. Board of Water Works of Pueblo would use the Interconnect rather than their emergency river intakes because water quality is poorer in the Arkansas River downstream from Pueblo Reservoir and because of power costs associated with diversion from the Arkansas River.

If the Interconnect were not built, Board of Water Works of Pueblo would switch to their emergency river intakes to meet their demands. Once system demands exceed 175 cfs, it would implement temporary restrictions so that system demand does not exceed available delivery capacity. It would be more costly, because additional chemicals would be required to treat water delivered from the Arkansas River and power costs would increase due to pumping water from the Arkansas River that would otherwise have been delivered by gravity.

Colorado Springs Utilities

By the time that Southern Delivery System is operating at full capacity in 2046, about 40 percent of Colorado Springs Utilities' water supplies will originate at Pueblo Reservoir. Six percent (20 cfs) of that water is delivered through the Fountain Valley Authority Pipeline at the south outlet works, and the remaining 34 percent (114 cfs) will be delivered through the Southern Delivery System, which will take delivery from the north outlet works. The remainder of Colorado Springs Utilities' water comes from sources other than Pueblo Reservoir:

- Homestake Pipeline originates at Twin Lakes Reservoir: 105 cfs (32 percent of total supply)
- Blue River Pipeline originates at Montgomery Reservoir: 30 cfs (9 percent of total supply)
- Local System Pipelines originate on Pikes Peak: 62 cfs (19 percent of total supply)

In 2010, Colorado Springs Utilities used 79,600 ac-ft of water, and projects to need 197,000 ac-ft by 2046. A comprehensive water conservation plan has been prepared, which includes conservation measures such as block rate structures, regulatory measures, education, rebates, and incentives. After construction of Upper Williams Creek Reservoir (part of the Southern Delivery System), Colorado Springs Utilities will have four terminal storage facilities: Northfield System, North Slope System, South Slope System, and Upper Williams Creek Reservoir. These reservoirs can supply about 6 months of normal demands or 10 months of reduced emergency demands.

Without the Interconnect, in the event of a shutdown of the north outlet works at Pueblo Reservoir, Colorado Springs Utilities would use their existing terminal storage facilities to meet water demand. In the future, after 2020, Colorado Springs Utilities could sustain a several week outage but an extended outage (beyond a month) would require that Colorado Springs Utilities to initiate their water shortage ordinance and potentially implement watering restrictions to minimize use.

If the Interconnect were in place, Colorado Springs Utilities would continue to use their water systems that do not take water from Pueblo Reservoir in the event of interrupted water service from Pueblo Reservoir. Colorado Springs Utilities would use the Interconnect in the event of an extremely long outage if Upper Williams Creek Reservoir were not online. The Interconnect would allow Colorado Springs Utilities additional flexibility in meeting demands during outages at the north outlet works.

If the Interconnect were not built, Colorado Springs Utilities could manage a short-term outage because of their diverse water delivery system. Exchanges from Pueblo Reservoir and Fountain Creek to the Upper Arkansas River would likely increase to ensure that the Homestake system were kept full, operating at maximum efficiency and that exchange waters were being fully utilized. If Southern Delivery System were online and running at or near capacity, Colorado Springs Utilities' water shortage ordinance would be activated to reduce demands. This would allow the remainder of its water delivery system to meet demands.

Fountain Valley Authority

The Fountain Valley Authority is part of the Fry-Ark project and serves the communities of Colorado Springs, Fountain, Security, Widefield, and Stratmoor Hills. Colorado Springs Utilities' need for the Interconnect is described above. The needs for Fountain, Security, Widefield, and Stratmoor Hills are discussed here.

Current water supplies and water demands for Fountain, Security, Widefield, and Stratmoor Hills are described by participant in earlier portions of this appendix. All of these participants rely on groundwater in addition to surface water supplies from the Fountain Valley Authority. The Fountain Valley Authority pipeline can withdraw up to 27.77 cfs from the south outlet works at Pueblo Reservoir.

Without the Interconnect, in the event of a shutdown of south outlet works at Pueblo Reservoir, the Fountain Valley Authority participants would rely on the existing storage tanks along the Fountain Valley Conduit and other existing supplies for a short shut down of several hours. For longer outages, Fountain, Security, Widefield, and Stratmoor Hills would rely on their groundwater sources and take measures to reduce demand. With the Interconnect, the Fountain Valley Authority would switch to the Interconnect after a shutdown of about one day to continue deliveries to the Fountain Valley Authority participants.

If the Interconnect were not built, Fountain, Security, Widefield, and Stratmoor Hills would secure agreements with other water providers for emergency outages.

Pueblo Fish Hatchery

The Pueblo Fish Hatchery is located just below Pueblo Reservoir and is fed by a separate buttress adjacent and south of the south outlet works with a capacity of 39 cfs. Some well water supplements water supplied by Pueblo Reservoir. However, the wells provide about five percent of total water demand and are insufficient to support fish. Hatchery flows may be needed at any time of the year but would be most critical during the summer.

Without the Interconnect, the fish hatchery has no redundancy in the event of a shutdown at Pueblo Reservoir. There is currently no feasible means of acquiring raw water for the fish hatchery if water delivery from Pueblo Reservoir failed. If the Interconnect were in place, the fish hatchery would begin using it immediately during interrupted water service from Pueblo Reservoir. If the Interconnect were not built, the fish hatchery would consider building a diversion off of the Bessemer Ditch for gravity feed of water to the solar supply pond.

Pueblo West

All of Pueblo West's water sources originate as surface water stored at Pueblo Reservoir. Pueblo West can draw up to 18.94 cfs of water from the south outlet works. Pueblo West is also a participant in the Southern Delivery System, and in the future will be able to draw 27.85 cfs of water from the north outlet works. Pueblo West has no other available potable water supplies other than those drawn from Pueblo Reservoir. Pueblo West's projected water demand is discussed above. Pueblo West uses Pueblo Reservoir as a terminal storage facility. It has no terminal storage other than Pueblo Reservoir.

Without the Interconnect, in the event of a shutdown of either the north or south outlet works at Pueblo Reservoir, Pueblo West would use the other outlet for emergency supplies. If both outlets were shutdown, or the Interconnect were to fail, Pueblo West could serve demands for several hours using existing treated water storage. If an outage were to last for one day or less during summer months (three days in winter), Pueblo West would activate their emergency plan of notifying large users such as schools and parks. If an outage at Pueblo Reservoir lasted for one week or more, Pueblo West would not be able to meet any water demands.

If the Interconnect were in place, Pueblo West would begin using it after about one day of interrupted water service from Pueblo Reservoir. This would allow them to maintain water service to customers in the event of an operations disruption at Pueblo Reservoir of one day or more.

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Appendix A.2 – AVC Participant Water Rights

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Table 1. AVC Participant Water Rights for Storage in the Master Contract and/or Delivery Through AVC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
1	96 Pipeline Company	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith.		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XAVCCrow_CC
2	96 Pipeline Company	See note [(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	4	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCCrow_Pr1; XAVCCrow_Pr13
3	Beehive Water Association	See note [(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	3	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCOte_Pr1; XAVCOte_Pr13

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
4	Beehive Water Association	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	OteDem_LAL; Ote_AugLAL
5	Bents Fort Water Company	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	According to Allocation Principles. Purchased Fry-Ark Return Flows may be exchanged under Fry-Ark Decrees.		Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCLJ_Pr1; XAVCLJ_Pr13
6	Bents Fort Water Company	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees	Decrees for Pueblo West Shares in the Twin Lakes Reservoir and Canal Company	34	acre-ft	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas River to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	AVCLJ_TL
7	Bents Fort Water Company	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	LJDem_LAL; LJ_AugLAL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
8	Crowley County Water Association	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XAVCCrow_CC
9	Crowley County Water Association	See note [1]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	312	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCCrow_Pr1; XAVCCrow_Pr13
10	Crowley County Water Association	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees	Decrees for Pueblo West Shares in the Twin Lakes Reservoir and Canal Company	8	acre-ft	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas River to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	AVCCrow_TL
11	Eads	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	Kio_LArk

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
12	Fayette Water Association	See note [(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	3	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCOte_Pr1; XAVCOte_Pr13
13	Fayette Water Association	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	OteDem_LAL; Ote_AugLAL
14	Fowler	See note [(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	106	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCFow_Pr1; XAVCFow_Pr13
15	Fowler	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	FowDem_LAL; Fow_AugLAL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
16	Hilltop Water Company	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	24	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCRF_Pr1; XAVCRF_Pr13
17	Hilltop Water Company	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	RFDem_LAL; RF_AugLAL
18	Holbrook Center Soft Water	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	2	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCLJ_Pr1; XAVCLJ_Pr13
19	Holbrook Center Soft Water	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	LJDem_LAL; LJ_AugLAL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
20	Homestead Improvement Association	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	4	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCLJ_Pr1; XAVCLJ_Pr13
21	Homestead Improvement Association	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	LJDem_LAL; LJ_AugLAL
22	La Junta	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	664	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCLJ_Pr1; XAVCLJ_Pr13
23	La Junta		Holbrook Mutual Canal	Exchange of Pro Rata Ownership of Transferred Holbrook Mutual Canal Shares	800	acre-feet	Change and Exchange of Consumptive Use Water	Holbrook Mutual Canal Headgate on Arkansas River	LJHol

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
24	Las Animas	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	313	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCBent_Pr1; XAVCBent_Pr13
25	Las Animas		Las Animas Consolidated Canal	Exchange of Pro Rata Ownership of Transferred Las Animas Consolidated Canal Shares	50	acre-feet	Change and Exchange of Consumptive Use Water	Las Animas Consolidated Canal Headgate on Arkansas River	LA_NP
26	Manzanola		Catlin Canal	Exchange of Pro Rata Ownership of Transferred Catlin Canal Shares	26	acre-feet	Change and Exchange of Consumptive Use Water	Catlin Canal Headgate Near Confluence of Arkansas River and Apishapa River	OteCat
27	Manzanola	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	31	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCOte_Pr1; XAVCOte_Pr13
28	Manzanola		Rocky Ford Highline Canal	Exchange of Pro Rata Ownership of Transferred Rocky Ford Highline Canal Shares	74	acre-feet	Change and Exchange of Consumptive Use Water	Rocky Ford Highline Canal Headgate on Arkansas River	OteHL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
29	May Valley Water Association	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	Lam_LArk
30	Newdale-Grand Valley Water Company	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	37	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCOte_Pr1; XAVCOte_Pr13
31	Newdale-Grand Valley Water Company	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	OteDem_LAL; Ote_AugLAL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
32	Olney Springs	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith.		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XAVCCrow_CC
33	Olney Springs	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees	Decrees for Pueblo West Shares in the Twin Lakes Reservoir and Canal Company	100	acre-ft	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas RIVER to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	AVCCrow_TL
34	Ordway	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith.		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XAVCCrow_CC
35	Ordway	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees	Decrees for Pueblo West Shares in the Twin Lakes Reservoir and Canal Company	450	acre-ft	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas River to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	AVCCrow_TL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
36	Patterson Valley	See note [(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	8	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCOte_Pr1; XAVCOte_Pr13
37	Patterson Valley	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	OteDem_LAL; Ote_AugLAL
38	Rocky Ford	Div. 2, 06CW49	Catlin Canal	Exchange of Pro Rata Ownership of Transferred Catlin Canal Shares	215	acre-feet	Change and Exchange of Consumptive Use Water	Catlin Canal Headgate Near Confluence of Arkansas River and Apishapa River	RFCat
39	Rocky Ford	See note [(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	366	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCRF_Pr1; XAVCRF_Pr13
40	Rocky Ford	Div. 2, 06CW49	Rocky Ford Ditch	Exchange of Pro Rata Ownership of Transferred Rocky Ford Ditch Shares	151	acre-feet	Change and Exchange of Consumptive Use Water	Rocky Ford Ditch Headgate on Arkansas River	RF_NP

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
41	South Side Water Association	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	3	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCOte_Pr1; XAVCOte_Pr13
42	South Side Water Association	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	OteDem_LAL; Ote_AugLAL
43	South Swink Water Company	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	50	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCOte_Pr1; XAVCOte_Pr13
44	South Swink Water Company	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	OteDem_LAL; Ote_AugLAL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
45	St. Charles Mesa Water District	Div. 2, 04CW08 & 09CW91	Bessemer Ditch	Exchange of Pro Rata Ownership of Transferred Bessemer Ditch Shares	4,665	acre-feet	Change and Exchange of Consumptive Use Water	Bessemer Ditch from Pueblo Reservoir to Bessemer Ditch Diversion Number 1 and Number 2	SCM_Bess
46	St. Charles Mesa Water District	Div. 2, W-4411	Cottonwood Irrigating Ditch	Decrees for Direct Flow Rights in Cottonwood Creek	1,040	acre-feet	Change and Exchange of Consumptive Use Water	Confluence of Cottonwood Creek and the Arkansas River to St. Charles Mesa Water District Diversion Point Downstream From Pueblo Reservoir	StChPumpL; ArkRivDecr_PuebIn
47	St. Charles Mesa Water District	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	816	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCPb_Pr1; XAVCPb_Pr13
48	St. Charles Mesa Water District	Div. 2, W-4791 & W-0228	Velasquez Rights	Alternate Point of Diversion for Six Replacement Tributary Wells	238	acre-feet	Change and Exchange of Consumptive Use Water	St. Charles Mesa Water District Boundaries	ZoellerD
49	St. Charles Mesa Water District	Div. 2, 80CW164	Zoeller Ditch	Decree for St. Charles Mesa Water District Shares in Zoeller Ditch	620	acre-feet	Change and Exchange of Consumptive Use Water	St. Charles River to St. Charles Mesa Water District Raw Water Reservoir	ZoellerD

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
50	Sugar City	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith.		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XAVCCrow_CC
51	Sugar City	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees	Decrees for Pueblo West Shares in the Twin Lakes Reservoir and Canal Company	62	acre-ft	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas River to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	AVCCrow_TL
52	Valley Water Company	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	22	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCFow_Pr1; XAVCFow_Pr13
53	Valley Water Company	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	FowDem_LAL; Fow_AugLAL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
54	Vroman	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	12	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCRF_Pr1; XAVCRF_Pr13
55	Vroman	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	RFDem_LAL; RF_AugLAL
56	West Grand Valley Water Incorporated	See note (1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	7	acre-ft	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XAVCRF_Pr1; XAVCRF_Pr13

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
57	West Grand Valley Water Incorporated	Div. 2, 10CW4	Lower Arkansas Valley Water Conservancy District Master Contract Supply Lease	Lower Arkansas Valley Water Conservancy District Owned Supplies and Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts Conditional on AVC and/or Augmentation Demand Gap		Leased Supply	Headwaters of the Roaring Fork and Arkansas River to East Slope Storage Including Pueblo, Twin Lakes and Turquoise Reservoirs; Various Canal Headgates Between Pueblo Reservoir and Fort Lyon Canal	RFDem_LAL; RF_AugLAL

Notes:
(1) Fryingpan-Arkansas Project Decrees.

West Slope Decrees	East Slope Decrees	Reuse and Exchange Decrees
District Court, Chaffee County, Civil Action No. 4613	District Court, Chaffee County, Civil Action No. 5141	District Court, Pueblo County, Civil Action No. B-42135
Div. 5, W-829-76	District Court, Pueblo County, Civil Action No. B-42135	Div. 2, 01CW151 (Pending)
Div. 5, 83CW352	Div. 2, 80CW6	

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Appendix A.3 – Non-AVC Participant Master Contract Water Rights

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Table 1. Non-AVC Participant Water Rights for Storage in the Master Contract

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
1	Canon City	Div. 2, W-4034	Canon City Water Works	Native Arkansas River Water Right	163	acre-feet	Native Arkansas River Water Right	Diversion points on the Arkansas River near Canon City	18640813_CCWW
2	Canon City	See note[(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	643	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	CCMC_FARF
3	Florence	Div. 2, 80CW93	Adobe/ Mineral Creek Water Right	Diversion of Consumptive Use Portion of Adobe/Mineral Creek Water Right	216	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Diversions near Florence on the Arkansas River, Adobe Creek, Mineral Creek, Newlin Creek; storage in Florence Reservoirs 1, 2 and 3	Flo_Misc
4	Florence	Div. 2, 80CW93	Newlin Creek Water Right	Diversion of Consumptive Use Portion of Newlin Creek Water Right	372	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Diversions near Florence on the Arkansas River, Adobe Creek, Mineral Creek, Newlin Creek; storage in Florence Reservoirs 1, 2 and 3	Flo_Misc
5	Florence	Div. 2, 80CW93	Coal Creek Pipe	Diversion of Consumptive Use Portion of Coal Creek Pipe	90	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Diversions near Florence on the Arkansas River, Adobe Creek, Mineral Creek, Newlin Creek; storage in Florence Reservoirs 1, 2 and 3	Flo_Misc
6	Florence	Div. 2, 80CW93	Williamsburg Pipe	Diversion of Consumptive Use Portion of Williamsburg Pipe	36	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Diversions near Florence on the Arkansas River, Adobe Creek, Mineral Creek, Newlin Creek; storage in Florence Reservoirs 1, 2 and 3	Flo_Misc

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
7	Florence	Div. 2, 80CW93, 99CW149, 10CW63 (pending)	Union Ditch	Diversion of Pro Rata Ownership of Union Ditch	4,124	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Diversions near Florence on the Arkansas River	Flo_UDFT
8	Fountain	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange (2)	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XFtn_CC
9	Fountain	See note(1)	Fryingpan-Arkansas Project Decrees (2)	Decrees for Fryingpan-Arkansas Project Water Return Flows	1,322	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XFtn_Pr1
10	Fountain	Div. 2, W-4396, W-4559, 85CW110, 01CW146 (pending), and future water court filings for 98 shares	Fountain Mutual Irrigation Company (2)	Change and exchange of Fountain's interests in Fountain Mutual Irrigation Company to wells as alternate points of diversion or augmentation of depletions caused by these wells	307	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Fountain	XFtn_Oth; Ftn_FMICMC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
11	Fountain	Water Court Action Needed	Fountain Mutual Ditch Priorities 4 and 17	Change and exchange of Fountain's interests in Fountain Mutual Ditch to wells as alternate points of diversion or augmentation of depletions caused by these wells	600	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Fountain	Ftn_FMICMC
12	Fountain	Div. 2, 06CW119	Chilcott Ditch	Change and exchange of Fountain's interests in Chilcott Ditch to wells as alternate points of diversion or augmentation of depletions caused by these wells	102	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Fountain	Ftn_ChilMC
13	Fountain	Div. 2, 03CW59	Miller Ditch	Change and exchange of Fountain's interests in Miller Ditch to wells as alternate points of diversion or augmentation of depletions caused by these wells	285	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Fountain	Ftn_MilMC
14	Fountain	Div. 2, 08CW47 (pending)	W.A. Bell Ditch Nos. 1, 2, and 3 (1/2 interest)	Diversion of Consumptive Use Portion of W.A. Bell Ditch Nos. 1, 2, and 3 Water Rights		acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Fountain Creek at or near the City of Fountain, Arkansas River between the mouth of Fountain Creek and inflows from Alvarado Creek and Venable Creek	Ftn_BellMC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
16	Lower Arkansas Valley Water Conservancy District		Catlin Canal	Exchange of Pro Rata Ownership of Transferred Catlin Canal Shares	0	acre-feet	Change and Exchange of Consumptive Use Water	Catlin Canal Headgate on Arkansas River	LAV_Misc
17	Lower Arkansas Valley Water Conservancy District		LAWMA	Change and exchange of Lower Arkansas Valley Water Conservancy District's interests in Catlin Canal	Unknown	acre-feet			LAV_Misc
18	Lower Arkansas Valley Water Conservancy District		Ft. Lyon Canal	Exchange of Pro Rata Ownership of Transferred Ft. Lyon Canal Shares	26	acre-feet	Change and Exchange of Consumptive Use Water	Ft. Lyon Canal Headgate on Arkansas River	LAV_Misc
19	Lower Arkansas Valley Water Conservancy District	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees	Decrees for Lower Arkansas Valley Water Conservancy District Shares in the Twin Lakes Reservoir and Canal Company	100	acre-feet	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas River to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	LAV_TL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
20	Lower Arkansas Valley Water Conservancy District	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	LAV_Misc
21	Lower Arkansas Valley Water Conservancy District		Bessemer Ditch	Exchange of Pro Rata Ownership of Transferred Bessemer Ditch Shares	44	acre-feet	Change and Exchange of Consumptive Use Water	Bessemer Ditch at Pueblo Reservoir	LAV_Misc
22	Lower Arkansas Valley Water Conservancy District		Holbrook Mutual Canal	Exchange of Pro Rata Ownership of Transferred Holbrook Mutual Canal Shares	76	acre-feet	Change and Exchange of Consumptive Use Water	Holbrook Mutual Canal Headgate on Arkansas River	LAV_Misc
23	Lower Arkansas Valley Water Conservancy District		Rocky Ford Ditch	Exchange of Pro Rata Ownership of Transferred Rocky Ford Ditch Shares	Unknown	acre-feet	Change and Exchange of Consumptive Use Water	Rocky Ford Ditch Headgate on Arkansas River	LAV_Misc
24	Lower Arkansas Valley Water Conservancy District		Las Animas Consolidated Canal	Exchange of Pro Rata Ownership of Transferred Las Animas Consolidated Canal Shares	1	acre-feet	Change and Exchange of Consumptive Use Water	Las Animas Consolidated Canal Headgate on Arkansas River	LAV_Misc

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
25	Lower Arkansas Valley Water Conservancy District		Rock Ford Highline Canal	Exchange of Pro Rata Ownership of Transferred Rocky Ford Highline Canal Shares	3	acre-feet	Change and Exchange of Consumptive Use Water	Rocky Ford Highline Canal Headgate on Arkansas River	LAV_Misc
26	Lower Arkansas Valley Water Conservancy District		Larkspur Ditch	Diversion of Consumptive Use Portion of Larkspur Ditch	500	acre-feet	Trans-mountain imports from the Gunnison River Basin to the Upper Arkansas River Basin		LAV_Larkspur
27	Lower Arkansas Valley Water Conservancy District	Div. 2, 10CW4	Bessemer Ditch	Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts dependent on annual participation rates, fallowing rates, and exchange potential		Leased Supply	Pueblo Reservoir to Bessmer Ditch Headgate	SD_Bess
28	Lower Arkansas Valley Water Conservancy District	Div. 2, 10CW4	Rocky Ford High Line Canal	Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts dependent on annual participation rates, fallowing rates, and exchange potential		Leased Supply	Pueblo Reservoir to Rocky Ford Highline Canal Headgate	SD_HL

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
29	Lower Arkansas Valley Water Conservancy District	Div. 2, 10CW4	Oxford Farmers Ditch	Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts dependent on annual participation rates, fallowing rates, and exchange potential		Leased Supply	Pueblo Reservoir to Oxford Farmers Ditch Headgate	SD_Oxford
30	Lower Arkansas Valley Water Conservancy District	Div. 2, 10CW4	Otero Canal	Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts dependent on annual participation rates, fallowing rates, and exchange potential		Leased Supply	Pueblo Reservoir to Otero Canal Headgate	SD_Otero
31	Lower Arkansas Valley Water Conservancy District	Div. 2, 10CW4	Catlin Canal	Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts dependent on annual participation rates, fallowing rates, and exchange potential		Leased Supply	Pueblo Reservoir to Catlin Canal Headgate	SD_Cat
32	Lower Arkansas Valley Water Conservancy District	Div. 2, 10CW4	Holbrook Mutual Canal	Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts dependent on annual participation rates, fallowing rates, and exchange potential		Leased Supply	Pueblo Reservoir to Holbrook Mutual Canal Headgate	SD_Hol

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
34	Lower Arkansas Valley Water Conservancy District	Div. 2, 10CW4	Fort Lyon Canal	Leased Supplies from Super Ditch Rotational Fallowing Program	Amounts dependent on annual participation rates, fallowing rates, and exchange potential		Leased Supply	Pueblo Reservoir to Fort Lyon Canal Headgate	SD_FtLyon
35	Penrose	See note(1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	74	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas Rivers to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	Pen_RFMC
36	Penrose	Div. 2, 06CW12	Pleasant Valley Ditch/ Alexander Ditch	Diversion of Consumptive Use Portion of Pleasant Valley/Alexander Ditch	151	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	De Weese Reservoir on Grape Creek, Brush Hollow Reservoir on Brush Hollow Creek, Skaguay Reservoir on West Beaver Creek, and Phantom Canyon Reservoir through the Phantom Canyon Diversion to the Arkansas River at Pueblo Reservoir	Pen_NPMC
37	Penrose	Water Court Action Needed	Pleasant Valley Ditch/ Alexander Ditch Return Flows	Reuse and Exchange of Reusable Return Flows	92	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	De Weese Reservoir on Grape Creek, Brush Hollow Reservoir on Brush Hollow Creek, Skaguay Reservoir on West Beaver Creek, and Phantom Canyon Reservoir through the Phantom Canyon Diversion to the Arkansas River at Pueblo Reservoir	Pen_RFMC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
38	Poncha Springs	See note[1]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	38	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	PS_RFMC
39	Poncha Springs	Div. 2, 99CW183, 01CW148	McPherson Ditch	Diversion of Consumptive Use Portion of McPherson Ditch	35	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	O'Haver Reservoir to confluence of South Arkansas River and Arkansas River	PS_CUMC
40	Poncha Springs	Div. 2, 07CW111 (pending)	Friend Ranch Water Rights	Diversion of Consumptive Use Portion of Friend Ranch Water Rights	125	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Little Cochetopa Creek upstream from the South Arkansas River; Pass Creek/Little Cochetopa Creek upstream from the South Arkansas River; Green Creek upstream from the South Arkansas River	PS_CUMC
41	Pueblo West	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange [2]	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XPblW_CC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
42	Pueblo West	Div. 2, 86CW118 A	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Reusable Return Flow Exchange- Sewered Phase [(2)]	Exchange of Pueblo West Reusable Return Flows from Transferred Colorado Canal Companies' Shares	Unknown	acre-feet	Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	XPblW_CC
43	Pueblo West	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees [(2)]	Decrees for Pueblo West Shares in the Twin Lakes Reservoir and Canal Company	2,380	acre-feet	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas River to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	TL_PuebInPW
44	Pueblo West	Div. 2, 85CW134 A, 85CW134 B	PWMD Reuse and Exchange - Part A & B [(2)]	Reuse and Exchange of Reusable Return Flows	1,200	acre-feet	Reusable Sewered and Non-Sewered Return Flows	Arkansas River from Pueblo Reservoir to Wildhorse Creek	XPblW_ReuRF
45	Pueblo West	Div. 2. 01CW152	Hill Ranch Water Rights	Diversion of Consumptive Use Portion of Hill Ranch Water Rights	1,080	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Arkansas River near Nathrop	PW_HRMC
46	Pueblo West	Under Agree-ment with Colorado Springs	Replacement Water from PFMP			acre-feet			

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
47	Pueblo West		Storage Releases from Reservoirs U/S from Pueblo Reservoir (Twin and Turquoise Carry Over)		3,740	acre-feet			
48	Pueblo West	Div. 2, 80CW160, 80CW171	Dakota/Purgatoire Formation Wells, Dakota/Lytle Formation Wells	Non-Tributary Wells	5,350	acre-feet	Non-Tributary Wells	PWMD	PblWest_Well
49	Pueblo West	Div. 2, 81CW0056	Wheel Ranch Ditch (2)	Diversion of Consumptive Use Portion of Wheel Ranch Ditch	2	cfs	Change and Alternate Point-of-Diversion of Consumptive Use Water	Arkansas River immediately upstream of Pueblo Reservoir and Pueblo Reservoir	PblW_MC_CCPAPB
50	Pueblo West	See note(1)	Fryingpan-Arkansas Project Decrees (2)	Decrees for Fryingpan-Arkansas Project Water - Not Previously Allocated Non-Irrigation Water	According to Allocation Principles and Southeaster Colorado Water Conservancy District Resolution.		Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	PblW_FAL
51	Salida	Div. 2, 84CW158	Harrington/ Champ Ditch	Diversion of Consumptive Use Portion of Harrington/Champ Ditch	543	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Diversion points on the South Arkansas River near Salida to the confluence of the South Arkansas River and Arkansas River	Sal_CUMC
52	Salida	Div. 2, 04CW125	Tenassee Ditch	Diversion of Consumptive Use Portion of Tenassee Ditch	347	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	South Arkansas River from North Fork Reservoir to Arkansas River below Salida Sewage Treatment Plant	Sal_CUMC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
53	Security	See note[(1)]	Fryingpan-Arkansas Project Decrees [(2)]	Decrees for Fryingpan-Arkansas Project Water Return Flows	840	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	XSec_Pr1
54	Security	Water Court Action Needed	Union Ditch	Diversion of Pro Rata Ownership of Union Ditch	300	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Diversions near Florence on the Arkansas River	Sec_UDMC
55	Security	Div. 2, 90CW28, 01CW149 (pending), 07CW51 (pending), and future water court filings for 108 shares	Fountain Mutual Irrigation Company	Change and exchange of Security's interests in Fountain Mutual Irrigation Company to wells as alternate points of diversion or augmentation of depletions caused by these wells	318	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Security	Sec_FMICMC
56	Security	Div. 2, 06CW117	Lock Ditch	Change and exchange of Security's interests in Lock Ditch to wells as alternate points of diversion or augmentation of depletions caused by these wells	164	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Security	Sec_LockMC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
57	Security	Div. 2, 06CW119	Chilcott Ditch	Change and exchange of Security's interests in Chilcott Ditch to wells as alternate points of diversion or augmentation of depletions caused by these wells	45	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Fountain	Sec_ChilMC
58	Security	Div. 2, 84CW62, 63, & 64	Colorado Canal Companies (Colorado Canal, Lake Henry, Lake Meredith) Change of Water Rights and Consumptive Use Exchange	Exchange of Pro Rata Ownership of Transferred Colorado Canal Companies' Shares	Constrained by available exchange potential and release rate from Lake Meredith		Change and Exchange of Consumptive Use Water	From Lake Meredith Outlet near Rocky Ford to Pueblo Reservoir	Sec_CCL
59	Strat-moor Hills	See note[(1)]	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	403	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	SH_MCFARF_Pr1
60	Upper Arkansas Water Conservancy District	Div. 5, 1936 Decree No. 284, W-1901, 84CW162	Independence Pass Transmountain Diversion System (Twin Lakes Reservoir and Canal Company) Decrees	Decrees for Upper Arkansas Water Conservancy District Shares in the Twin Lakes Reservoir and Canal Company	345	acre-feet	Trans-mountain imports from the Roaring Fork River to the Upper Arkansas River Basin	Headwaters of the Roaring Fork and Arkansas River to east slope storage including Pueblo, Twin Lakes and Turquoise Reservoirs	UA_TLMC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
61	Upper Arkansas Water Conservancy District	Div. 2, 91CW19	White Ditch	Diversion of Consumptive Use Portion of White Ditch	26	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	North Fork Reservoir to diversion points along the South Arkansas River	UA_CUMC
62	Upper Arkansas Water Conservancy District	Div. 2, 94CW5, 95CW208	Thompson Ditch	Diversion of Consumptive Use Portion of Thompson Ditch	23	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Cottonwood Creek drainage and all tributaries, including Cottonwood Lake; Rainbow Lake	UA_CUMC
63	Upper Arkansas Water Conservancy District	Div. 2, 10CW30 (pending)	A. Katzenstein Ditch No. 1	Diversion of Consumptive Use Portion of A. Katzenstein Ditch No. 1	86	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Conquistador Reservoir No. 1 on Middle Taylor Creek to the Arkansas River at Pueblo Reservoir	UA_CUMC
64	Upper Arkansas Water Conservancy District	Div. 2, 93CW31	Lester Attebury Ditch	Diversion of Consumptive Use Portion of Lester Attebury Ditch	28	acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Arkansas River near Florence	UA_CUMC
65	Div. 2, 82CW20 483CW1 41	North Fork Reservoir	Storage account in North Fork Reservoir	Upper Arkansas Water Conservancy District	1,095	acre-feet storage capacity	Storage right	North Fork Reservoir to diversion points along the South Arkansas River	
66	Div. 2, 82CW20 5	O'Haver Reservoir	Storage account in O'Haver Reservoir	Upper Arkansas Water Conservancy District	193	acre-feet storage capacity	Storage right	O'Haver Reservoir	

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
67	Colorado Session Laws 1897, 1935, 1953, 1963, 1981, & CRS37-88-208	Boss Lake	Storage account in Boss Lake	Upper Arkansas Water Conservancy District	689	acre-feet storage capacity	Storage right	Boss Lake	
68	Widefield	See note(1)	Fryingpan-Arkansas Project Decrees	Decrees for Fryingpan-Arkansas Project Water Return Flows	900	acre-feet	Trans-mountain imports from the Fryingpan River to the Upper Arkansas River Basin and native east slope waters	Headwaters of the Fryingpan and Arkansas River to Project storage including Pueblo, Twin Lakes and Turquoise Reservoirs	Wid_RF_Pr1
69	Widefield	Div. 2, 81CW229 & future water court filing for 216 shares	Fountain Mutual Irrigation Company	Change and exchange of Widefield's interests in Fountain Mutual Irrigation Company to wells as alternate points of diversion or augmentation of depletions caused by these wells	394	acre-feet	Change and Exchange of Consumptive Use Water	Fountain Creek at or near the City of Widefield	Wid_FMICMC
70	Widefield	Div. 2, 08CW47 (pending)	W.A. Bell Ditch Nos. 1, 2, and 3 (1/2 interest)	Diversion of Consumptive Use Portion of W.A. Bell Ditch Nos. 1, 2, and 3 Water Rights		acre-feet	Change and Alternate Point-of-Diversion of Consumptive Use Water	Fountain Creek at or near the City of Widefield, Arkansas River between the mouth of Fountain Creek and inflows from Alvarado Creek and Venable Creek	Wid_BellMC

Row No.	Entity	Decree No.	Name	Description	Amounts		Type	Approximate Geographic Extent	Surface Water Hydrology Daily Model Node or Link
71	Widefield		Fully consumable sewered return flows provided to Widefield by Colorado Springs Utilities		1,021	acre-feet			Wid_CSURFMC
72	Widefield	Water Court Action Needed	Cody Water Rights	Change and exchange of Widefield's interest in Owen and Hall Ditch – Priority No. 8; Laughlin Ditch – Priority Nos. 10 and 17; Reclamation Water associated with development of land near Cheyenne Mountain Ranch and the Broadmoor/ Carson Valley	1,273	acre-feet	Change and Exchange of Consumptive Use Water		Wid_MiscMC

Notes:
(1) Fryingpan-Arkansas Project Decrees.

West Slope Decrees	East Slope Decrees	Reuse and Exchange Decrees
District Court, Chaffee County, Civil Action No. 4613	District Court, Chaffee County, Civil Action No. 5141	District Court, Pueblo County, Civil Action No. B-42135
Div. 5, W-829-76	District Court, Pueblo County, Civil Action No. B-42135	Div. 2, 01CW151 (Pending)
Div. 5, 83CW352	Div. 2, 80CW6	

(2) Water rights also proposed for storage in Southern Delivery System excess capacity account.

Appendix B.1 - Alternatives Development

Introduction

The purpose of the alternatives analysis was to develop a range of reasonable alternatives to be evaluated in the Arkansas Valley Conduit (AVC) and Long-Term Excess Capacity Master Contract, Fryingpan-Arkansas Project Environmental Impact Statement (EIS). Alternatives were developed using a structured alternative development and screening process. The goal of this process was to identify a reasonable range of alternatives to meet the purpose and needs of AVC, Interconnect, and Master Contract. The following terminology is used in this process:

> **Component –** Discrete activities or facilities (e.g., an intake location) that, when combined with other components, form an alternative.
>
> **Option –** An alternate way of implementing a component, or an alternative geographic location for a component, such as alternative methods for diverting water or alternative geographic locations for a water intake. Options generate the differences among alternatives.
>
> **Alternative –** A complete project that has all the components necessary to fulfill the purpose and need of the proposed actions.

A schematic of the alternatives development process is presented in Figure 1. The first step of the process generally consisted of component and options development with the Interconnect included as an engineering sub-component of AVC. Six components to the project were identified, including water supply, regulating storage, intake location, conveyance through Pueblo, conveyance east of Pueblo, and water treatment.

Detailed and conceptual options were developed that potentially could be used to implement each of the components. This initial long list of options was consolidated to a short list of options using a two-step screening process that considered both significant logistical and technical issues and environmental characteristics. The significant issues screening was a pass/fail type of test used to quickly eliminate options that could not meet the purpose and need of the proposed actions. The environmental screening process assigned technical data to either eliminate or determine which options best met certain criteria.

Next short-listed options were compiled into alternatives. Using information from public scoping, alternative themes were identified. Short-listed options best fulfilled alternative themes, and development of final alternatives was based on consolidated alternative themes and options. Once options were developed to meet the alternative themes, the alternative themes were consolidated into alternatives for study in the EIS based on overlapping options between alternative themes.

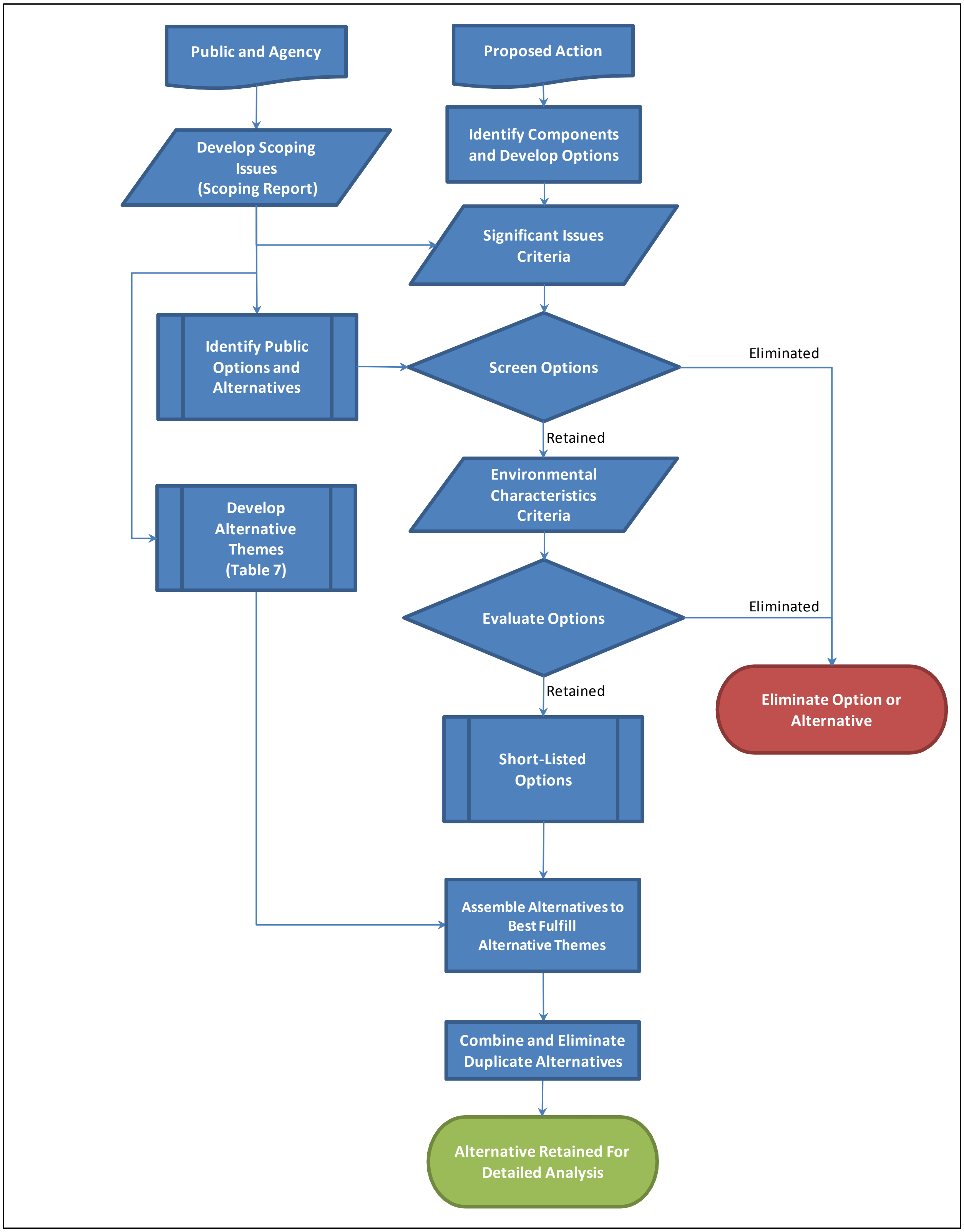


Figure 1. Alternatives Screening and Development Process

Overall, approximately 170 options were identified for screening, and approximately 40 options passed through the screening process to the table of short-listed options. A total of 13 alternative themes were developed and were consolidated into six action alternatives and a No Action Alternative. This appendix provides a description of the options, alternatives, and processes used to develop these action alternatives.

Project Components and Range of Options

To develop a reasonable range of alternatives, the proposed federal actions were separated into components. Components were developed based on the description of proposed actions as described in the Notice of Intent and subsequent investigations by the EIS team. For purposes of the alternatives analysis, AVC is comprised of the following components:

- Water Supply
- Regulating Storage
- Intake Location
- Conveyance – Through Pueblo
- Conveyance – East of Pueblo
- Water Treatment

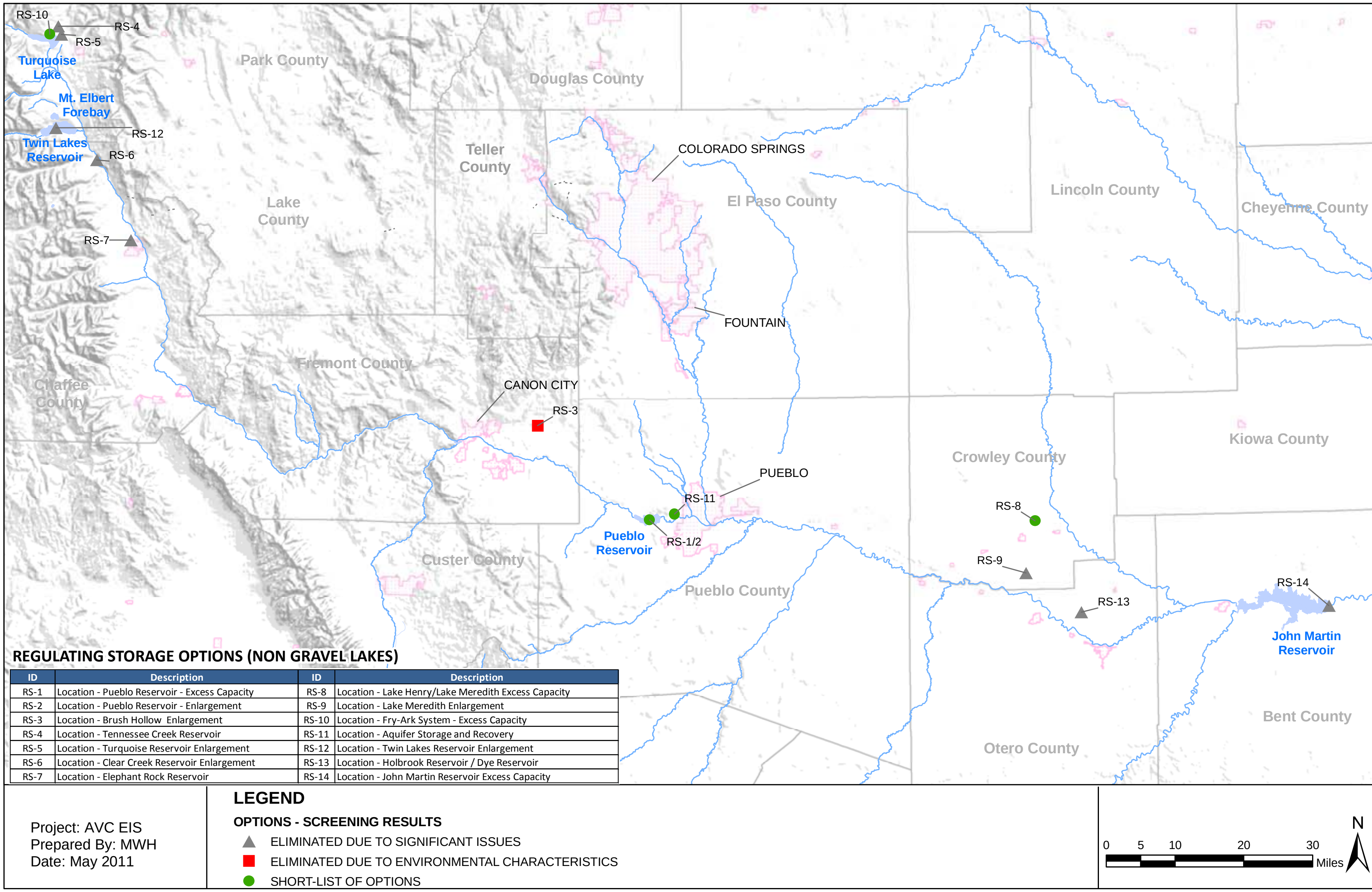
Options were then identified for each component. Options were developed from the STAG report (Black & Veatch 2010), the AVC Value Planning Report (Reclamation 2010a), public or agency input from public scoping (Reclamation 2010b), the Southern Delivery System EIS Alternatives Analysis report (Reclamation 2006), Reclamation, the EIS interdisciplinary team, the participants, and other studies. These options provided a full range for evaluation using the screening process.

Options fall into two categories:

1. Location/source options – These options have specific details regarding the proposed location of the component (for example, a specific pipeline route) or source for water supply (for example, transfers from a specific ditch).

2. Conceptual options – These types of options are more general in nature. In comparison to the examples provided for location/source options, a conceptual option would be a general description of a pipeline route or a general water supply concept such as agricultural transfers.

The methods by which location/source and conceptual options are integrated into specific alternatives are described in later sections of this appendix. The following sub-sections provide a general overview of the options considered for development of alternatives. Maps of the intake, conveyance and water treatment options appear in Figure 2 through Figure 7.



ID	Description	ID	Description
RS-1	Location - Pueblo Reservoir - Excess Capacity	RS-8	Location - Lake Henry/Lake Meredith Excess Capacity
RS-2	Location - Pueblo Reservoir - Enlargement	RS-9	Location - Lake Meredith Enlargement
RS-3	Location - Brush Hollow Enlargement	RS-10	Location - Fry-Ark System - Excess Capacity
RS-4	Location - Tennessee Creek Reservoir	RS-11	Location - Aquifer Storage and Recovery
RS-5	Location - Turquoise Reservoir Enlargement	RS-12	Location - Twin Lakes Reservoir Enlargement
RS-6	Location - Clear Creek Reservoir Enlargement	RS-13	Location - Holbrook Reservoir / Dye Reservoir
RS-7	Location - Elephant Rock Reservoir	RS-14	Location - John Martin Reservoir Excess Capacity

Figure 2. Regulating Storage Options (Non Gravel-Lakes)

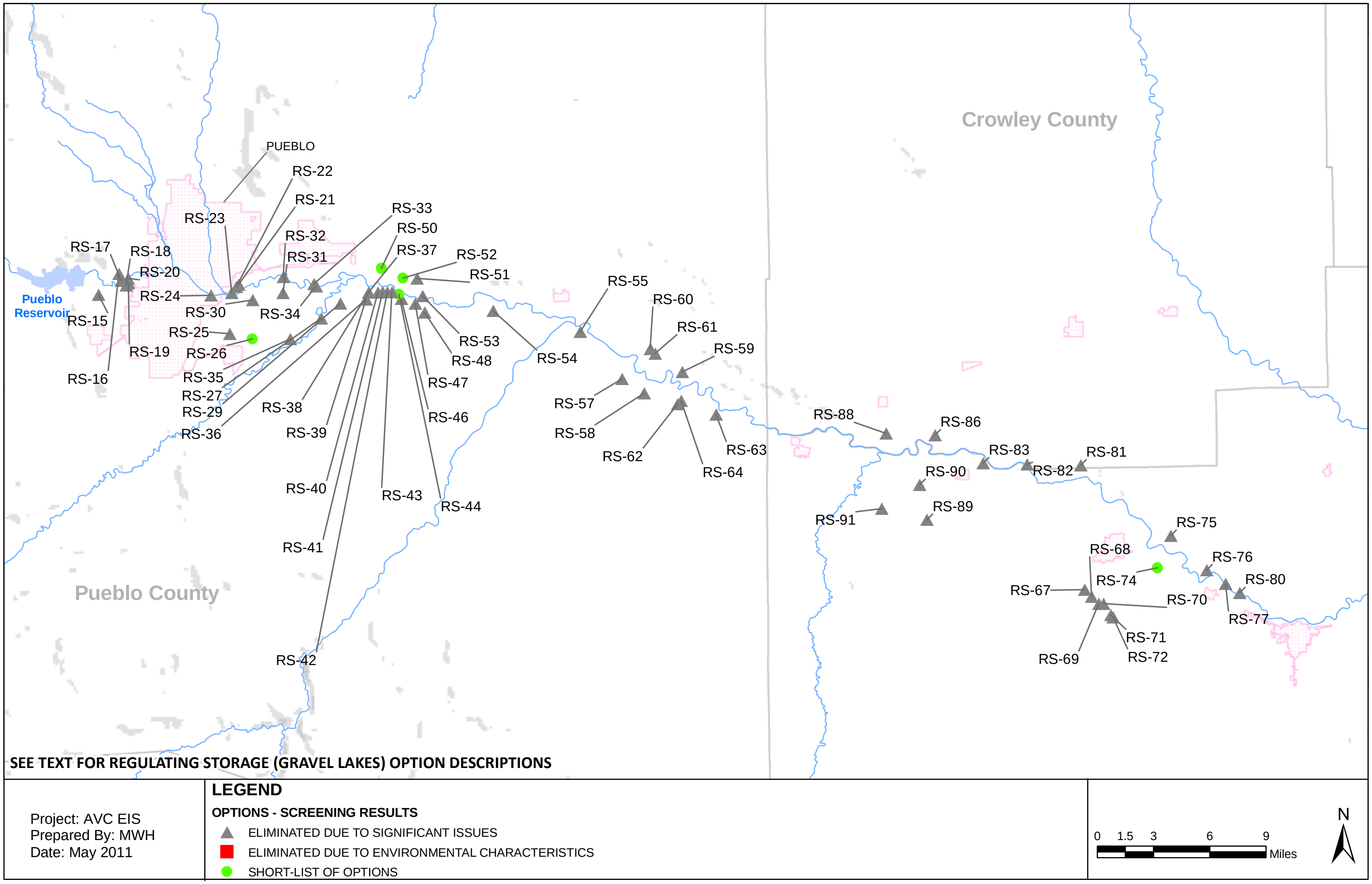
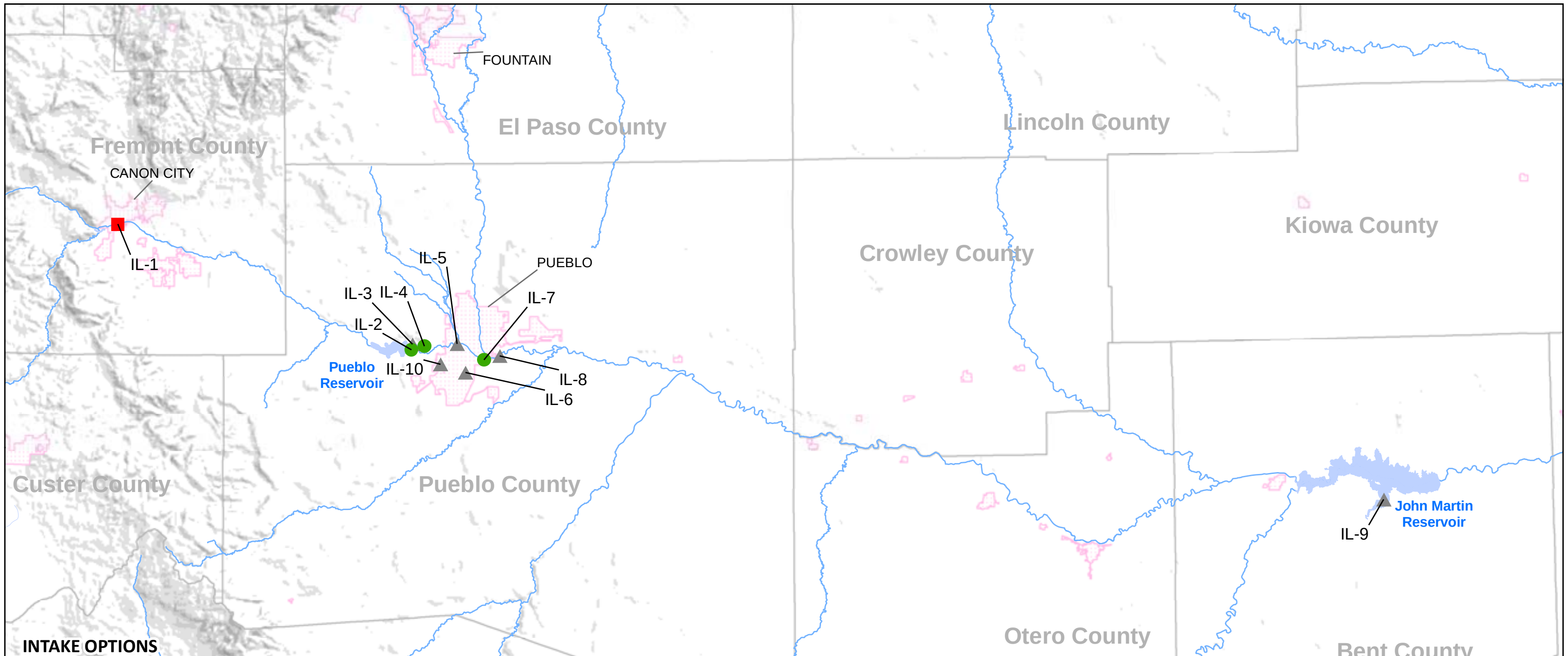


Figure 3. Regulating Storage Options (Gravel Lakes)



INTAKE OPTIONS

ID	Description
IL-1	Concept - Diversion above Pueblo Dam (Representative Location)
IL-2	Location - Pueblo Reservoir South Outlet Works
IL-3	Location - Pueblo Reservoir North Outlet Works (SDS)
IL-4	Location - Joint Use Pipeline (JUP) at Pueblo Boulevard
IL-5	Location - Whitlock WTP
IL-6	Concept - Bessemer Ditch (Representative Location)
IL-7	Location - Arkansas River upstream of the Fountain Creek confluence
IL-8	Concept - Arkansas River downstream of the Fountain Creek confluence (Representative Location)
IL-9	Concept - Downstream Regulating Storage (Lake Henry, Lake Meredith, Holbrook, Dye, John Martin, Gravel Lakes) (Representative Location)
IL-10	Concept - CF&I Conduit / Minnequa Ditch (Representative Location)

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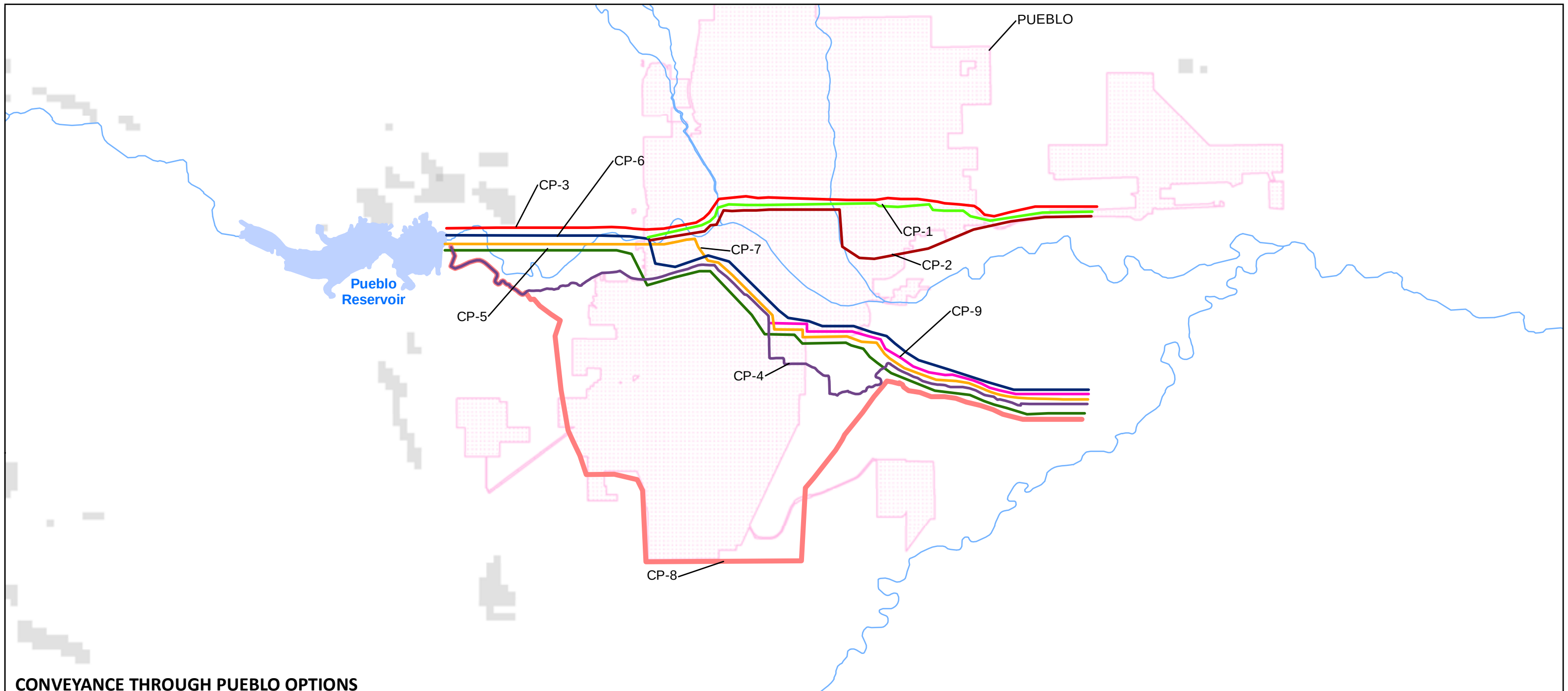
Intake Options

- ELIMINATED DUE TO SIGNIFICANT ISSUES
- ELIMINATED DUE TO ENVIRONMENTAL CHARACTERISTICS
- SHORT-LIST OF OPTIONS

Figure 4. Intake Options



CONVEYANCE THROUGH PUEBLO OPTIONS

ID	Description	Screening Results	ID	Description	Screening Results
CP-1	Location - North (JUP Wye, along 11th Street)	——	CP-11	Concept - Bessemer Ditch - In channel pipeline dedicated for AVC (Not Shown in Map)	– – –
CP-2	Location - North (JUP Wye, along railroad)	——	CP-12	Concept - Bessemer Ditch - All water (Agricultural and AVC) into one pipeline (Not Shown in Map)	– – –
CP-3	Location - North (Pueblo Dam, JUP route, along 11th Street)	——	CP-13	Concept - BWWP System, with or without replacement (Not Shown in Map)	– – –
CP-4	Location - South (Pueblo Dam, along Bessemer Ditch)	——	CP-14	Location - CF&I Conduit / Minnequa Ditch (Not Shown in Map)	– – –
CP-5	Location - South (JUP Wye, along Bessemer Ditch)	——	CP-15	Concept - Tunnel the main pipe (Not Shown in Map)	– – –
CP-6	Location - South (Pueblo Dam, JUP route, Bessemer Ditch)	——	CP-16	Concept - Rail water to users (Not Shown in Map)	– – –
CP-7	Location - South (Whitlock, along Bessemer Ditch)	——	CP-17	Location - Run conduit within riverbed (Not Shown in Map)	– – –
CP-8	Location - South (Comanche route)	——	CP-18	Concept - Interconnect (Not Shown in Map)	——
CP-9	Location - Downstream Intake	——	CP-19	Concept - Canal to WTP (Not Shown in Map)	– – –
CP-10	Concept - Bessemer Ditch - Flow in existing open channel (Not Shown in Map)	– – –	CP-20	Concept - Directional drill under Pueblo (Not Shown in Map)	– – –
			CP-21	Concept - Run parallel pipes (Not Shown in Map)	——

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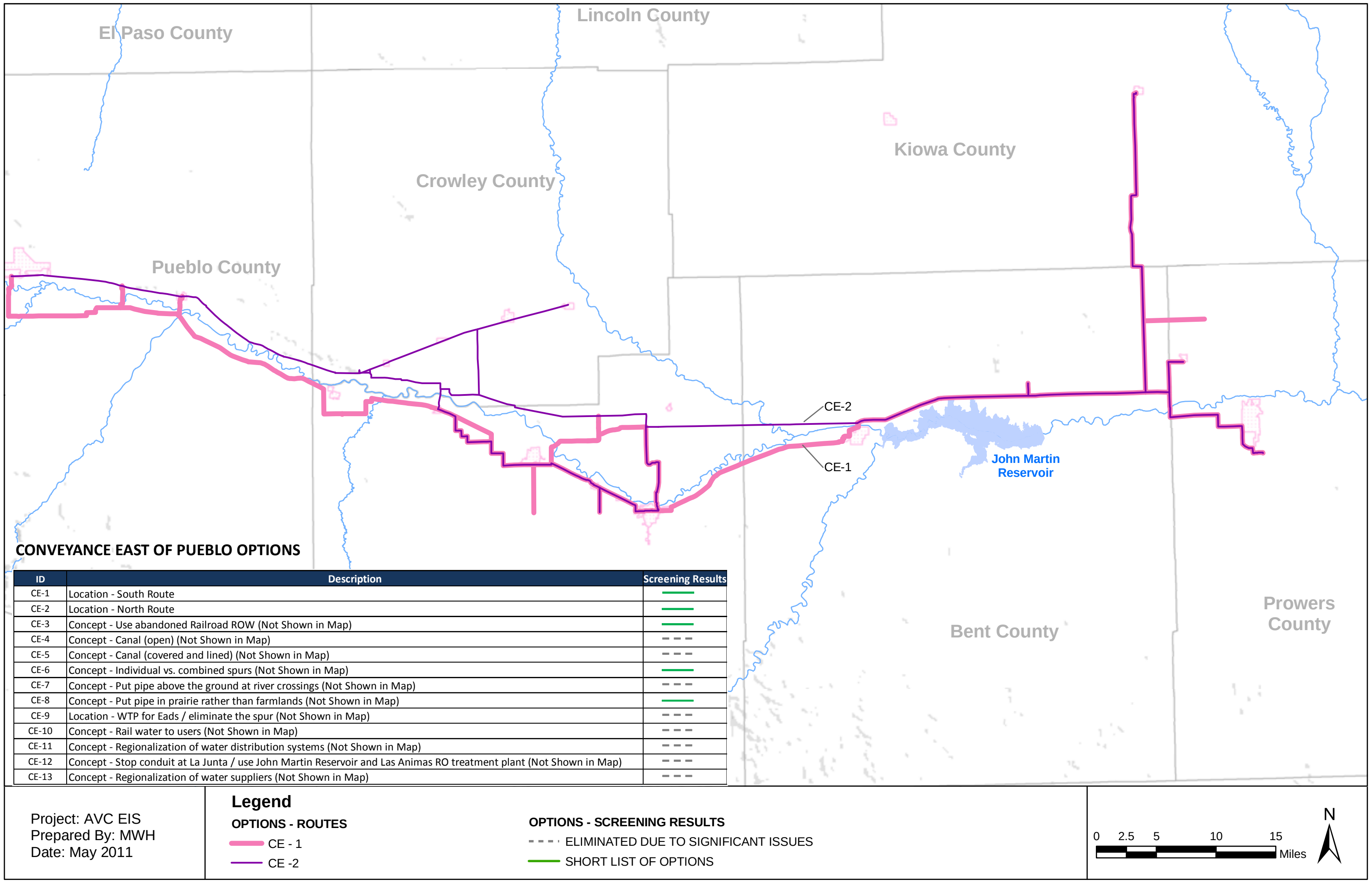
OPTIONS - ROUTES CP-1, CP-2, CP-3, CP-4, CP-5, CP-6, CP-7, CP-8, CP-9

OPTIONS - SCREENING RESULTS
- - - ELIMINATED DUE TO SIGNIFICANT ISSUES
—— SHORT-LIST OF OPTIONS

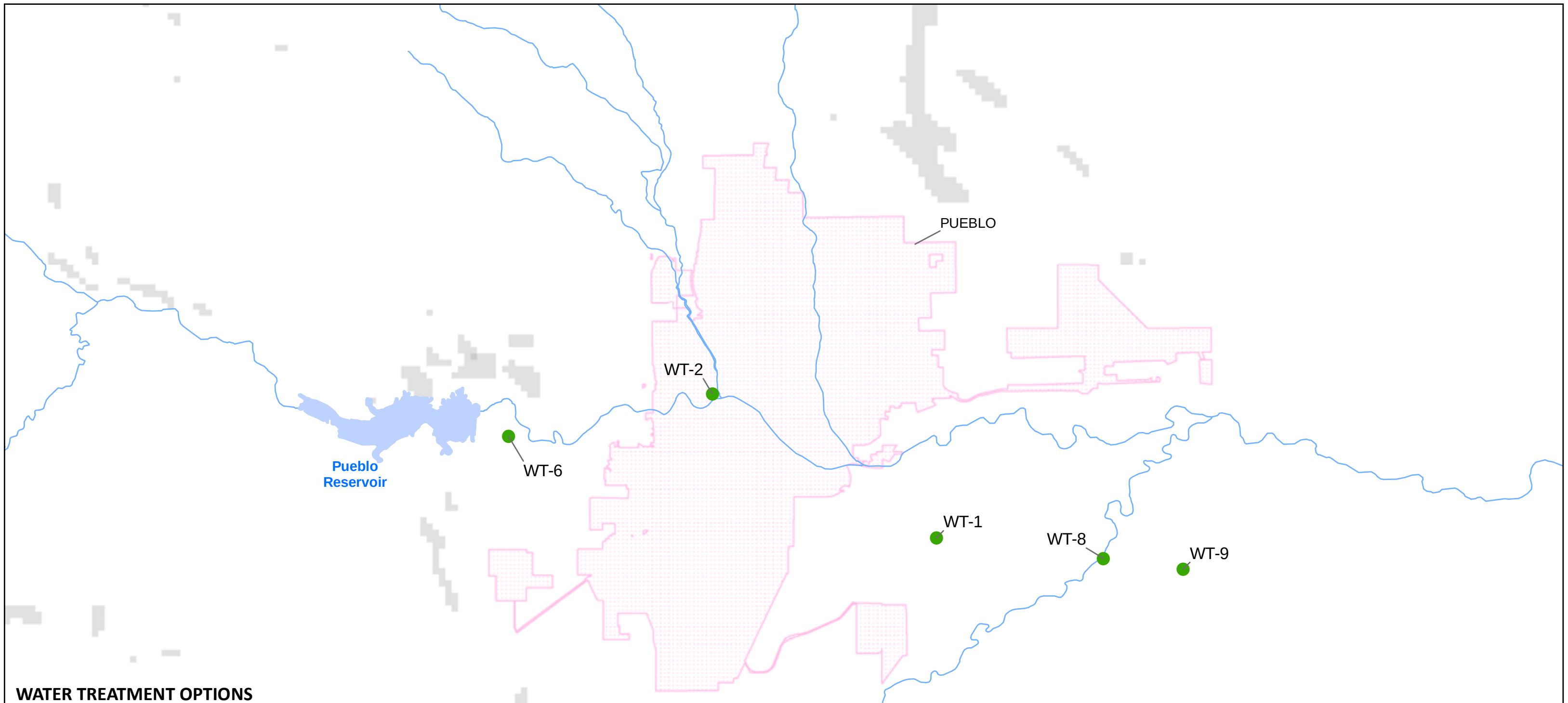
0 0.5 1 2 3 Miles
N

Figure 5. Conveyance Options Through Pueblo. For clarity, conveyance options have been offset to show overlapping alignments



ID	Description	Screening Results
CE-1	Location - South Route	———
CE-2	Location - North Route	———
CE-3	Concept - Use abandoned Railroad ROW (Not Shown in Map)	———
CE-4	Concept - Canal (open) (Not Shown in Map)	- - -
CE-5	Concept - Canal (covered and lined) (Not Shown in Map)	- - -
CE-6	Concept - Individual vs. combined spurs (Not Shown in Map)	———
CE-7	Concept - Put pipe above the ground at river crossings (Not Shown in Map)	- - -
CE-8	Concept - Put pipe in prairie rather than farmlands (Not Shown in Map)	———
CE-9	Location - WTP for Eads / eliminate the spur (Not Shown in Map)	- - -
CE-10	Concept - Rail water to users (Not Shown in Map)	- - -
CE-11	Concept - Regionalization of water distribution systems (Not Shown in Map)	- - -
CE-12	Concept - Stop conduit at La Junta / use John Martin Reservoir and Las Animas RO treatment plant (Not Shown in Map)	- - -
CE-13	Concept - Regionalization of water suppliers (Not Shown in Map)	- - -

Figure 6. Conveyance Options East of Pueblo



WATER TREATMENT OPTIONS

ID	Description	Screening Results	ID	Description	Screening Results
WT-1	Location - New WTP located near South Road and 21st Street	●	WT-10	Concept - Filtered treatment (Not Shown in Map)	●
WT-2	Location - Whitlock WTP (BWWP)	●	WT-11	Concept - Filtered and disinfected treatment (Not Shown in Map)	●
WT-3	Concept - Blended supplies (Not Shown in Map)	●	WT-12	Concept - Convert all participants to chloramines (Not Shown in Map)	■
WT-4	Concept - De-centralized, regional facilities (Not Shown in Map)	●	WT-13	Concept - Point -of-Use (POU) treatment under sink (Not Shown in Map)	▲
WT-5	Concept - Reverse Osmosis for existing water supplies (Not Shown in Map)	■	WT-14	Concept - Individualized water treatment plants (Not Shown in Map)	■
WT-6	Location - New WTP located below Pueblo Dam (on BOR property) (Not Shown in Map)	●	WT-15	Concept - Pueblo water system to convert to chlorine disinfection (Not Shown in Map)	▲
WT-7	Concept - Deliver Treated Water to St Charles Mesa (Not Shown in Map)	●	WT-16	Concept - Challenge water quality regulations (Not Shown in Map)	▲
WT-8	Location - New WTP located adjacent to the existing St. Charles Mesa WTP (Not Shown in Map)	●	WT-17	Concept - UV/Ozone treatment at WTP (Not Shown in Map)	▲
WT-9	Location - New WTP downstream from St Charles Mesa (Not Shown in Map)	●	WT-18	Concept - Advanced treatment at WTP (Not Shown in Map)	▲

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Prepared By: MWH
Date: May 2011

LEGEND

OPTIONS - SCREENING RESULTS

▲ ELIMINATED DUE TO SIGNIFICANT ISSUES
■ ELIMINATED DUE TO ENVIRONMENTAL ISSUES
● SHORT- LIST OF OPTIONS

0 0.5 1 2 3 Miles

N

Figure 7. Water Treatment Options

Water Supply

Multiple sources of water would be needed for AVC or Master Contract. Water supply is the source from which water would be supplied to AVC or stored in Master Contract storage space. AVC requires enough water supply to provide average annual deliveries through AVC, or approximately 9,200 ac-ft per year (see Chapters 1 and 2[1]). Due to an estimated 5 percent water loss through the water treatment plant, about 9,700 ac-ft of total supply would be needed to deliver that amount. Water loss in AVC would be negligible.

The Master Contract participants require enough water to meet the intended use of the Master Contract storage space. As described in Appendix A, this use varies by participant. For instance, participants using Master Contract water supplies for drought protection may only need enough water to initially fill the storage space, fill following a drought, and maintain water levels due to evaporative losses. In comparison, entities using Master Contract storage space for average annual supply may need enough water to fill the storage space one or more times per year.

Specific water supply options in the Arkansas Basin, other portions of the state, and in the Western U.S. were considered. A summary of water supply options is in Table 1.

Table 1. Options Considered for Water Supply

ID	Description	Source of Option	Description
WS-1	Source - Fry-Ark Project Water	STAG	Use "East of Pueblo" allocation of Fry-Ark Project yields. Fry-Ark Project water is the primary proposed water source for AVC, as identified in the STAG report.
WS-2	Source - Fry-Ark Project Return Flows (1939 Decree)	STAG	Use return flows generated from uses of Fry-Ark Project water. Measured municipal Fry-Ark Project return flows purchased from Southeastern by the entity that generated them can be exchanged under Southeastern's existing 1939 exchange decree. Fry-Ark Project Return flows can be used to extinction.
WS-3	Source - Fry-Ark Project Return Flows (01CW151)	STAG	Use return flows generated from uses of Fry-Ark Project water. Measured municipal Fry-Ark Project return flows purchased by other users and unmeasured municipal and agricultural return flows can be exchanged under Southeastern's proposed 01CW151 exchange decree. Southeastern is currently adjudicating this water right. It is expected that this water right will be decreed prior to completion of the AVC EIS. Fry-Ark Project Return flows can be used to extinction.
WS-4	Concept - Use of Existing Agricultural Water Rights	EIS Team	Use existing transfers of water from agricultural to municipal uses. Several AVC and Master Contract participants have proposed using existing decreed agricultural water rights transfers. These water rights are from a variety of sources upstream and downstream of Pueblo Reservoir and in the Fountain Creek basin.

[1] An average annual AVC delivery of 9,200 acre-feet was used in the alternatives development process. Subsequent EIS investigations estimated annual demand of approximately 10,200 acre-feet (see Chapter 1 and 2). This change in annual AVC demand does not change results of the alternatives analysis.

ID	Description	Source of Option	Description
WS-5	Concept - Use of New Agricultural Water Rights	EIS Team	Use new transfers of water from agricultural to municipal uses. Several AVC and Master Contract participants are proposing new agricultural water rights transfers. These water supplies are in a variety of states, with some sources in the process of being identified and others in the transfer process. These water rights are from a variety of sources upstream and downstream of Pueblo Reservoir and in the Fountain Creek basin.
WS-6	Concept - Rotational Fallowing and Leasing	EIS Team	Develop new contracts with ditch companies or farms to temporarily lease water from farms. General rotational fallowing and leasing programs have been identified as potential water sources.
WS-7	Source - Water Rights specifically for AVC associated with the Super Ditch Project	EIS Team	Use water supplies from the proposed Arkansas River Super Ditch, a coordinated rotational fallowing program among several ditches in the lower Arkansas Basin. Several AVC and Master Contract participants have identified water sources associated with the proposed Arkansas Valley Super Ditch.
WS-8	Concept - New Western Slope Project	Previous NEPA	Construct new or expanded diversion projects from Colorado's Western Slope to the Eastern Slope. No specific projects were identified as part of this option. As currently proposed, these projects would only provide supplemental water to the Arkansas River basin and would not convey water to participants.
WS-9	Source - Flaming Gorge Pipeline	Previous NEPA	Construct new diversion and conveyance project from Flaming Gorge Reservoir in southwestern Wyoming to Colorado's Front Range. As currently proposed, this project would only provide supplemental water to the Arkansas River basin and not convey water to participants. This project is also known as the Regional Watershed Supply Project.
WS-10	Concept - Canada or Alaska Water Supply Project	Previous NEPA	Construct a new water project to convey water from Canada or Alaska to the Colorado Front Range. Details on this project are unknown.
WS-11	Source - Fort Lyon Ditch/ Great Plains Reservoirs	EIS Team	Purchase and transfer shares of the Fort Lyon Ditch and Great Plains Reservoirs. It is unclear how these water supplies would be conveyed to Pueblo Reservoir.
WS-12	Concept - New Groundwater	Public Scoping	Develop new groundwater supplies in tributary alluvial aquifers and non-tributary bedrock aquifers. Aquifer sources available to AVC participants are generally the same sources as those currently used by participants.
WS-13	Source - Central Colorado Project (CCP)	Public Scoping	Divert water from the Gunnison River basin on Colorado's Western Slope to the Arkansas River basin on the Eastern Slope. As currently proposed, this project would provide supplemental water to the Arkansas River basin but not convey water to participants.
WS-14	Concept - Conservation	Public Scoping	Incorporate active and passive conservation projects by water supplier customers to reduce overall demand. Although not specifically a water supply, it has been included in this category, because it could offset the need for a supply reducing demand.
WS-15	Concept - Reuse (Potable/Non-Potable) of Available Supplies	Public Scoping, Value Planning Study	Construct new facilities for direct potable or non-potable reuse, which would require downstream diversion structures, advanced treatment systems, other infrastructure, and agreements/exchanges with other water users.

ID	Description	Source of Option	Description
WS-16	Concept - Dual Use, Non-Potable System	Public Scoping, Value Planning Study	Construct separate non-potable distribution systems for each participant to deliver non-potable water for landscape irrigation, industrial, and other uses in which lower quality water could be used. This would require substantial infrastructure to retrofit existing distribution systems.
WS-17	Concept - Build a bottled water treatment plant	Value Planning Study	Construct a bottled water plant to provide potable water to participants rather than building a new conveyance system.
WS-18	Concept - Cloud Seeding	Value Planning Study	Incorporate cloud seeding as a water supply component. The concept of cloud seeding has been on-going in the upper Arkansas River basin for many years in hopes of to increasing overall yield of the river basin. However, based on Colorado Water Law, an entity cannot directly take delivery of increased yields due to cloud seeding.
WS-19	Concept - Exchange return Fryingpan-Arkansas flows for Fryingpan-Arkansas agricultural deliveries	Value Planning Study	Develop a "paper exchange" of Fry-Ark Project Return Flows and agricultural deliveries. Rather than directly releasing water from Pueblo Reservoir, deliveries would use Fry-Ark Project Return Flows, and a like amount of water would be stored in Pueblo Reservoir. This type of operation likely would require a water rights decree to quantify return flows.
WS-20	Concept - Remove tamarisk / phreatophytes	Value Planning Study	Incorporate tamarisk/phreatophyte removal in Arkansas River as a water supply. Removal has been in progress in the Lower Arkansas River basin with the intent of increasing overall yield of the river basin. However, based on Colorado Water Law, an entity cannot directly take delivery of increased yields that may occur due to tamarisk/phreatophyte removal.
WS-21	Concept - Pump back for return flows	Value Planning Study	Divert reusable return flows from downstream portions of the Arkansas Basin and convey them through a pipeline to upstream locations (i.e. Pueblo Reservoir). Although a project such as this is technically feasible, there would be substantial legal, permitting and financial obstacles to overcome. Although not specifically a water supply, it has been included in this category because it is a specific method for recovering return flows.

Regulating Storage

Regulating storage would provide the Master Contract participants the ability to store non Fry-Ark water and deliver that water to an untreated water intake location. Water stored in regulating storage could be delivered directly to the unfiltered water intake facility (if the regulating storage facility is downstream of the water source) or exchanged into the facility (if the regulating storage facility is upstream of the water source). Ideally, the regulating storage facility should be upstream of the intake location so that stored water can be delivered directly to the intake rather than needing an exchange. The regulating storage would also provide the ability to store water if not immediately delivered to the water conveyance system (also known as “carry-over storage”).

As proposed, Master Contract participants would need approximately 32,000 ac-ft of excess capacity storage in Pueblo Reservoir. Options were developed which would provide this storage as excess capacity storage in Pueblo Reservoir, as well as both excess capacity and firm storage in other existing and new storage facilities in the Arkansas River Basin. A summary of non-gravel lakes regulating storage options is provided in Table 2. Due to the large number of gravel lakes storage options, they are identified in Table 3.

Table 2. Range of Options - Regulating Storage (Non-Gravel Lake Options)

ID	Description	Source of Option	Description
RS-1	Location - Pueblo Reservoir - Excess Capacity	STAG	Provide storage using excess capacity storage space in existing Pueblo Reservoir, similar to other long-term excess capacity contracts (i.e. Pueblo Board of Water Works, SDS). Spill priorities would be the same as existing spill priorities, with the spill priority being equal between all long-term Excess Capacity contracts.
RS-2	Location - Pueblo Reservoir – Enlargement	Previous NEPA, Value Planning Study	Enlarge existing Pueblo Reservoir to provide firm storage capacity. This alternative was studied by Southeastern during the Preferred Storage Options Plan (GEI 2000).
RS-3	Location - Brush Hollow Enlargement	Previous NEPA	Enlarge existing Brush Hollow Reservoir near Penrose. Deliveries from the Arkansas River could potentially be made through existing canal infrastructure. Water rights would potentially need to be changed to store in Brush Hollow Reservoir, as many existing water rights are not decreed for storage in Brush Hollow Reservoir.
RS-4	Location - Tennessee Creek Reservoir	Previous NEPA	Construct a new reservoir on Tennessee Creek in the Upper Arkansas River basin. This option has been studied in previous EIS documents. Tennessee Creek is a perennial stream.
RS-5	Location - Turquoise Reservoir Enlargement	Previous NEPA	Enlarge existing Turquoise Reservoir to provide firm storage capacity. This alternative was studied by Southeastern during the Preferred Storage Options Plan.
RS-6	Location - Clear Creek Reservoir Enlargement	Previous NEPA	Enlarge existing Clear Creek Reservoir in the upper Arkansas River Basin to provide firm water storage capacity. Clear Creek Reservoir is owned by the Board of Water Works of Pueblo. Water would need to be exchanged into the reservoir. Any deliveries directly from the Arkansas River would require substantial pumping and pipeline infrastructure.
RS-7	Location - Elephant Rock Reservoir	Previous NEPA	Construct a new reservoir on the Arkansas River near Buena Vista. Colorado Springs Utilities has an existing conditional water right for this reservoir.
RS-8	Location - Lake Henry/Lake Meredith Excess Capacity	Previous NEPA	Provide storage using excess capacity storage space in the existing Colorado Canal System reservoirs (Lake Henry and Lake Meredith). Details on operations would need to be discussed with these Colorado Canal companies and their existing share-holders.
RS-9	Location - Lake Meredith Enlargement	Previous NEPA	Enlarge existing Lake Meredith Reservoir within the existing Colorado Canal system of the lower Arkansas Valley. Enlargement of this facility has been considered in previous NEPA documents (Reclamation 2006).

ID	Description	Source of Option	Description
RS-10	Location - Fry-Ark System - Excess Capacity	STAG	Provide storage using excess capacity storage space in existing Pueblo Reservoir, Twin Lakes, and Turquoise Reservoir. Contracts would be similar to other long-term excess capacity contracts (i.e. Board of Water Works of Pueblo, Southern Delivery System). Spill priorities would be the same as existing spill priorities, with the spill priority being equal between all long-term excess capacity contracts. Upper basin storage would be used to store water for entities west of Pueblo. Details on these operations would be determined by Reclamation.
RS-11	Location - Aquifer Storage and Recovery	Previous NEPA, Value Planning Study	Store water supplies in available alluvial and/or bedrock aquifers. In the Arkansas Basin, most aquifers suitable for this type of operation are east of Pueblo Reservoir.
RS-12	Location - Twin Lakes Reservoir Enlargement	Previous NEPA	Enlarge existing Twin Lakes Reservoir in upper Arkansas River Basin. Little information is available regarding this enlargement.
RS-13	Location - Holbrook Reservoir / Dye Reservoir	Previous NEPA	Provide storage in existing Holbrook and Dye Reservoirs in lower Arkansas River Basin. Holbrook and Dye are smaller reservoirs in the lower Arkansas Basin that potentially could be used for excess capacity storage. Municipal water supplies currently are stored in Holbrook Reservoir. Therefore, storage capacity would be limited.
RS-14	Location - John Martin Reservoir Excess Capacity	Previous NEPA	Provide storage using excess capacity in existing John Martin Reservoir. Details on operations would be determined by the Corps and the Arkansas River Compact Committee. Execution of these contracts could take many years.

Use of gravel lakes for water supply storage is a common practice in Colorado. Typically, a water user will contract directly with a gravel mining company to reserve the option to operate a gravel pit as a water supply facility once gravel mining is complete. The State Engineer’s Office has rules and regulations regarding construction of the gravel lake in order to prevent infiltration and seepage and ensure proper water accounting (Colorado Division of Water Resources 1999). Gravel lakes storage sites identified as potential options for regulating storage were identified from permitted gravel mining sites from the Colorado Division of Reclamation and Mining Safety GIS data (2010). GIS data was queried for those gravel lakes between Pueblo Reservoir and the Fort Lyon Canal headgate (it would be difficult to use any storage downstream of the Fort Lyon Canal headgate for regulating storage). Potential storage volumes were estimated assuming an average 20-foot depth. A summary of gravel lakes regulating storage options is provided in Table 3.

Table 3. Range of Options - Regulating Storage (Gravel Lake Options)

ID	Gravel Lake Operation	Permitted Operation Area (acres)	Estimated Capacity [(1)] (ac-ft)	Permit Status	Post Mining Land use
RS-15	Bessemer Pit	3.6	72	Terminated	Rangeland
RS-16	Smokstad Pit	5.3	106	Terminated	Rangeland
RS-17	Institutions Pit	32	640	Terminated	Unknown

ID	Gravel Lake Operation	Permitted Operation Area (acres)	Estimated Capacity [(1)] (ac-ft)	Permit Status	Post Mining Land use
RS-18	Pueblo West Pit	127	2,540	Active	Residential
RS-19	Hausman-Xmas Pit	7.9	158	Denied	Commercial/Industrial
RS-20	Wington/Datz Pit	0	0	Application Withdrawn	Rangeland
RS-21	Mine Pit 111	14.3	286	Terminated	
RS-22	Stockyard Pit	45.7	914	Active	
RS-23	Beltramo Mine	7.8	156	Terminated	
RS-24	Runyon Lake	24	480	Terminated	Rangeland
RS-25	Vista Mine	20.9	418	Active	
RS-26	Chantala Pit	640	12,800	Active	
RS-27	Glover	0	0	Application Withdrawn	
RS-28	Fisher Pit	39.3	786	Terminated	Pastureland
RS-29	34th Lane Pit	9.4	188	Terminated	Rangeland
RS-30	Pueblo Pit	83	1,660	Terminated	
RS-31	Tomich Pit	8.6	172	Terminated	
RS-32	Oakleaf Pit	0	0	Terminated	
RS-33	RBK Pit No. 30	9.9	198	Terminated	
RS-34	RBK Pit No. 31	9.9	198	Terminated	
RS-35	Morgan Pit	12.1	242	Terminated	
RS-36	Pisciotta Gravel Pit	10	200	Terminated	Rangeland
RS-37	Pisciotta Gravel Pit	0	0	Terminated	Rangeland
RS-38	Pisciotta Gravel Pit	5	100	Terminated	
RS-39	Andenusio-Buffalo Pit	9.9	198	Terminated	Wildlife Habitat
RS-40	Piscotte Gravel Pit	0	0	Denied	Rangeland
RS-41	Cullen S & G Pit	9.9	198	Terminated	
RS-42	Allen Pit	9.8	196	Terminated	Industrial/Commercial
RS-43	Special Operation	9.9	198	Terminated	General Agriculture
RS-44	Rich Pit	364	7,280	Active	Wildlife Habitat
RS-45	Rich Pit	9.9	198	Terminated	Wildlife Habitat
RS-46	Beltramo No. 2	9.9	198	Terminated	
RS-47	Stealey Mine #1	9.9	198	Active	
RS-48	Stealey Mine #2	60.3	1,206	Active	Pastureland
RS-49	Grant Pit	10	200	Terminated	Wildlife Habitat
RS-50	Blue Grass Gravel Pit	323	6,460	Active	
RS-51	Stonewall Springs Quarry	0	0	In Review	
RS-52	Evans #2 Pit	448	8,960	Active	Recreation
RS-53	St. Barbara Sand and Gravel	364	7,280	Active	Cropland
RS-54	Murillow Gravel Pit	9.9	198	Active	Rangeland
RS-55	Wayt Pit	9.9	198	Terminated	Rangeland
RS-56	Two Rivers Pit	30	600	Terminated	Rangeland
RS-57	Big G Gravel Pit	193	3,860	Active	Rangeland
RS-58	Fowler Pit	30	600	Active	Rangeland
RS-59	Nepesta Hills Pit	0	0	Terminated	Rangeland
RS-60	Boone-Martin Pit	9.9	198	Active	Rangeland
RS-61	Boone-Filmore Pit	84	1,680	Active	Rangeland
RS-62	Lucero Pit	5	100	Terminated	Rangeland
RS-63	Fellhauer Pit	7	140	Denied	Rangeland
RS-64	Pheasant Run Gravel Pit	92.7	1,854	Active	Rangeland
RS-65	Filmore	0	0	Application Withdrawn	Rangeland
RS-66	Filmore Pit	9.9	198	Terminated	Rangeland
RS-67	Hancock Gravel Pit	92	1,840	Active	Rangeland
RS-68	Rocky Ford South Pit	147.4	2,948	Active	Rangeland
RS-69	Hancock Pit	30	600	Active	Rangeland

ID	Gravel Lake Operation	Permitted Operation Area (acres)	Estimated Capacity [1] (ac-ft)	Permit Status	Post Mining Land use
RS-70	Rocky Ford Pit	23.4	468	Active	Rangeland
RS-71	Caldwell Pit	0	0	Terminated	Rangeland
RS-72	Caldwell Brothers 3	51	1,020	Active	General Agriculture
RS-73	Campbell Pit	2	40	Terminated	Rangeland
RS-74	Rocky Ford East Pit	189.2	3,784	Active	Wildlife Habitat
RS-75	Nichols Pit	10	200	Terminated	Pastureland
RS-76	Paul Scott Pit	7	140	Terminated	Rangeland
RS-77	Cuckow Gravel Pit	0	0	Terminated	General Agriculture
RS-78	Reed Pit	32.2	644	Terminated	Rangeland
RS-79	Reed Pit	32.3	646	Active	Rangeland
RS-80	Witt-Man Pit	0	0	Withdrawn	Rangeland
RS-81	Harold Edgar Pit	5.4	108	Terminated	Rangeland
RS-82	Korinek S&G Pit	8.5	170	Active	Mining
RS-83	Caldwell Nesselhuf Pit No. 1	92	1,840	Active	Rangeland
RS-84	Walter Pit	0.3	6	Terminated	Rangeland
RS-85	Walter Pit	20	400	Active	Wildlife Habitat
RS-86	Ordway Pit	29.67	593	Terminated	Rangeland
RS-87	Ordway Pit	98	1,960	Active	Rangeland
RS-88	Crowley County Grav 2	30	600	Active	Rangeland
RS-89	Rough Cut Pit	467	9,340	Active	Rangeland
RS-90	Argo Gravel Pit	229	4,580	Active	Rangeland
RS-91	Cash Pit	166	3,320	Active	Rangeland
RS-92	State Pit	0	0	Application Withdrawn	Rangeland

Notes:
(1) Assumed depth of 20 feet.
(2) Source of all Gravel Lakes Options: Previous NEPA (Reclamation 2006); Colorado Division of Reclamation and Mining Safety (2010)
(3) (Description of all Gravel Lakes Options: Use existing gravel lakes for water supply storage.

Intake

The intake is the location at which untreated water is diverted for conveyance to a water treatment plant. To meet purpose and need, the untreated water intake must be capable of diverting approximately 20 million gallons per day (mgd) of untreated water from the Arkansas River or a regulating storage facility. Concepts and locations for the untreated water intake are presented in Table 4. Because the Arkansas River varies in water quality throughout its length, the location of the untreated water intake determines source water quality. Water quality at some intake locations may require additional treatment facilities for sediment and salt removal that are not included in the proposed action.

Table 4. Range of Options – Intake Location

ID	Description	Source of Option	Description
IL-1	Concept - Diversion above Pueblo Dam	Value Planning Study	Construct a diversion from the Arkansas River upstream of Pueblo Reservoir, likely in Fremont County.
IL-2	Location - Pueblo Reservoir South Outlet Works	STAG	Divert water from the existing South Outlet Works at Pueblo Reservoir.
IL-3	Location - Pueblo Reservoir North Outlet Works (SDS)	STAG	Divert water from the future North Outlet Works at Pueblo Reservoir. The North Outlet works are currently being designed and constructed as part of the Southern Delivery System.

ID	Description	Source of Option	Description
IL-4	Location - Joint Use Pipeline (JUP) at Pueblo Boulevard	STAG	Divert water from the existing Joint Use Pipeline "wye" immediately upstream of Pueblo Boulevard, north of the Arkansas River. This pipeline currently delivers water from Pueblo Reservoir to the Whitlock Water Treatment Plant. Excess capacity is likely available in the pipeline upstream of the "wye" to potentially serve AVC.
IL-5	Location - Whitlock water treatment plant	EIS Team	Divert water before, during or following treatment at the Board of Water Works of Pueblo's existing Whitlock Water Treatment Plant.
IL-6	Concept - Bessemer Ditch	STAG	Divert water out of the Bessemer Ditch, likely downstream of the City of Pueblo in the St. Charles Mesa area.
IL-7	Location - Arkansas River upstream of the Fountain Creek confluence	STAG	Construct a diversion from the Arkansas River between Pueblo Reservoir and the Fountain Creek confluence. It is assumed, at this point, the diversion would be located at the existing St. Charles Mesa diversion structure. However, water quality may be better slightly upstream of this structure (upstream of stormwater system discharges), and should be investigated during design.
IL-8	Concept - Arkansas River downstream of the Fountain Creek confluence	STAG	Construct a diversion from the Arkansas River downstream of the Fountain Creek confluence. The diversion would need to remain in Pueblo County in order to best serve AVC participants.
IL-9	Concept - Downstream Regulating Storage (Lake Henry, Lake Meredith, Holbrook, Dye, John Martin, Gravel Lakes)	Previous NEPA	Construct a diversion from one of the potential downstream regulating storage facilities.
IL-10	Concept - CF&I Conduit / Minnequa Ditch	STAG	Construct a diversion from either the CF&I Conduit or Minnequa Ditch. It is likely that this diversion would be east of Pueblo.

AVC Conveyance – Through Pueblo

The conveyance components of AVC would convey unfiltered water from the intake location to a water treatment plant, then convey treated water from the water treatment plant to the tie-in location for each participant. Conveyance components would include a pipeline, pumping stations, water tanks, and electrical and communication facilities to serve facility. The Conveyance – Through Pueblo component includes conveyance from the intake location (if in or west of Pueblo) to approximately the Pueblo County line. To meet purpose and need, the conveyance options must be capable of delivering 20 mgd. A range of options developed for conveyance through Pueblo is presented in Table 5.

It should be noted that the Interconnect is included as conceptual option CP-18. Reclamation considered several design options for the Interconnect. However, since the variations in potential Interconnect design options would have little difference in environmental effects, only a single conceptual option was considered.

Table 5. Range of Options – Conveyance Through Pueblo

ID	Description	Source of Option	Description
CP-1	Location - North (JUP Wye, along 11th Street)	STAG	Convey AVC water through the existing JUP, then construct a new pipeline that follows 11th street to Hwy 50.

ID	Description	Source of Option	Description
CP-2	Location - North (JUP Wye, along railroad)	STAG	Convey AVC water through the existing JUP, then construct a new pipeline generally adjacent to railroad on north side of Hwy 50.
CP-3	Location - North (Pueblo Dam, JUP route, along 11th Street)	EIS Team	Construct new pipeline from Pueblo Dam that parallels the JUP, then follows 11th street to Hwy 50.
CP-4	Location - South (Pueblo Dam, along Bessemer Ditch)	STAG	Construct a new pipeline from Pueblo Dam that follows the Bessemer Ditch alignment. Note a portion of this alignment from the Pueblo Dam may follow Hwy 96.
CP-5	Location - South (JUP Wye, along Bessemer Ditch)	STAG	Convey AVC water through the existing JUP, then construct a new pipeline that follows the Bessemer Ditch alignment.
CP-6	Location - South (Pueblo Dam, JUP route, Bessemer Ditch)	EIS Team	Construct new pipeline from Pueblo Dam that parallels the JUP, then follow the Bessemer Ditch alignment.
CP-7	Location - South (Whitlock, along Bessemer Ditch)	STAG	Convey AVC water through the existing JUP, then construct a new pipeline to the Whitlock water treatment plant, and a new pipeline from the Whitlock water treatment plant along the Bessemer Ditch alignment.
CP-8	Location - South (Comanche route)	STAG, Value Planning Study	Construct a new pipeline from Pueblo Dam that follows an alignment generally along the existing pipeline to the Comanche Power Plant pipeline south of the City of Pueblo.
CP-9	Location - Downstream Intake	Value Planning Study	Construct a new pipeline from the Arkansas River upstream of Fountain Creek, then along a route south of the Arkansas River.
CP-10	Concept - Bessemer Ditch - Flow in existing open channel	Value Planning Study	Convey AVC water in the Bessemer ditch (along with existing ditch deliveries).
CP-11	Concept - Bessemer Ditch - In channel pipeline dedicated for AVC	Value Planning Study	Construct a pipeline in the current Bessemer Ditch channel that would convey AVC water only.
CP-12	Concept - Bessemer Ditch - All water (Agricultural and AVC) into one pipeline	STAG, Value Planning Study	Replace the current open channel Bessemer Ditch and construct a new pipeline along this alignment that would convey all flows (AVC water and existing ditch deliveries).
CP-13	Concept - BWWP System, with or without replacement	STAG, Value Planning Study	Convey AVC water through the existing Board of Water Works of Pueblo delivery systems. These deliveries would be fully treated water.
CP-14	Location - CF&I Conduit / Minnequa Ditch	EIS Team	Convey AVC water in the existing CF&I Conduit and/or Minnequa Ditch.
CP-15	Concept - Tunnel the main pipe	Value Planning Study	Construct a pipeline that would be tunneled under the City of Pueblo to avoid conflicts. The exact alignment is unknown at this time.
CP-16	Concept - Rail water to users	Value Planning Study	Use the existing railroad system to deliver water to project participants in railcars.
CP-17	Location - Run pipeline within riverbed	Value Planning Study	Construct a new pipeline that runs in the existing Arkansas riverbed.
CP-18	Concept - Interconnect	STAG	Construct a new pipeline beneath the Arkansas River immediately below Pueblo Dam to connect the north and south outlet works pipelines. This concept would provide redundancy and operational flexibility in Pueblo Dam releases to support maintenance and other occurrences that could require an outlet to be out of service.
CP-19	Concept - Canal to water treatment plant	Value Planning Study	Convey AVC water in a new canal rather than a pipeline.

ID	Description	Source of Option	Description
CP-20	Concept - Directional drill under Pueblo	Value Planning Study	Directional drill a new pipeline beneath the City of Pueblo. Similar to CP-15 except it would use directional drilling construction method.
CP-21	Concept - Run parallel pipes	Value Planning Study	Construct parallel pipelines to provide redundancy, convey different water qualities, and/or deliver from north and south routes/participants.

AVC Conveyance – East of Pueblo

The Conveyance – East of Pueblo component of AVC would convey treated water from the water treatment plant to the tie-in location for each participant. The component would include a pipeline, pumping stations (if necessary), water tanks (if necessary), and electrical and communication facilities. The Conveyance – East of Pueblo component includes conveyance from approximately the Pueblo County line downstream to all remaining participant tie-in locations, including spurs. To meet purpose and need, the conveyance options must be capable of delivering 20 mgd. A range of options developed for conveyance east of Pueblo is presented in Table 6.

Table 6. Range of Options – Conveyance East of Pueblo

ID	Description	Source of Option	Description
CE-1	Location - South Route	STAG	Construct a new pipeline following the Highway 50 route as identified in the STAG report. This route generally corresponds to the route identified in STAG Alternative 1.
CE-2	Location - North Route	STAG	Construct a new pipeline following the North of the Arkansas River route as identified in the STAG report. This route generally corresponds to the route identified in STAG Alternative 2.
CE-3	Concept - Use abandoned Railroad ROW	STAG	Construct pipelines using routes that take advantage of abandoned railroad ROW that exists in portions of the north alignment. The exact ownership and availability of this ROW is unknown at this time but can be further investigated if retained.
CE-4	Concept - Canal (open)	Value Planning Study	Construct a new open canal to convey AVC water rather than a pipeline. Several alignments could be available for this conceptual option.
CE-5	Concept - Canal (covered and lined)	EIS Team	Construct a new canal that is covered and lined, to convey AVC water rather than a pipeline. Several alignments could be available for this conceptual option.
CE-6	Concept - Individual vs. combined spurs	Public Scoping	Convey AVC water in individual spurs versus combined spurs to each participant.
CE-7	Concept - Put pipe above the ground at river crossings	Value Planning Study	Construct a pipeline above ground at river and other crossings rather than drilling or open cuts.
CE-8	Concept - Put pipe in prairie rather than farmlands	Value Planning Study	Maximize AVC routes that go through prairie versus farmlands whenever practicable.
CE-9	Location – Water treatment plant for Eads / eliminate the spur	Value Planning Study	Locate a new water treatment plant at Eads rather than conveying AVC water to them directly in a pipeline. The water treatment plant would treat existing and future groundwater supplies.
CE-10	Concept - Rail water to users	Value Planning Study	Use the existing railroad system to deliver water to project participants in railcars.

ID	Description	Source of Option	Description
CE-11	Concept - Regionalization of water distribution systems	Value Planning Study	Regionalize participants through interconnecting their distributions systems and convey AVC water to these newly regionalized systems.
CE-12	Concept - Stop conduit at La Junta / use John Martin Reservoir and Las Animas reverse osmosis treatment plant	Value Planning Study	Construct a new pipeline to La Junta, then integrate John Martin Reservoir and the Las Animas existing reverse osmosis plant (upgraded and expanded as needed) for water deliveries further east.
CE-13	Concept - Regionalization of water suppliers	Value Planning Study	Regionalize participants' water supplies and infrastructure and convey AVC water to these newly regionalized systems.

AVC Water Treatment

The water treatment plant would treat water for distribution to the participants. In general, the water treatment plant would have a relatively small footprint and associated environmental effects when compared with the overall pipeline facility. However, environmental analysis is required for the footprint of the facility, so specific locations for this facility were identified. In addition, several different conceptual options for the type and level of treatment were identified. To meet purpose and need, the treatment option must be capable of delivering 20 mgd of water to the participants, and the final water quality of treated water must meet primary and secondary drinking water quality standards. A range of options developed for water treatment is presented in
Table 7.

Table 7. Range of Options – Water Treatment

ID	Description	Source of Option	Description
WT-1	Location - New water treatment plant located near South Road and 21st Street	STAG	Construct a new water treatment plant near South Road and 21st Street in St. Charles Mesa. No specific location is identified, however options do exist that will need to be further evaluated in the Appraisal Level if retained for further investigation.
WT-2	Location - Whitlock water treatment plant (BWWP)	STAG, Value Planning Study	Use the existing Whitlock water treatment plant facilities with necessary improvement and expansion to meet AVC water.
WT-3	Concept - Blended supplies	STAG, Value Planning Study	Blend existing water with AVC water at some or all of the Participant locations.
WT-4	Concept - De-centralized, regional facilities	Value Planning Study	Construct more than one water treatment plant along the AVC route verses just one water treatment plant location for the entire AVC.
WT-5	Concept - High pressure membranes for existing water supplies.	Public Scoping, Value Planning Study	Construct Reverse Osmosis or nanofiltration water treatment plants to treat existing waters that require this level of treatment verses conveying AVC water to these participants.
WT-6	Location - New water treatment plant located below Pueblo Dam (on Reclamation property)	STAG	Construct a new water treatment plant on existing Reclamation property just below the Pueblo Dam.

ID	Description	Source of Option	Description
WT-7	Concept - Deliver Treated Water to St Charles Mesa	EIS Team	Deliver treated (water filtered or higher level of treatment) to St Charles Mesa rather than raw water.
WT-8	Location - New water treatment plant located adjacent to the existing St. Charles Mesa water treatment plant	STAG	Construct a new water treatment plant adjacent to the existing St Charles Mesa water treatment plant.
WT-9	Location - New water treatment plant downstream from St Charles Mesa	STAG	Construct a new water treatment plant downstream from the existing St Charles Mesa water treatment plant. There are a few potential sites that need to be considered. More detailed analysis of these sites will be required if this location is retained to determine the preferred site location.
WT-10	Concept - Filtered treatment	EIS Team	Treat AVC water to the "filtered" level, no disinfection, for conveyance to project participants' delivery points.
WT-11	Concept - Filtered and disinfected treatment	Value Planning Study	Treat AVC water to the "filtered and disinfected" level treatment, for conveyance to project participants' delivery points.
WT-12	Concept - Convert all participants to chloramines	Value Planning Study	Use chloramines in the water treatment process. Each participant would need to be able to accommodate this in their systems.
WT-13	Concept - Point-of-Use (POU) treatment under sink	Value Planning Study	Require each individual home, tap, etc to treat water at their location. There would be limited or no prior treatment.
WT-14	Concept - Individualized water treatment plants	Value Planning Study	Require each participant to have their own treatment plant to treat conveyed AVC water. There would be no prior treatment by the AVC system.
WT-15	Concept - Pueblo water system to convert to chlorine disinfection	Value Planning Study	Request that the Board of Water Works of Pueblo water system convert to chlorine disinfection.
WT-16	Concept - Challenge water quality regulations	Value Planning Study	Challenge the current water quality regulations such that the Colorado Department of Public Health and Environment (Health Department) would "relax" water quality requirements for potable water delivered by the participants.
WT-17	Concept - UV / Ozone disinfection at water treatment plant	Value Planning Study	Use UV / Ozone treatment disinfection at the AVC water treatment plant.
WT-18	Concept - Advanced treatment at water treatment plant	Value Planning Study	Use advanced treatment technologies at the AVC water treatment plant, including those identified in the CORADS study as feasible technologies for the Lower Arkansas Basin (Malcolm Pirnie 2009).

Options Development and Screening

As previously shown (Figure 1), a two-step screening process was used to develop a short-list of options. First, options were screened using criteria for substantial logistical, technical and environmental deficiencies. These criteria used readily available information and data sources to evaluate each option. Options with one or more substantial logistical, technical, or environmental deficiency were eliminated from further consideration. Remaining options were screened using a set of indicators reflecting general environmental characteristics (e.g., land surface disturbance type, size, and magnitude). Options with more favorable environmental characteristics were retained. Options which were clearly inferior to other retained options based on the environmental characteristics were eliminated from further consideration.

Significant Issues Screening

The significant issues screening process is a "fatal flaw" or "pass/fail" level of screening, and eliminates options that likely cannot be implemented due to logistical, technical or environmental issues. This allows the alternatives analysis to focus on options that have a realistic potential for meeting the purpose and need of the project.

Criteria

Significant issues screening criteria, the method for evaluating each criterion, and the rationale for retaining options are described in
Table 8. If a criterion was determined not to be applicable to an option, that option was assumed to have satisfied (passed) the criterion. The following general categories were used to evaluate an option's characteristics:

> **Logistical -** These criteria assess legal, institutional, and practicality constraints such as land use, outside protected or restricted areas and interstate highways, providing required capacities of facilities and timing of project implementation.
>
> **Technical -** These criteria assess technical constraints such as using existing technologies and ensuring constructability and stability.
>
> **Environmental -** These criteria assess environmental constraints such as avoiding sites with substantial effects on waters of the United States, and meeting water quality standards.

Each option had to pass all criteria, indicating that it lacked substantial deficiencies, to be retained. Any option that failed one or more criteria was eliminated from further consideration. Significant issues screening criteria are presented in
Table 8.

Table 8. Significant Issues Screening Criteria (Options)

Screening Category	Criterion Description	Rationale/Basis for Screening Criterion
Logistical		
Capacity of Supply/Conveyance	Must be able to convey project deliveries	To be retained, an option must be able to supply at least 20 mgd of water and convey it to the participant service areas.
Land Use	Must be consistent with permitted land-use	This screening criteria was only used for gravel lakes storage. For gravel pits, permitted reclaimed use must be consistent with water storage. Gravel lake land uses for farming activities, rangeland and industrial activities will be eliminated.
Capacity of Intakes	Must provide 100 percent of the required intake capacity to meet average yield	To be retained, an option must provide the capacity required to meet the participants' projected water demands (20 mgd) as required in the purpose and need.
Storage Capacity	Must provide at least 10 percent of the required regulating storage capacity	To be retained, an option must provide the required storage (about 32,000 ac-ft[2]) or be capable of being combined with other facilities to provide required storage as defined by the purpose and need.

[2] A requested Master Contract storage amount of 32,000 acre-feet was used in the alternatives development process. Subsequent EIS investigations estimated a storage amount of approximately 30,000 acre-feet (see Chapter 1 and 2). This change in Master Contract storage does not change results of the alternatives analysis.

Screening Category	Criterion Description	Rationale/Basis for Screening Criterion
		The 10 percent criterion was used to eliminate sites that would not have adequate capacity. Use of more than 10 facilities (other than regulating operational storage tanks, new or existing) or enlargements of existing facilities to fulfill the purpose of a single storage component would be inefficient and also impact excessive areas of land.
Water Supply Timing	Must be available and be decreed within 5 years of issuance of the Final EIS.	Water Supplies must be able to be decreed within 5 years of the Final EIS. Reclamation can only enter into contracts using decreed water supplies.
Conveyance of Bulk Water	Must be able to meet the requirements of the Project's Purpose and Need	To be retained an option must convey bulk water to all participants. Modifications to participants' distribution systems or options that do not convey water to all participants are not consistent with the purpose and need.
Time for Implementation	Project completion must be expected within the approximate anticipated construction schedule outlined in the purpose and need.	To be retained, an option must provide a reasonable schedule that is consistent with the AVC schedule (approximately a 3-year permitting schedule and an 8-year design and construction schedule) as identified in the purpose and need.
Technical		
Proven Technology	Must use existing technology	To be retained an option must use existing technologies, in an application consistent with sound engineering practices that can be permitted by the regulatory agencies (i.e., Health Department, Colorado State Engineer's Office). Technologies that differ substantially from current sound engineering practices involve increased risks of failure and risks to public health and safety.
Long-term Stability	Must avoid geological features that could adversely affect long-term stability of component	To be retained, an option must avoid known geological features, such as landslides, mines, and/or active faults that could adversely affect long-term stability.
Environmental		
New Reservoirs on Perennial Streams	Must not involve new or enlarged reservoirs on perennial streams	To be retained, a new or enlarged storage option must not be located on a perennial stream (e.g., Arkansas River and Fountain Creek). New storage components located off-channel and/or on an intermittent stream were not eliminated with this criterion. If options involving off-channel locations, intermittent stream locations, or existing or enlarged facilities were available, construction of new or enlarged reservoirs on a perennial stream would likely have greater adverse impacts on the aquatic ecosystem and would not meet Clean Water Act 404(b)(1) Guidelines.
Wetland Disturbance	Must avoid fens (a special wetland type)	To be retained, an option must not have effects to a substantial amount of wetlands or special aquatic sites. An option was eliminated if any fen was permanently disturbed.
Drinking Water Quality	Must Meet Drinking Water Quality Standards	Must convey water to participants that can be treated to meet current primary and secondary drinking water standards.

Methods

Assumptions made during significant issues screening and data sources used for screening are described below for each screening criterion. It should be noted that for options that were evaluated in Southern Delivery System EIS Alternatives Analysis report (Reclamation 2006), further evaluation was not performed if the evaluation methods and underlying data sources have not changed from the previous NEPA studies.

Logistical

Conveyance Capacity: Options that would use existing facilities must have the capacity to convey the proposed project capacity of 20 mgd of treated water to meet maximum daily demand. Hydraulic capacity of existing options were researched and compared to their remaining, unallocated capacity. Options that did not have the necessary capacity available and could not be practicably modified to convey the necessary capacities were eliminated from further consideration.

Land Use: Land use was used to screen alternatives that are not consistent with permitted land use activities for the facility. The only options screened using this category were gravel lakes regulating storage facilities. Gravel lakes were screened out if permitted post-mining land-use identified in the permits was not consistent with use of the lake for storage, such as post-mining land-use identified as rangeland, pastureland, cropland, general agriculture, or industrial/ commercial. Wildlife habitat was considered to be consistent with the use of the lake for storage.

Capacity of Intakes: With the exception of intakes at Pueblo Dam, the intake options would be new facilities and were assumed to be capable of being sized based on project needs. Options that did not have the physical or unallocated capacity to convey 20 mgd of untreated water were eliminated from further consideration.

Capacity of Regulating Storage Components: The storage options under consideration were mostly existing facilities or enlargements of existing facilities. Because use of many of these existing facilities to fulfill the purpose of a regulating storage facility would have greater environmental impacts and be inefficient compared to existing conditions, storage options were required to provide at least 10 percent of the necessary storage. This is approximately 3,000 ac-ft. Use of more than 10 facilities would be operationally inefficient and impact excessive areas of land.

For proposed new or enlarged regulating storage options, studies completed for Colorado Springs Utilities (GEI 1998), Southeastern Colorado Water Conservancy District (Black & Veatch 2000), Reclamation (MWH 2004), and the Southern Delivery System EIS (Reclamation 2006) were reviewed to obtain the maximum feasible storage capacity of the new or additional space. For gravel lakes storage, data and assumptions described in the previous section were used (see Table 3). An option was retained if studies indicated that the potential storage volume of each option was sufficient to accommodate the regulating storage need. It was assumed that the full proposed capacity of any new space could be made available to the project.

Water Supply Timing: Reclamation can only enter into contracts using decreed water supplies for each entity requesting storage. Therefore, only water rights that can be fully decreed by the time these contracts are expected to be signed are included as a reasonable water supply option. "Change of water right and plan for augmentation cases routinely take two to three years or longer to adjudicate in water court, and have been known to take more than 20 years" (Trout et al 2004). For purposes of this alternatives analysis, it was assumed that a water right could be adjudicated within 5 years of the Final EIS if a specific ditch system has been identified and actions have been taken to adjudicate or otherwise secure this water source (such as application filed with water court or shares purchased). Any water supply in which specific actions have not been undertaken, or if the water rights case is more complex and likely could not be adjudicated within 5 years of the Final EIS (based on professional judgment) were eliminated.

Conveyance of Bulk Water: Based on the project purpose and need, an alternative must supply bulk water to all participants. For purposes of this analysis, bulk water is defined as delivery of water to each participant at a single location in the participants' existing delivery system without substantial modification to the participants' system for further distribution to individual water users by the participant. Any option involving the delivery of water to individual water users was eliminated. Furthermore, any alternative that does not have the ability to deliver water to all participants was eliminated. These determinations were made based on descriptions of individual options.

Time for Implementation: Because of existing Health Department water quality enforcement actions on multiple AVC participants, time is of the essence for completion of AVC. Enforcement actions require the participant to come into compliance within a given timeframe; the deadlines for most enforcement actions have already passed. Any option that could not be expected to be completed within the anticipated schedule of AVC was eliminated due to the enforcement actions against some AVC participants. The current anticipated schedule for AVC is an approximately 3-year feasibility-level engineering design and permitting schedule and 8-year final design, procurement and construction schedule. Where available, known project timelines for each option were used to determine whether this schedule could be met. Otherwise, professional judgment based on similar types of projects was used.

Technical

Proven Technology: Engineering judgment was used to determine if an option used proven technology and was consistent with technologies used by other major water providers in the Front Range and Western U.S. Options that did not use sound engineering practices or had documented deficiencies were eliminated from further consideration.

Long-term Stability: Seismic hazard (USGS 2004) and landslide incidence and susceptibility (USGS 2001) data were compared to the location of each option. Options that were located in areas with a high seismic hazard or landslide area risk were eliminated from further consideration.

Environmental

New Reservoirs on Perennial Streams: U.S. Geological Survey 7.5-minute quadrangle maps were reviewed for each reservoir option to determine whether a perennial stream (those that flow year-round) would be inundated. Reservoir options that would be located on intermittent streams (those that do not flow year-round) or off-channel were retained, while options for new reservoirs that were located on perennial streams were eliminated from further consideration. Enlargements of existing reservoirs were retained regardless of the type of stream on which they were located.

Wetland Disturbance: Data from Southern Delivery System EIS Alternatives Analysis report (Reclamation 2006) was used if available to determine wetland and fen disturbance. Reservoir options that would permanently fill a fen were eliminated from further consideration. Options that would have effects on substantial amounts of wetlands or special aquatic sites were also eliminated. No strict limit on the amount of wetlands or special aquatic sites was used for the analysis. Rather, professional judgment was used to determine whether disturbance would be substantial. Potential wetland effects due to crossings by pipeline options were assumed avoidable or temporary.

Drinking Water Quality: USGS water quality data (Miller et al. 2010) and participant water quality data (as made available through STAG questionnaires), along with current drinking water standards, were used to determine whether options could meet existing standards. Options that could not meet existing standards were eliminated.

Results

Each option was evaluated against the significant issues screening criteria. Options eliminated based on logistical, technical, or environmental considerations were not considered further. Options eliminated from further consideration, and the basis for their elimination, are identified in Table 9 and discussed below.

Table 9. Significant Issues Screening (Options) – Eliminated Options

ID	Description	Reason for Elimination
Water Supply		
WS-8	Concept - New Western Slope Project	Water Supply Timing, Time for Implementation
WS-9	Source - Flaming Gorge Pipeline	Water Supply Timing, Time for Implementation
WS-10	Concept - Canada or Alaska Water Supply Project	Water Supply Timing, Time for Implementation
WS-12	Concept - New Groundwater	Drinking Water Quality, Conveyance of Bulk Water
WS-13	Source - Central Colorado Project (CCP)	Water Supply Timing , Time for Implementation, Conveyance of Bulk Water
WS-15	Concept - Reuse (Potable/Non-Potable) of Available Supplies	Proven Technology, Drinking Water Quality, Conveyance of Bulk Water
WS-17	Concept - Build a bottled water treatment plant	Conveyance of Bulk Water
WS-18	Concept - Cloud Seeding	Proven Technology, Capacity of Supply/Conveyance
WS-19	Concept - Exchange return Fryingpan-Arkansas flows for Fryingpan-Arkansas agricultural deliveries	Capacity of Supply/Conveyance
WS-20	Concept - Remove tamarisk / phreatophytes	Capacity of Supply/Conveyance
WS-21	Concept - Pump back for return flows	Water Supply Timing
Regulating Storage		
RS-2	Location - Pueblo Reservoir – Enlargement	Reservoir on Perennial Stream, Time for Implementation
RS-4	Location - Tennessee Creek Reservoir	Reservoir on Perennial Stream, Time for Implementation
RS-5	Location - Turquoise Reservoir Enlargement	Reservoir on Perennial Stream, Time for Implementation
RS-6	Location - Clear Creek Reservoir Enlargement	Reservoir on Perennial Stream, Time for Implementation
RS-7	Location - Elephant Rock Reservoir	Reservoir on Perennial Stream,

ID	Description	Reason for Elimination
		Time for Implementation
RS-9	Location - Lake Meredith Enlargement	Wetland Disturbance
RS-10	Location – Fry-Ark System	Proven Technology
RS-12	Location - Twin Lakes Reservoir Enlargement	Reservoir on Perennial Stream, Time for Implementation
RS-13	Location - Holbrook Reservoir / Dye Reservoir	Capacity of Regulating Storage
RS-14	Location - John Martin Reservoir Excess Capacity	Time for Implementation
RS-15	Location - Bessemer Pit	Capacity of Regulating Storage
RS-16	Location - Smokstad Pit	Capacity of Regulating Storage
RS-17	Location - Institutions Pit	Capacity of Regulating Storage
RS-18	Location - Pueblo West Pit	Capacity of Regulating Storage
RS-19	Location - Hausman-Xmas Pit	Capacity of Regulating Storage
RS-20	Location - Wington/Datz Pit	Capacity of Regulating Storage
RS-21	Location - Mine Pit 111	Capacity of Regulating Storage
RS-22	Location - Stockyard Pit	Capacity of Regulating Storage
RS-23	Location - Beltramo Mine	Capacity of Regulating Storage
RS-24	Location - Runyon Lake	Capacity of Regulating Storage
RS-25	Location - Vista Mine	Capacity of Regulating Storage
RS-27	Location – Glover	Capacity of Regulating Storage
RS-28	Location - Fisher Pit	Capacity of Regulating Storage
RS-29	Location - 34th Lane Pit	Capacity of Regulating Storage
RS-30	Location - Pueblo Pit	Capacity of Regulating Storage
RS-31	Location - Tomich Pit	Capacity of Regulating Storage
RS-32	Location - Oakleaf Pit	Capacity of Regulating Storage
RS-33	Location - RBK Pit No. 30	Capacity of Regulating Storage
RS-34	Location - RBK Pit No. 31	Capacity of Regulating Storage
RS-35	Location - Morgan Pit	Capacity of Regulating Storage
RS-36	Location - Pisciotta Gravel Pit	Capacity of Regulating Storage
RS-37	Location - Pisciotta Gravel Pit	Capacity of Regulating Storage
RS-38	Location - Pisciotta Gravel Pit	Capacity of Regulating Storage
RS-39	Location - Andenusio-Buffalo Pit	Capacity of Regulating Storage
RS-40	Location - Piscotte Gravel Pit	Capacity of Regulating Storage
RS-41	Location - Cullen S & G Pit	Capacity of Regulating Storage
RS-42	Location - Allen Pit	Capacity of Regulating Storage
RS-43	Location - Special Operation	Capacity of Regulating Storage
RS-45	Location - Rich Pit	Capacity of Regulating Storage
RS-46	Location - Beltramo No. 2	Capacity of Regulating Storage
RS-47	Location - Stealey Mine #1	Capacity of Regulating Storage
RS-48	Location - Stealey Mine #2	Capacity of Regulating Storage
RS-49	Location - Grant Pit	Capacity of Regulating Storage
RS-51	Location - Stonewall Springs Quarry	Capacity of Regulating Storage
RS-53	Location - St. Barbara Sand and Gravel	Land Use
RS-54	Location - Murillow Gravel Pit	Capacity of Regulating Storage
RS-55	Location - Wayt Pit	Capacity of Regulating Storage
RS-56	Location - Two Rivers Pit	Capacity of Regulating Storage
RS-57	Location - Big G Gravel Pit	Land Use
RS-58	Location - Fowler Pit	Capacity of Regulating Storage
RS-59	Location - Nepesta Hills Pit	Capacity of Regulating Storage
RS-60	Location - Boone-Martin Pit	Capacity of Regulating Storage
RS-61	Location - Boone-Filmore Pit	Capacity of Regulating Storage
RS-62	Location - Lucero Pit	Capacity of Regulating Storage
RS-63	Location - Fellhauer Pit	Capacity of Regulating Storage
RS-64	Location - Pheasant Run Gravel Pit	Capacity of Regulating Storage
RS-65	Location – Filmore	Capacity of Regulating Storage
RS-66	Location - Filmore Pit	Capacity of Regulating Storage
RS-67	Location - Hancock Gravel Pit	Capacity of Regulating Storage
RS-68	Location - Rocky Ford South Pit	Land Use
RS-69	Location - Hancock Pit	Capacity of Regulating Storage

ID	Description	Reason for Elimination
RS-70	Location - Rocky Ford Pit	Capacity of Regulating Storage
RS-71	Location - Caldwell Pit	Capacity of Regulating Storage
RS-72	Location - Caldwell Brothers 3	Capacity of Regulating Storage
RS-73	Location - Campbell Pit	Capacity of Regulating Storage
RS-75	Location - Nichols Pit	Capacity of Regulating Storage
RS-76	Location - Paul Scott Pit	Capacity of Regulating Storage
RS-77	Location - Cuckow Gravel Pit	Capacity of Regulating Storage
RS-78	Location - Reed Pit	Capacity of Regulating Storage
RS-79	Location - Reed Pit	Capacity of Regulating Storage
RS-80	Location - Witt-Man Pit	Capacity of Regulating Storage
RS-81	Location - Harold Edgar Pit	Capacity of Regulating Storage
RS-82	Location - Korinek S&G Pit	Capacity of Regulating Storage
RS-83	Location - Caldwell Nesselhuf Pit No. 1	Capacity of Regulating Storage
RS-84	Location - Walter Pit	Capacity of Regulating Storage
RS-85	Location - Walter Pit	Capacity of Regulating Storage
RS-86	Location - Ordway Pit	Capacity of Regulating Storage
RS-87	Location - Ordway Pit	Capacity of Regulating Storage
RS-88	Location - Crowley County Grav 2	Capacity of Regulating Storage
RS-89	Location - Rough Cut Pit	Land Use
RS-90	Location - Argo Gravel Pit	Land Use
RS-91	Location - Cash Pit	Capacity of Regulating Storage
RS-92	Location - State Pit	Capacity of Regulating Storage
RS-15	Bessemer Pit	Capacity of Regulating Storage
RS-16	Smokstad Pit	Capacity of Regulating Storage
RS-17	Institutions Pit	Capacity of Regulating Storage
RS-18	Pueblo West Pit	Capacity of Regulating Storage
RS-19	Hausman-Xmas Pit	Capacity of Regulating Storage
RS-20	Wington/Datz Pit	Capacity of Regulating Storage
RS-21	Mine Pit 111	Capacity of Regulating Storage
RS-22	Stockyard Pit	Capacity of Regulating Storage
RS-23	Beltramo Mine	Capacity of Regulating Storage
RS-24	Runyon Lake	Capacity of Regulating Storage
RS-25	Vista Mine	Capacity of Regulating Storage
RS-27	Glover	Capacity of Regulating Storage
RS-28	Fisher Pit	Capacity of Regulating Storage
RS-29	34th Lane Pit	Capacity of Regulating Storage
RS-30	Pueblo Pit	Capacity of Regulating Storage
RS-31	Tomich Pit	Capacity of Regulating Storage
RS-32	Oakleaf Pit	Capacity of Regulating Storage
RS-33	RBK Pit No. 30	Capacity of Regulating Storage
RS-34	RBK Pit No. 31	Capacity of Regulating Storage
RS-35	Morgan Pit	Capacity of Regulating Storage
RS-36	Pisciotta Gravel Pit	Capacity of Regulating Storage
RS-37	Pisciotta Gravel Pit	Capacity of Regulating Storage
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RS-39	Andenusio-Buffalo Pit	Capacity of Regulating Storage
RS-40	Piscotte Gravel Pit	Capacity of Regulating Storage
RS-41	Cullen S & G Pit	Capacity of Regulating Storage
RS-42	Allen Pit	Capacity of Regulating Storage
RS-43	Special Operation	Capacity of Regulating Storage
RS-45	Rich Pit	Capacity of Regulating Storage
RS-46	Beltramo No. 2	Capacity of Regulating Storage
RS-47	Stealey Mine #1	Capacity of Regulating Storage
RS-48	Stealey Mine #2	Capacity of Regulating Storage
RS-49	Grant Pit	Capacity of Regulating Storage
RS-51	Stonewall Springs Quarry	Capacity of Regulating Storage
RS-53	St. Barbara Sand and Gravel	Land Use
RS-54	Murillow Gravel Pit	Capacity of Regulating Storage

ID	Description	Reason for Elimination
RS-55	Wayt Pit	Capacity of Regulating Storage
RS-56	Two Rivers Pit	Capacity of Regulating Storage
RS-57	Big G Gravel Pit	Land Use
RS-58	Fowler Pit	Capacity of Regulating Storage
RS-59	Nepesta Hills Pit	Capacity of Regulating Storage
RS-60	Boone-Martin Pit	Capacity of Regulating Storage
RS-61	Boone-Filmore Pit	Capacity of Regulating Storage
RS-62	Lucero Pit	Capacity of Regulating Storage
RS-63	Fellhauer Pit	Capacity of Regulating Storage
RS-64	Pheasant Run Gravel Pit	Capacity of Regulating Storage
RS-65	Filmore	Capacity of Regulating Storage
RS-66	Filmore Pit	Capacity of Regulating Storage
RS-67	Hancock Gravel Pit	Capacity of Regulating Storage
RS-68	Rocky Ford South Pit	Land Use
RS-69	Hancock Pit	Capacity of Regulating Storage
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RS-71	Caldwell Pit	Capacity of Regulating Storage
RS-72	Caldwell Brothers 3	Capacity of Regulating Storage
RS-73	Campbell Pit	Capacity of Regulating Storage
RS-75	Nichols Pit	Capacity of Regulating Storage
RS-76	Paul Scott Pit	Capacity of Regulating Storage
RS-77	Cuckow Gravel Pit	Capacity of Regulating Storage
RS-78	Reed Pit	Capacity of Regulating Storage
RS-79	Reed Pit	Capacity of Regulating Storage
RS-80	Witt-Man Pit	Capacity of Regulating Storage
RS-81	Harold Edgar Pit	Capacity of Regulating Storage
RS-82	Korinek S&G Pit	Capacity of Regulating Storage
RS-83	Caldwell Nesselhuf Pit No. 1	Capacity of Regulating Storage
RS-84	Walter Pit	Capacity of Regulating Storage
RS-85	Walter Pit	Capacity of Regulating Storage
RS-86	Ordway Pit	Capacity of Regulating Storage
RS-87	Ordway Pit	Capacity of Regulating Storage
RS-88	Crowley County Grav 2	Capacity of Regulating Storage
RS-89	Rough Cut Pit	Land Use
RS-90	Argo Gravel Pit	Land Use
RS-91	Cash Pit	Capacity of Regulating Storage
RS-92	State Pit	Capacity of Regulating Storage
RS-77	Cuckow Gravel Pit	Capacity of Regulating Storage
RS-78	Reed Pit	Capacity of Regulating Storage
RS-79	Reed Pit	Capacity of Regulating Storage
RS-80	Witt-Man Pit	Capacity of Regulating Storage
RS-81	Harold Edgar Pit	Capacity of Regulating Storage
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RS-87	Ordway Pit	Capacity of Regulating Storage
RS-88	Crowley County Grav 2	Capacity of Regulating Storage
RS-89	Rough Cut Pit	Land Use
RS-90	Argo Gravel Pit	Land Use
RS-91	Cash Pit	Capacity of Regulating Storage
RS-92	State Pit	Capacity of Regulating Storage
Intake Location		
IL-3	Location - Pueblo Reservoir North Outlet Works (SDS)	Capacity of Intakes
IL-5	Location - Whitlock water treatment plant	Capacity of Intakes
IL-6	Concept - Bessemer Ditch	Capacity of Intakes
IL-10	Concept - CF&I Conduit / Minnequa Ditch	Capacity of Intakes

ID	Description	Reason for Elimination
Conveyance - Through Pueblo		
CP-10	Concept - Bessemer Ditch - Flow in existing open channel	Capacity of Supply/Conveyance, Drinking Water Quality
CP-11	Concept - Bessemer Ditch - In channel pipeline dedicated for AVC	Capacity of Supply/Conveyance
CP-12	Concept - Bessemer Ditch - All water (Agricultural and AVC) into one pipeline	Capacity of Supply/Conveyance, Drinking Water Quality
CP-13	Concept - BWWP System, with or without replacement	Capacity of Supply/Conveyance
CP-14	Location - CF&I Conduit / Minnequa Ditch	Capacity of Supply/Conveyance
CP-15	Concept - Tunnel the main pipe	Time for Implementation
CP-16	Concept - Rail water to users	Capacity of Supply/Conveyance
CP-17	Location - Run pipeline within riverbed	Proven Technology
CP-19	Concept - Canal to water treatment plant	Drinking Water Quality
CP-20	Concept - Directional drill under Pueblo	Proven Technology
Conveyance - East of Pueblo		
CE-4	Concept - Canal (open)	Drinking Water Quality, Capacity of Supply/Conveyance
CE-5	Concept - Canal (covered and lined)	Capacity of Supply/Conveyance
CE-7	Concept - Put pipe above the ground at river crossings	Capacity of Supply/Conveyance
CE-9	Location - water treatment plant for Eads / eliminate the spur	Conveyance of Bulk Water
CE-10	Concept - Rail water to users	Capacity of Supply/Conveyance
CE-11	Concept - Regionalization of water distribution systems	Conveyance of Bulk Water
CE-12	Concept - Stop conduit at La Junta / use John Martin Reservoir and Las Animas reverse osmosis treatment plant	Conveyance of Bulk Water
CE-13	Concept - Regionalization of water suppliers	Conveyance of Bulk Water
Water Treatment		
WT-13	Concept - Point-of-Use (POU) treatment under sink	Drinking Water Quality, Conveyance of Bulk Water
WT-16	Concept - Challenge water quality regulations	Drinking Water Quality

Water Supply

Of the 21 water supply options originally considered, 11 options were eliminated from further study through the significant issues screening process. Four of these options (WS-8, WS-9, WS-10 and WS-13) were larger water supply projects from various locations in Colorado or elsewhere, and were determined that they could not be implemented within the AVC permitting and construction time frame. Similarly, a project in which return flows would be pumped from their source (typically at wastewater treatment facilities) back to Pueblo Reservoir (WS-21) was eliminated because this type of system likely could not be implemented within the timeframe required by AVC.

Several options were eliminated due to water quality issues either directly or through the inability to use proven technology to address these issues. The new groundwater option (WS-12, which would be developed using the same sources as existing supplies) was eliminated due to continued issues with drinking water quality and inability to convey bulk water supplies. Reuse of available supplies for potable and non-potable purposes (WS-15) was eliminated because large-scale reuse of water for potable purposes would likely have the same source water quality issues as current water supplies. The non-potable portion of this option could potentially be successfully implemented (and is currently implemented in many communities) but would not convey a bulk drinking water supply to the participants.

Construction of a bottled water plant (WS-17) was eliminated as a water supply option because this option would not supply bulk water to each participant. It should be noted that this option is also not considered by the Health Department to be a feasible permanent solution to address the participants' water quality issues (Health Department 2009). However, this option could potentially be implemented as an interim measure until AVC is constructed.

Two water supply options were eliminated because they likely could not supply the required amount of water for AVC or the Master Contract storage space. Exchange of Fry-Ark return flows for Fry-Ark agricultural deliveries (WS-19; i.e. making agricultural deliveries using municipal return flows) likely could not be implemented on a large-enough scale to meet water supply requirements because each municipal entity has the first right of refusal to purchase and exchange their return flows. Furthermore, current water court action by Southeastern (Case No. 01CW151, Division 2) would require Fry-Ark return flows that are not purchased by the entity that generated them to be offered for well augmentation use prior to other purposes. Therefore, there is unknown certainty regarding the availability and reliability of these return flows. Gaining water supply through removal of tamarisk and other phreatophytes (WS-20) was eliminated because currently, there is no legal mechanism for a water user to divert a quantity of water that is "saved" from this type of action. Rather, this "saved" water would be diverted based on the priority system.

Cloud seeding (WS-18) was eliminated as a water supply option due to proven technology. Cloud seeding is the primary weather modification activity recognized by the State of Colorado. Policy statements by the American Meteorological Society and the World Meteorological Organization support the effectiveness of winter orographic cloud seeding projects, and can produce between 5-20% more snow in a target watershed (Colorado Water Conservation Board 2011). As with phreatophyte removal, the primary issue affecting the viability of this supply for AVC is that under current state water law, there is no way for AVC to take direct delivery of this water as a water supply. Any additional water made available in a basin due to cloud seeding would be diverted by senior water rights first. Only rarely would it be likely that a new junior water right would be able to take delivery of this water. Therefore, it would not provide a reliable water supply for AVC.

Regulating Storage

Of the 14 non-gravel lake regulating storage options identified, 9 options were eliminated from further study. Six options (RS-2, RS-4, RS-5, RS-6, RS-7, and RS-12) were eliminated based on the amount of time that would be required for implementation of the project and because they are located on a perennial stream. Based on the history of recent new storage projects in Colorado, it is unlikely that a storage project could be permitted within the schedule that is anticipated for AVC (which includes an approximate 3-year permitting schedule). Several recent NEPA permitting activities in Colorado, including those for the Northern Integrated Supply Plan, Windy Gap Firming Project, Moffat Collection System, and Southern Delivery System EIS, have taken 6 years or longer, with several of the processes remaining incomplete after 8-10 years.

Lake Meredith Enlargement was eliminated because enlargement would inundate about 450 acres of wetlands with a 15,000 acre-foot enlargement (Reclamation 2006). This amount of wetlands was determined to be substantial when compared with other regulating storage options available, including non-structural options.

Use of the upper Fry-Ark system reservoirs (RS-10) was eliminated because it is not compatible with Fry-Ark project operations. Reclamation considers many factors in determining excess storage capacity. The first and foremost factor is to ensure that utilizing excess capacity will not harm the Project. Because of power, dead and inactive pools, and non-Project firm space contracts, less than 25 percent of Turquoise and Twin Lakes Reservoirs (including the Mt. Elbert Forebay) are continuously available for Project water. Reclamation utilizes all the available Project space in the upper reservoirs first, only vacating enough space for the coming year's imports. Storing Project water in the upper reservoirs reduces evaporation; facilitates water deliveries of non-Project water stored in the upper reservoirs; and enables the efficient operation of the Mount Elbert Power Plant. In addition, Reclamation can import twice as much Project water as there is storage space in the upper reservoirs, yet is constrained by its ability to vacate the reservoirs. Therefore, for all of these reasons and for all practical purposes, Reclamation has no excess capacity in Turquoise or Twin Lakes Reservoirs.

The Holbrook Reservoir/Dye Reservoir option (RS-13) was eliminated because it is likely that inadequate storage capacity is available. Holbrook Reservoir has a permitted capacity of approximately 7,443 ac-ft while Dye Reservoir has a permitted capacity of approximately 7,986 ac-ft (Colorado Division of Water Resources 2011). Both of these reservoirs are currently used for storage or irrigation water. Additionally, Holbrook Reservoir is part of the Restoration-of-Yield program administered by partners in the Pueblo Flow Management Program. Therefore, it is unlikely that at least 3,000 ac-ft of storage is available in these reservoirs on a consistent basis.

Excess capacity storage in John Martin Reservoir (RS-14) was eliminated due to the length time it would likely require to secure this storage. Agreements would be required between Colorado and Kansas that this is a feasible option given compliance constraints under the Arkansas River Compact in order for this to be analyzed in the EIS. Based on the implementation time for past rules and regulations to be promulgated, and the uncertainty involved in its feasibility, it is unlikely that this option could be implemented consistent with the AVC schedule.

Unlike the other options evaluated, at the outset of the options screening process, certain physical properties of gravel lakes options were assigned in order to quickly eliminate those gravel lakes that are unrealistic to carry forward for further evaluation. For all of these gravel lakes, information contained in the Colorado Division of Reclamation and Mining Safety mine permits database was used to evaluate the options. Data included permitted surface area, which was then used to estimate capacity based on an assumed depth of 20 feet, mine status, and post mining land use.

Based on this information, each gravel lake was eliminated or kept for further study. For most gravel lakes eliminated, elimination was based on regulating storage capacity, which needed to be at least 10 percent of the total regulating storage requirement, or approximately 3,000 ac-ft. For a few gravel lakes, permitted post mining land-use identified in the permits was not consistent with use of the lake for storage.

Overall, of the 78 gravel lakes identified for potential use as regulating storage, 24 were eliminated because the ultimate build-out storage capacity of the facility was less than 3,000 ac-ft, 5 were eliminated because post-mining land-use was not consistent with water storage, and 44 were eliminated for both capacity and land-use. Only 5 of the gravel lakes were retained for further study (Table 17 shows short listed options).

Intake Location

Ten intake options between a location upstream of Pueblo Reservoir and locations in the lower Arkansas River Basin were evaluated. Of those options, 4 were eliminated from further study due to the capacity of the intake. The proposed North Outlet Works at Pueblo Reservoir (IL-3) is being constructed as part of the Southern Delivery System. This outlet work upstream of the proposed Interconnect is currently being constructed with a capacity only to serve the Southern Delivery System participants, and thus no capacity is available for AVC participants. Although it is feasible that the design could be changed to accommodate AVC, it would not be economical to construct additional capacity in the future north outlet works when capacity is available in the existing South Outlet Works.

Similarly, the existing pipeline serving the Whitlock Water Treatment Plant (IL-5) is sized to accommodate only that plant downstream of the wye previously reserved for Southern Delivery System. Therefore, there is inadequate capacity to serve AVC. For both the Bessemer Ditch and CF&I/Minnequa Ditch options (IL-6 and IL-10), the ditches are incapable of continuous open-channel flow to a water treatment plant during winter months due to ice problems. This is evidenced by the need for the St. Charles Mesa Water District to pump water directly from the Arkansas River during the winter months rather than divert water using its typical Bessemer Ditch delivery.

Conveyance – Through Pueblo

Of the 21 location specific and conceptual options identified for conveyance routes through the City of Pueblo, 10 of the options were eliminated from further study as part of the significant issues screening. Three of the options eliminated involved the conveyance of water using the Bessemer Ditch. An option to convey water within the existing Bessemer Ditch open channel (CP-10) was eliminated due to the capacity of the Bessemer Ditch and water quality concerns. Similar to an intake location on the Bessemer Ditch, deliveries could not be made during some winter months due to freezing issues. Additionally, raw water quality would degrade between Pueblo Dam and a water treatment plant primarily due to stormwater discharges directly to the Bessemer Ditch, and also because of inadvertent spills. Treated water could not be conveyed in an open channel due to water quality concerns. The second Bessemer Ditch option eliminated was conveyance of AVC in a pipeline within the Bessemer Ditch itself (CP-11). This type of pipeline would substantially decrease the capacity of the Bessemer Ditch and could not make deliveries during some winter months due to freezing. Finally, an alternative that would convey the entire Bessemer Ditch and AVC in a single pipe or conduit (CP-12) was eliminated due to conveyance capacity (freezing issues) as well as potential water quality issues. If the ditch would need to continue to intercept stormwater flows as it currently does, this would cause a deterioration in water quality between Pueblo Dam and the water treatment plant.

Use of the existing Board of Water Works of Pueblo raw water conveyance system (to Whitlock) or treated water distribution system (CP-13) was eliminated due to capacity of conveyance.

Investigations during the STAG report (Black & Veatch 2010) found that there is inadequate capacity and other technical issues involved in using the distribution system. As discussed for intakes, use of the CF&I Conduit and Minnequa Ditch (CP-14) was also eliminated due to the capacity issues. Similar to all open-channel options, a more general concept of delivering AVC water through an open channel (CP-19) was eliminated due to capacity as a result of freezing during winter months.

Two options that considered conveyance of water "beneath" the city through tunnels or pipelines were eliminated. Tunneling the main pipe through the city or portions of the city (CP-15) was eliminated due to the time for implementation. Tunneling is a slow process and typically used either for short bores under highways and rivers, or for longer reaches such as water or highway tunnels through mountainous regions. A tunnel beneath the city would be multiple miles and likely could not be constructed consistent with the overall EIS schedule. Directional drilling (CP-20) was also eliminated. Directional drilling involves drilling non-vertical holes for wells and underground utilities. Installation lengths up to 6,500 feet are possible, with diameters up to 48 inches for shorter runs (Diversified Underground Inc. 2011). Thus using directional drilling for a longer length, larger diameter pipeline would be a substantial deviation from current practices. Therefore, using this technology as the primary construction method for the pipeline through the City of Pueblo was eliminated. Based on construction requirements, it is possible that either tunneling or directional drilling may be implemented as construction techniques in certain parts of the overall project. This will be determined during final design and/or construction.

Delivering water by rail to water users (CP-16) was eliminated due to the capacity of supply and conveyance. More information on this option is provided in the following section.

Construction of AVC within a riverbed (more specifically the Arkansas River) was eliminated because it is highly unlikely that this type of construction configuration could be permitted through the NEPA process and the Corps 404 permit process. This type of construction would result in substantial disturbance to a perennial river. Additionally, the rerouting of river flow and dewatering during the construction process would be challenging and could make this option infeasible.

Conveyance – East of Pueblo

A total of 13 options were evaluated for conveyance east of Pueblo. Of those, 8 were eliminated from further study as part of the significant issues screening process. Both options that consider conveyance through canals were eliminated. The open channel option (CE-4) was eliminated due to poor drinking water quality and capacity of supply/conveyance, while the covered and/or lined option (CE-5) was eliminated due to capacity. Similar to intake options downstream of Fountain Creek, using either existing or new open canals for conveyance of AVC water would likely encounter substantial water quality issues due to surface and sub-surface agricultural return flows, stormwater interception, and evaporative concentration of salts. Based on the quality of water of other open canals in the Lower Arkansas River basin, it is highly unlikely that secondary drinking water quality standards could be met using water from this type of option. Either option would not have the ability to deliver water to participants during the winter months due to icing, thus both options have inadequate capacity. Similarly, an alternative that conveys water above ground at river crossings (CE-7) was eliminated due to the potential for icing problems.

Delivering water by rail from another location (CE-10) was eliminated due to the capacity of supply/conveyance. Based on 49 CFR 179, tanker cars must not exceed 34,500 gallons capacity. AVC is being designed to deliver approximately 20 million gallons per day. Based on this design capacity, more than 500 rail cars per day would be needed to delivery water to all participants during summer months to meet peak demands. This would require multiple trains per day. Additionally, the logistics of making deliveries to each participant from these trains would be challenging and unrealistic.

Three options (CE-9, CE-11 and CE-12) were eliminated because the option does not deliver bulk water to all participants. The purpose and need for the project has shown that all participants require bulk water delivery to meet primary and secondary drinking water quality standards. Each of these options contemplates AVC deliveries to only a portion of the participants, which does not meet purpose and need. Furthermore, these types of options are included in the No Action Alternative, thus will be evaluated as part of the EIS.

Water Treatment

A total of 18 location-specific and conceptual water treatment options were identified during the options development process. Of those, two were eliminated during the significant issues screening process. Both were conceptual options eliminated due to the drinking water quality criterion.

The point-of-use treatment system option (WT-13) was eliminated for both conveyance of bulk water supplies and drinking water quality. As stated in Chapter 1, part of the purpose and need for the project is to convey bulk water to the participants. Point-of-use treatment systems would not convey bulk water to the participants, but would use existing supplies for each provider and treat this water “at the tap” for each customer. Although current Safe Drinking Water Act standards no longer prohibit these systems (Health Department 2011), there are substantial startup, maintenance and monitoring activities that may be challenging for all but the smallest participants to enact (Malcolm Pirnie 2009). For these reasons, point-of-use treatment was eliminated as an option for AVC. However, point-of-use treatment may be feasible as an interim measure, and was also considered as an option in the No Action Alternative.

Challenging water quality regulations (WT-16) was eliminated as an option because this option would not address the water quality issues described in purpose and need. Even if the regulations were not in place, currently accepted science has determined that certain water quality constituents present in the participants’ current water supplies pose dangers to human health (see Chapter 1).

Environmental Characteristics Screening

Unlike the significant issues screening process, which is intended to be a “fatal flaw” or “pass/fail” level of screening, the environmental characteristics screening is intended to provide qualitative and quantitative evaluations of each option. This allows the options to be compared to one another and those options with the least impact or that best meet environmental indicators

(Table 10) can be identified. The outcomes for these indicators can then be used during the alternative development process to choose options that best meet specific alternative themes.

Indicators

Options for water supplies, storage, intakes, pipelines and water treatment retained after application of the significant issues screening criteria were evaluated with regard to their general environmental characteristics. Indicators were used to compare the environmental characteristics of each option. Options with more favorable environmental characteristics were retained. In some cases, where environmental characteristics for a particular option were far inferior to other options, the option was eliminated from further consideration. For instance, longer pipeline routes would have less favorable environmental characteristics because a larger area would be disturbed, and most likely have a larger environmental impact. A summary of the environmental characteristics indicators is presented in Table 10, while more detailed discussion of each category is provided in the following sub-sections.

Table 10. Environmental Characteristics Indicators (Options)

Screening Category	Units
Water Supplies	
Substantial New Infrastructure Required	Yes/No
Dry-Up Irrigated Agriculture	None/Temporary/Permanent
Storage	
New or Existing Reservoir	New/Existing
Surface Area Disturbance	Acres
Wetland Area\Playa Disturbance	Acres
Annual Evaporation	Ac-ft/year/ac-ft storage
Intakes	
New or Existing Diversion Structure	New/Existing
Distance between the Intake Location and Nearest AVC Delivery	Miles
Annual Arkansas River Streamflow Effects Through City of Pueblo	Miles of River Affected
Source Water Quality – TDS	mg/l, 75th percentile
Compatible with Short-Listed Water Treatment	Yes/No
Compatible with Existing Fry-Ark Water Rights and Operations	Yes/No
Pipelines	
Surface Area Disturbance	Acres
Pipeline Length	Miles
Wetland Area\Playa Disturbance	Acres
Species of Concern	Acres
Highway 50 Right-of-Way Interface	Maximized/Incidental
Urban Area Disturbance	Acres
Farmland Disturbance	Acres
Water Treatment	
New or Existing Water Treatment Plant	New/Existing
Health Department Permitting Issues	Unlikely/Possible/Substantial
Logistical Issues	Unlikely/Possible/Substantial
Distance to Nearest Delivery Point	Miles

Methods

GIS layers were used to determine spatial values including areas of disturbance (measured in acres), river lengths, and pipeline lengths. Routes of intake locations, pipeline alignments, regulating storage facilities, and water treatment plant locations were overlain on GIS layers to determine approximate spatial effects. Where available, GIS layers with existing and proposed facilities were taken from the STAG report (Black & Veatch 2010), data and reports prepared for Southern Delivery System EIS (Reclamation 2006; Reclamation 2008) and other information as previously described. Where existing data was not available, additional pipeline routes were approximated by the EIS team using GIS mapping and descriptions of the routes. As previously described, gravel lakes storage locations were taken from a GIS layer available from the Colorado Division of Reclamation and Mining Safety (2010).

Prime farmland and wetlands GIS layers were taken from a raster dataset that was obtained from the Multi-Resolution Land Characteristics Consortium website (USGS 2010). Municipal boundaries were used to estimate the amount of urban area disturbed, and taken from a polygon shapefile obtained from Colorado Department of Transportation website (Department of Transportation 2010). Surface Area Disturbance was calculated using a 50-foot buffer on both sides of the pipeline routes.

GIS layers for species of concern habitat areas were developed from polygon shapefiles obtained from the Colorado Division of Wildlife website (CDOW 2004). The species maps layers shown in Table 11 were obtained. For layers with species activity within the study area, only those species that did not show activity throughout the entire study area were used for the species of concern overlays. Those species with activity throughout the study area do not show differentiation between options, thus the acreages were not included in the analysis. Because this analysis was only used for land-based impacts, aquatic species were not included in the analysis. The analyses described in this appendix were used to develop the alternatives only; the environmental consequences described in Chapter 4 evaluate the effects of the alternatives on wildlife and supersede any analyses performed in this appendix.

Table 11. Species Activity Map Layers

Common Name	No Activity Within Study Area (1)	Activity Within Study Area (1)	
		Not Used for Overlays (Activity Throughout Study Area)	Used for Overlays
Birds			
Least Tern	X		
Plains Sharp-Tailed Grouse	X		
Piping Plover	X		
Lesser Prairie Chicken			X
Gunnison Sage-Grouse	X		
American Peregrine Falcon	X		
Greater Sage Grouse	X		
Columbian Sharp-Tailed Grouse	X		
Mammals			
Preble's Meadow Jumping Mouse			X
Kit Fox	X		
Black-Tailed Prairie Dog		X	

Note:
(1) The analyses described in this appendix were used to develop the alternatives only; the environmental consequences described in Chapter 4 evaluate the effects of the alternatives on wildlife and supersede any analyses performed in this appendix.

Annual evaporation rates for reservoirs were calculated using the surface acreage at the normal pool elevation (Reclamation 2006, Colorado Division of Reclamation and Mining Safety 2010), storage capacity, and annual pan evaporation rate multiplied by 0.7 to account for differences in pan versus open water evaporation rates. Where available, GIS layers from the STAG report (Black & Veatch 2010) were used for the pipeline alignments. In a few cases where alignments not developed in the STAG report were considered (primarily the alignment along the existing Joint Use Pipeline and intake from the Arkansas River upstream of Fountain Creek), alignments were estimated using existing mapping and GIS layers.

To evaluate annual Arkansas River streamflow effects through the City of Pueblo, hydrologic disturbance was estimated using the length of the Arkansas River that would experience a net annual change (increase or reduction) in streamflow as a result of untreated water intake location and return flow location. The proposed AVC would use Fry-Ark water that historically has primarily been delivered to agricultural water users, as well as non Fry-Ark Project water supplies, some of which would be transferred from agricultural water uses downstream of Pueblo Reservoir. Use of these supplies in this manner would diminish streamflow in the Arkansas River. For purposes of this analysis, the reach through the City of Pueblo was defined from Pueblo Dam to Fountain Creek. Therefore, for diversions from Pueblo Dam, the affected length was the entire reach of river from Pueblo Dam to Fountain Creek. For the river intake, the affected length was from the river intake to Fountain Creek.

Except as noted, water quality data at intake locations is taken from a recent USGS compilation of data the lower Arkansas Basin (Miller et al. 2010). Figure 8 presents a graph from the USGS report containing the data. Data was taken from the USGS streamflow gage closest to the proposed intake location.

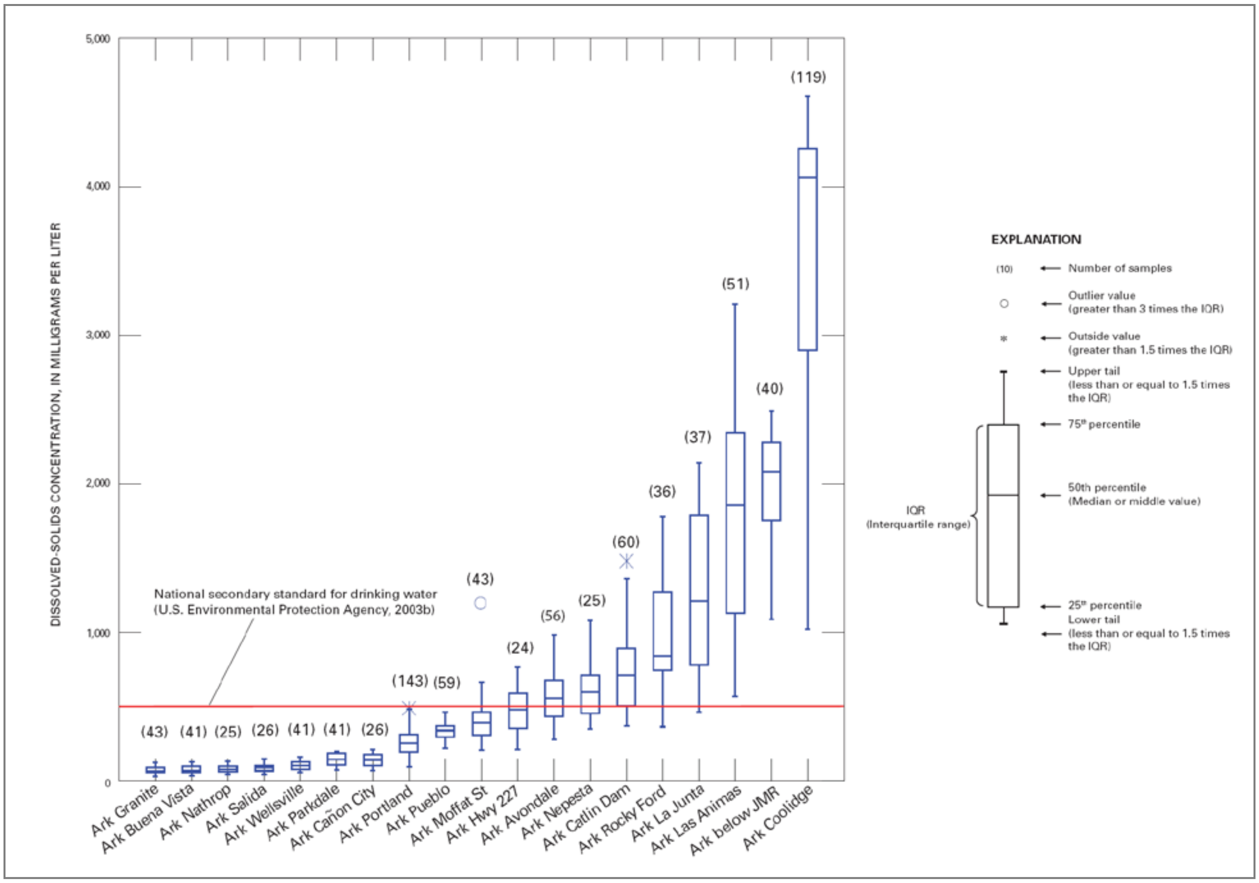

Figure 8. Spatial distribution of dissolved-solids concentrations in the Arkansas River from Granite, Colorado, to Coolidge, Kansas, 1976–2007 (Miller et al. 2010)

The remaining categories are qualitative descriptions. More details regarding these qualitative descriptions are contained in the following sub-section.

Results

Options that were retained in the significant issues screening process were evaluated using the environmental characteristics indicators described in the previous sub-section. Screening was based on an examination of the numerical value, percentage, and/or qualitative description for each indicator. Most options were retained through this process because they were not clearly inferior to other options or they specifically met one of the alternative themes described in the following section. Environmental characteristics and screening results are described below.

Water Supplies

Water supply environmental characteristics are shown in Table 12. Both of the characteristics are non-quantitative evaluations. If substantial new infrastructure is required, it indicates that the water supply will likely have a higher degree of complexity, environmental permitting, and anticipated cost than other options. Dry-up of irrigated agriculture is an indication as to whether the option involves temporary or permanent agricultural dry-up.

Of the 10 water supply options that were retained in the significant issues screening process, eight of the options were further retained in the environmental characteristics screening process. Two of the options were eliminated. The Fort Lyon Ditch/Great Plains Reservoirs water supply option (WS-11) was eliminated because substantial new infrastructure would likely be required to transfer this from the Fort Lyon Ditch to Pueblo Reservoir. It is likely that without significant infrastructure (i.e. a pipeline and pump stations), substantial supplies would need to be purchased in order to provide a firm supply. Exchange potential from these systems is fairly low and it is likely that at least some level of pipelines and/or reservoirs would be required. Because other options exist that could meet the water supply requirements without new infrastructure, this option was eliminated.

Dual-use non-potable water supply systems (WS-16) were also eliminated. Where economically and physically feasible, several participants already have dual-use systems that serve golf course demands, some residential landscape irrigation, and other non-potable uses. In communities where these systems are not currently in place, substantial infrastructure investment 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.

Regulating Storage

Environmental screening characteristics for regulating storage are shown in Table 13. For all of the options except Brush Hollow Enlargement (RS-3), there was no disturbance because they either use excess capacity in existing reservoirs, use a gravel pit that would have already disturbed the land as part of their initial use, or do not involve surface disturbance.

All but one option were retained. Brush Hollow Enlargement (RS-3) was eliminated because more than 55 acres of wetlands would be inundated (Reclamation 2006). Therefore, the Brush Hollow Enlargement option was determined to be an inferior option when compared with the other options.

Intake Location

Environmental screening characteristics for intake locations are shown in Table 14. Three of the characteristics are quantitative while the others are qualitative. Water quality data at each intake location was taken from previous studies to determine the level of treatment that may be required to treat source water. This was then compared to the short-list of water treatment options. Any location in which the 75th percentile total dissolved solids concentration exceeded the secondary water quality standard of 500 mg/l was assumed to need high pressure membrane treatment (reverse osmosis or nanofiltration). This was then compared with the short-list of water treatment options to determine whether the intake option was compatible with water treatment options.

In the case of intakes, compatibility of Fry-Ark operations was primarily dependent on the location of the intake. Intakes upstream of Pueblo Reservoir would use Fry-Ark water delivered directly from Twin Lakes and Turquoise Reservoir. Any non Fry-Ark Project water stored in excess capacity storage space in Pueblo Reservoir would need to be exchanged to an upstream location which could jeopardize the ability to deliver this stored water during dry periods and may affect the ability to meet flow targets for the Upper Arkansas Voluntary Flow Management Program. As with intakes at or below Pueblo Dam, non-Project water available from Upper Basin sources, including Twin Lakes Reservoir and Canal Company water, would be delivered directly to the intake.

Of the six intake locations evaluated, three were eliminated from further study through the environmental characteristics process. An AVC diversion upstream of Pueblo Reservoir (IL-1) was eliminated for several reasons, including increased length of stream affected by operations, the length of pipe between the diversion point and nearest AVC delivery, and compatibility with Fry-Ark operations. The diversion location for this option was determined to be incompatible with Fry-Ark operations because it would require delivery of Fry-Ark water directly from Twin Lakes, Turquoise Reservoir, or exchange of that water from Pueblo Reservoir. Two intake options downstream of Fountain Creek (IL-8 and IL-9) were eliminated because the level of water treatment that would be required for these intake locations (high pressure membranes) was not a short-listed water treatment option.

Conveyance

Environmental characteristics for both the conveyance through Pueblo and conveyance east of Pueblo options are shown in Table 15. Of the characteristics, all but one was quantitative in nature and determined by simply overlaying the option on a GIS layer. The one qualitative characteristic was Highway 50 interface. Quantitative evaluations were not performed for this characteristic because both the AVC alignments and the potential future Highway 50 alignments are conceptual in nature and thus a strict GIS overlay may not be meaningful. It was determined that certain alignments provide better opportunities for sharing right-of-way (“incidental” or “maximized” in Table 15) or avoiding conflicts in the right-of-way (“none” in Table 15). Five of the conveyance options were conceptual in nature, so environmental characteristics could not be assigned.

None of the conveyance options were eliminated as part of the environmental characteristics screening. However, the characteristics developed were important in determining which options best met the alternative themes.

Water Treatment

Water treatment environmental characteristics are shown in Table 16. All of the characteristics for water treatment were qualitative in nature, and describe the complexity, permitting and logistical issues anticipated for each option. The level of likely permitting issues was determined based on a review of information in the STAG report (Black & Veatch 2010), review of the CORADS study, and subsequent meetings with the Health Department. Logistical issues were determined based on the information gathered for permitting issues, as well as construction, operation and maintenance issues.

Of the 16 options retained after the significant issues screening, eleven were retained in the environmental issues screening while two were eliminated from further study. Conceptual options to convert all participants to chloramines for disinfection (WT-12) and to convert the Board of Water Works of Pueblo water system to chlorine disinfection (WT-15) were eliminated because of substantial logistical issues and possible Health Department permitting issues. Similarly, individualized water treatment plants (WT-14) were eliminated because of likely substantial permitting and logistical issues. Permitting and logistical issues are likely for several reasons, including the ability for each participant to fund and operate a water treatment plant, the limited number of qualified operators available, and the large number of water treatment plants and infrastructure that would be required when compared to that of a single water treatment plant.

Advanced treatment (WT-18) and high pressure membranes (WT-5) using existing water quality sources was eliminated because these types of treatment technologies have already been investigated by the Health Department as part of the CORADS study, and have noted issues with cost and residuals management. The CORADS study noted that brine disposal by direct surface water discharge, groundwater discharge, spray irrigation, deep well injection, or blending of liquid residuals with wastewater treatment plant effluent would likely not be permitted. Some of these technologies are considered in the No Action Alternative, and could be used as interim treatment measures.

Table 12. Environmental Characteristics Indicators - Water Supplies

ID	Description	Substantial New Infrastructure Required (Yes/No)	Dry-Up Irrigated Agriculture (None/temp/perm)	Result
WS-1	Source - Fry-Ark Project Water	No	None	Retain
WS-2	Source - Fry-Ark Project Return Flows (1939 Decree)	No	None	Retain
WS-3	Source - Fry-Ark Project Return Flows (01CW151)	No	None	Retain
WS-4	Concept - Use of Existing Agricultural Water Rights	No	Permanent	Retain
WS-5	Concept - Use of New Agricultural Water Rights	No	Temporary	Retain
WS-6	Concept - Rotational Fallowing and Leasing	No	Permanent	Retain
WS-7	Source - Water Rights specifically for AVC associated with the Super Ditch Project	No	None	Retain
WS-11	Source - Fort Lyon Ditch/ Great Plains Reservoirs	Yes	Permanent	Eliminate
WS-14	Concept – Conservation	No	None	Retain
WS-16	Concept - Dual Use, Non-Potable System	Yes	None	Eliminate

Table 13. Environmental Characteristics Indicators - Storage

ID	Description	New or Existing Reservoir (New/ Existing)	Surface Area Disturbance [1] (Acres)	Wetland Area/Playa Disturbance [1] (Acres)	Annual Water Lost Due to Evaporation [2] (ac-ft/year/ ac-ft storage)	Result
RS-1	Location - Pueblo Reservoir - Excess Capacity	Existing	0	0	0.54	Retain
RS-3	Location - Brush Hollow Enlargement	New	> 55	55	3.91	Eliminate
RS-8	Location - Lake Henry/Lake Meredith Excess Capacity	Existing	0	0	1.24	Retain
RS-11	Location - Aquifer Storage and Recovery	Existing	0	0	0	Retain
RS-26	Location (Gravel Lake) - Chantala Pit (est. cap. 12800 ac-ft)	Existing	0	0	3.78	Retain
RS-44	Location (Gravel Lake) - Rich Pit (est. cap. 7280 ac-ft)	Existing	0	0	3.78	Retain
RS-50	Location (Gravel Lake) - Blue Grass Gravel Pit (est. cap. 6460 ac-ft)	Existing	0	0	3.78	Retain
RS-52	Location (Gravel Lake) - Evans #2 Pit (est. cap. 8960 ac-ft)	Existing	0	0	3.78	Retain
RS-74	Location (Gravel Lake) - Rocky Ford East Pit (est. cap. 3784 ac-ft)	Existing	0	0	3.78	Retain

Notes:

(1) For all excess capacity and gravel lakes options, assume that no additional land disturbance occurs beyond that currently occupied by the facility.

(2) For Pueblo Reservoir and Fry-Ark System, assume all regulating storage could be stored in facilities. For gravel lakes, use gravel lake capacity. For Lake Henry/Lake Meredith, assume half of regulating storage requirement in facilities. Annual loss accounts for pro-rationing of storage with other accounts in the reservoir. Therefore, options that share storage with other accounts have lower net evaporation losses than options in which storage is the only account in the reservoir. Evaporation rates from WRCC 2011.

Table 14. Environmental Characteristics Screening - Intakes

ID	Description	New or Existing Diversion Structure (New/ Existing)	Distance between Intake and Nearest AVC Delivery [(1)] (Miles)	Streamflow Effects Through City of Pueblo [(2)] (Miles of River Affected)	Source Water Quality - TDS [(3)] (mg/l)	Compatible with Short-Listed Water Treatment (yes/no)	Compatible with Existing Fry-Ark Water Rights and Operations (yes/no)	Result
IL-1	Concept - Diversion above Pueblo Dam	New	29.6 [(4)]	26.3 [(4)]	311	Yes	No	Eliminate
IL-2	Location - Pueblo Reservoir South Outlet Works	Existing	12.1	10.1	371	Yes	Yes	Retain
IL-4	Location - Joint Use Pipeline (JUP) at Pueblo Boulevard	Existing	8.9	10.1	371	Yes	Yes	Retain
IL-7	Location - Arkansas River upstream of the Fountain Creek confluence	New	5.7	1.3	463	Yes	Yes	Retain
IL-8	Concept - Arkansas River downstream of the Fountain Creek confluence	New	0 [(5)]	0.0	675	No	Yes	Eliminate
IL-9	Concept - Downstream Regulating Storage (Lake Henry, Lake Meredith, Holbrook, Dye, John Martin, Gravel Lakes)	New	0 [(5)]	0.0	877 [(6)]	No	Yes	Eliminate

Notes:

(1) For all diversions, straight-line distance St. Charles Mesa Water Treatment Plant.
(2) Measured as distance between intake and Fountain Creek confluence.
(3) Except as noted, 75^{th} percentile values taken from Table 10, USGS Report 2010–5069 (Miller et al. 2010), at nearest gaging location to option.
(4) Assumes intake near Portland at Highway 120 bridge over Arkansas River. Other routes may be possible.
(5) Exact pipeline location unknown. Set to 0 because participants upstream and downstream of intake.
(6) From SDS EIS Water Quality Technical Report (MWH 2008), 85^{th} percentile values for Lake Meredith.

Table 15. Environmental Characteristics Screening - Pipelines

ID	Description	Surface Area Disturbance (Acres)	Pipeline Length (miles)	Wetland Area/Playa Disturbance (Acres)	Species of Concern (Acres)	Highway 50 Right-of-Way Interface (Maximized/ Incidental)	Urban Area Disturbance (Acres)	Farmland Disturbance (Acres)	Result
Conveyance Through Pueblo									
CP-1	Location - North (JUP Wye, along 11th Street)	102	8	5	12	Incidental	89	0	Retain
CP-2	Location - North (JUP Wye, along railroad)	110	10	5	24	Incidental	79	0	Retain
CP-3	Location - North (Pueblo Dam, JUP route, along 11th Street)	152	12	17	22	Incidental	89	0	Retain
CP-4	Location - South (Pueblo Dam, along Bessemer Ditch)	171	14	3	2	None	48	0	Retain
CP-5	Location - South (JUP Wye, along Bessemer Ditch)	120	10	4	9	None	59	0	Retain
CP-6	Location - South (Pueblo Dam, JUP route, Bessemer Ditch)	170	14	16	19	None	59	0	Retain
CP-7	Location - South (Whitlock, along Bessemer Ditch)	104	9	1	3	None	48	0	Retain
CP-8	Location - South (Comanche route)	236	20	4	2	None	12	0	Retain
CP-9	Location - Downstream Intake	73	6	0	0	None	18	0	Retain
CP-18	Concept - Interconnect	Concept only - no data available.							Retain
CP-21	Concept - Run parallel pipes	Concept only - no data available.							Retain
Conveyance East of Pueblo									
CE-1	Location - South Route	2,223	183	34	4,656	Maximized	97	314	Retain
CE-2	Location - North Route	2,452	208	40	4,561	Incidental	150	264	Retain
CE-3	Concept - Use abandoned Railroad ROW	Concept only - no data available.							Retain
CE-6	Concept - Individual vs. combined spurs	Concept only - no data available.							Retain
CE-8	Concept - Put pipe in prairie rather than farmlands	Concept only - no data available.							Retain

Table 16. Environmental Characteristics Screening - Water Treatment Plants

ID	Description	New or Existing Water Treatment Plant (New/Existing)	CDPHE Permitting Issues (Unlikely/ Possible/ Substantial)	Logistical Issues (Unlikely/ Possible/ Substantial)	Result
WT-1	Location - New water treatment plant located near South Road and 21st Street	New	Unlikely	Unlikely	Retain
WT-2	Location - Whitlock water treatment plant (BWWP)	Existing	Unlikely	Unlikely	Retain
WT-3	Concept - Blended supplies	N/A	Possible	Possible	Retain
WT-4	Concept - De-centralized, regional facilities	N/A	Possible	Possible	Retain
WT-5	Concept - High pressure membrane for existing water supplies	New	Substantial	Substantial	Eliminate
WT-6	Location - New water treatment plant located below Pueblo Dam (on BOR property)	New	Unlikely	Unlikely	Retain
WT-7	Concept - Deliver Treated Water to St Charles Mesa	N/A	Unlikely	Unlikely	Retain
WT-8	Location - New water treatment plant located adjacent to the existing St. Charles Mesa water treatment plant	New	Unlikely	Unlikely	Retain
WT-9	Location - New water treatment plant downstream from St Charles Mesa	New	Unlikely	Unlikely	Retain
WT-10	Concept - Filtered treatment	N/A	Possible	Unlikely	Retain
WT-11	Concept - Filtered and disinfected treatment	N/A	None	Unlikely	Retain
WT-12	Concept - Convert all participants to chloramines	New	Possible	Substantial	Eliminate
WT-14	Concept - Individualized water treatment plants	New	Substantial	Substantial	Eliminate
WT-15	Concept - Pueblo water system to convert to chlorine disinfection	New	Possible	Substantial	Eliminate
WT-17	Concept - UV / Ozone disinfection at water treatment plant	New	Unlikely	Unlikely	Retain
WT-18	Concept - Advanced treatment at water treatment plant	New	Possible	Possible	Eliminate

A short-list of options was developed that includes all of the options retained from the environmental characteristics and screening process (Table 17). This list constitutes the menu of short-listed options used to select options for each of the alternative themes. The following comments were noted regarding the menu of short-listed options:

- Several water supplies are being proposed by the participants. Because water supplies in Colorado are limited and alternate water supplies would take a number of years to complete (in general) water supplies as identified by the participants are used in all alternatives. Only the No Action Alternative uses a substantially different set of water supplies than the other alternatives.
- Conservation is considered in the base demand projections. Therefore, it is inherently included in all alternatives.
- Regulating storage must be located upstream of the AVC intake in order for AVC to be able to use regulating storage in the manner intended. Therefore, because all intake options are located upstream of Fountain Creek, any regulating storage option located downstream of Fountain Creek was not considered for use in the alternatives.
- As noted in the table, several of the short-listed options are essentially design elements that do not have measureable environmental effects. Therefore, these options will be evaluated at the time of design.
- Although the de-centralized regional facility option was short-listed, there are concerns with this option that were discussed during STAG (Black & Veatch 2010) and the Value Planning Study (Reclamation 2010a). Concerns with this option include spreading of operators and O&M costs, and a likely net increase in pipeline length.

The short-listed options in the table are for consideration to fulfill the alternative themes only. There is no requirement that each option be included in an alternative. If the option does not directly address one of the alternative themes, and is not a substantially better option than other options developed based on the environmental characteristics, then the option may not be used for the alternatives studied in detail.

Table 17. Short-Listed Options

ID	Description	Notes
Water Supply		
WS-1	Source - Fry-Ark Project Water	Participants' proposed supply - Use in all Action Alternatives
WS-2	Source - Fry-Ark Project Return Flows (1939 Decree)	Participants' proposed supply - Use in all Action Alternatives
WS-3	Source - Fry-Ark Project Return Flows (01CW151)	Participants' proposed supply - Use in all Action Alternatives
WS-4	Concept - Use of Existing Agricultural Water Rights	Participants' proposed supply - Use in all Action Alternatives
WS-5	Concept - Use of New Agricultural Water Rights	Participants' proposed supply - Use in all Action Alternatives
WS-6	Concept - Rotational Fallowing and Leasing	
WS-7	Source - Water Rights specifically for AVC associated with the Super Ditch Project.	Participants' proposed supply - Use in all Action Alternatives
WS-14	Concept – Conservation	Considered in base demand calculations - Use in all alternatives
Regulating Storage		
RS-1	Location - Pueblo Reservoir - Excess Capacity	

ID	Description	Notes
RS-8	Location - Lake Henry/Lake Meredith Excess Capacity	Located downstream of Fountain Creek
RS-11	Location - Aquifer Storage and Recovery	Located downstream of Fountain Creek
RS-26	Chantala Pit	Located downstream of Fountain Creek
RS-44	Rich Pit	Located downstream of Fountain Creek
RS-50	Blue Grass Gravel Pit	Located downstream of Fountain Creek
RS-52	Evans #2 Pit	Located downstream of Fountain Creek
RS-74	Rocky Ford East Pit	Located downstream of Fountain Creek
Intake Location		
IL-2	Location - Pueblo Reservoir South Outlet Works	
IL-4	Location - Joint Use Pipeline (JUP) at Pueblo Boulevard	
IL-7	Location - Arkansas River upstream of the Fountain Creek confluence	
Conveyance - Through Pueblo		
CP-1	Location - North (JUP Wye, along 11th Street)	
CP-2	Location - North (JUP Wye, along railroad)	
CP-3	Location - North (Pueblo Dam, JUP route, along 11th Street)	
CP-4	Location - South (Pueblo Dam, along Bessemer Ditch)	The eastern portion of this alignment from the Pueblo Dam may follow Hwy 96
CP-5	Location - South (JUP Wye, along Bessemer Ditch)	
CP-6	Location - South (Pueblo Dam, JUP route, Bessemer Ditch)	
CP-7	Location - South (Whitlock, along Bessemer Ditch)	
CP-8	Location - South (Comanche route)	
CP-9	Location - Downstream Intake	
CP-18	Concept - Interconnect	
CP-21	Concept - Run parallel pipes	To be considered in final design
Conveyance - East of Pueblo		
CE-1	Location - South Route	
CE-2	Location - North Route	
CE-3	Concept - Use abandoned Railroad ROW	To be considered in final design. Also need better understanding of ownership/status of ROW.
CE-6	Concept - Individual vs. combined spurs	To be considered in final design
CE-8	Concept - Put pipe in prairie rather than farmlands	Considered as an Alternative Theme
Water Treatment		
WT-1	Location - New water treatment plant located near South Road and 21st Street	
WT-2	Location - Whitlock water treatment plant (BWWP)	
WT-3	Concept - Blended supplies	Where water source is of sufficient quality.
WT-4	Concept - De-centralized, regional facilities	Although this option was short-listed, there are concerns with this option that were discussed during STAG and the Value Planning Study. Concerns with this option include spreading of operators and O&M costs, and a likely net increase in pipeline length.
WT-6	Location - New water treatment plant located below Pueblo Dam (on BOR property)	
WT-7	Concept - Deliver Treated Water to St Charles Mesa	
WT-8	Location - New water treatment plant located	

ID	Description	Notes
	adjacent to the existing St. Charles Mesa water treatment plant	
WT-9	Location - New water treatment plant downstream from St Charles Mesa	Various open areas are located along the route to be considered based on engineering, ownership and availability.
WT-10	Concept - Filtered treatment	
WT-11	Concept - Filtered and disinfected treatment	
WT-17	Concept - UV / Ozone disinfection at water treatment plant	To be considered in final design

Alternatives Development and Screening

The next step of the process was compilation of short-listed options into alternatives. This process consisted of identification of alternative themes, determination of which short-listed options best fulfilled the alternative themes, and development of final alternatives based on consolidation of alternative themes and options.

Alternative Themes

Alternative themes address key scoping issues, and were developed based on information from the scoping process. A total of 14 alternative themes were developed and are presented in Table 18. Descriptions of the alternative themes and the rationale for their inclusion are included in the following section.

Development of Alternatives

Options that best meet each of the alternative themes were determined using the information developed during the environmental characteristics screening process. A summary of the options used for each alternative theme is presented in Table 19. If there were no options that were clearly superior to the other options for meeting the alternative theme, or if specific components were not related to the alternative theme, then no option was included in the alternatives theme table. This allowed themes to be more easily consolidated into the action alternatives described in the next section.

Table 18. Alternative Themes

Theme Number	Alternative Theme	Description
1	No Action	A No Action Alternative is required by NEPA
2	Minimize Cost	The participants, Reclamation, and the public have an interest in evaluating the least cost alternative.
3	Minimize Wetland Acres Disturbed	This NEPA document could serve as the basis for the 404(b)(1) permit. An alternative that minimizes wetlands disturbed should be analyzed.
4	Highest Minimum Flow in the Arkansas River through Pueblo	Several commenters, as well as comments received during previous NEPA activities in the basin, have concerns about depletions to streamflow through the City of Pueblo, especially during low streamflow conditions.
5	Minimize Farmland Disturbed	Several comments were received requesting that alternatives minimize the amount of farmland disturbed.
6	Minimize Construction Disturbance	Construction disturbances in general can be somewhat indicative of environmental effects.
7	Minimize Urban Construction Disturbance	Construction disturbance through the City of Pueblo and through other communities is a key scoping issue.
8	Maximize Use of Existing Right of Way	Several comments were received requesting that alternatives maximize the use of existing right of way, including the Highway 50 expansion corridor.
9	Avoid Highway 50 Expansion Corridor	Initial reaction from CDOT was to minimize the amount of pipeline that could be within the Highway 50 expansion corridor.
10	Maximize Non-Structural Options	Comments were received requesting non-structural solutions.
11	Maximize Source Water Quality and Yield	The overall purpose and need is to provide high-quality water. Some alternatives would provide higher quality than others.
12	Maximize Operational Flexibility	With 41 participants and additional Master Contract participants, operational flexibility is desirable.
13	Master Contract Only	Required by Reclamation to analyze the effects if AVC were not constructed but the Master Contract was issued.
14	AVC Only Alternative	Required by Reclamation to analyze the effects if the Master Contract were not issued but AVC was constructed.

Theme 1 – No Action Alternative

Development of the No Action Alternative is described in the following section. This alternative was not developed using the same methods as the other action alternatives, although some of the options included in the No Action Alternative were also considered for the action alternatives.

Theme 2 - Minimize Cost

This theme seeks to find the set of options that minimizes the overall cost of the project. In developing the options for this alternative, it was generally assumed that operation and maintenance costs were approximately the same for options within each component, and that replacement costs were directly related to capital costs. Therefore, only differences in capital costs were used to develop the options. Because no cost estimates were developed for options as part of the EIS process, the lowest cost alternative from the STAG report (Alternative 2; Black & Veatch 2010) was used as the minimum cost alternative. This includes an intake location from the Joint Use Pipeline at Pueblo Boulevard (IL-4), a north route through Pueblo and east of Pueblo (CP-1 and CE-2) and treatment at the Whitlock water treatment plant (WT-2). Because the only options available for regulating storage are excess capacity in existing Fry-Ark reservoirs, it was assumed that the cost for regulating storage was approximately the same for both options, thus no specific regulating storage option was identified.

Theme 3 - Minimize Wetland Acres Disturbed

This alternative theme may minimize the permanent effect on wetlands and may better fulfill the Corps' 404(b)(1) Guidelines for evaluating an alternative that would minimize the discharge of dredged or fill material to wetlands. This alternative would also minimize effects on playas, wetland-dependent wildlife, aquatic life, and recreation. Based on GIS overlays of conveyance facilities on wetland layers, the South alignment from the Whitlock Water Treatment Plant along the Bessemer Ditch option (CP-7) and the Downstream Intake option (CP-9) disturbed the least amount of wetlands for conveyance through Pueblo, and the South Route (CE-1) disturbed the least amount of wetlands (Table 15) for conveyance east of Pueblo. No regulating storage, intake locations or water treatment plant sites were specifically identified for this alternative theme since none of these options are expected to have an impact on wetlands.

It should be noted that all wetland disturbances are based on the wetland layers previously defined. More thorough evaluations of wetland disturbance completed as part of the EIS will determine actual wetland disturbance for each alternative. Also, it is anticipated that most of the wetland impacts from conduit construction would be temporary.

Theme 4 - Highest Minimum Flow in the Arkansas River through Pueblo

This alternative theme may minimize the hydrologic effect on the Arkansas River between Pueblo Dam and Fountain Creek. The concerns identified during scoping are associated with minimum flows through Pueblo for recreational boating uses. Although target flows for recreational boating are protected by an Intergovernmental Agreement with major municipal water providers in the basin and a Recreational In-Channel Diversion Water Right held by the City of Pueblo (Case No. 01CW160, Water Division 2), commenters felt that any reduction in flow in this stream reach would be detrimental to the river. The Pueblo Fish Hatchery could also potentially benefit from higher minimum flows through this reach. This alternative theme would provide the highest minimum flows at the Arkansas River above Pueblo gage (i.e., downstream of Pueblo Reservoir). Options that would maintain the highest minimum flow through Pueblo would incorporate an intake and associated pipeline that divert water from the Arkansas River upstream of the Fountain Creek confluence (IL-7) and associated conveyance from that intake (CP-9). The location of regulating storage options upstream of the intake, conveyance east of Pueblo and water treatment options do not affect flows differently through the City of Pueblo, thus options for these components were not specifically identified.

Theme 5 - Minimize Farmland Disturbed

This alternative theme would minimize the amount of farmland temporarily or permanently disturbed by infrastructure, and was developed in direct response from comments received during the public scoping process. Data used to determine impacts to farmland were developed from GIS overlays of the conveyance routes on prime farmland. Prime farmland GIS layers are not available for Pueblo County, which encompasses those routes through the City of Pueblo. Therefore, it was assumed that the north routes through Pueblo (CP-1 and CP-2) had the greatest potential for minimizing farmland impacts. East of Pueblo, the GIS overlays showed that the north route (CE-2) would minimize farmland impacts. No regulating storage, intake locations or water treatment plant sites were specifically identified for this alternative theme since none of these options are expected to have a substantial impact of farmland. Some water treatment plant sites could potentially displace existing farmland. However, exact locations of treatment facilities within parcels are difficult to determine, so no specific estimates were made.

Theme 6 - Minimize Construction Disturbance

This alternative theme would minimize the amount of construction disturbance in general. This alternative theme was developed in response to public comments. In addition, because the amount of disturbance for this project is directly a result of pipeline construction, this alternative theme would be fairly consistent with the least amount of pipeline construction. Data for conveyance options was taken from GIS overlays of pipeline corridors, which determined that the downstream intake pipeline route (CP-9) and the north route from the Joint Use Pipeline wye (CP-1) would minimize overall construction disturbance through Pueblo. The Joint Use Pipeline wye does not have construction is western Pueblo, but includes construction in downtown Pueblo, while the downstream intake pipeline would have little construction in downtown Pueblo. The south route (CE-1) would minimize construction disturbance east of Pueblo. Connection to the wye in the Joint Use Pipeline (IL-4) would be the best intake location for this alternative theme. Although a downstream intake would be required for the downstream intake pipeline route, this option would not minimize construction disturbance when compared with the Joint Use Pipeline. Use of the existing Whitlock Water Treatment Plant (WT-2) would minimize water treatment plant construction since this is an existing facility. Because available regulating storage above the pipeline intake would not involve construction, no regulating storage options were specified for this alternative theme.

Theme 7 - Minimize Urban Construction Disturbance

The basis for this alternative theme is similar to that for reduction of overall construction disturbance, except that construction disturbances are focused on municipal areas. This alternative theme was developed to address public comments about pipeline construction in municipal areas, primarily the City of Pueblo. GIS overlays of construction disturbance were used similar to Theme 6, however, only that disturbance that occurred in municipal areas was included. These overlays resulted in an intake located upstream of the City of Pueblo from the existing south outlet works at Pueblo Dam (IL-2) coupled with a pipeline route south of Pueblo generally following the existing Comanche Power Plant pipeline route (CP-8). These two options generally avoid construction within the City of Pueblo. East of Pueblo, it was determined that the south route (CE-1) had the least amount of urban construction disturbance. No water treatment plant option was specified because all water treatment facilities would be constructed on vacant parcels without disturbance to municipal areas. As with Theme 6, because available regulating storage above the pipeline intake would not involve construction, no regulating storage options were specified for this alternative theme.

Theme 8 - Maximize Use of Existing Right-of-Way

During the public scoping process, comments were received that requested alternatives that maximize the use of existing right-of-way. Typically, all alternatives would maximize use of existing right-of-way when possible, and for most components, no options were clearly superior to other options. However, for conveyance east of Pueblo, the south route (CE-1) would clearly maximize the amount of existing right-of-way use due to its alignment along existing highways and county roads. The north route has more overland route reaches, and thus was inferior in this perspective. The location of regulating storage options upstream of the intake, intake locations, conveyance through Pueblo and water treatment options do not have a substantial affect on the amount of existing right-of-way used, thus no specific options were identified. It should be noted that the Whitlock Water Treatment Plant (WT-2) and a new water treatment plant located below Pueblo Dam (WT-6) would both use parcels where additional land would not need to be purchased. However, this was not an environmental characteristic defined for water treatment plants, and the amount of land required for water treatment plants is fairly minor when compared to the amount of right-of-way for a pipeline. Therefore, these specific water treatment plant options were not specified for this alternative theme.

Theme 9 - Avoid Highway 50 Expansion Corridor

Comments were received during the public and agency scoping process that requested minimizing the amount of Highway 50 interface in order to allow the maximum flexibility when Highway 50 is expanded and/or rerouted in the future. At this time, Highway 50 is not planned to be expanded or rerouted through Pueblo, therefore, there is no advantageous route through Pueblo. East of Pueblo, the north route (CE-2) has the best potential to avoid these conflicts. The south route (CE-1) was specifically sited to follow and use the existing Highway 50 right-of-way in certain locations, thus it is inferior to the north route for this alternative theme. The location of regulating storage options upstream of the intake, intake locations, conveyance through Pueblo and water treatment options do not have a substantial affect on the Highway 50 corridor, thus no specific options were identified.

Theme 10 - Maximize Non-Structural Options

Public comments were received that requested evaluation of alternatives that maximized non-structural solutions. In general, it was found that the No Action Alternative considers non-structural options. Based on the purpose and need, all action alternatives involve the construction of facilities and thus would not meet this alternative theme. Therefore, no action was identified to satisfy this theme and a separate non-structural action alternative was not developed.

Theme 11 - Maximize Source Water Quality and Yield

Source water quality is a direct need identified for AVC. Furthermore, it is generally a best practice to implement solutions that will maximize yield from available water sources. Water supplies that can be diverted nearest to Pueblo Reservoir would typically have the best source water quality and the greatest yield due to minimal conveyance losses and better water quality directly from the reservoir. The Pueblo Reservoir south outlet works (IL-2) and the Joint Use Pipeline at Pueblo Boulevard (IL-4) are the intake locations that best meet the alternative theme. For water treatment plants, locations that are closer to the participants would require lesser amounts of booster disinfection due to shorter delivery times to the participants. The water treatment plant location downstream from St. Charles Mesa (WT-9) would be the best for this alternative theme. Furthermore, the concept that includes both filtered and disinfected water treatment (WT-11) would deliver the best water quality to the participants. There are no regulating storage locations upstream of the intake and conveyance components that are superior for this alternative theme, thus no specific option was identified.

Theme 12 - Maximize Operational Flexibility

In general, AVC participants desire an option that provides the greatest operational flexibility. Operational flexibility has several different meanings and varies with the component. For intake locations, the south outlet works (IL-2) provides more flexibility than the Joint Use Pipeline because capacity and operations may be limited by other water users in that reach of pipeline. Conveyance through Pueblo would include the Interconnect (CP-18) to provide flexibility and redundancy associated with use of the Pueblo Reservoir outlet works. Conveyance east of Pueblo using the north route (CE-2) would provide more flexibility because it avoids the Highway 50 corridor which could limit both pipeline routing as well as pipeline access. For water treatment, a filtered water only treatment concept (WT-10) provides more operational flexibility for each participant to provide appropriate disinfection systems for their community.

Theme 13 - Master Contract Only

Because Reclamation could potentially determine that the preferred alternative would only include issuance of the Master Contract, at least one of the alternatives studied in detail needs to include only the Master Contract. For purposes of this analysis, it was determined that a contract for excess capacity storage in Pueblo Reservoir (RS-1) is the most likely outcome of that decision. Because this alternative theme does not include AVC, none of the other components that are specifically related to AVC were included. This alternative considers the No Action Alternative options for AVC participants.

Theme 14 - AVC Only

Because Reclamation could potentially determine that the preferred alternative would only include building AVC, at least one of the alternatives studied in detail needs to include only AVC. Hydrologically, the effects of AVC action alternatives would only vary between Pueblo Reservoir and the intake location. Therefore, any AVC action alternative could be evaluated to isolate hydrologic and land-based effects of AVC. Because this alternative theme does not include the Master Contract, regulating storage was not included. This alternative considers the No Action Alternative options for Master Contract participants.

Table 19. Alternatives Development

Theme No.	Alternative Theme	Regulating Storage	Intake Location	Conveyance - Through Pueblo	Conveyance - East of Pueblo	Water Treatment
1	No Action	Short-Term If & When Contracts	Wells	N/A	Regional Conveyance	Regional water treatment plant
2	Minimize Cost		IL-4: Location - Joint Use Pipeline (JUP) at Pueblo Boulevard	CP-1: Location - North (JUP Wye, along 11th Street)	CE-2: Location - North Route	WT-2: Location - Whitlock water treatment plant (BWWP)
3	Minimize Wetland Acres Disturbed			CP-7: Location - South (Whitlock, along Bessemer Ditch); CP-9: Location - Downstream Intake	CE-1: Location - South Route	
4	Highest Minimum Flow in the Arkansas River through Pueblo		IL-7: Location - Arkansas River upstream of the Fountain Creek confluence	CP-9: Location - Downstream Intake;		
5	Minimize Farmland Disturbed			CP-1: Location - North (JUP Wye, along 11th Street); CP-2: Location - North (JUP Wye, along railroad)	CE-2: Location - North Route	
6	Minimize Construction Disturbance		IL-4: Location - Joint Use Pipeline (JUP) at Pueblo Boulevard	CP-9: Location - Downstream Intake; CP-1: Location - North (JUP Wye, along 11th Street)	CE-1: Location - South Route	WT-2: Location - Whitlock water treatment plant (BWWP)
7	Minimize Urban Construction Disturbance		IL-2: Location - Pueblo Reservoir South Outlet Works	CP-8: Location - South (Comanche route)	CE-1: Location - South Route	
8	Maximize Use of Existing Right-of-Way				CE-1: Location - South Route	
9	Avoid Highway 50 Expansion Corridor				CE-2: Location - North Route	
10	Maximize Non-Structural Options	See No Action Alternative				
11	Maximize Source Water Quality and Yield		IL-2: Location - Pueblo Reservoir South Outlet Works; IL-4: Location - Joint Use Pipeline (JUP) at Pueblo Boulevard			WT-9: Location - New water treatment plant downstream from St Charles Mesa; WT-11: Concept - Filtered and disinfected treatment
12	Maximize Operational Flexibility		IL-2: Location - Pueblo Reservoir South Outlet Works	CP-18: Concept - Interconnect	CE-2: Location - North Route	WT-10: Concept - Filtered treatment
13	Master Contract Only	RS-1: Location - Pueblo Reservoir - Excess Capacity				
14	AC Only	None				

Consolidation of Alternatives

The alternative themes identified in the previous section do not constitute complete alternatives because they do not have specific options identified for each component. There are also some alternative themes that overlap (i.e. the same options were identified for two or more different alternative themes). Therefore, the alternative themes were consolidated into alternatives identified for further study. During the consolidation of alternative themes into alternatives, attempts were made to include a broad range of options from the short-listed options (Table 17) to fill in where specific options were not needed to meet a specific alternative theme.

The alternatives to be studied in detail, including the options included in the alternatives for each component, are shown in Table 20. The table provides information on which of the major alternative themes each alternative addresses. Most of the short-listed options were in at least one of the alternatives to be studied in detail. However, some options were not needed to meet an alternative theme or were not determined to be clearly superior to another option, so they were not included in an alternative.

The following are noted regarding the short-listed options and alternatives to be studied in detail:

- All action alternatives use the same conceptual water supplies that were identified by the participants. The Master Contract Only alternative only uses water supplies identified by non-AVC Master Contract participants and those AVC participants that requested Master Contract storage without AVC. Fry-Ark supplies would be used as part of the No Action Alternative for AVC participants with this alternative.
- Conservation is included as an option in all action alternatives. Conservation plans are currently being more fully developed individually by several AVC and Master Contract participants. For those participants without conservation plans, Southeastern is developing an AVC conservation plan that addresses conservation activities. Therefore, demand projections being performed as part of the EIS include reductions of about 9 percent in per capita water use due to conservation for most participants.
- None of the regulating storage options that are downstream of Fountain Creek were included in the alternatives to be studied in detail because none of the intake locations are downstream of Fountain Creek. As previously described, in order for regulating storage to provide an effective storage option for AVC, they must be located upstream of the intake structure. For the Master Contract Only alternative, the Federal decision is whether to issue a Master Contract for storage in Fry-Ark facilities. Therefore, when considering this action alone, the alternative must relate directly to the proposed Federal action, thus evaluation of excess capacity storage in Pueblo Reservoir was chosen as the regulating storage option.
- The Interconnect was not included in three alternatives. The Interconnect was not included in the Pueblo Dam-South alternative in order to analyze one alternative that diverts water from Pueblo Dam but does not include the interconnect. The Interconnect was not included in the River-South alternative because AVC would not divert from the Pueblo Dam outlet structures, thus no redundancy is needed by AVC in these facilities since multiple outlet facilities are available at Pueblo Dam for release to the river. For

the Master Contract alternative, AVC is not constructed thus the Interconnect is not constructed.

- The Master Contract was not included in one alternative (JUP-North) in order to evaluate one alternative that includes AVC but does not include the Master Contract, since it may be possible for this to be the outcome of the Federal Actions evaluated as part of the EIS.
- Several short-listed options were identified for evaluation during appraisal-level design, including running parallel pipes where needed when pipelines exist or different levels of water treatment are needed by different participants (i.e. St. Charles Mesa; CP-21), use of abandoned railroad right-of-way (CE-3), and combined spurs rather than individual spurs (CE-6). Other options that were not included in the screening analysis, but were included in either the STAG report or Value Planning Study, were also considered during the design process such as additional water treatment options and locations, use of rights-of-way and locations of spur alignments.
- The conceptual conveyance option that would align AVC in prairie rather than farmland (CE-6) was evaluated as one of the alternative themes (theme 5).
- The water treatment option with de-centralized regional facilities (WT-4) was not used in any alternative. Although this option was short-listed, there are concerns with this option that were discussed during STAG and the Value Planning Study including spreading of operators and O&M costs, and a likely net increase in pipeline length. Furthermore, it does not address any alternative themes.

Revised Comanche South Alternative

As part of the Appraisal Study analyses performed by Reclamation (2012), the Comanche South Alternative was revised from its original configuration as developed using the process above. Modifications to the alternative include:

- The water treatment plant was moved to federal property below Pueblo Reservoir.
- Water treatment was changed from filtered and disinfected to just filtered reflecting recommendations of the Health Department.
- The Fowler storage tanks were moved north of the town of Fowler based on engineering recommendations.
- The La Junta-Rocky Ford loop spur was changed to match the River South Alternative.

Except as noted in the surface water hydrology, the Comanche South Alternative analyzed in this EIS reflects these changes. The meets the same alternative themes as developed in the original alternatives analysis described in this appendix.

Table 20. Alternatives to be Studied in Detail

Name [1]	Regulating Storage	Intake Location	Conveyance - Through Pueblo [2]	Conveyance - East of Pueblo [2]	Treatment	Alternative Theme [3]
No Action	Short-Term If & When Contracts	Wells/Existing River Diversion Points	N/A	N/A	Regional water treatment plants Individual treatment	1, 10
Comanche - South	Location - Pueblo Reservoir - Excess Capacity	Location - Pueblo Reservoir South Outlet Works	Location - South (Comanche route) Concept - Interconnect	Location - South Route	Location - New water treatment plant located below Pueblo Dam (on BOR property) Concept - Filtered only treatment	7, 8, 11
Pueblo Dam - South	Location - Pueblo Reservoir - Excess Capacity	Location - Pueblo Reservoir South Outlet Works	Location - South (Pueblo Dam, along Bessemer Ditch)	Location - South Route	Location - New water treatment plant located near South Road and 21st Street Concept - Filtered only treatment	3, 8
JUP - North	None	Location - Joint Use Pipeline (JUP) at Pueblo Boulevard	Location - North (JUP Wye, along 11th Street) Concept - Interconnect	Location - North Route	Location - Whitlock water treatment plant (BWWP) Concept - Filtered only treatment	2, 5, 6, 9, 14
Pueblo Dam - North	Location - Pueblo Reservoir - Excess Capacity	Location - Pueblo Reservoir South Outlet Works	Location - North (Pueblo Dam, JUP route, along 11th Street) Concept - Interconnect	Location - North Route	Location - New water treatment plant located below Pueblo Dam (on BOR property) Concept - Filtered only treatment	9,12
River - South	Location - Pueblo Reservoir - Excess Capacity	Location - Arkansas River upstream of the Fountain Creek confluence	Location - Downstream Intake	Location - South Route	Location - New water treatment plant located adjacent to the existing St. Charles Mesa water treatment plant Concept - Filtered and disinfected treatment	3, 4, 8
Master Contract	Location - Pueblo Reservoir - Excess Capacity	Wells/Existing River Diversion Points	N/A	N/A	Regional water treatment plants Individual treatment	13

Notes:

(1) All Action Alternatives include the following:

Water Supplies
- WS-1 Source - Fry-Ark Project Water
- WS-2 Source - Fry-Ark Project Return Flows (1939 Decree)
- WS-3 Source - Fry-Ark Project Return Flows (01CW151)
- WS-4 Concept - Use of Existing Agricultural Water Rights
- WS-5 Concept - Use of New Agricultural Water Rights
- WS-6 Concept - Rotational Fallowing and Leasing
- WS-7 Source - Water Rights specifically for AVC associated with the Super Ditch Project.
- WS-14 Concept – Conservation

Water Treatment
- WT-3 Concept - Blended supplies

(2) Includes all spurs, connection points, pump stations, operational storage, and any other engineered features required to support the option.

(3) Numbers correspond to Alternative Theme numbers in Table 18.

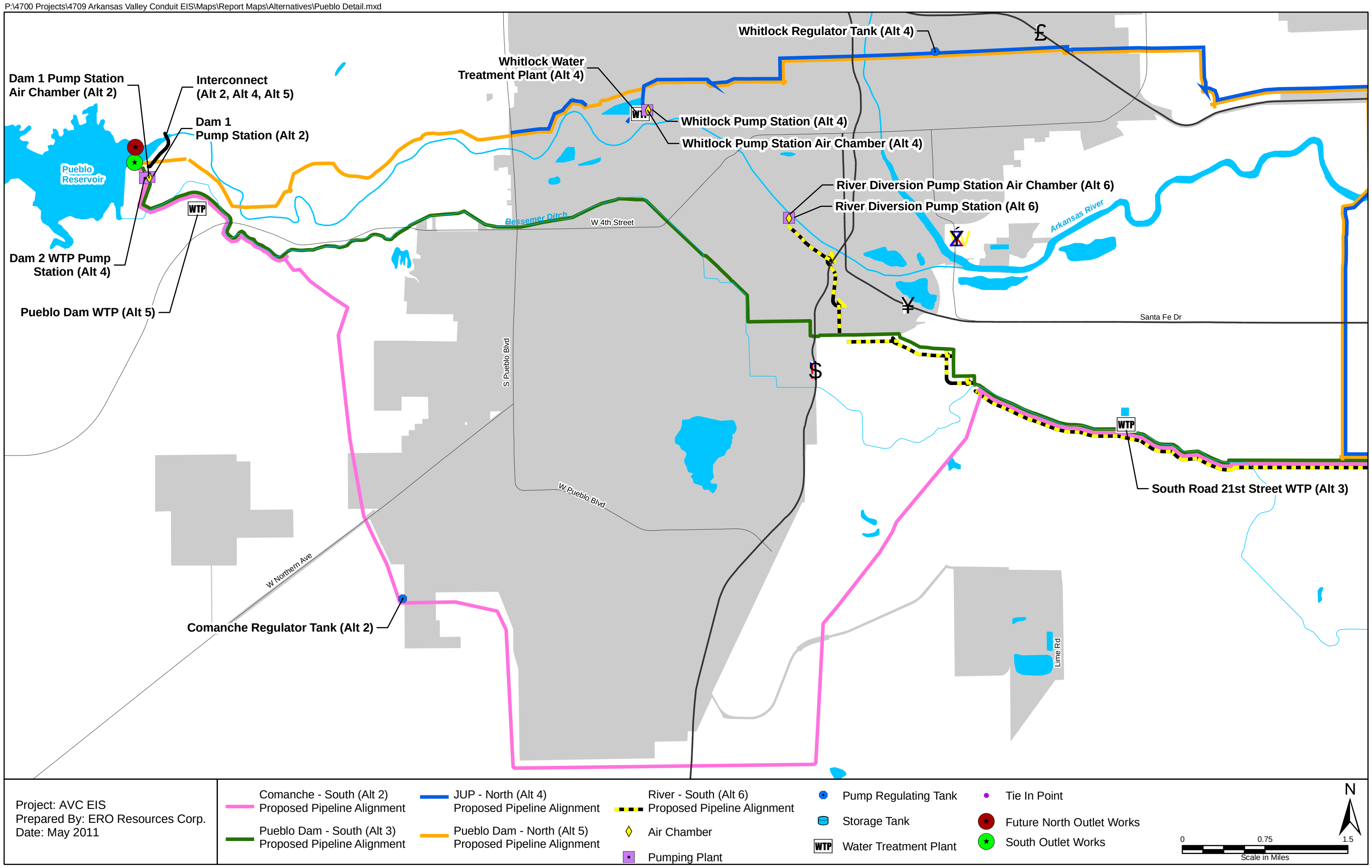

Figure 9. Detail Map of City of Pueblo for All Alternatives.

No Action Alternative Development

NEPA requires a No Action Alternative to be studied in an EIS. "No action" represents a projection of current conditions to the most reasonable future responses or conditions that could occur during the life of the project without any action alternatives being implemented. The No Action Alternative should not automatically be considered the same as the existing conditions. The No Action Alternative represents the most likely actions the participants would take in the absence of the federal actions evaluated in this EIS (i.e., construction of AVC and issuance of a Master Contract). "No action" is therefore often described as "the future without the project" (Reclamation Draft NEPA Handbook 2000). The No Action Alternative evaluated in this EIS is divided into three components:

- The Arkansas Valley Conduit no action describes what AVC participants would likely do if Reclamation chose not to use federal funds to construct AVC or grant special use permits for AVC to cross Reclamation lands.
- The Interconnect no action describes what the Interconnect participants would likely do if Reclamation chose not to build AVC (Interconnect is an engineering feature of AVC), or if Reclamation chose to build AVC without the Interconnect
- The Master Contract no action describes what the Master Contract participants would likely do if Reclamation chose not to issue a 40-year Master Contract for storage of non-Fry-Ark project water in Fry-Ark reservoirs.

Methods and Limitations

Information used to develop the AVC No Action Alternative was taken from the STAG report (Black & Veatch 2010), responses to questionnaires provided by the EIS team to the participants, discussions with the Health Department, the CORADS study (Malcolm Pirnie 2009), and discussions with Southeastern personnel. The following general assumptions were made to develop the AVC No Action Alternative:

- Those AVC participants who are currently meeting Primary Drinking Water Standards would continue their current treatment processes.
- AVC participants who are under enforcement actions from the Health Department would regionalize with larger neighboring water utilities whose systems are in compliance or upgrade their treatment systems.
- Other smaller water providers who expressed interest in regionalization would also be served by a neighboring water utility. Regional water utilities were identified based on geographical proximity and ability to serve.
- The No Action Alternative would meet the same existing and future volumetric demands as the action alternatives.
- Future water supplies to meet the additional demand would be taken from the same group of supplies being proposed for the action alternatives.

The Interconnect no action was also developed based on prospective participant questionnaire responses, which are summarized below.

The Master Contract no action was developed based on responses to questionnaires provided to the participants by Reclamation and professional judgment. Master Contract questionnaires were reviewed to get a general idea of what the Master Contract participants were planning in the event the Master Contract is denied.

Arkansas Valley Conduit No Action

The No Action Alternative was developed using AVC participant information in Southeastern's STAG report (Black & Veatch 2010), information from CORADS information (Health Department 2009, Health Department 2011, Malcolm Pirnie 2009), and participant comments.

The AVC No Action Alternative is a combination of regional water treatment systems and local independent systems. Local independent systems would include those participants that have the ability to meet primary drinking water standards, and are not a provider for a regional system. Regional systems are combinations of participants that would be served by a larger neighboring utility's water treatment plant.

Regional Systems

Smaller water providers who cannot meet primary drinking water standards or who are interested in regionalization for other reasons would be combined with a nearby larger water provider. The regional water systems are presented in Table 21 below. The participants are identified in Table 21 according to their reasons for regionalization. Some participants need to regionalize because they have an enforcement action that they would satisfy by obtaining a different water source that is in compliance with primary drinking water standards, and other participants would regionalize for other reasons, such as financial reasons.

Table 21. Regional Water Providers Under the AVC No Action Alternative

County	Service Provider	Participant	Other Regionalization Interest	Health Department Enforcement Actions
Otero	Fowler	Fowler		
		Valley Water Co.		√
Otero	La Junta	Bents Fort Water Co.[1]	√	
		Cheraw, Town of		√
		East End Water Assn.		√
		Holbrook Center Soft Water		√
		Homestead Improvement Assn.	√	√
		La Junta		
		Swink		√
Prowers	Lamar	Lamar		
		May Valley Water Assoc.[2]		√
Otero	Rocky Ford	Hancock Inc.	√	√
		Hilltop Water Co.	√	
		Rocky Ford		
		Vroman		√
		West Grand Valley Water Inc.	√	

Notes:
(1) Bent's Fort Water Company currently receives a portion of their water from La Junta.
(2) May Valley Water Association may regionalize with Wiley instead of Lamar. This will be determined after negotiations are final.

Supply Source

Existing water supplies that meet primary drinking water standards would continue to be used. Participants that have an enforcement action due to radionuclide contamination would abandon those sources. To make up for those water sources that can no longer be used and to meet future water demands in 2070, additional water sources would be sought.

Each of the regional water providers, Fowler, La Junta, Lamar, and Rocky Ford, currently use alluvial groundwater. Therefore, the most likely new water source would be additional alluvial groundwater or use of Fry-Ark allocations not previously requested. Table 22 presents the existing water sources that would be used by the regional providers, as well as the amount of groundwater that would need to be obtained to meet future water demands. Because this alluvial groundwater affects surface water flows in the Arkansas River, alluvial groundwater pumping must be offset by releasing augmentation water to the river to make up for effects to surface water flows. The regional water system participants would release their Fry-Ark allocations to the Arkansas River for augmentation of their alluvial groundwater pumping.

Table 22. Regional Water Supplies Under the AVC No Action Alternative

	Water Supply for No Action Alternative			
Regional Service Provider	**Existing Deep Well Water (ac-ft)**	**Future Deep Well Water (ac-ft)**	**Existing Alluvial Well Water (ac-ft)**	**Future Alluvial Well Water (ac-ft)**
Fowler	--	--	210	51
La Junta	--	--	2,040	561
Lamar	213	--	2,400	333
Rocky Ford	--	--	890	277
Total	**213**	**--**	**5,540**	**1,223**

Water Treatment

Regional water treatment plants would be located at the regional provider's current site, although expansion may be required to accommodate additional demands for the regional customers. The current treatment process would continue to be used, with the possibility of slight modifications to account for changes in source water quality:

- Fowler uses conventional water treatment processes. At its North Springs facility chlorine is the only treatment. At the Hammond Springs facility, chlorine and bag filter treatment is used. Conventional treatment using chlorine disinfection and possibly filtration would continue to be used.
- La Junta uses reverse osmosis water treatment. This treatment facility was constructed in 2004. Currently, flow is split between reverse osmosis and pressure filters. Pressure filters are designed for the oxidation and removal of iron and manganese. Currently, 80% of product water is from reverse osmosis system, but there is flexibility to adjust the blend ratio. The facility uses cartridges filters prior to reverse osmosis, but has ports available for bag filters prior to cartridge filtration. La Junta currently mixes brine from the reverse osmosis process with their wastewater treatment plant effluent and discharges it to the Arkansas River. The CORADS report (Malcolm Pirnie 2009) indicated that this type of discharge would likely not be allowed to continue in the future. In the future, brine disposal techniques could include residuals minimization strategies and zero liquid discharge techniques.
- 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 to be used in the future.

- Rocky Ford uses a conventional treatment plant (no additional information was available) which has been recently upgraded. This treatment method would continue to be used in the future.

Independent Systems

Other participants who can meet primary drinking water standards would continue to operate independent water systems. Some of these participants, Eureka, Fayette Water Association, Patterson Valley, and South Swink Water Company, are currently under an enforcement action by the Health Department and would upgrade their treatment facilities to come into compliance for high levels of radionuclides. All other participants would use their existing water treatment facilities. Table 23 presents those AVC participants who would continue to operate as independent water providers under the AVC No Action Alternative.

Table 23. Independent Water Providers Under the AVC No Action Alternative

County	Participant	Health Department Enforcement Actions	Upgrade Treatment of Existing Supplies
Pueblo	Avondale		
	Boone		
	St. Charles Mesa Water District		
Crowley	96 Pipeline Co.		
	Crowley County Water Assoc.		
	Crowley, Town of		
	Ordway, Town of		
	Olney Springs		
	Sugar City		
Otero	Beehive Water Assn		
	Eureka Water Co.(1)	√	√
	Fayette Water Assn. (1)	√	√
	Manzanola		
	Newdale-Grand Valley Water Co.		
	North Holbrook Water		
	Patterson Valley (1)	√	√
	South Side Water Assoc. (La Junta)		
	South Swink Water Co.(1)	√	√
	West Holbrook Water		
Bent	Hasty Water Company		
	Las Animas		
	McClave Water Assoc.		
Prowers	Wiley		
Kiowa	Eads		

Note:
(1) These participants with enforcement actions would upgrade their treatment systems and continue to use deep bedrock well water.

Supply Source

Each of the independent water providers either have water sources that meet primary drinking water standards, or would treat their existing sources to meet primary drinking water standards (i.e., Eureka, Fayette Water Association, Patterson Valley, and South Swink Water Company). To meet future water demands in 2070, additional water sources may be needed.

Each of the independent participants uses either deep bedrock groundwater or alluvial groundwater. St. Charles Mesa is the only participant who also uses surface water. The most likely source of additional water supplies in the future would be additional groundwater. The participants would most likely use the same type of water that is already available to them; those participants who use deep bedrock groundwater would seek additional deep bedrock groundwater supplies, and those participants who use alluvial groundwater would seek additional alluvial groundwater supplies. Table 24 presents the existing and predicted future water sources for the independent water providers under the AVC No Action Alternative.

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 make up for effects to surface water flows. Those participants using alluvial groundwater would release their Fry-Ark allocations to the Arkansas River for augmentation of their alluvial groundwater pumping. Participants who would continue to use deep bedrock groundwater that does not require augmentation would forego their Fry Ark allocation, leaving them available to other AVC participants who require additional augmentation water for purchase.

Table 24. Water Supplies for Independent Water Providers Under AVC No Action Alternative

County	Participant	Water Supply for No Action Alternative				
		Existing Surface Water (ac-ft)	Existing Deep Well Water (ac-ft)	Future Deep Well Water (ac-ft)	Existing Alluvial Well Water (ac-ft)	Future Alluvial Well Water (ac-ft)
Pueblo	Avondale				160	77
	Boone				66	45
	St. Charles Mesa Water District	1,460			200	1,038
Crowley	96 Pipeline Co.				62	0
	Crowley County Water Assoc.				643	204
	Crowley, Town of				38	44
	Ordway, Town of				316	0
	Olney Springs				40	20
	Sugar City				82	46
Otero	Beehive Water Assn		8	0		
	Eureka Water Co.		74	12		
	Fayette Water Assn.		12	2		
	Manzanola		39	0		
	Newdale-Grand Valley Water Co.		57	3		
	North Holbrook Water		7	1		
	Patterson Valley		15	2		
	South Side Water Assoc. (La Junta)		7	0		
	South Swink Water Co.		86	10		
	West Holbrook Water		14	4		
Bent	Hasty Water Company		32	1		
	Las Animas				570	34
	McClave Water Assoc.		56	3		
Prowers	Wiley		24	0		
Kiowa	Eads				250	0
Total		**1,460**	**427**	**38**	**2,427**	**1,508**

Water Treatment

Existing water treatment plants would continue to be used except for those participants who are under an enforcement action and must upgrade their treatment systems to come into compliance for radionuclides. All of the participants would continue to use their existing water treatment processes except for South Swink Water Company, Eureka, Patterson Valley, and Fayette Water Association (Table 25).

South Swink Water Company, Eureka, Patterson Valley, and Fayette Water Association would upgrade their existing conventional water treatment plants to use preformed hydrous manganese oxide filtration technology. This technology is effective at removing radionuclides from water and would bring these participants in line with primary drinking water standards. Radionuclides are adsorbed into preformed hydrous manganese oxide. The hydrous manganese oxide is then removed by filtration. Liquid and solid waste from this treatment process could require hazardous materials disposal methods.

Except for Las Animas, all of the other participants would continue to use existing conventional treatment technology. Las Animas uses reverse osmosis water treatment. This treatment facility was constructed in 1996. Las Animas currently mixes brine from the reverse osmosis process with their wastewater treatment plant effluent and discharges it to the Arkansas River. The CORADS report (Malcolm Pirnie 2009) 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.

Table 25. Treatment Processes for Independent Water Providers Under AVC No Action Alternative

County	Participant	Treatment Method	Upgrade to Comply with Primary Drinking Water Standards?
Pueblo	Avondale	Green Sand Pressure Filter and Granular Activated Carbon	
	Boone	Chlorine Gas	
	St. Charles Mesa Water District	Chlorine Dioxide Pretreatment Activated Carbon, Flocculation, Alum and Polymer Addition	
Crowley	96 Pipeline Co.	Purchased from Crowley County Water Association	
	Crowley County Water Assoc.	Chlorine Gas	
	Crowley, Town of	Purchased from Crowley County Water Association	
	Ordway, Town of	Purchased from Crowley County Water Association	
	Olney Springs	Purchased from Crowley County Water Association	
	Sugar City	Not Available	
Otero	Beehive Water Assn	Not Available	
	Eureka Water Co.	Hydrous Manganese Oxide with Filtering	√
	Fayette Water Assn.	Hydrous Manganese Oxide with Filtering	√
	Manzanola	Iron Removal Filters and Blending For Radium, Chlorine Gas	
	Newdale-Grand Valley Water Co.	Green Sand Pressure Filters	
	North Holbrook Water	Not Available	
	Patterson Valley	Hydrous Manganese Oxide with Filtering	√
	South Side Water Assoc. (La Junta)	Not Available	
	South Swink Water Co.	Hydrous Manganese Oxide with Filtering	√
	West Holbrook Water	Not Available	
Bent	Hasty Water Company	Chlorination	
	Las Animas	Reverse Osmosis	
	McClave Water Assoc.	Chlorination	
Prowers	Wiley	Chlorination and Filtration	
Kiowa	Eads	Phosphates for Corrosion and Chlorine Gas	

The AVC No Action Alternative would not meet the purpose and need of the project because it would not provide water quality that meets secondary maximum contaminant level guidelines. However, future water demands for AVC participants would be met. The following elements of purpose and need for AVC would be met by the No Action Alternative:

- Water Quality: Ability to Meet Primary Drinking Water Standards – Primary Drinking Water Standards would be met under the No Action Alternative through delivery of an alternate source of water to those AVC participants with enforcement actions. The alternate source water would be Fry-Ark water (used as augmentation for alluvial groundwater), reliable deep and alluvial groundwater supplies, and currently undeveloped water which meet all Primary Drinking Water Standards, including radionuclide standards. The water sources used in the AVC No Action Alternative would be the same as the those used in the AVC action alternatives.

- Meet Existing and Future Water Demands – Existing and future demands would be met through continued use of current supplies that meet Primary Drinking Water Standards, Fry-Ark water, and development of a small amount of additional water in the future. The source of the undeveloped water has not yet been identified, but would be the same water developed under the Proposed Action.

The following elements of purpose and need for AVC would not be met by the AVC No Action Alternative:

- Water Quality: The No Action Alternative does not include treatment to comply with Secondary Maximum Contaminant Level Guidelines and involves only conventional treatment: Secondary water quality standards for total dissolved solids (e.g., salinity) cannot be met using conventional treatment methods. As an example, Las Animas' source water salinity concentration is more than six times the secondary water quality standard for salinity. Las Animas and La Junta currently use reverse osmosis, which is a treatment method to reduce salinity in their drinking water. It is assumed that Las Animas and La Junta will continue to use this treatment technology to provide water of acceptable taste and appearance to their customers. Other participants who continue to use existing conventional treatment methods would not be able to meet secondary maximum contaminant level guidelines.

Engineering and cost estimates for the No Action Alternative are presented in Appendix B.2.

Interconnect No Action Alternative

Without the Interconnect, the Interconnect participants would take other measures to increase redundancy and reliability, as needed. These expected measures were provided by the participants in questionnaires and are identified in Table 26.

Table 26. Interconnect No Action Alternative

Interconnect Participant	No Action Alternative
Colorado Springs Utilities	Continue Current Operations
Pueblo West	Build pump station to divert water from Arkansas River
Fountain, Security, Widefield, and Stratmoor Hills	Secure agreements with other water providers
Board of Water Works of Pueblo	Use existing emergency river intakes
AVC Participants	Varies by participant; management of systems to minimize disruptions
Pueblo Fish Hatchery	Build diversion from Bessemer Ditch

Master Contract No Action Alternative

The Master Contract participants are requesting long-term excess capacity storage space in Pueblo Reservoir to store non Fry-Ark project water, and project water return flows to fulfill future water demand, store water for delivery in AVC, drought protection or well augmentation. Table 27 presents the participants' No Action Alternative presented in their questionnaire, as well as best professional judgment for those No Action Alternatives that cannot reasonably be evaluated in the EIS as requested by the participants. Some of the responses provided in the questionnaires were too general and non-specific to be evaluated in the EIS. In those cases, professional judgment was used to determine the most likely No Action Alternative.

Some participants would continue with current operations if the Master Contract were not awarded. Consequences of continuing current operations include possible water shortages or loss of the ability to exercise water rights to the maximum extent practicable. For those participants who would pursue alternate means of storage, the most likely alternate storage would be temporary "If and When" contracts with Reclamation for storage of non Fry-Ark project water and project water return flows in Fry-Ark reservoirs. If and When contracts undergo NEPA review, either annually or in multi-year cycles. These contracts are not guaranteed to be issued every year. These contracts also have a lower spill priority and would subject to spill more often than the Master Contract.

For those Master Contract participants who are also participants in AVC, If and When storage contracts would be pursued to improve operation of AVC. AVC participants who have had an If and When contract would continue to pursue those contracts independently. The remaining smaller AVC participants would either apply for one AVC-wide If and When contract together, or individual contracts.

Table 27. Master Contract No Action Alternative

Participant	Contract Request (ac-ft)	AVC Participant	No Action Per Questionnaire	EIS No Action	No Action Rationale
Chaffee County					
Poncha Springs	200		Continue Current Operations	Continue Current Operations – No Storage	NA
Salida	2,000		If & When Contracts	If & When Contracts	Current If and When Contract for 625 ac-ft
Upper Arkansas Water Conservancy District	1,000		If & When Contracts, Reservoir Enlargement, or New Reservoir	If & When Contracts	Site of new or enlarged reservoir is not defined. Current If and When Contract for 1,000 ac-ft
Fremont County					
Canon City	1,000		Continue Current Operations	Continue Current Operations – No Storage	NA
Florence	2,250		Acquire ditch rights and/or construct new reservoir	If & When Contracts	Site of new reservoir or ditch rights are not defined
Penrose	900		Alternate storage	If & When Contracts	Other storage alternatives not identified
Pueblo County					
Pueblo West	6,000		If & When Contracts	If & When Contracts	Current If and When Contract for 9,000 ac-ft. Also participating in SDS.
St. Charles Mesa	2,000	√	Continue Current Operations	Continue Current Operations – No Storage	If and When Contracts in 2008 and 2009 for 500 ac-ft. Would not continue to renew If and When contracts.

Participant	Contract Request (ac-ft)	AVC Participant	No Action Per Questionnaire	EIS No Action	No Action Rationale
El Paso County					
Fountain	1,000		If & When Contracts	If & When Contracts	Current If and When Contract for 600 ac-ft. Also participating in SDS.
Security	1,500		If & When Contracts	If & When Contracts	Current If and When Contract for 200 ac-ft. Also participating in SDS.
Stratmoor Hills	200		If & When Contracts	If & When Contracts	Current If and When Contract for 200 ac-ft. Also participating in SDS.
Widefield	650		If & When Contracts	If & When Contracts	Current If and When Contract for 400 ac-ft. Also participating in SDS.
Otero County					
Beehive	18	√	No Response	If and When Contracts	N/A
Bents Fort	10	√	No Response	If and When Contracts	N/A
Fayette	16	√	No Response	If and When Contracts	N/A
Fowler	1,000	√	No Response	If & When Contracts	Regional provider per AVC no action
Hilltop	35	√	No Response	If and When Contracts	N/A
Holbrook Center Soft Water	6	√	No Response	If and When Contracts	AVC no action
La Junta	2,000	√	If & When Contracts	If & When Contracts	N/A
Lower Arkansas Valley Water Conservancy District	5,000		Pipeline to El Paso County and two reservoirs	If & When Contracts	Site of new reservoirs and pipeline route are undefined. Current If and When Contracts for 500 ac-ft (municipal and industrial use) and 2,000 ac-ft (irrigation use).
Manzanola	30	√	No Response	If and When Contracts	N/A
Newdale-Grand Valley	50	√	No Response	If and When Contracts	N/A
Patterson Valley	40	√	No Response	If and When Contracts	N/A
Rocky Ford	2,500	√	Continue Current Operations	If & When Contracts	Regional provider per AVC no action. Current If and When Contract for 50 ac-ft.
South Side	8	√	No Response	If and When Contracts	N/A
South Swink	80	√	No Response	If and When Contracts	N/A
Valley	47	√	Dissolution	If and When	N/A

Participant	Contract Request (ac-ft)	AVC Participant	No Action Per Questionnaire	EIS No Action	No Action Rationale
				Contracts	
Vroman	41	√	Dissolution	If and When Contracts	N/A
West Grand Valley	15	√	Regionalize	If and When Contracts	N/A
Crowley County					
96 Pipeline Company	25	√	No Response	If and When Contracts	N/A
Crowley County Commissioners	1,000	√	Continue Current Operations	If and When Contracts	N/A
Ordway	150	√	Continue Current Operations	If and When Contracts	N/A
Olney Springs	750	√	Continue Current Operations	If and When Contracts	N/A
Bent County					
Las Animas	300	√	No Response	If and When Contracts	N/A
Prowers County					
May Valley Water Association	600	√	Purchase water from neighbor or treat water	If and When Contracts	N/A
Kiowa County					
Eads	50	√	No Response	If and When Contracts	N/A

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Appendix B.2 – Alternative Maps

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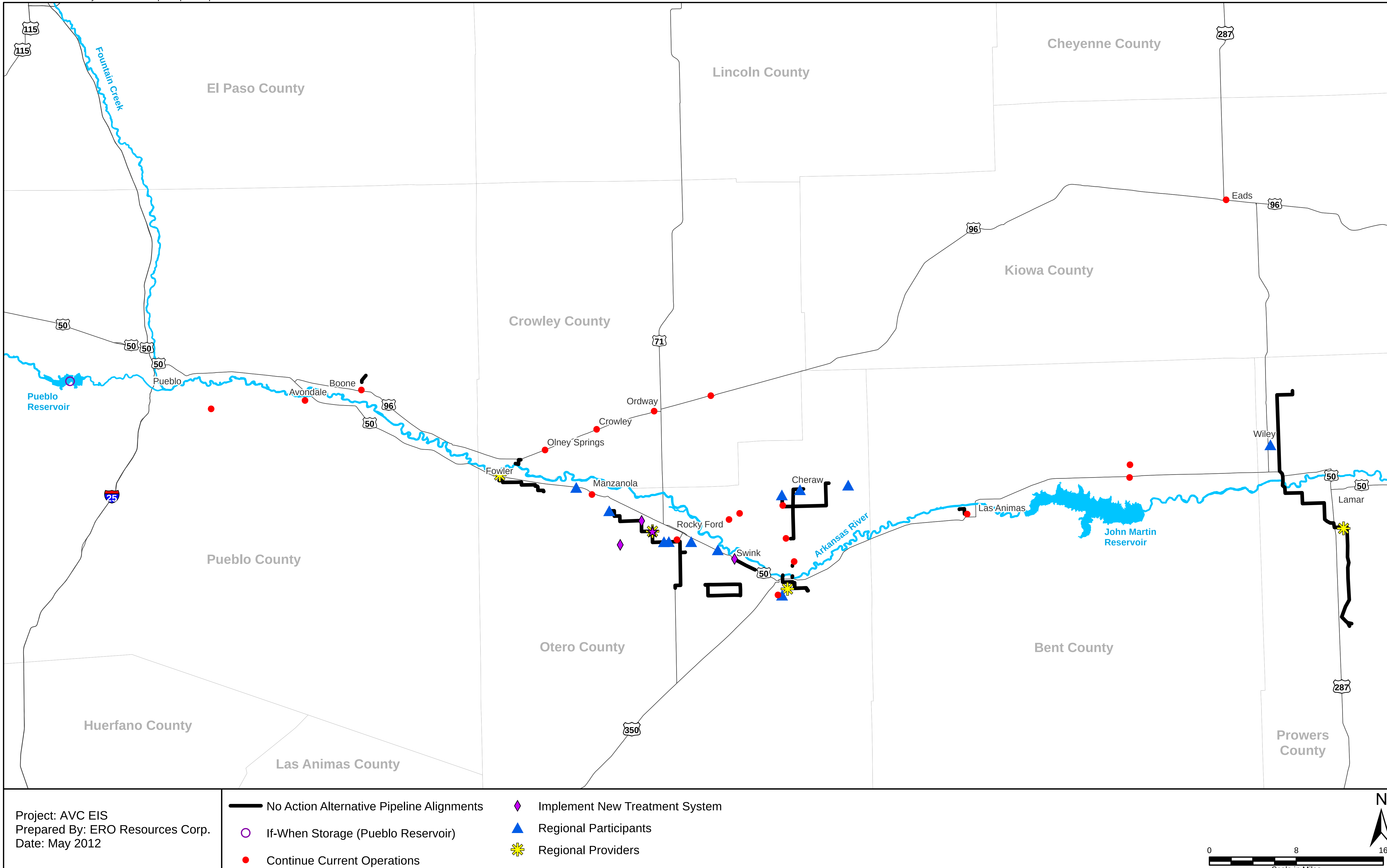

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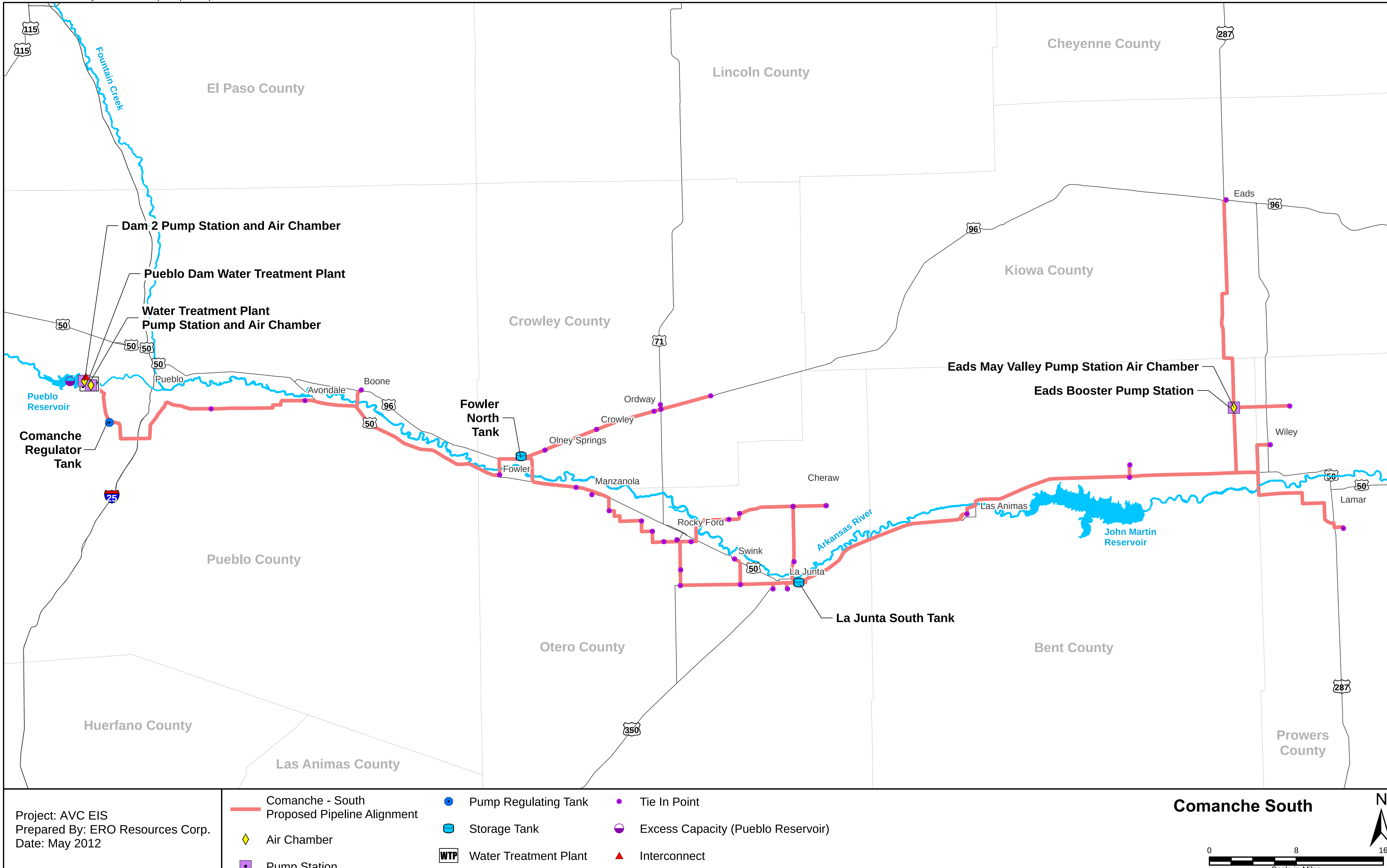

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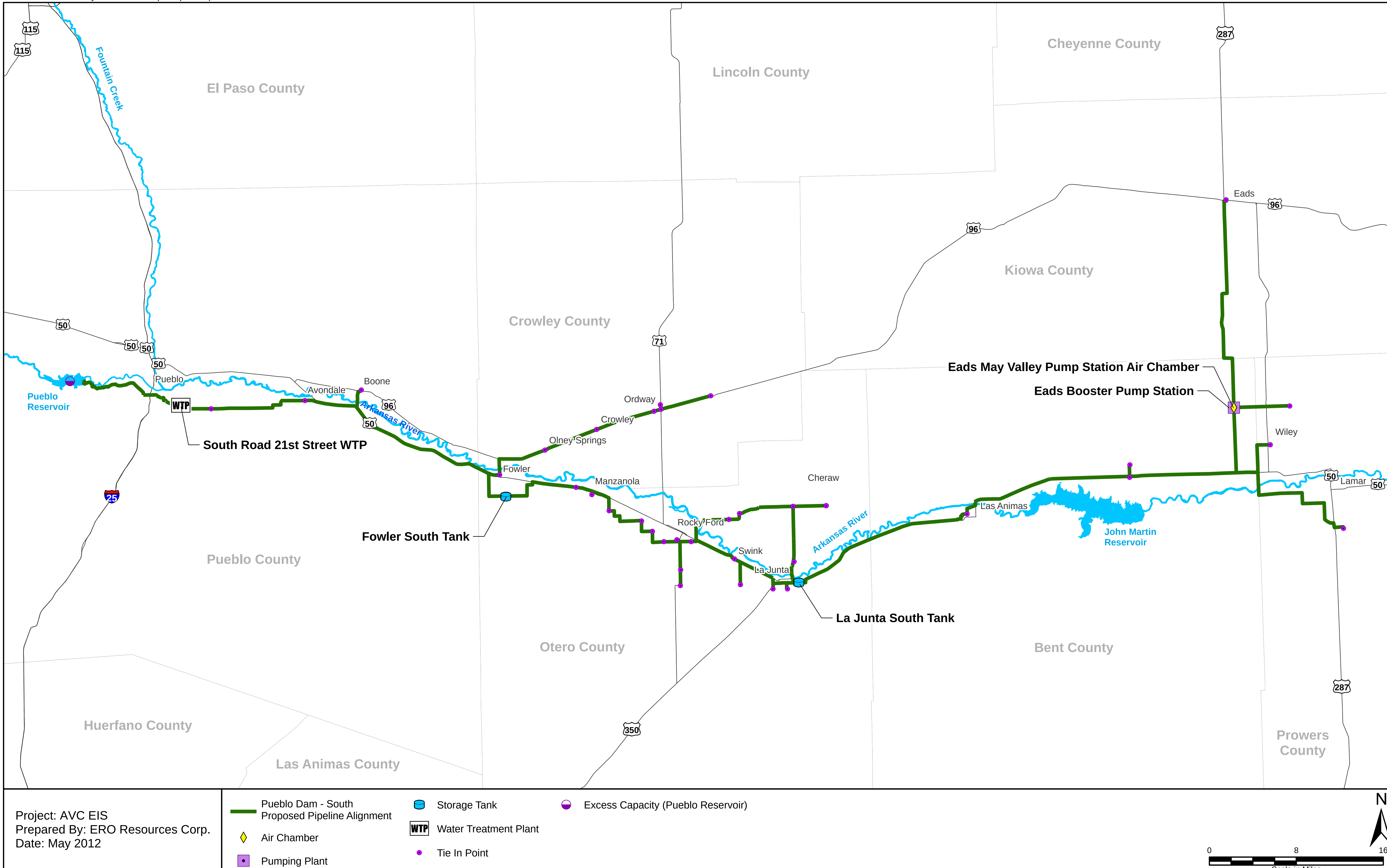

Project: AVC EIS
Prepared By: ERO Resources Corp.
Date: May 2012

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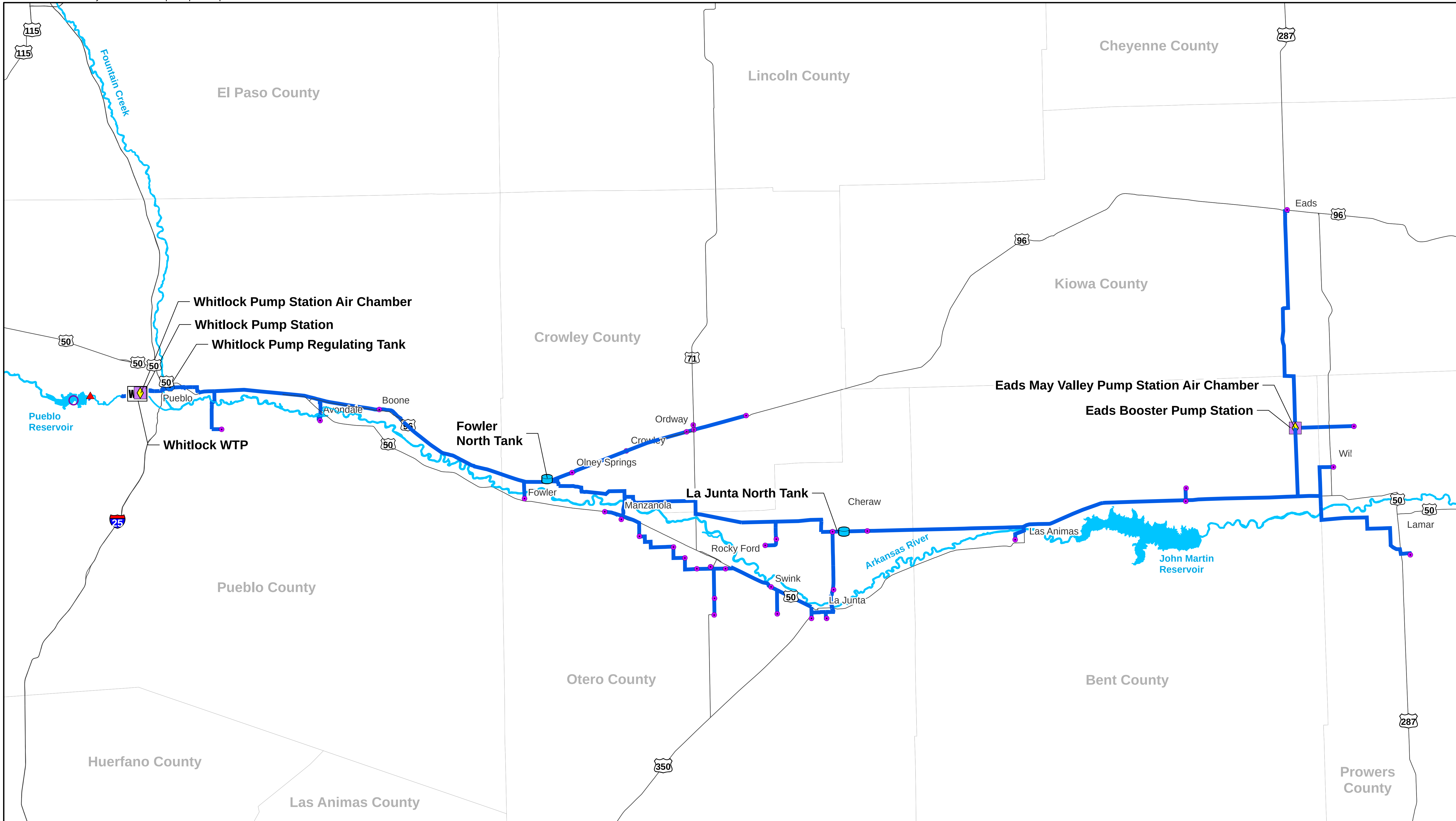

Project: AVC EIS
Prepared By: ERO Resources Corp.
Date: May 2012

JUP - North Proposed Pipeline Alignment
Air Chamber
Pump Station
Pump Regulating Tank
Storage Tank
WTP Water Treatment Plant
Tie In Point
If-When Storage (Pueblo Reservoir)
Interconnect

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Scale in Miles

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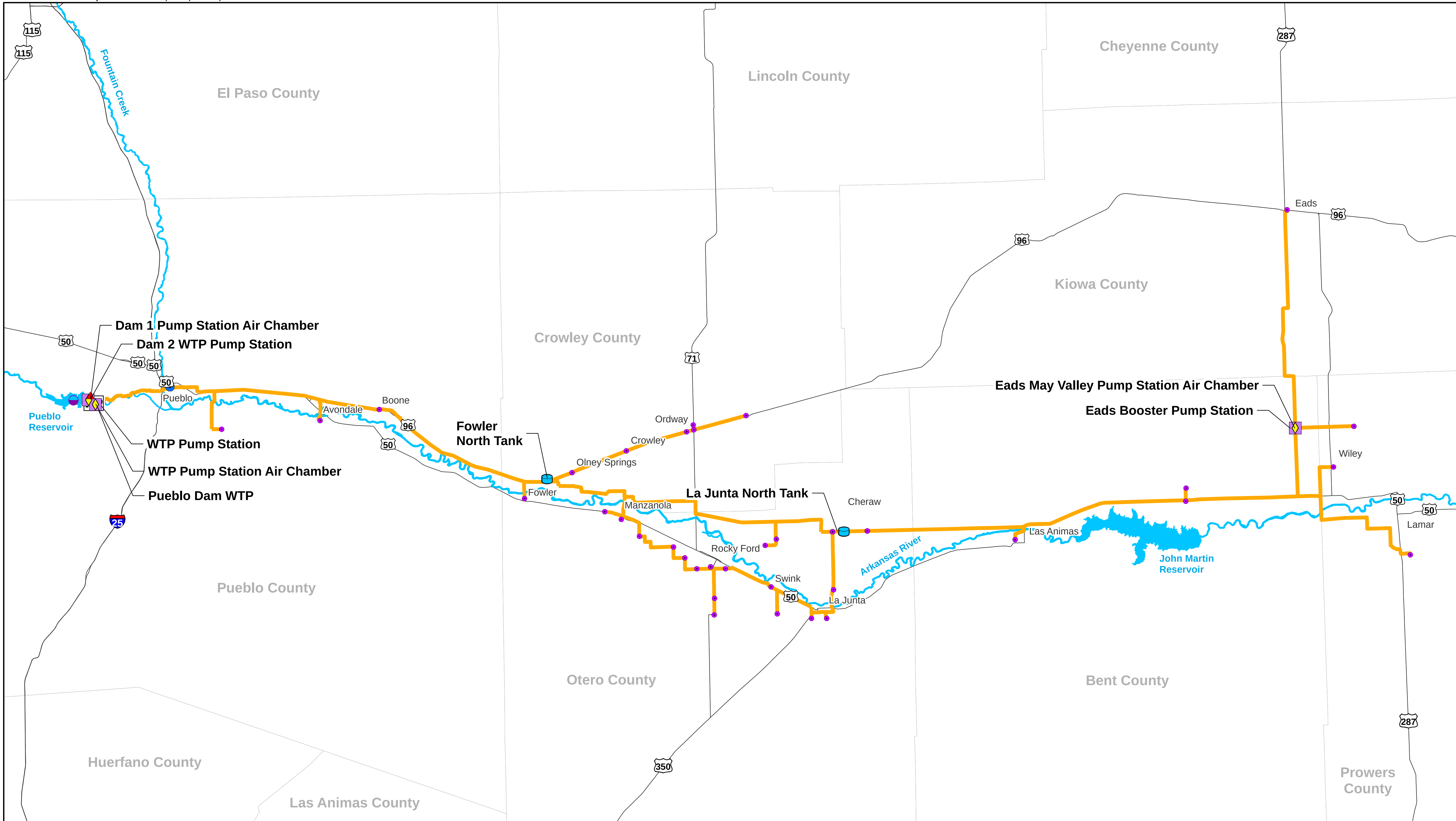

Pueblo Dam - North Proposed Pipeline Alignment
Air Chamber
Pump Station
Surge Regulator
Storage Tank
WTP Water Treatment Plant
Tie In Point
Excess Capacity (Pueblo Reservoir)
Interconnect

Project: AVC EIS
Prepared By: ERO Resources Corp.
Date: May 2012

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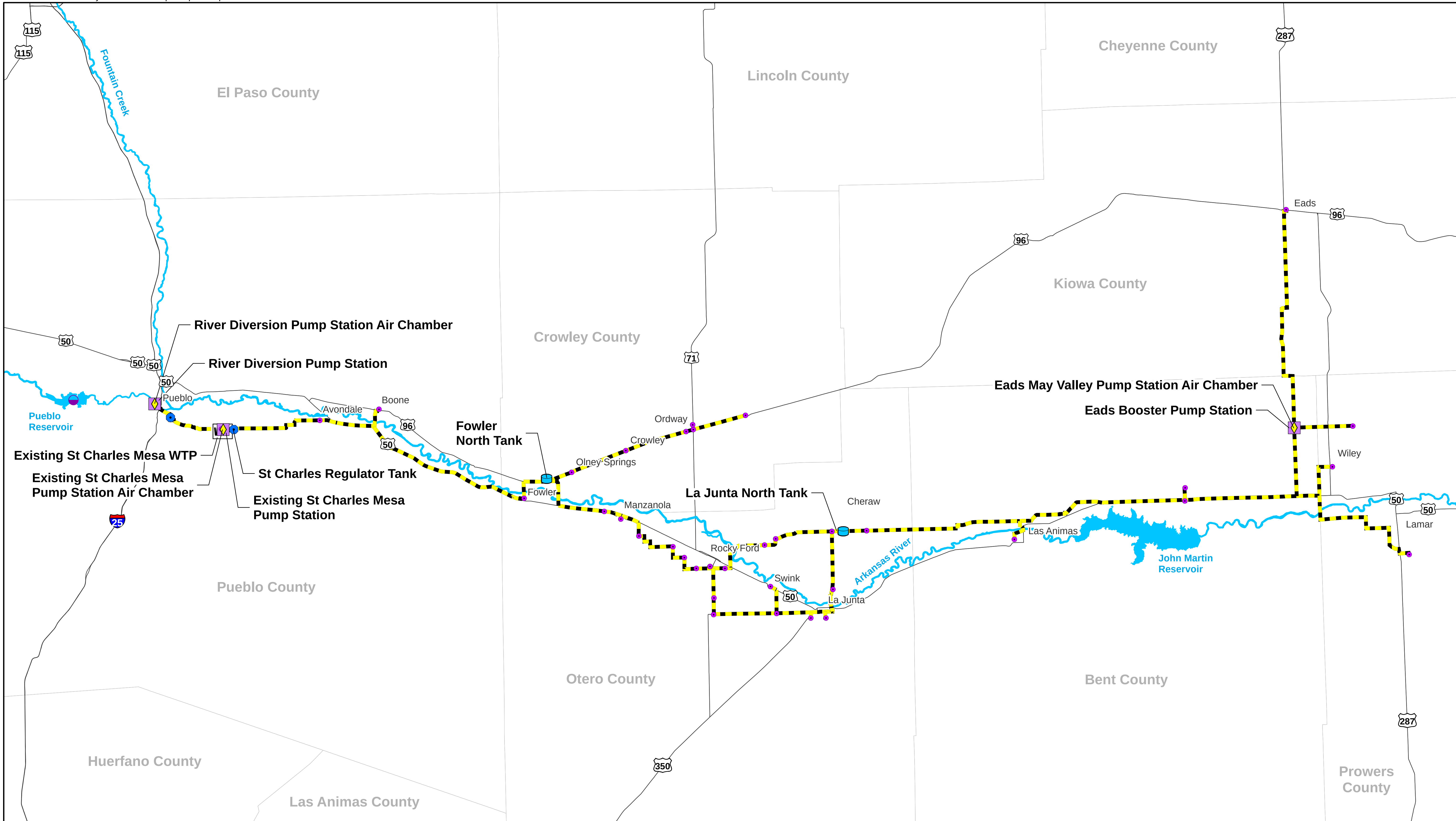

Project: AVC EIS
Prepared By: ERO Resources Corp.
Date: May 2012

River - South Proposed Pipeline Alignment
Air Chamber
Pump Station
Pump Regulating Tank
Storage Tank
Water Treatment Plant
Tie In Point
Excess Capacity (Pueblo Reservoir)

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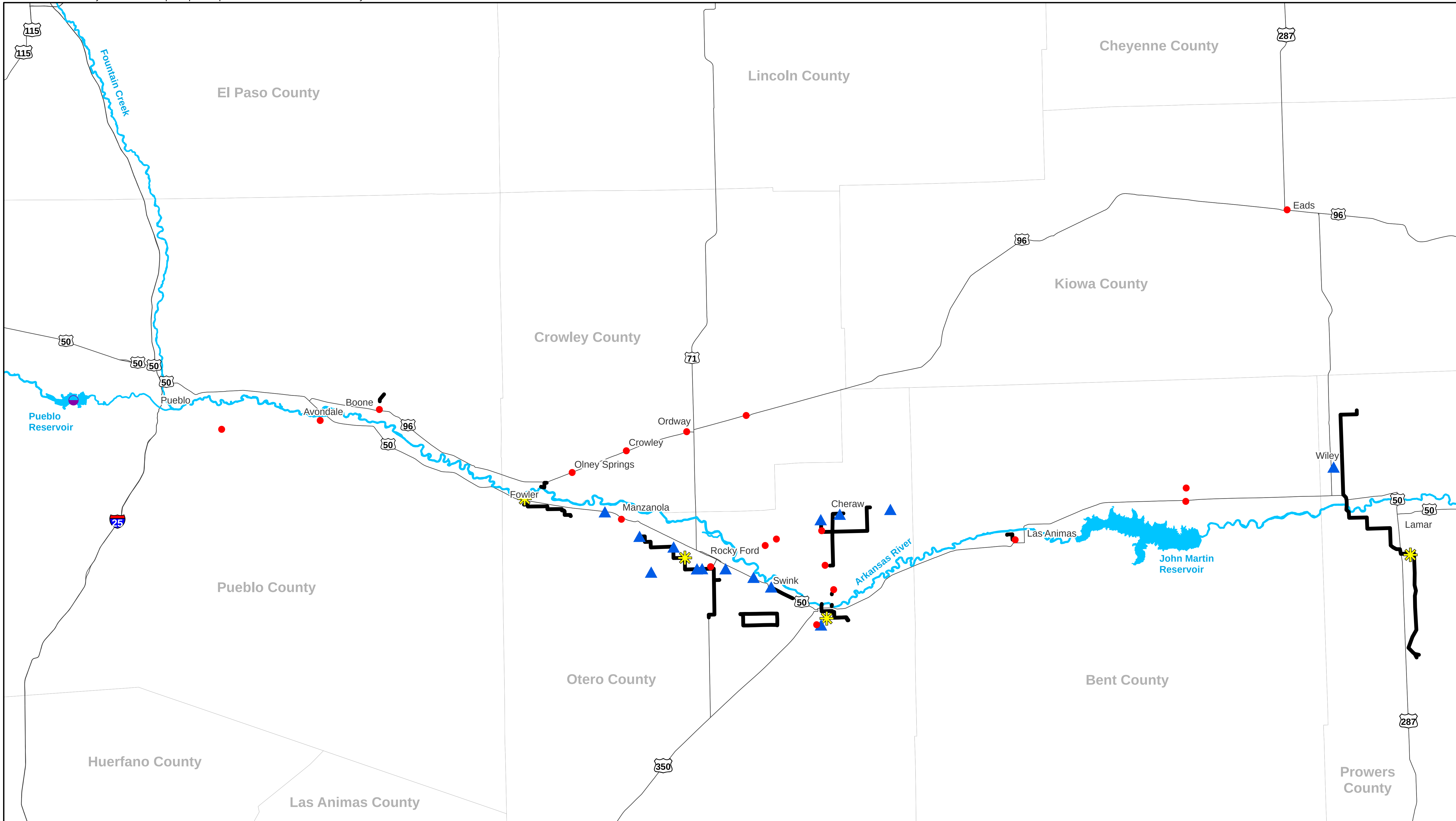

Project: AVC EIS
Prepared By: ERO Resources Corp.
Date: May 2012

No Action Alternative Pipeline Alignments
Excess Capacity (Pueblo Reservoir)
Continue Current Operations
Regional Participants
Regional Providers

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Scale in Miles

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Appendix B.3 – AVC No Action Alternative Engineering and Costs

This appendix presents the No Action Alternative evaluated in the EIS.

Executive Summary

The No Action Alternative represents how the participants may meet their future water needs without the Arkansas Valley Conduit (AVC), Interconnect contract, or Master Contract.

If an action alternative is not implemented, the AVC participants would likely meet water supply and water quality needs with a combination of regionally integrated and independent systems. Regional systems would be combinations of smaller participants that would be served by a larger neighboring utility's water system. Independent systems would include those participants with the ability to meet primary drinking water regulations and who would not be a provider for a regional system.

Four regional providers were identified for the regional systems (Fowler, Rocky Ford, La Junta, and Lamar) along with 12 smaller participating systems. The smaller regional participants who cannot meet primary drinking water regulations and who would be interested in regionalization for other reasons would likely connect to a nearby larger water provider. The regional providers would supply all the water for their respective system and its participating systems. Additional infrastructure including treatment expansion, pipelines, pumping stations, and/or storage would be required to deliver water from the regional provider to its participating systems.
Twenty four independent system participants would continue to meet their own drinking water needs and would not supply other systems. The independent systems would expand or modify their existing facilities as required to satisfy increased demand or comply with additional treatment requirements to remove radionuclides.

Table ES-1 summarizes the total construction costs, the 50-year total periodic costs, and the 50-year total operations and maintenance costs.

Table ES-1. Summary of Costs

	Total Construction Costs	Total Periodic (Replacement) Costs	Total Annual Operations and Maintenance Costs
Regional Systems			
Fowler	$5,756,000	$195,000	$762,000
Rocky Ford	$15,647,000	$623,000	$2,822,000
La Junta	$81,654,000	$1,169,000	$61,639,000
Lamar	$43,342,000	$204,000	$4,458,000
Subtotal 1 – Regional Systems	$147,000,000	$2,191,000	$69,681,000
Independent Systems			
Avondale	$0	$0	$0
Boone	$2,541,000	$113,000	$650,000
St. Charles Mesa Water District	$2,620,000	$0	$382,000
96 Pipeline	$0	$0	$0
Crowley County Water Assn.	$2,405,000	$44,000	$714,000
Crowley	$0	$0	$0
Ordway	$457,000	$0	$66,000
Olney Springs	$365,000	$0	$54,000
Sugar City	$0	$0	$0
Beehive Water Assn.	$0	$0	$0
Eureka Water Co.	$2,049,000	$0	$2,137,000
Fayette Water Assn.	$1,202,000	$0	$2,015,000
Manzanola	$0	$0	$0
Newdale-Grand Valley Water Co.	$0	$0	$0
North Holbrook Water	$2,174,000	$13,000	$2,074,000
Patterson Valley	$1,202,000	$0	$2,015,000
South Side Water Assn.	$0	$0	$0
South Swink Water Co.	$9,940,000	$33,000	$2,588,000
West Holbrook Water	$0	$0	$0
Hasty Water Co.	$0	$0	$0
Las Animas	$19,490,000	$198,000	$19,219,000
McClave Water Assn.	$0	$0	$0
Wiley	$0	$0	$0
Eads	$0	$0	$0
Subtotal 2 – Independent Systems	$45,000,000	$401,000	$31,914,000
Total	$192,000,000	$2,592,000	$101,595,000

Introduction

The No Action Alternative represents how the participants may meet their future water needs without the AVC, Interconnect contract, or Master Contract. The purpose of this memorandum is to describe the No Action Alternative for the AVC. The No Action Alternative for the Interconnect contract and Master Contract are discussed in other documents.

The No Action Alternative would be needed to meet water supply and water quality needs. The No Action Alternative is designed to meet Colorado Primary Drinking Water Regulations using existing and additional water treatment of available surface and ground water supplies. Currently, fourteen participants produce and deliver water that does not meet Colorado Primary Drinking Water Regulations. These participants only water source is from deep wells that currently contaminated (primarily from radium). Because the aquifer is the source of the contamination, any new wells would also be contaminated. Please reference the Environmental Impact Statement (EIS), Chapter 2, for a discussion of the screening process and alternatives as they relate to solutions for the contaminated deep wells.

Table 1 and Table 9 identify participants who are not in compliance with Colorado Primary Drinking Water Regulations. Please reference the Colorado Department of Public Health and Environment (Health Department) website for current information about these participants.

If an action alternative is not implemented, the AVC participants would likely meet water supply and water quality needs with a combination of regionally integrated and independent systems. Regional systems would be combinations of smaller participants that would be served by a larger neighboring utility's water system. Independent systems would include those participants with the ability to meet primary drinking water regulations and who would not be a provider for a regional system. Please refer to the EIS, Appendix B.1 for additional information on the development of the No Action Alternative concept and breakdown of the participants between regional systems and independent systems.

An overview of the No Action Alternative is in Figure 1. The regional providers are shown with a star, the participants in the regional systems are shown with a circle, and the independent systems are marked with a triangle.

The names of the participants of the regional and independent systems are included in subsequent sections.

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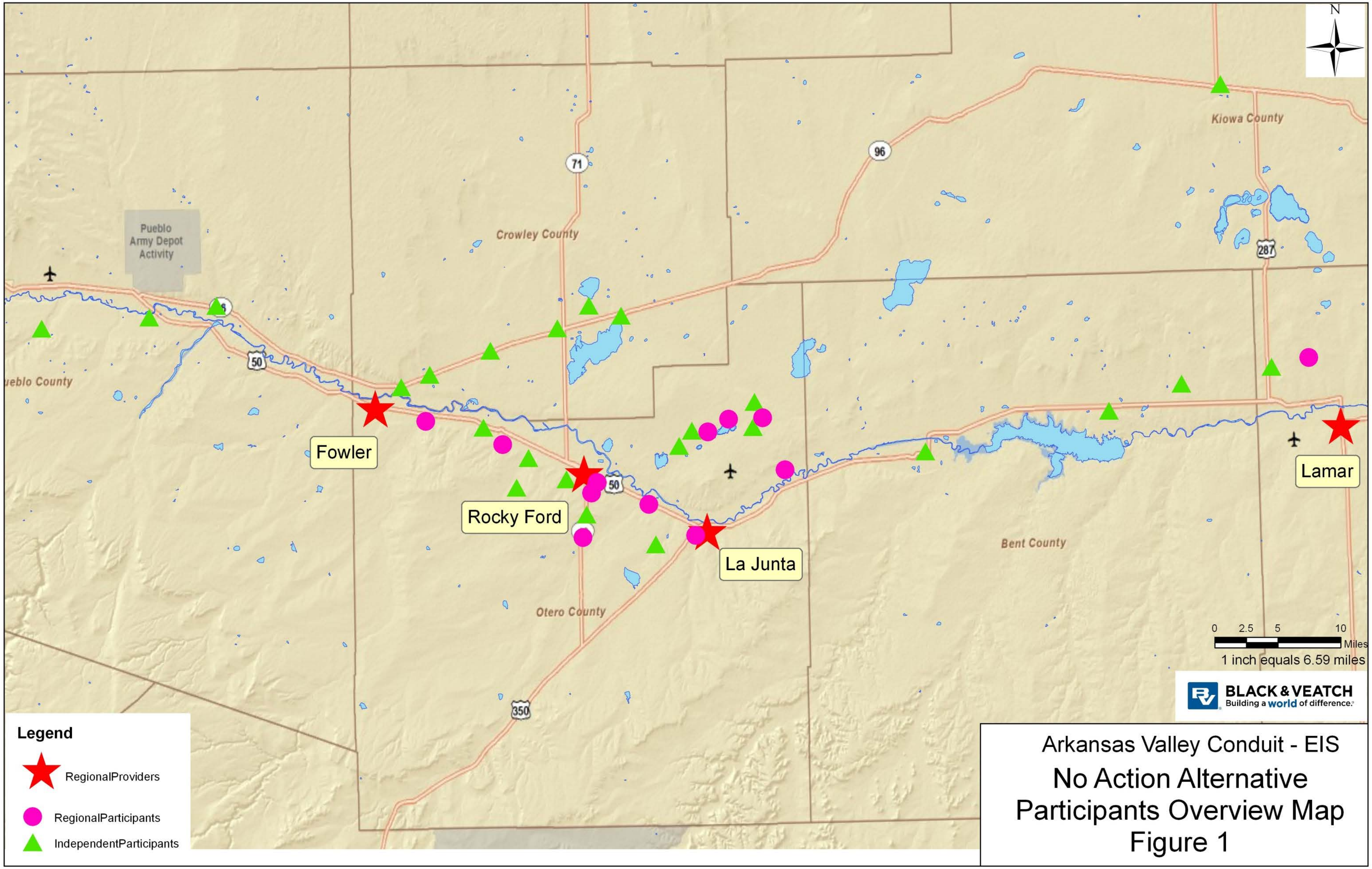
Pueblo Army Depot Activity
Crowley County
Kiowa County
Pueblo County
Otero County
Bent County
Fowler
Rocky Ford
La Junta
Lamar
71
96
287
50
350
N
0 2.5 5 10 Miles
1 inch equals 6.59 miles
BLACK & VEATCH
Building a world of difference.
Legend
RegionalProviders
RegionalParticipants
IndependentParticipants
Arkansas Valley Conduit - EIS
No Action Alternative
Participants Overview Map
Figure 1

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Regional Systems

Four regional providers were identified for the regional systems (Fowler, Rocky Ford, La Junta, and Lamar). The smaller regional participants who cannot meet primary drinking water regulations and who would be interested in regionalization for other reasons would likely connect to a nearby larger water provider. The regional providers would supply all the water for their respective system and its participating systems.

The regional provider would not own or operate any part of the participant's system, but would only be a wholesale provider of water to their system. The participating systems would either be a consecutive system or an integrated system. Consecutive systems would subject to the monitoring and reporting provisions of the Colorado Primary Drinking Water Regulations and must meet the maximum contaminant levels and other requirements of the Colorado Primary Drinking Water Regulations. An integrated system is a public water system that receives treated water from a wholesale system that it then distributes (only that water) through a distribution system that it owns. An integrated system may or may not have additional disinfection; however, it cannot be considered an integrated system if it uses any treatment other than disinfection. This memorandum did not evaluate whether the participating systems would be classified as a consecutive system or an integrated system at this level of evaluation.

It was assumed that the regional provider would have full use of its participating system's existing water supply sources and water rights to deliver treated water to its participating systems. The ownership of existing water rights would not be transferred to the regional provider.

The regional water systems are presented in Table 1 below. The participating systems were identified as those that specifically expressed an interest in regionalization, or had an enforcement action and had not specifically identified a treatment system that would address the enforcement action. This information was gathered through surveys conducted as part of the Pre- National Environmental Policy Act (NEPA) State and Tribal Assistance Grant (STAG) investigations (Black & Veatch, 2010), and information provided by the participants during the EIS process.

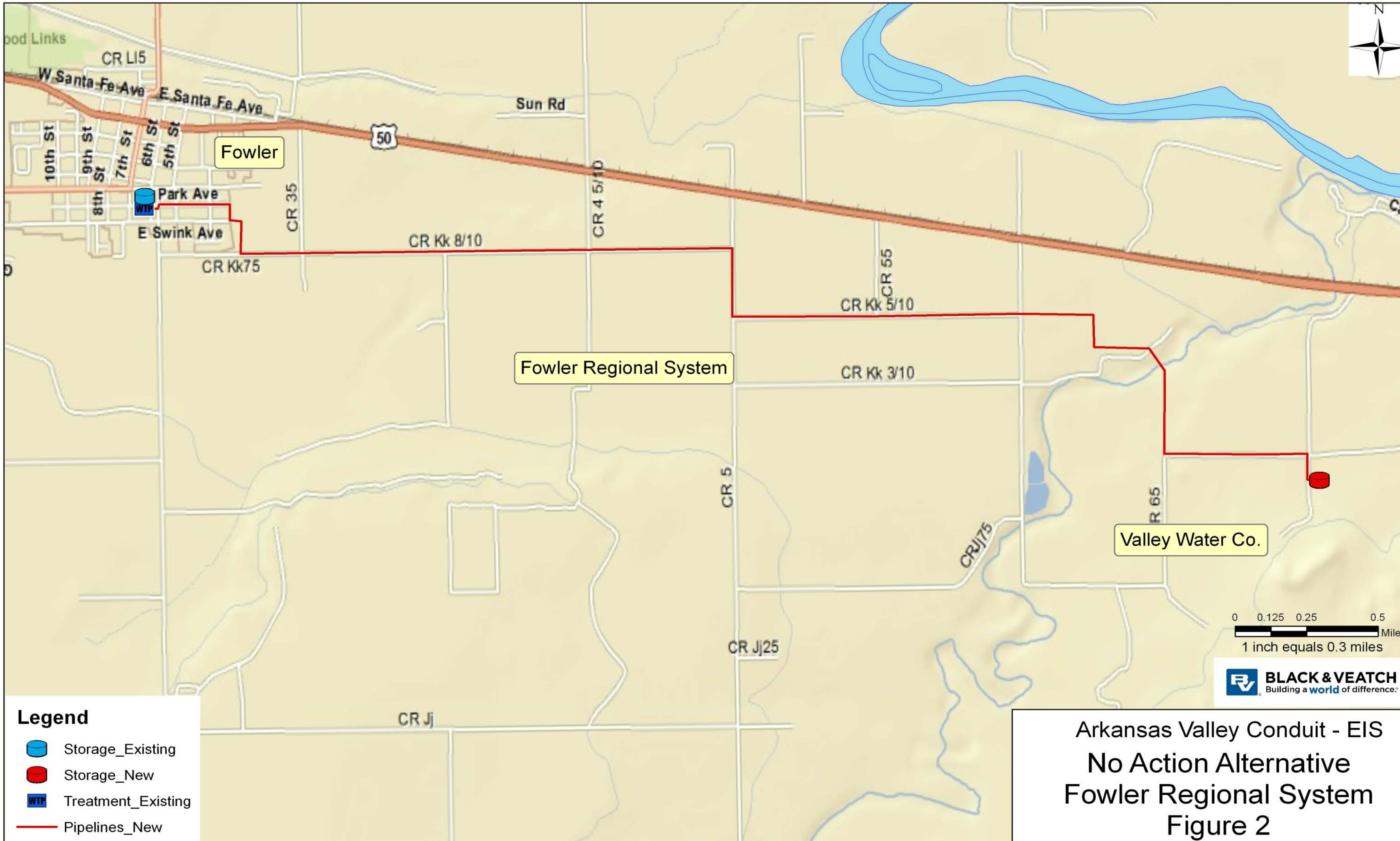
Additional infrastructure including treatment expansion, pipelines, pumping stations, and/or storage required to deliver water from the regional provider to its participating systems. Participants with Health Department enforcement actions are indicated in the table.

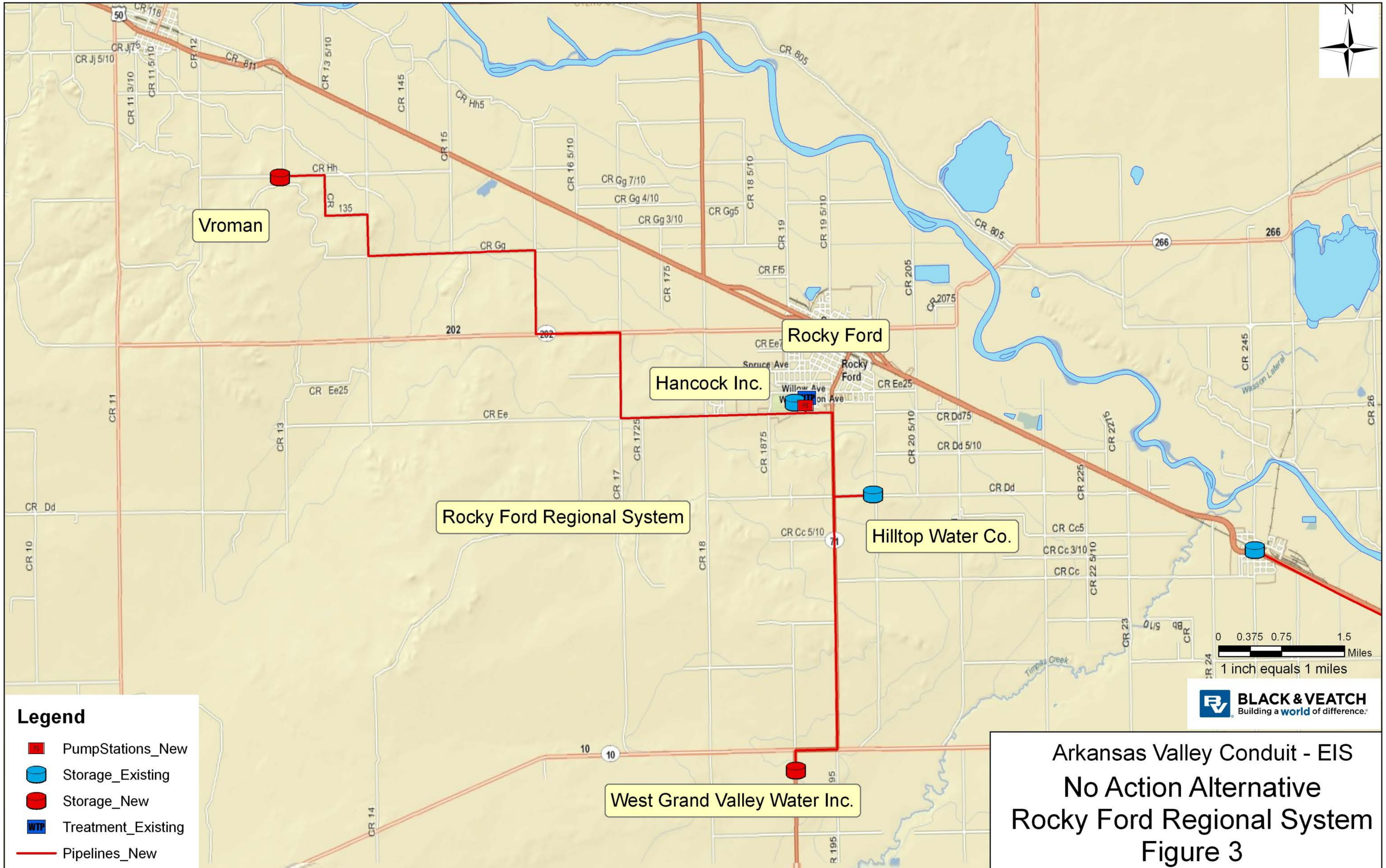
A map of each regional system is presented in Figures 2, 3, 4, and 5.

Table 1. Regional Systems

County	Regional Provider	Participating Systems	Health Department Enforcement Action
Otero	Fowler	Fowler	No
		Valley Water Co.	Yes [4]
Otero	Rocky Ford	Rocky Ford	No
		Hancock Inc. [1]	Yes [4]
		Hilltop Water Co.	No
		Vroman	Yes [4]
		West Grand Valley Water Inc.	No
Otero	La Junta	La Junta	No
		Bents Fort Water Co. [2]	No
		Cheraw	Yes [4]
		East End Water Assn.	Yes [4]
		Holbrook Center Soft Water	Yes [4]
		Homestead Improvement Assn. [3]	Yes [4]
		Swink	Yes [4]
Prowers	Lamar	Lamar	No
		May Valley Water Assn.	Yes [4]

Notes:
[1] Rocky Ford currently provides 100% of Hancock's water.
[2] La Junta currently provides a portion of Bents Fort's water.
[3] La Junta currently provides 100% of Homestead's water.
[4] Existing contaminated wells would be abandoned because participant does not desire to provide additional treatment for the contaminated supplies to meet the regulations.


CR Ll5
W Santa Fe Ave
E Santa Fe Ave
Sun Rd
50
Fowler
10th St
9th St
8th St
7th St
6th St
5th St
Park Ave
E Swink Ave
CR Kk75
CR 35
CR Kk 8/10
CR 4 5/10
CR 55
CR Kk 5/10
CR Kk 3/10
Fowler Regional System
CR 5
Valley Water Co.
CRJj75
CR Jj25
CR Jj
N
0
0.125
0.25
0.5
Miles
1 inch equals 0.3 miles
BLACK & VEATCH
Building a world of difference.
Legend
Storage_Existing
Storage_New
Treatment_Existing
Pipelines_New
Arkansas Valley Conduit - EIS
No Action Alternative
Fowler Regional System
Figure 2


Vroman
Rocky Ford
Hancock Inc.
Rocky Ford Regional System
Hilltop Water Co.
West Grand Valley Water Inc.
Legend
PumpStations_New
Storage_Existing
Storage_New
Treatment_Existing
Pipelines_New
0 0.375 0.75 1.5
Miles
1 inch equals 1 miles
BLACK & VEATCH
Building a world of difference.
Arkansas Valley Conduit - EIS
No Action Alternative
Rocky Ford Regional System
Figure 3


East End Water Assn.
Cheraw
Holbrook Center Soft Water
La Junta Regional System
Bents Fort Water Co.
Swink
La Junta Muni
La Junta
Legend
Storage_Existing
Storage_New
Treatment_Expansion
Wells_New
Pipelines_Existing
Pipelines_New
BrineEvapPonds
0 0.375 0.75 1.5 Miles
1 inch equals 1 miles
BLACK & VEATCH
Building a world of difference.
Arkansas Valley Conduit - EIS
No Action Alternative
La Junta Regional System
Figure 4


May Valley Water Assn.
Prowers County
196
50
50
196
Lamar
Lamar's Existing Wells
287
Lamar's Existing Wells
Lamar Regional System
Lamar's Existing Wells
N
0 1 2 4
Miles
1 inch equals 2.25 miles
BLACK & VEATCH
Building a world of difference.
Legend
PumpStations_New
Storage_Existing
Storage_New
Treatment_Expansion
Wells_New
Pipelines_New
Arkansas Valley Conduit - EIS
No Action Alternative
Lamar Regional System
Figure 5

Regional System Demands

The No Action Alternative is based on meeting participant demands in 2070, the same demands as for the action alternatives. The current and 2070 demands for the regional participants are shown in Table 2. Table 2 also sums the total current and 2070 demands for each regional system.

Table 2. Regional Systems Current and 2070 Demands

Regional Provider	Participating Systems	Current Demand (ac-ft)	Current Max Day [(1)] (mgd)	2070 Demand [(2)] (ac-ft)	2070 Max Day (mgd)
Fowler	Fowler	210	0.45	222	0.48
	Valley Water Co.	38	0.08	39	0.08
	Fowler Regional System	248	0.53	261	0.56
Rocky Ford	Rocky Ford	890	1.91	1,032	2.21
	Hancock Inc.	17	0.04	18	0.04
	Hilltop Water Co.	45	0.10	50	0.11
	Vroman	32	0.07	37	0.08
	West Grand Valley Water Inc.	25	0.05	30	0.06
	Rocky Ford Regional System	1,009	2.16	1,167	2.50
La Junta	La Junta	2,040	4.37	2,417	5.18
	Bents Fort Water Co.	63	0.13	55	0.12
	Cheraw	48	0.10	57	0.12
	East End Water Assn.	11	0.02	13	0.03
	Holbrook Center Soft Water	18	0.04	22	0.05
	Homestead Improvement Assn.	7	0.01	7	0.01
	Swink	38	0.08	30	0.06
	La Junta Regional System	2,225	4.77	2,601	5.57
Lamar	Lamar	2,400	5.14	2,511	5.38
	May Valley Water Assn.	410	0.88	435	0.93
	Lamar Regional System	2,810	6.02	2,946	6.31

Notes:
(1) Average day to maximum day ratio of 2.4 used for all participants.
(2) Current and 2070 demands (ac-ft) are from "AVC Preliminary Water Demands" MWH (December 16, 2010) which developed preliminary water demands for use in this memorandum and the Appraisal Design Report (Reclamation 2012). These estimates have since been updated in the EIS. This table and the No Action Alternative analysis continue the use of the preliminary estimates to be consistent with the Appraisal Design Report (Reclamation 2012).

Regional System Water Supplies

Existing water supplies that meet primary drinking water regulations would continue to be used. The four regional providers (Fowler, Rocky Ford, La Junta, and Lamar) currently use alluvial groundwater. The alluvial groundwater is chlorinated to meet primary drinking water regulations and varying levels of treatment is used to improve aesthetic quality for secondary standards. Rocky Ford also uses surface water supplies in the summer from their water treatment plant (WTP) to meet peak demands. Refer to Section 3.3 for additional information on treatment. The regional providers would continue to use alluvial groundwater as the primary source to meet regional future demands. The existing water supplies are listed in Table 3. The surface water supplies in Table 3 do not require augmentation water and would be used at a WTP. The available augmentation water is listed in Table 4.

Table 3. Regional Systems Existing Supplies

Regional Provider	Participating Systems	Deep Wells (ac-ft)	Alluvial Wells (ac-ft)	Surface Water Supplies (ac-ft)	Total Existing Supplies (ac-ft)
Fowler	Fowler	0	210	0	210
	Valley Water Co. (1)	38	0	0	38
	Fowler Regional System	0	210	0	210
Rocky Ford	Rocky Ford	0	1,122	365	1,487
	Hancock Inc. (1)	17	0	0	17
	Hilltop Water Co. (2)	45	0	0	45
	Vroman (1)	32	0	0	32
	West Grand Valley Water Inc. (2)	25	0	0	25
	Rocky Ford Regional System	0	1,122	365	1,487
La Junta	La Junta	0	2,040	0	2,040
	Bents Fort Water Co. (2)	35	30 (4)	0	65
	Cheraw (1)	48	0	0	48
	East End Water Assn. (1)	11	0	0	11
	Holbrook Center Soft Water (1)	18	0	0	18
	Homestead Improvement Assn. (2)	7	0	0	7
	Swink (1)	38	0	0	38
	La Junta Regional System	0	2,040	0	2,040
Lamar	Lamar	0	2,400	0	2,400
	May Valley Water Assn. (3)	213	0	0	213
	Lamar Regional System	213	2,400	0	2,613

Notes:
(1) Under Health Department Enforcement Action and existing supply would no longer be used.
(2) No Health Department Enforcement Action, but existing supply would no longer be used and supply would be provided by regional provider.
(3) Under Health Department Enforcement Action. Supply shown is non-contaminated wells that would continue to be used by participant.
(4) Provided by La Junta.

Regional participating systems that have water supplies that do not meet radionuclide standards would abandon these supplies. To make up for those water supplies that can no longer be used and to meet future water demands in 2070, additional water supplies would be required. Because the participating systems additional water would come from a regional provider, the new water supplies would be additional alluvial groundwater from the regional provider.

Because alluvial groundwater pumping affects surface water flows in the Arkansas River, it must be offset by releasing augmentation water to the river to compensate for depletions to surface water flows. The participating systems would need to release their Fryingpan-Arkansas Project (Fry-Ark Project) water, and/or other non Fry-Ark Project supplies to the Arkansas River for augmentation. As stated previously, it is assumed that the participating systems would allow the regional provider full use of their existing water rights, including Fry-Ark Project water, to be used for the additional augmentation required for the additional alluvial groundwater. Each participating system would need to provide sufficient raw water to meet augmentation requirements for the additional water delivered to them from the regional provider. Table 4 lists the Fry-Ark Project water and other water rights available for augmentation.

Table 5 shows the demand that could be met with the existing water rights and if any additional water rights would be required to meet 2070 demands. Fowler, La Junta, and Rocky Ford could benefit from additional storage in Pueblo Reservoir for the additional augmentation water supplies. The configuration of excess capacity contracts for the No Action Alternative is addressed in Chapter 2 of the AVC EIS.

Table 4. Regional Systems Existing Water Allocations/Rights

Regional Provider	Participating Systems	Total Fry-Ark Project Water Allocation [1] (ac-ft)	Total Other Water Rights [2] (ac-ft)	Total Water Allocations / Rights (ac-ft)
Fowler	Fowler	135	0	135
	Valley Water Co.	29	0	29
	Fowler Regional System	164	0	164
Rocky Ford	Rocky Ford	466	191 [3]	657
	Hancock Inc.	14	0	14
	Hilltop Water Co.	31	0	31
	Vroman	15	0	15
	West Grand Valley Water Inc.	9	0	9
	Rocky Ford Regional System	536	0	727
La Junta	La Junta	815	265 [4]	1,080
	Bents Fort Water Co.	97	1	98
	Cheraw	23	0	23
	East End Water Assn.	8	0	8
	Holbrook Center Soft Water	5	0	5
	Homestead Improvement Assn.	7	0	7
	Swink	76	0	76
	La Junta Regional System	1,030	266	1,296
Lamar	Lamar	895	384 [5]	1,279
	May Valley Water Assn.	139	0	139
	Lamar Regional System	1,033	384	1,417

Notes:

(1) Includes Fry-Ark Project Water and Not Previously Allocated Non-Irrigation Water (NPANIW) allocations and Fry-Ark flows that may be purchased from Southeastern Colorado Water Conservancy District. Also includes Arkansas River transit loss reduction between Pueblo Reservoir and participant location.

(2) Includes transit loss reduction from source to participant location.

(3) 194.173 shares of Catlin Canal at 0.984 ac-ft/share equal 191 ac-ft.

(4) 884 shares of Holbrook (265 ac-ft (dry year) to 884 ac-ft (average year)) is used for augmentation. Dry year yield is used and is from Pre-NEPA STAG Report, Appendix 5-1 (Black & Veatch, 2010). Water use restrictions during dry years could be implemented.

(5) 3199.6 shares Fort Bent Ditch; 350 shares Lamar Canal; 290 shares LAWMA included. Assume Shares x 10% = ac-ft. Note – 10% conversion is conservative and is likely higher.

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Table 5. Regional Systems Demand vs. Water Rights

Regional Provider	Participating Systems [1]	Column 1 Total Existing Supplies (ac-ft) [2]	Column 2 Total Water Allocations / Rights Available (ac-ft) [3]	Column 3 Water Rights Used for Existing Supplies (ac-ft) [4]	Column 4 Additional Well Supplies Available Using Remaining Water Rights (ac-ft) [5]	Column 5 Total Potential Supplies That Could be Produced and Therefore Demand That Could Be Met with Existing Water Rights (ac-ft) [6]	Column 6 2070 Demand (ac-ft) [7]	Column 7 Additional Water Rights Required (ac-ft) (2:1 Ratio) [8]
Fowler	Fowler	210	135	105	60	270	222	0
	Valley Water Co.	38 [9]	29	0	59	59	39	0
	Fowler Regional System	210	164	105	119	329	261	0
Rocky Ford	Rocky Ford	1,487	657	561	193	1,680	1,032	0
	Hancock Inc.	17 [9]	14	0	29	29	18	0
	Hilltop Water Co.	45 [9]	31	0	62	107	50	0
	Vroman	32 [9]	15	0	31	31	37	0
	West Grand Valley Water Inc.	25 [9]	9	0	18	18	30	0
	Rocky Ford Regional System	1,487	727	561	332	1,819	1,167	0
La Junta	La Junta	2,040	1,080	1,020	120	2,160	2,417	2
	Bents Fort Water Co.	65 [9]	98	15 (for 30 ac-ft leased from La Junta)	167	232	55	0
	Cheraw	48 [9]	23	0	46	46	57	1
	East End Water Assn.	11 [9]	8	0	15	15	13	0
	Holbrook Center Soft Water	18 [9]	5	0	11	11	22	1
	Homestead Improvement Assn.	7 [9]	7	0	13	13	7	0
	Swink	38 [9]	76	0	152	152	30	0
	La Junta Regional System	2,040	1,296	1,020	552	2,592	2,601	4
Lamar	Lamar	2,400	1,279	1,200	158	2,558	2,511	0
	May Valley Water Assn.	213	139	0	278	491	435	0
	Lamar Regional System	2,613	1,417	1,200	434	3,047	2,946	0

Notes:

(1) Because alluvial groundwater pumping affects surface water flows in the Arkansas River, it must be offset by releasing augmentation water to the river to compensate for depletions to surface water flows. Averaged over an entire year, it is assumed that for every 2 gallons of alluvial groundwater pumped; one gallon is consumed and must be replaced with surface water released from another source (augmentation water). The other gallon that is pumped is replaced by return flows from the participant.

(2) From Table 3.

(3) From Table 4.

(4) Based on a 2:1 ratio of existing alluvial supplies. Alluvial supplies of column 1 divided by 2, but no greater than column 2. Note: Rocky Ford's 365 ac-ft surface water supply is subtracted from existing supply before calculation is completed.

(5) Based on a 2:1 ratio. (Column 2 minus Column 3) times 2.

(6) Total existing supplies plus additional well supplies available. Column 1 plus Column 4. Amounts for regional totals are not added, but are calculated by Column 1 plus Column 4. \

(7) From Table 2.

(8) Additional water rights are based on the regional system and are based on a 2:1 ratio. (Column 6 minus Column 5) divided by 2. I.E., the La Junta Regional System requires 4 additional ac-ft (2 ac-ft to La Junta, 1 ac-ft to Cheraw, and 1 ac-ft to Holbrook Center Soft Water.

(9) Supply would not be used in regional system because it is either contaminated, not desired to be used, or is already leased from the regional provider.

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Regional Systems Treatment

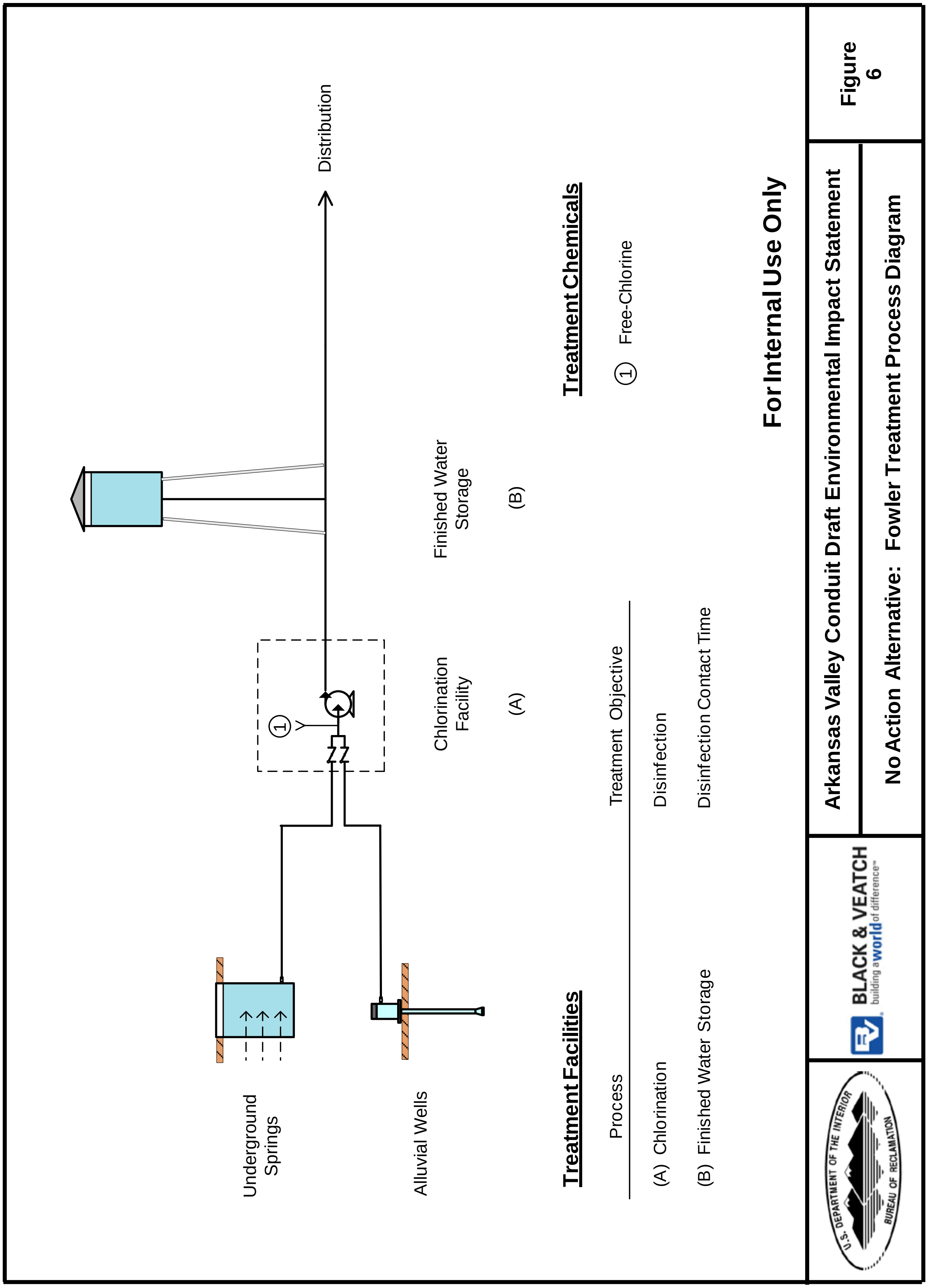
The regional providers would continue to use their existing WTPs to accommodate additional demands and meet future demands for its new participating systems. The current treatment process would continue to be used, with modifications as needed to account for changes in water quality or to comply with new regulations. La Junta and Lamar would require expansion to their WTPs as discussed further in Section 3.4. A summary of the regional providers' WTPs follows.

- Fowler has two water sources: 1) underground springs located north of the Arkansas River, and 2) alluvial wells located adjacent to the Arkansas River.
  - The springs are collected in an underground system and are conveyed to the central chlorination station in the town of Fowler. The water is then chlorinated and stored in the elevated storage tanks.
  - Similarly, the alluvial wells are pumped to the central chlorination station for chlorination and then stored in the elevated storage tanks.
  - The alluvial wells are Fowler's primary source of water and any additional future capacity would be met from alluvial wells. Conventional treatment using chlorine disinfection would continue.
- Rocky Ford has a conventional WTP for water diverted from the Catlin Canal and alluvial wells along the Arkansas River.
  - The WTP is used in the summer (or spring to early fall) and is used for approximately 50% of Rocky Ford's supply. The WTP has pre-sedimentation, rapid mix, two flocculation trains, two sedimentation trains with plates, three filters, ultraviolet disinfection, and chlorine gas disinfection.
  - The remainder of Rocky Ford's water is from alluvial wells along the Arkansas River. Chlorine is added directly at the well head. The well water enters the distribution system at a tee between the WTP and storage tanks.
- La Junta uses reverse osmosis (RO) water treatment of water from alluvial wells.
  - The treatment facility was constructed in 2004. The WTP uses a 3:1 blend ratio (3 parts RO water to 1 part non-RO water).
  - The facility uses RO and pressure filters for removal of iron and manganese.
  - The WTP has cartridge pre-filters for the RO trains, 3 RO membrane trains (2.2 mgd each), 2 forced air decarbonation units for RO permeate, pressurized sand filters for the bypass flow, on-site hypochlorite disinfection, a dedicated clearwell for providing disinfection contact time credit, and high service pumping. Caustic soda is used for finished water pH adjustment and stabilization. The RO influent piping is set up for sulfuric acid addition; however, this is not added.
  - Pressurized greensand filters are used for iron and manganese removal for the portion of raw water that bypasses RO. The bypass flow is pre-chlorinated and blended with RO permeate to stabilize finished water and add chlorination.
  - The RO brine is currently blended with raw water and conveyed to the wastewater treatment facility where it is mixed with wastewater treatment plant effluent and discharged to the Arkansas River, in accordance with City of La Junta Discharge Permit Number CO-0021261. The CORADS report (Malcolm Pirnie 2009) indicated that discharge of brine back to the Arkansas River would likely not be allowed to continue in the future, although no timeframe was given. In the future, brine disposal techniques could include residuals minimization strategies and zero liquid discharge

(ZLD) techniques. La Junta is currently participating in a Water Environment Research Foundation (WERF) ZLD pilot study. For the purposes of the No Action, ZLD is assumed to be required.

- Lamar uses conventional water treatment processes for its alluvial wells, which includes chlorination and fluoridation. This treatment method would continue to be used in the future.
  - The well water is pumped through 3 separate conveyance pipelines to the chlorination facility. The chlorination facility is located on the same site as the two storage tanks located south of town.
  - Hypochlorite is generated on-site and added directly to the well water through a single combined pipe. The disinfected water is then conveyed to the storage tanks where contact time is achieved.
  - Fluoride is also added at the chlorination facility.

The existing treatment process schematics for the regional providers are shown in Figures 6 through 9. As a regional provider under No Action, the existing treatment processes would remain unchanged with the exception of La Junta using ZLD for brine disposal. Table 6 summarizes the regional systems supplies and treatment systems. Table 6 also summarizes any issues with the source water and if the source issues remain after treatment. The four regional providers have treatment schemes that produce finished water that complies with current Colorado Primary Drinking Water Regulations.


Underground Springs
Alluvial Wells
1
Chlorination Facility
(A)
Finished Water Storage
(B)
Distribution
Treatment Facilities
Process
(A) Chlorination
(B) Finished Water Storage
Treatment Objective
Disinfection
Disinfection Contact Time
Treatment Chemicals
1 Free-Chlorine
For Internal Use Only
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BLACK & VEATCH
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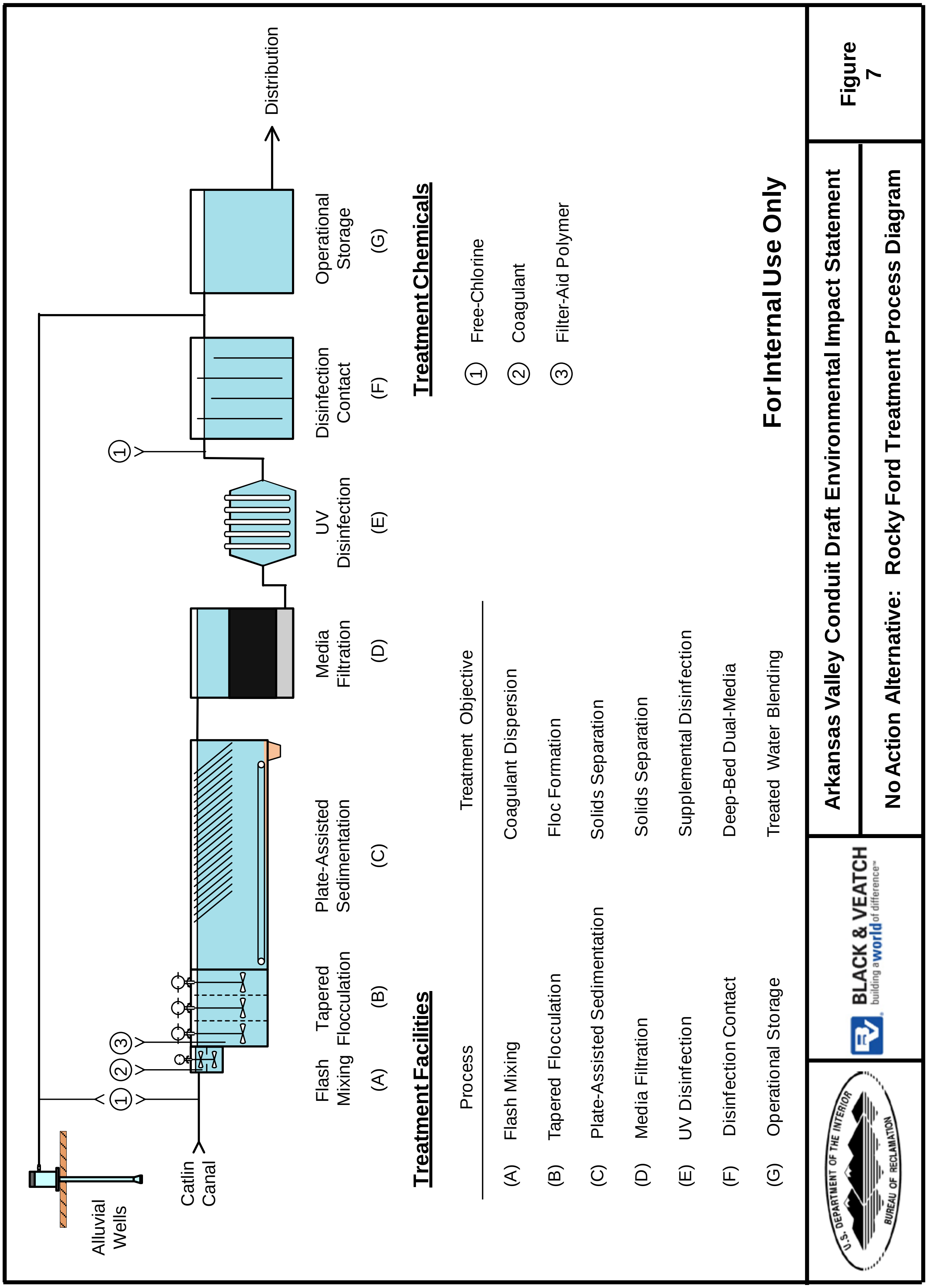
Arkansas Valley Conduit Draft Environmental Impact Statement
No Action Alternative: Fowler Treatment Process Diagram
Figure 6


Alluvial Wells
Catlin Canal
Distribution
Flash Mixing (A)
Tapered Flocculation (B)
Plate-Assisted Sedimentation (C)
Media Filtration (D)
UV Disinfection (E)
Disinfection Contact (F)
Operational Storage (G)
Treatment Facilities
Process
Treatment Objective
(A) Flash Mixing
Coagulant Dispersion
(B) Tapered Flocculation
Floc Formation
(C) Plate-Assisted Sedimentation
Solids Separation
(D) Media Filtration
Solids Separation
(E) UV Disinfection
Supplemental Disinfection
(F) Disinfection Contact
Deep-Bed Dual-Media
(G) Operational Storage
Treated Water Blending
Treatment Chemicals
1 Free-Chlorine
2 Coagulant
3 Filter-Aid Polymer
For Internal Use Only
Arkansas Valley Conduit Draft Environmental Impact Statement
No Action Alternative: Rocky Ford Treatment Process Diagram
Figure 7
BLACK & VEATCH
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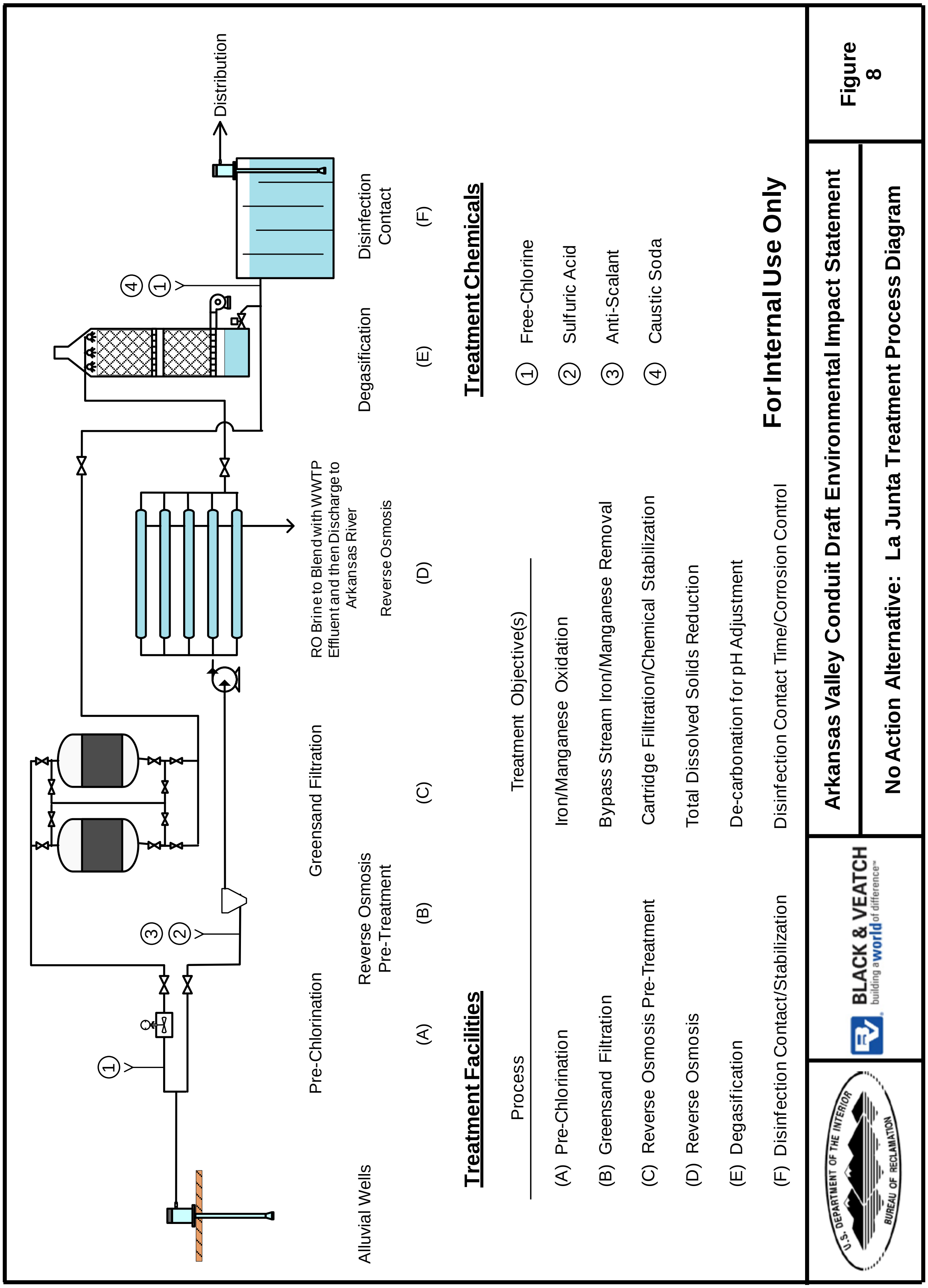
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION


Alluvial Wells
Pre-Chlorination
Reverse Osmosis Pre-Treatment
Greensand Filtration
RO Brine to Blend with WWTP Effluent and then Discharge to Arkansas River
Reverse Osmosis
Degasification
Disinfection Contact
Distribution
(A)
(B)
(C)
(D)
(E)
(F)
Treatment Facilities
Process
Treatment Objective(s)
(A) Pre-Chlorination
Iron/Manganese Oxidation
(B) Greensand Filtration
Bypass Stream Iron/Manganese Removal
(C) Reverse Osmosis Pre-Treatment
Cartridge Filltration/Chemical Stabilization
(D) Reverse Osmosis
Total Dissolved Solids Reduction
(E) Degasification
De-carbonation for pH Adjustment
(F) Disinfection Contact/Stabilization
Disinfection Contact Time/Corrosion Control
Treatment Chemicals
1 Free-Chlorine
2 Sulfuric Acid
3 Anti-Scalant
4 Caustic Soda
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U.S. DEPARTMENT OF THE INTERIOR
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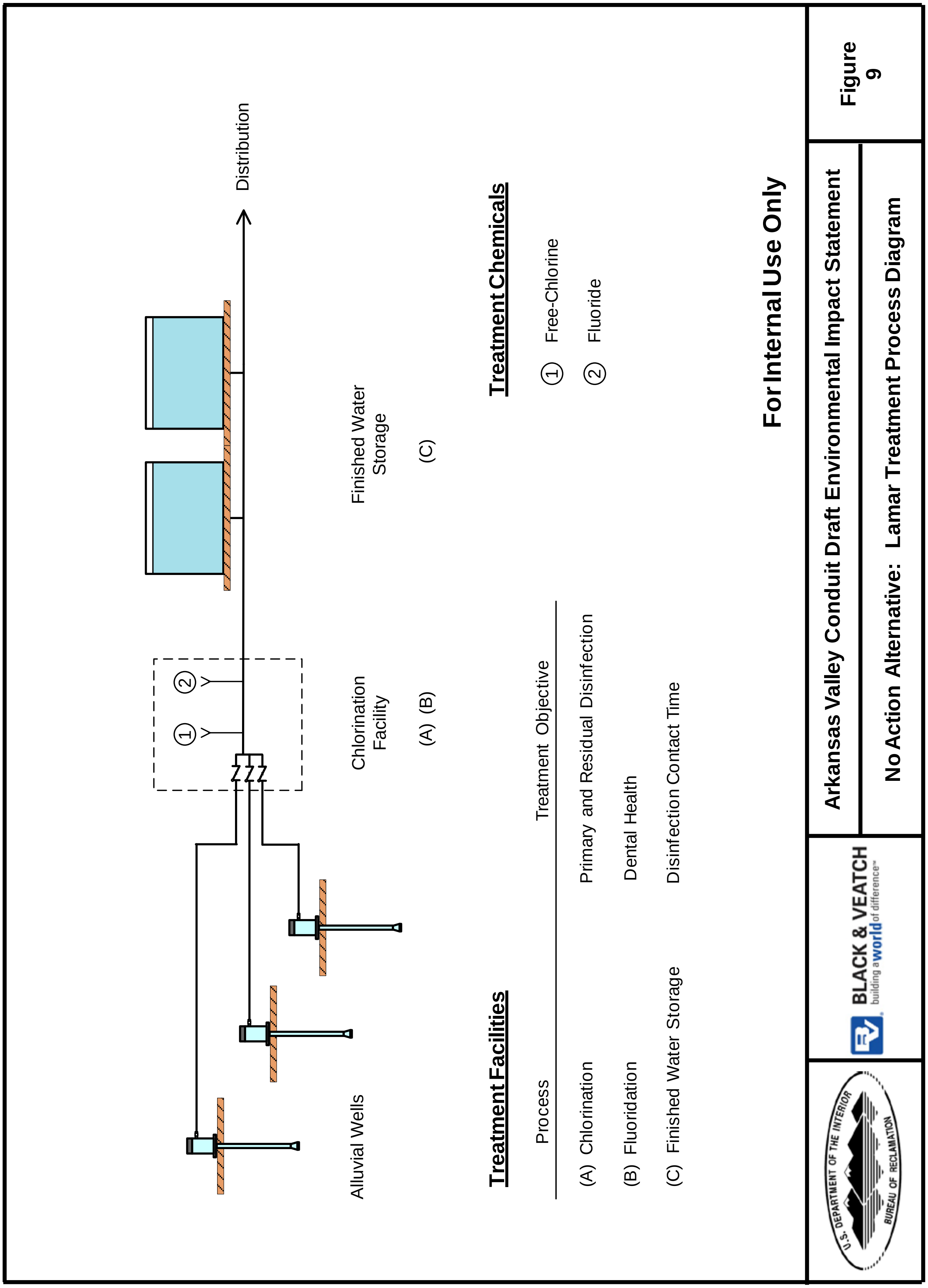
Arkansas Valley Conduit Draft Environmental Impact Statement
No Action Alternative: La Junta Treatment Process Diagram
Figure 8


Distribution
Alluvial Wells
Chlorination Facility
(A) (B)
Finished Water Storage
(C)
Treatment Chemicals
1 Free-Chlorine
2 Fluoride
Treatment Facilities
Process
Treatment Objective
(A) Chlorination
Primary and Residual Disinfection
(B) Fluoridation
Dental Health
(C) Finished Water Storage
Disinfection Contact Time
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No Action Alternative: Lamar Treatment Process Diagram
Figure 9

Table 6. Regional Systems Treatment Summary

Regional Provider	Participating Systems	Deep Bedrock	Alluvial	Surface	Issues with Source	Potential Continued Challenges with Treated Water	Enforcement Order	Treatment Method	System Age Years
Fowler	Fowler		X		Selenium	Selenium		North Springs - Chlorine, Hammond Springs - Chlorine, bag filter	22 (1)
	Valley Water Co.	X			Radium 226/228	Radium 226/228	Yes	Pressure filters (sand), chlorine gas	17 to 48 (1)
Rocky Ford	Rocky Ford		X	X	None reported	None known		Conventional	1 to ~50 (2)
	Hancock Inc.	X			GAA, radium 226/228	GAA, radium 226/228	Yes	Ozone, pressure filters (sand), sodium hypochlorite	42 (1)
	Hilltop Water Co.	X			Poor quality, no details	Poor quality, no details		Pressure filters (sand), sodium hypochlorite	53 (1)
	Vroman	X			Radium 226/228, iron	Radium 226/228, iron	Yes	Sodium hypochlorite, Pressure filters (sand/gravel/anthracite)	53 (1)
	West Grand Valley Water Inc.	X			Poor water quality, details not reported.	Poor water quality, details not reported.		Ozone, pressure filters (sand), calcium hypochlorite	10 to 54 (1)
La Junta	La Junta		X		Iron, manganese, TDS, selenium, uranium, radium, sulfate	Selenium, uranium, radium, sulfate		1) Cartridge filters, RO 2) Pressure filters (80/20 RO blend), OSG sodium hypochlorite	7 (3)
	Bents Fort Water Co.	X			None reported	None known		Sodium Hypochlorite	47 (1)
	Cheraw	X			Radium 226/228, iron, manganese	Radium 226/228, iron, manganese	Yes	Prechlorination, pressure filters (sand), post-chlorination	8 (1)
	East End Water Assn.	X			Radium 226/228	Radium 226/228	Yes	Clorox	Not reported (1)
	Holbrook Center Soft Water	X			Radium 226/228	Radium 226/228	Yes	Calcium hypochlorite	57 (1)
	Homestead Improvement Assn.	X			Radium 226/228	Radium 226/228	Yes	None	N/A (1)
	Swink	X			Radium 226/228, fluoride	Radium 226/228, fluoride	Yes	Not reported	35 (1)
Lamar	Lamar		X		Iron, manganese	Iron, manganese		OSG hypochlorite, fluoridation, sequestering agent	1 to 49 (4)
	May Valley Water Assn.	X			Radium 226/228, GAA	Radium 226/228, GAA	Yes	Pressure filters (sand), sodium hypochlorite	48 (1)

Key: GAA -- gross alpha particle activity, OSG -- on-site generated, RO -- reverse osmosis, TDS -- total dissolved solids

Notes:

(1) Condition of treatment system is unknown. No information is known on any system improvements and/or the schedule for improvements.
(2) Rocky Ford's WTP is generally in acceptable condition. No information is known on any system improvements and/or the schedule for improvements.
(3) La Junta's WTP is generally in good condition. No information is known on any system improvements and/or the schedule for improvements.
(4) Lamar's WTP is generally in good condition. No information is known on any system improvements and/or the schedule for improvements.

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Regional Systems Infrastructure

Additional infrastructure, including treatment expansion, wells, conveyance pipelines and pump stations, and/or storage, would be required to deliver water from the regional provider to the regional participant. The timing for these improvements is complicated by many factors including compliance requirements, growth rates, executed agreements between participants, funding, etc.; therefore, no completion dates were assigned for the improvements. The costs for the improvements are shown in January 2011 dollars (see Section 5 for further clarification).

Table 7 shows the existing well capacities of the regional provider and if additional wells would be required.

Table 8 lists the regional providers' current treatment capacity and needed expansion for 2070 demands (ZLD included).

Table 7. Regional Providers Well Capacities

Regional Provider	Participating Systems	No. of Existing Wells	Average Capacity Per Well (gal/min) (3)	Total Capacity (mgd)	Required Capacity (mgd) (Max Day)	Delivery Gap (mgd)	No. of Additional Wells Required
Fowler	Fowler	---	---	---	---	---	0
	Valley Water Co. (1)	---	---	---	---	---	0
	Fowler Regional System	6	780	6.73	0.56	0	0
Rocky Ford	Rocky Ford	---	---	---	---	---	0
	Hancock Inc. (1)	---	---	---	---	---	0
	Hilltop Water Co. (2)	---	---	---	---	---	0
	Vroman (1)	---	---	---	---	---	0
	West Grand Valley Water Inc. (2)	---	---	---	---	---	0
	Rocky Ford Regional System	3	950	4.1	2.5	0	0
La Junta	La Junta	---	---	---	---	---	0
	Bents Fort Water Co. (2)	---	---	---	---	---	1
	Cheraw (1)	---	---	---	---	---	
	East End Water Assn. (1)	---	---	---	---	---	
	Holbrook Center Soft Water (1)	---	---	---	---	---	
	Homestead Improvement Assn. (2)	---	---	---	---	---	
	Swink (1)	---	---	---	---	---	
	La Junta Regional System	13	855	16	5.57 (4)	0	1
Lamar	Lamar	---	---	---	---	---	2
	May Valley Water Assn. (1)	---	---	---	---	---	2
	Lamar Regional System	20	175	5.04	6.31 (5)	0.82	4

Notes:

(1) Existing contaminated wells would be abandoned.
(2) Existing wells would no longer be used.
(3) No information currently exists regarding service life of existing wells and/or aquifer depletion.
(4) La Junta also uses existing wells for RO brine blending. An additional well for the participants is needed for redundancy.
(5) Delivery gap for Lamar accounts for 213 ac-ft of wells from May Valley that would remain in service.

Table 8. Regional Systems Treatment Capacity and Expansion

Regional Provider	Participating Systems	Radionuclides (Health Department Enforcement Actions)	2010 Demand (ac-ft)	2010 Max Day (mgd)	2070 Demand (ac-ft)	2070 Max Day (mgd)	Deep GW Treatment Capacity Max Day (mgd)	Alluvial Treatment Capacity Max Day (mgd)	SW Treatment Capacity Max Day (mgd)	Total Treatment Capacity Max Day (mgd)	Treatment Expansion Max Day (mgd)	Additional Treatment Facilities
Fowler	Fowler [1]	No	210	0.45	222	0.48	---	6.73	---	6.73	---	---
	Valley Water Co.	Yes	38	0.08	39	0.08	---	---	---	---	---	---
	Fowler Regional System Total	No	248	0.53	261	0.56	---	6.73	---	6.73	0.00	None required
Rocky Ford	Rocky Ford [2]	No	890	1.91	1,032	2.21	---	4.10	3	7.10	---	---
	Hancock Inc.	Yes	17	0.04	18	0.04	---	---	---	---	---	---
	Hilltop Water Co.	No	45	0.10	50	0.11	---	---	---	---	---	---
	Vroman	Yes	32	0.07	37	0.08	---	---	---	---	---	---
	West Grand Valley Water Inc.	No	25	0.05	30	0.06	---	---	---	---	---	---
	Rocky Ford Regional System Total	No	1,009	2.17	1,167	2.50	---	4.10	3.00	7.10	0.00	None required
La Junta	La Junta [3]	No	2,040	4.37	2,417	5.18	---	6.60	---	6.60	---	---
	Bents Fort Water Co.	No	63	0.13	55	0.12	---	---	---	---	---	---
	Cheraw	Yes	48	0.10	57	0.12	---	---	---	---	---	---
	East End Water Assn.	Yes	11	0.02	13	0.03	---	---	---	---	---	---
	Holbrook Center Soft Water	Yes	18	0.04	22	0.05	---	---	---	---	---	---
	Homestead Improvement Assn.	Yes	7	0.01	7	0.01	---	---	---	---	---	---
	Swink	Yes	38	0.08	30	0.06	---	---	---	---	---	---
	La Junta Regional System Total	No	2,225	4.75	2,601	5.57	---	6.60	---	6.60	0.36	2.2 mgd RO skid, ZLD for RO concentrate disposal
Lamar	Lamar [4]	No	2,400	5.14	2,511	5.38	---	5.5	---	5.50	---	---
	May Valley Water Assn.	Yes	410	0.88	435	0.93	---	---	---	---	---	---
	Lamar Regional System Total	No	2,810	6.02	2,946	6.31	---	5.50	---	5.50	2.39	Chlorination and fluoridation capacity expansion in existing building

Key: GW – ground water, SW – surface water

Notes:

(1) Regional Provider: current alluvial well capacity (6 wells) is 4,675 gal/min or 6.73 mgd.
(2) Regional Provider: current treatment capacity is 3 mgd SW WTP and 3 wells (950 gal/min average) at 4.1 mgd or 7.1 mgd.
(3) Regional Provider: current capacity of RO facility is 6.6 mgd.
(4) Regional Provider: current capacity of chlorination facility is 5.5 mgd.

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Infrastructure improvements for the regional systems (providers and participants) are summarized below.

Fowler Regional System

Fowler

- No new alluvial wells would be required.
- No treatment expansion would be required.

Valley Water Co.

- A new pipeline (6" diameter, 27,050 feet long) from the Fowler Tank to Valley Water.
- A new storage tank sized for twice the maximum day demand (160,000 gallons).
- Decommissioning of existing contaminated facilities and wells (not included in costs).

Rocky Ford Regional System

Rocky Ford

- No new alluvial wells would be required.
- No treatment expansion would be required.

Hancock Inc.

- Rocky Ford currently provides 100% of Hancock's water.
- A new storage tank sized for twice the maximum day demand (80,000 gallons).
- Decommissioning of existing contaminated facilities and wells (not included in costs).

Hilltop Water Co.

- A new pipeline (4" diameter, 2,500 feet long plus 7,500 feet shared capacity with West Grand Valley of a 6" pipe) from the Rocky Ford WTP to Hilltop. The pipeline would be upsized to 6" between Rocky Ford and the tap for Hilltop.
- A pumping station located at the Rocky Ford WTP site. Capacity would be shared with West Grand Valley and Vroman.
- Use existing storage tank.

Vroman

- A pumping station located at the Rocky Ford WTP site. Capacity would be shared with West Grand Valley and Hilltop.
- A new pipeline (6" diameter, 49,260 feet long) from the Rocky Ford WTP to Vroman.
- A new storage tank sized for twice the maximum day demand (160,000 gallons).
- Decommissioning of existing contaminated facilities and wells (not included in costs).

West Grand Valley Water Inc.

- A new pipeline (4" diameter, 19,820 feet long plus 7,500 feet shared capacity with Hilltop of a 6" pipe) from the Rocky Ford WTP to West Grand Valley. The pipeline would be upsized to 6" between Rocky Ford and the tap for Hilltop.

- A pumping station located at the Rocky Ford WTP site. Capacity would be shared with Hilltop and Vroman.
- A new storage tank sized for twice the maximum day demand (120,000 gallons).

La Junta Regional System

La Junta

- Acquire 2 ac-ft of fully consumable water right at same location as alluvial wells (not included in costs).
- 1 new raw water alluvial well (new well would be for regional partners).
- New raw water conveyance pipeline from wells to WTP (12" diameter, 8,660 feet long).
- Expand WTP by adding fourth bank of RO membranes (2.2 mgd expansion) (expansion would be only for regional partners).
- New pipeline crossing (12" diameter, total length of 950 feet) of Arkansas River and Ft Lyon Canal to provide redundancy for Bents Fort, Cheraw, East End, and Holbrook.
- Regional partners to north would receive water directly from a new storage tank located west of the airport that would be supplied from La Junta's existing system. The new storage tank would be sized for twice the maximum day demand of Cheraw, East End, and Holbrook Center Soft Water (400,000 gallons).
- New brine disposal evaporation ponds (25 acres).
- New RO concentrators and management facility.
- New pipeline from the WTP to the brine disposal ponds (4" diameter, 10,500 feet long).
- A pumping station to pump the brine from the WTP to the brine disposal ponds (0.05 mgd, 120 ft TDH).

Bents Fort Water Co.

- Bents Fort already receives a portion of its water from La Junta. Assume that no new facilities would be required to receive additional water.

Cheraw

- Acquire 1 ac-ft of fully consumable water right at same location as La Junta's alluvial wells (not included in costs).
- Cheraw would receive water directly from La Junta's existing tank located west of the airport. A single pipeline (6" diameter, 17,070 feet) with shared capacity with East End and Holbrook would extend from La Junta's storage tank to the intersection of Highway 266 and 109.
- A new pipeline (6" diameter, 13,270 feet long) from the intersection of Highway 266 and 109 to Cheraw.
- Use existing storage tank.
- Decommissioning of existing contaminated facilities and wells (not included in costs).

East End Water Assn.

- East End would receive water directly from La Junta's existing tank located west of the airport. A single pipeline (6" diameter, 17,070 feet) with shared capacity with Cheraw

and Holbrook would extend from La Junta's storage tank to the intersection of Highway 266 and 109.
- A new pipeline (4" diameter, 28,650 feet long) from the intersection of Highway 266 and 109 to East End.
- A new storage tank sized for twice the maximum day demand (60,000 gallons).
- Decommissioning of existing contaminated facilities and wells (not included in costs).

<u>Holbrook Center Soft Water</u>
- Acquire 1 ac-ft of fully consumable water right at same location as La Junta's alluvial wells (not included in costs).
- Holbrook would receive water directly from La Junta's existing tank located west of the airport. A single pipeline (6" diameter, 17,070 feet) with shared capacity with East End and Cheraw would extend from La Junta's storage tank to the intersection of Highway 266 and 109.
- A new pipeline (4" diameter, 10,650 feet long) from the intersection of Highway 266 and 109 to Holbrook.
- A new storage tank sized for twice the maximum day demand (100,000 gallons).
- Decommissioning of existing contaminated facilities and wells (not included in costs).

<u>Homestead Improvement Assn.</u>
- La Junta currently provides 100% of Homestead's water. No improvements required.

<u>Swink</u>
- A new pipeline (6" diameter, 11,100 feet long) extending from La Junta's existing system at Wal-Mart to Swink. The pipeline would be along Highway 50. A larger pipe would be used to reduce friction loss to eliminate pumping.
- Use existing storage tank.
- Decommissioning of existing contaminated facilities and wells (not included in costs).

<u>Lamar Regional System</u>

<u>Lamar</u>
- 4 new raw water alluvial wells (2 for Lamar and 2 for May Valley).
- Wells pump directly to existing storage tanks (116 ft TDH).
- New conveyance pipeline for 4 new wells to existing storage tanks (12" diameter, 49,425 feet long).

<u>May Valley Water Assn.</u>
- Shared raw water wells and conveyance with Lamar (see Lamar).
- Expansion of Lamar's chlorination facility for May Valley's additional capacity.
- New conveyance pipeline from Lamar's existing storage tanks to a new storage tank on the north side of May Valley's system (10" diameter, 101,810 feet long).
- New pump station at Lamar's existing storage tanks to pump May Valley's water to its storage tank (0.5 mgd, 305 ft TDH). Pump station would be equipped with a master meter.

- New 0.56 MG storage tank on the north side of May Valley's system.
- Decommissioning of existing contaminated facilities and wells (not included in costs).

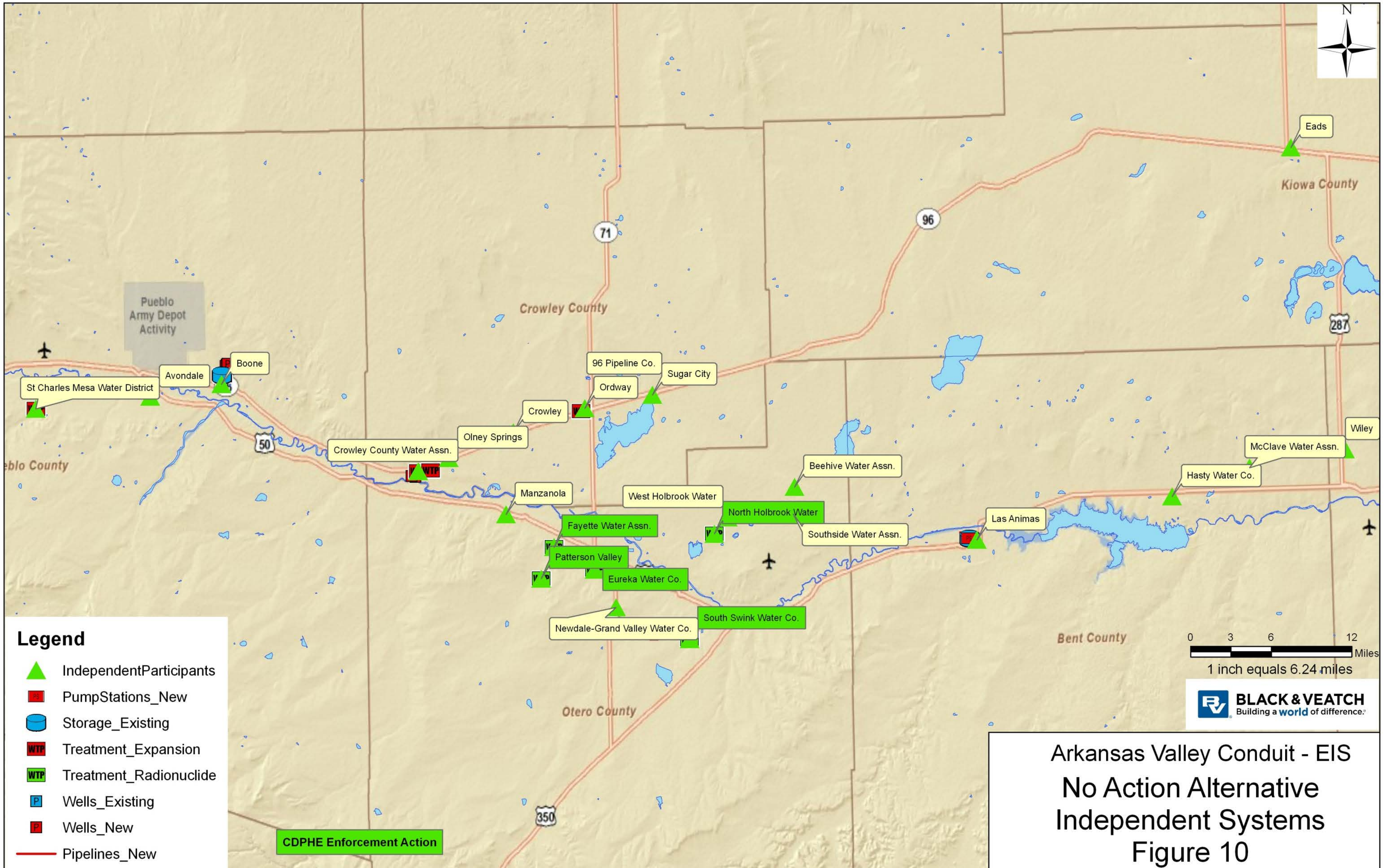
Independent Systems

The independent system participants would continue to meet their own drinking water needs and would not supply other systems. The independent systems would expand or modify their existing facilities as required to satisfy increased demand or comply with additional treatment requirements. All independent systems would meet primary drinking water regulations including any required treatment upgrades to be in compliance for radionuclides. Attainment of secondary standards (TDS, hardness, etc.) would be similar to existing conditions; no additional treatment to meet secondary standards is included in this No Action Alternative.

Table 9 presents those AVC participants that would continue to operate independently under the AVC No Action Alternative. Additional infrastructure including pipelines, wells, and/or treatment upgrades would be required to meet 2070 demands and/or primary drinking water regulations. An overview map of the independent systems is presented in Figure 10.

Table 9. Independent Systems

County	Independent Participant	Health Department Enforcement Action
Pueblo	Avondale	No
	Boone	No
	St. Charles Mesa Water District	No
Crowley	96 Pipeline	No
	Crowley County Water Assn.	No
	Crowley	No
	Ordway	No
	Olney Springs	No
	Sugar City	No
Otero	Beehive Water Assn.	No
	Eureka Water Co.	Yes
	Fayette Water Assn.	Yes
	Manzanola	No
	Newdale-Grand Valley Water Co.	No
	North Holbrook Water	Yes
	Patterson Valley	Yes
	South Side Water Assn.	No
	South Swink Water Co.	Yes
	West Holbrook Water	No
Bent	Hasty Water Co.	No
	Las Animas	No
	McClave Water Assn.	No
Prowers	Wiley	No
Kiowa	Eads	No


N
Eads
Kiowa County
96
71
287
Pueblo Army Depot Activity
Crowley County
96 Pipeline Co.
Sugar City
Ordway
Boone
Avondale
St Charles Mesa Water District
Crowley
Olney Springs
Crowley County Water Assn.
50
Pueblo County
Wiley
McClave Water Assn.
Hasty Water Co.
Beehive Water Assn.
Manzanola
West Holbrook Water
North Holbrook Water
Southside Water Assn.
Las Animas
Fayette Water Assn.
Patterson Valley
Eureka Water Co.
South Swink Water Co.
Newdale-Grand Valley Water Co.
Bent County
0 3 6 12 Miles
1 inch equals 6.24 miles
BLACK & VEATCH
Building a world of difference.
Otero County
350
Legend
IndependentParticipants
PumpStations_New
Storage_Existing
Treatment_Expansion
Treatment_Radionuclide
Wells_Existing
Wells_New
Pipelines_New
CDPHE Enforcement Action
Arkansas Valley Conduit - EIS
No Action Alternative
Independent Systems
Figure 10

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Independent System Demands

The No Action Alternative is based on meeting participant demands in 2070, the same demands as for the action alternatives. The current and 2070 demands for the independent participants are shown in Table 10.

Table 10. Independent Systems Current and 2070 Demands

Independent Participant	Current Demand (ac-ft)	Current Max Day [(1)] (mgd)	2070 Demand [(2)] (ac-ft)	2070 Max Day (mgd)
Avondale	160	0.34	237	0.51
Boone	66	0.14	111	0.24
St. Charles Mesa Water District	1,660	3.56	2,698	5.78
96 Pipeline	56	0.12	52	0.11
Crowley County Water Assn.	564	1.21	824	1.77
Crowley	27	0.06	65	0.14
Ordway	250	0.54	414	0.89
Olney Springs	40	0.09	60	0.13
Sugar City	82	0.18	128	0.27
Beehive Water Assn.	8	0.02	6	0.01
Eureka Water Co. [(3)]	74	0.16	86	0.18
Fayette Water Assn. [(3)]	12	0.03	14	0.03
Manzanola	39	0.08	37	0.08
Newdale-Grand Valley Water Co.	57	0.12	60	0.13
North Holbrook Water [(3)]	7	0.01	8	0.02
Patterson Valley [(3)]	15	0.03	17	0.04
South Side Water Assn.	7	0.01	7	0.01
South Swink Water Co. [(3)]	82	0.18	88	0.19
West Holbrook Water	14	0.03	18	0.04
Hasty Water Co.	32	0.07	33	0.07
Las Animas	570	1.22	604	1.29
McClave Water Assn.	56	0.12	59	0.13
Wiley	24	0.05	16	0.03
Eads	250	0.54	232	0.50
Total Vol. Meeting Primary Drinking Water Regulations	3,962	---	5,661	---
Total Vol. Not Meeting Primary Drinking Water Regulations	190	---	213	---

Notes:
(1) Average day to maximum day ratio of 2.4 used for all participants.
(2) Current and 2070 demands (ac-ft) are from "AVC Preliminary Water Demands" MWH (December 16, 2010) which developed preliminary water demands for use in this memorandum and the Appraisal Design Report (Reclamation 2012). These estimates have since been updated in the EIS. This table and the No Action Alternative analysis continue the use of the preliminary estimates to be consistent with the Appraisal Design Report (Reclamation 2012).
(3) Health Department Enforcement Action.

Independent System Water Supplies

Independent participants would continue using existing water supplies that meet primary drinking water regulations. Additional treatment would occur for other existing supplies that do not meet radionuclide standards. The independent systems with supplies that require additional treatment would be Eureka Water Co., Fayette Water Assn., Patterson Valley, South Swink Water Co., and North Holbrook Water.

To meet future water demands in 2070, additional water supplies would be needed by some participants. Each of the independent systems typically uses either deep bedrock groundwater or alluvial groundwater. St. Charles Mesa is the only independent participant who also uses surface water in addition to its alluvial groundwater. The existing water supplies are listed in Table 11. The surface water supplies in Table 11 do not require augmentation water and would be used at a WTP. The available augmentation water is listed in Table 12.

Table 11. Independent Systems Existing Supplies

Independent Participant	Deep Wells (ac-ft)	Alluvial Wells (ac-ft)	Surface Water Supplies (ac-ft)	Total Existing Supplies (ac-ft)
Avondale	0	160	0	160
Boone	0	66	0	66
St. Charles Mesa Water District	0	200	1,898	2,098
96 Pipeline	0	44	0	44
Crowley County Water Assn.	0	701	0	701
Crowley	0	27	0	27
Ordway	0	125	0	125
Olney Springs	0	40	0	40
Sugar City	0	82	0	82
Beehive Water Assn.	8	0	0	8
Eureka Water Co.	74	0	0	74
Fayette Water Assn.	12	0	0	12
Manzanola	10	29	0	39
Newdale-Grand Valley Water Co.	57	0	0	57
North Holbrook Water	7	0	0	7
Patterson Valley	15	0	0	15
South Side Water Assn.	7	0	0	7
South Swink Water Co.	86	0	0	86
West Holbrook Water	14	0	0	14
Hasty Water Co.	32	0	0	32
Las Animas	0	570	0	570
McClave Water Assn.	56	0	0	56
Wiley	24	0	0	24
Eads	0	266	0	266

Independent participants would most likely seek additional water supplies of the type(s) they currently use. The most likely source of additional supplies would be additional groundwater, except for St. Charles Mesa who would likely use additional surface water (no additional water rights would be required for St. Charles Mesa to expand their WTP to meet 2070 demands). The participants would most likely use the same type of groundwater already available to them; those participants who use deep bedrock groundwater would seek additional deep bedrock groundwater supplies, and those participants who use alluvial groundwater would seek additional alluvial groundwater supplies. It is assumed that the additional groundwater supplies would be readily available at each location.

Because alluvial groundwater pumping affects surface water flows in the Arkansas River, it must be offset by releasing augmentation water to the river to compensate for depletions to surface water flows. Those participants using alluvial groundwater would release their Fry-Ark Project water to the Arkansas River for augmentation use. Participants who would continue to use deep bedrock groundwater that does not require augmentation would likely not require their Fry-Ark

Project water and could make that Fry-Ark Project water available to other AVC participants who require additional augmentation water. Table 12 lists the participants Fry-Ark Project water and other water rights available for augmentation.

Table 13 shows the demand that could be met with the existing water rights and if any additional water rights would be required to meet 2070 demands. Some participants could benefit from additional storage in Pueblo Reservoir for the additional augmentation supplies. St. Charles Mesa likely would use additional surface water supplies and may require additional storage to use their Bessemer Ditch shares. Olney Springs and Ordway have identified a need for storage, even if the AVC were not built to facilitate leases of their excess supplies to other entities. The configuration of excess capacity contracts for the No Action Alternative is addressed in Chapter 2 of the AVC EIS.

Table 12. Independent Systems Existing Water Allocations/Rights

Independent Participant	(1) Total Fry-Ark Project Water Allocation (ac-ft)	(2) (3) Total Other Water Rights (ac-ft)	Total Water Allocations / Rights (ac-ft)
Avondale	134	0	134
Boone	40	0	40
St. Charles Mesa Water District	1,072	4,665	5,737
96 Pipeline	22	0	22
Crowley County Water Assn.	392	14	406
Crowley	21	41	61
Ordway	136	289	426
Olney Springs	43	61	103
Sugar City	44	48	92
Beehive Water Assn.	16	0	16
Eureka Water Co.	44	0	44
Fayette Water Assn.	7	0	7
Manzanola	58	100	158
Newdale-Grand Valley Water Co.	51	0	51
North Holbrook Water	6	0	6
Patterson Valley	10	0	10
South Side Water Assn.	4	0	4
South Swink Water Co.	64	0	64
West Holbrook Water	2	0	2
Hasty Water Co.	28	0	28
Las Animas	375	50	425
McClave Water Assn.	43	0	43
Wiley	49	0	49
Eads	76	0	76

Notes:

(1) Includes Fry-Ark Project water and NPANIW allocations and Fry-Ark flows that may be purchased from SECWCD. Also includes Arkansas River transit loss reduction between Pueblo Reservoir and participant location.

(2) Includes transit loss reduction from source to participant location.

(3) Colorado Canal and Lake Meredith shares were not included because their dry year yield is nearly zero.

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Table 13. Independent Systems Demand vs. Water Rights [8]

Independent Participant	Column 1 Total Existing Supplies (ac-ft) [1]	Column 2 Total Water Allocations / Rights Available (ac-ft) [2]	Column 3 Water Rights Used for Existing Demand (ac-ft) [3][4]	Column 4 Additional Well Supplies Available Using Remaining Water Rights (ac-ft) [4] [5]	Column 5 Total Potential Supplies That Could be Produced and Therefore Demand That Could Be Met with Existing Water Rights (ac-ft) [6]	Column 6 2070 Demand (ac-ft) [7]	Column 7 Additional Water Rights Required (ac-ft) (2:1 Ratio) [4] [8]
Avondale	160	134	80	109	269	237	0
Boone	66	40	33	15	81	111	15
St. Charles Mesa Water District	2,098	5,737	100	1,945	8,708	2,698	0
96 Pipeline	44	22	22	0	44	52	4
Crowley County Water Assn.	701	406	351	111	812	824	6
Crowley	27	61	14	96	123	65	0
Ordway	125	426	0	851	976	414	0
Olney Springs	40	103	20	167	207	60	0
Sugar City	82	92	41	102	184	128	0
Beehive Water Assn.	8	16	0	33	8	6	0
Eureka Water Co.	74	44	0	88	86	86	0
Fayette Water Assn.	12	7	0	13	14	14	0
Manzanola	39	158	15	287	326	37	0
Newdale-Grand Valley Water Co.	57	51	0	101	60	60	0
North Holbrook Water	7	6	0	13	8	8	0
Patterson Valley	15	10	0	20	17	17	0
South Side Water Assn.	7	4	0	9	7	7	0
South Swink Water Co.	86	64	0	127	88	88	0
West Holbrook Water	14	2	0	4	18	18	0
Hasty Water Co.	32	28	0	56	33	33	0
Las Animas	570	425	285	281	851	604	0
McClave Water Assn.	56	43	0	86	59	59	0
Wiley	24	49	0	99	24	16	0
Eads	266	76	76	0	266	232	0

Notes:
(1) From Table 11.
(2) From Table 12.
(3) Based on a 2:1 ratio of existing alluvial supplies. Alluvial supplies of column 1 divided by 2, but no greater than column 2.
(4) Because alluvial groundwater pumping affects surface water flows in the Arkansas River, it must be offset by releasing augmentation water to the river to compensate for depletions to surface water flows. Averaged over an entire year, it is assumed that for every 2 gallons of alluvial groundwater pumped; one gallon is consumed and must be replaced with surface water released from another source (augmentation water). The other gallon that is pumped is replaced by return flows from the participant.
(5) Based on a 2:1 ratio. (Column 2 minus Column 3) times 2. St. Charles Mesa Bessemer Ditch water (4,665 ac-ft) is used as a surface water supply for the WTP.
(6) Total existing supplies plus additional well supplies available. Column 1 plus Column 4. For participants solely on deep wells, this value is the maximum of the 2070 and current demand.
(7) From Table 10.
(8) Additional water rights are based on a 2:1 ratio. (Column 6 minus Column 5) divided by 2.

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Independent Systems Water Treatment

All of the independent participants would continue to use their existing water treatment processes (typically only chlorination of groundwater) except for Eureka Water Co., Fayette Water Assn., Patterson Valley, South Swink Water Co., and North Holbrook Water. These participants would upgrade their existing conventional WTPs to use preformed hydrous manganese oxide (HMO) filtration technology. This technology is effective at removing radium from water. If the HMO system is properly designed and appropriately operated, it would bring these systems into compliance with radionuclide standards. The HMO treatment process diagram is shown in Figure 11.

Spent filter media from these treatment plants likely would contain high levels of radionuclides, and therefore require specialized disposal. If anticipated exposure to workers would be greater than 25 millirems per year, a radioactive materials license may be required. A radioactive materials license requires facilities to have more detailed procedures and training for working in and around radioactive materials, in addition to periodic inspections and licensure fees. The HMO training, inspection, licensing, and disposal costs would be included in the operation and maintenance costs. Preformed HMO filtration technology is not designed to remove dissolved solids from water. Therefore, water quality for these participants still might not meet secondary water quality standards despite upgraded radionuclide treatment systems.

Except for Las Animas, all of the other participants would use existing conventional treatment technology. Las Animas uses RO water treatment. This treatment facility was constructed in 1996. Similar to La Junta, Las Animas currently mixes brine from the RO process with their wastewater treatment plant effluent and discharges it to the Arkansas River. In the future, brine disposal techniques could include residuals minimization strategies and ZLD techniques. For the purposes of the No Action, ZLD is assumed to be required.

Table 14 summarizes the independent systems supplies and treatment systems. Table 14 also summarizes any issues with the source water and if the source issues remain after treatment.

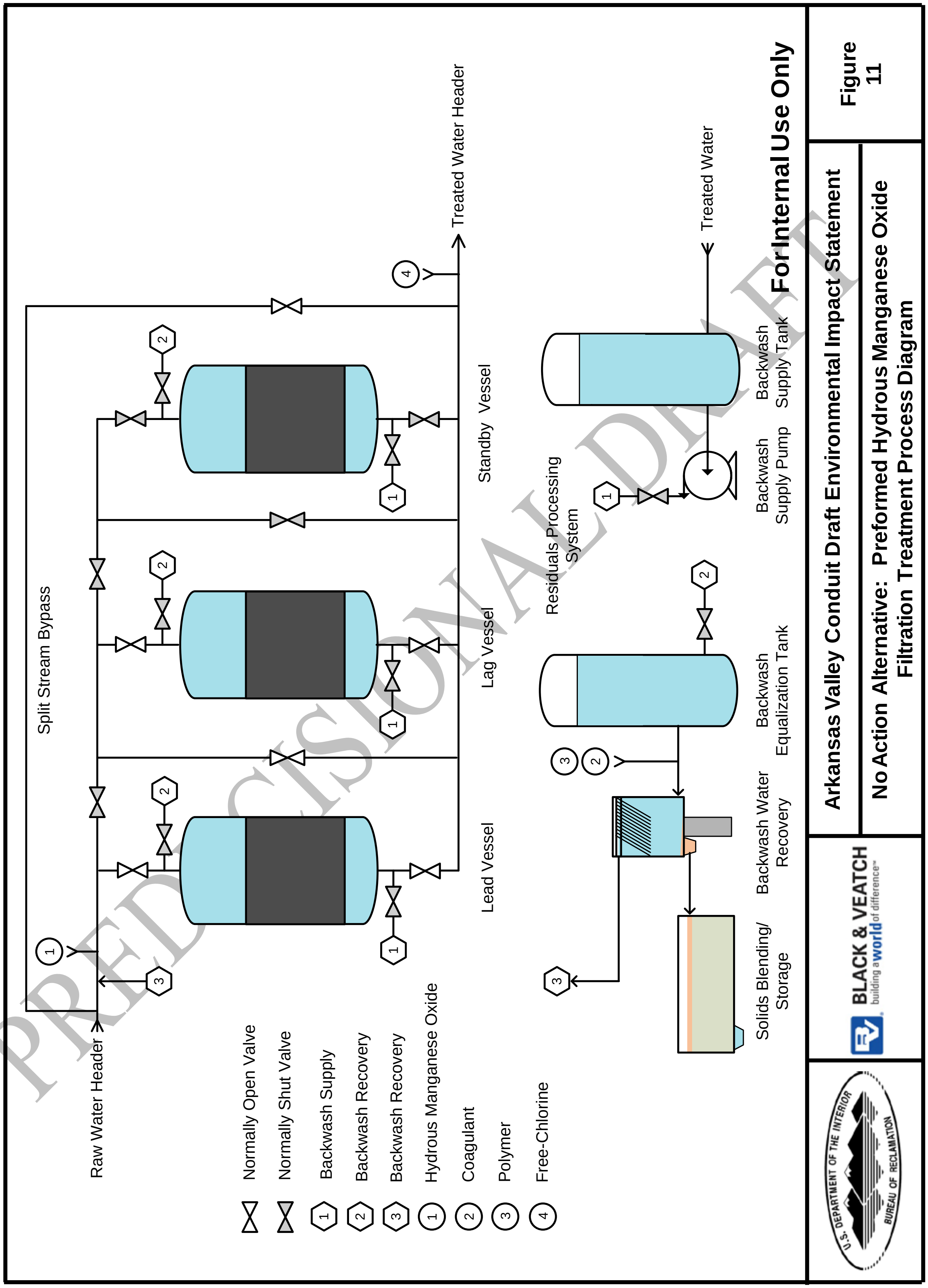
Treated Water Header
Split Stream Bypass
Standby Vessel
Lag Vessel
Lead Vessel
Raw Water Header
Residuals Processing System
Treated Water
Backwash Supply Tank
Backwash Supply Pump
Backwash Equalization Tank
Backwash Water Recovery
Solids Blending/ Storage
Normally Open Valve
Normally Shut Valve
Backwash Supply
Backwash Recovery
Backwash Recovery
Hydrous Manganese Oxide
Coagulant
Polymer
Free-Chlorine
For Internal Use Only
PREDECISIONAL DRAFT
Arkansas Valley Conduit Draft Environmental Impact Statement
No Action Alternative: Preformed Hydrous Manganese Oxide Filtration Treatment Process Diagram
Figure 11
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Table 14. Independent Systems Treatment Summary

Independent Participant	Deep Bedrock	Alluvial	Surface	Issues with Source	Potential Continued Challenges with Treated Water	Enforcement Order	Treatment Method	System Age Years (1)
Avondale		X		TNT residual	TNT residual		Pressure filters (greensand), GAC	40
Boone, Town of		X		None reported	None known		Chlorine gas	49
St. Charles Mesa Water District		X	X	None reported	None known		Chlorine dioxide, PAC, alum, polymer, Micro-Floc TR840, chlorine	33
96 Pipeline Company		X		None reported	None known		Not reported	Not reported
Crowley County Water Assoc.		X		None reported	None known		Chlorine gas	Not reported
Crowley, Town of		X		Hardness	Hardness		Not reported	Not reported
Ordway, Town of		X		Poor quality, no details	Poor quality, no details		Not reported	Not reported
Olney Springs, Town of		X		Selenium, manganese	Selenium, manganese		Chlorine gas	Not reported
Sugar City, Town of		X		None reported	None known		Not reported	Not reported
Beehive Water Association	X			None Reported	None known		Not reported	Not reported
Eureka Water Co.	X			GAA, radium 226/228	GAA, radium 226/228	Yes	Filtration, sodium hypochlorite	44
Fayette Water Assn.	X			Radium 226/228	Radium 226/228	Yes	Chlorination, filtration	53
Manzanola, Town of	X			Radium 226/228, uranium, hardness	Radium 226/228, uranium, hardness		Pressure filters, blending, chlorine gas	8
Newdale-Grand Valley Water Co.	X			Radionuclides	Radionuclides		Pressure filters (greensand), chlorine gas	47
North Holbrook Water	X			Radium 226/228	Radium 226/228	Yes	Not reported	Not reported
Patterson Valley	X			GAA, radium 226/228	GAA, radium 226/228	Yes	Conventional, bleach	50
South Side Water Assoc. (La Junta)	X			None reported	None known		Not reported	Not reported
South Swink Water Co.	X			Gross Alpha, Radium 226/228, TDS, Iron	Gross Alpha, Radium 226/228, TDS, Iron	Yes	Chlorine gas, pressure filters (sand/anthracite)	52
West Holbrook Water	X			None reported	None known		Not reported	Not reported
Hasty Water Company	X			Iron	Iron		Chlorine gas	Not reported
Las Animas, City of		X		Poor quality, no details	Poor quality, no details		RO	15
McClave Water Assoc.	X			Fluoride, Radium 226/228	Fluoride, Radium 226/228		Blending. sodium hypochlorite	None
Wiley, Town of	X			None reported	None known		Chlorination, filtration	6
Eads, Town of		X		Alkalinity, hardness, TDS	Alkalinity, hardness, TDS		Blended phosphates and chlorine gas	21

Key: GAA -- gross alpha particle activity, GAC -- granular activated carbon, PAC -- powdered activated carbon, RO -- reverse osmosis, TDS -- total dissolved solids

Note:

(1) Condition of treatment system is unknown. No information is known on any system improvements and/or the schedule for improvements.

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Independent Systems Infrastructure

Additional infrastructure including treatment expansion/modifications, wells, conveyance pipelines and pump stations, and/or storage would be required for each independent participant. The timing for these improvements would be complicated by many factors including compliance requirements, growth rates, funding, etc.; therefore, no completion dates were assigned for the improvements. The costs for the improvements are shown in January 2011 dollars (see Section 5 for further clarification).

Figures 12 through 15 show the layouts of the independent systems with significant modifications. Table 15 shows the existing well capacities and if additional wells would be required.

Table 15. Independent Systems Well Capacities

Independent Participant	No. of Existing Wells	Average Capacity Per Well (gal/min) (1	Total Capacity (mgd)	Required Capacity (mgd) (Max Day)	Delivery Gap (mgd)	No. of Additional Wells Required
Avondale	3	200	0.866	0.51	0	0
Boone	10	10	0.14	0.24	0.10	8
St. Charles Mesa Water District	4	150	0.86	1.78	0.92 (2)	0
96 Pipeline	0	---	---	---	---	---
Crowley County Water Assn.	1	550	0.79	1.7	0.91	2
Crowley	5	69	0.5	0.14	0	0
Ordway	8	23	0.27	0.27	0	0
Olney Springs	1	300	0.43	0.13	0	0
Sugar City	4	86	0.5	0.27	0	0
Beehive Water Assn.	3	5	0.02	0.01	0	0
Eureka Water Co.	3	41	0.18	0.18	0	0
Fayette Water Assn.	1	30	0.04	0.03	0	0
Manzanola	4	14	0.08	0.08	0	0
Newdale-Grand Valley Water Co.	4	312	1.8	0.13	0	0
North Holbrook Water	1	7	0.01	0.02	0.01	1
Patterson Valley	1	30	0.04	0.04	0	0
South Side Water Assn.	2	8	0.02	0.01	0	0
South Swink Water Co.	4	31	0.18	0.19	0.01	1
West Holbrook Water	2	13	0.04	0.04	0	0
Hasty Water Co.	3	26	0.11	0.07	0	0
Las Animas	9	94	1.22	1.29	0.07 (3)	0
McClave Water Assn.	4	27	0.15	0.13	0	0
Wiley	1	35	0.05	0.03	0	0
Eads	4	174	1.0	0.5	0	0

Notes:
(1) No information was known regarding service life of existing wells and/or aquifer depletion.
(2) Rather than drilling additional wells, the WTP would be expanded.
(3) Existing well capacity is unknown. Due to variations in peak day demand factor, and that it is likely the existing wells pump around 1.5 times max day demand for RO brine blending, a new well is not needed.

Table 16 lists the independent systems' current treatment capacity and needed expansion for 2070 demands (ZLD included).

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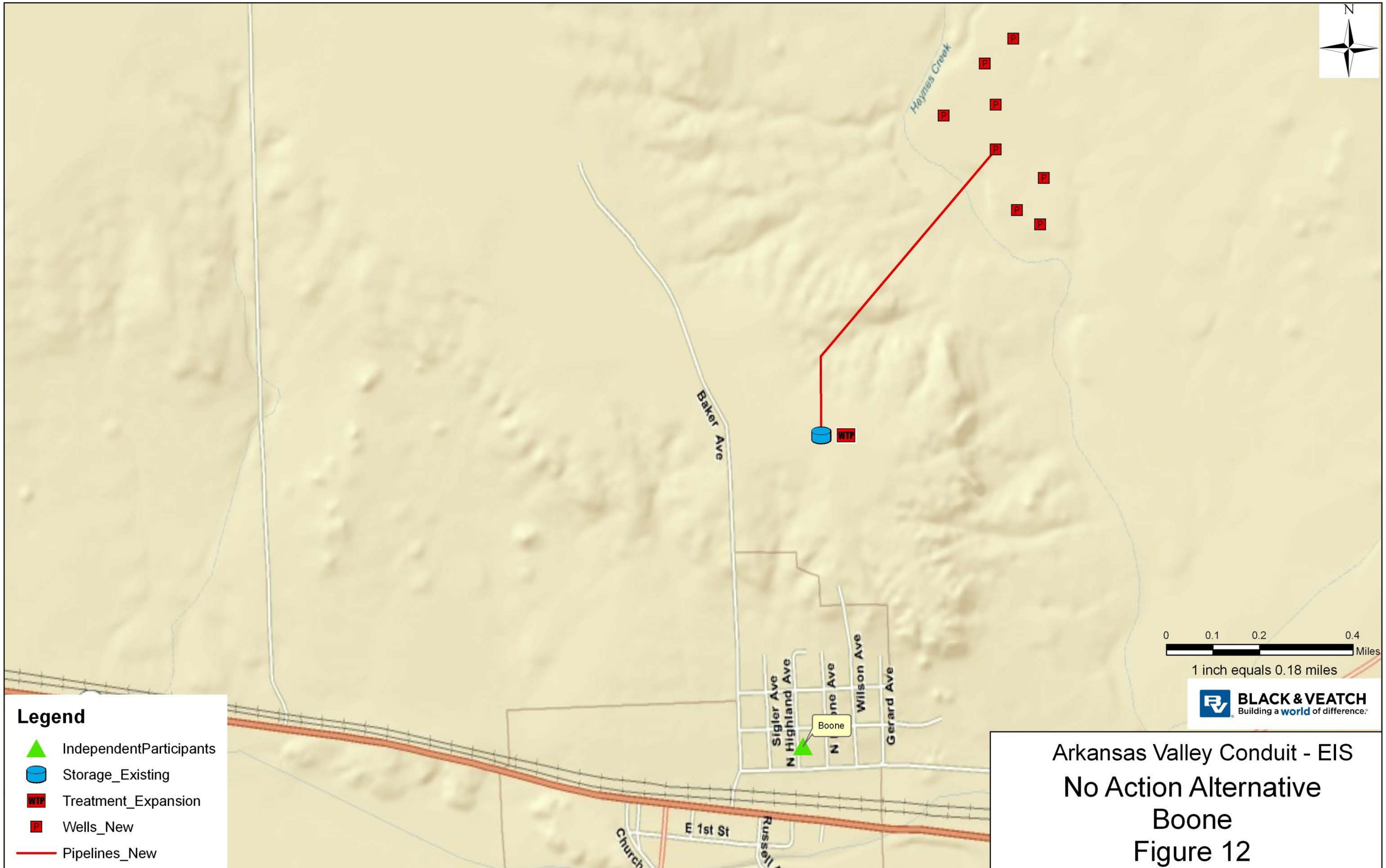
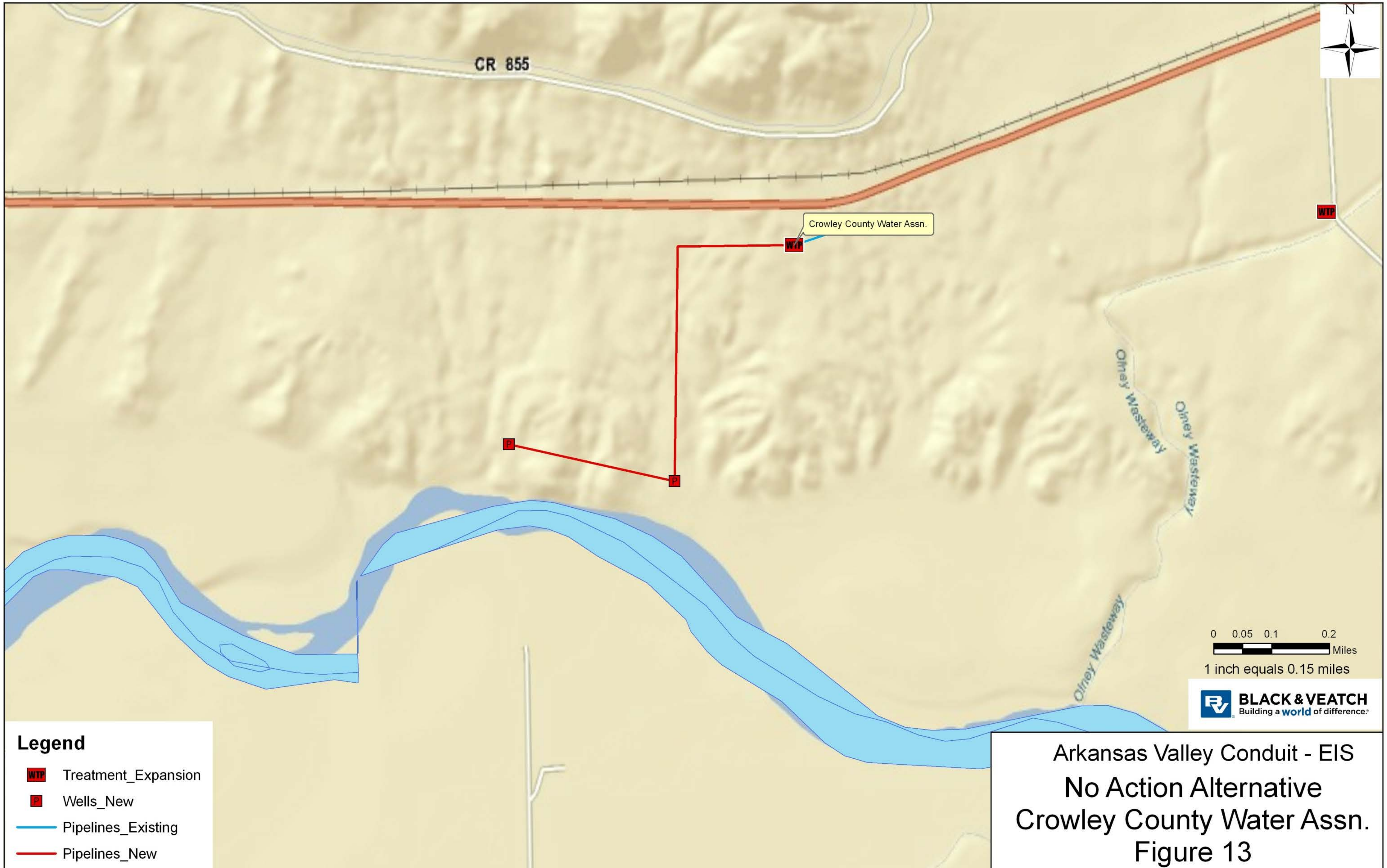
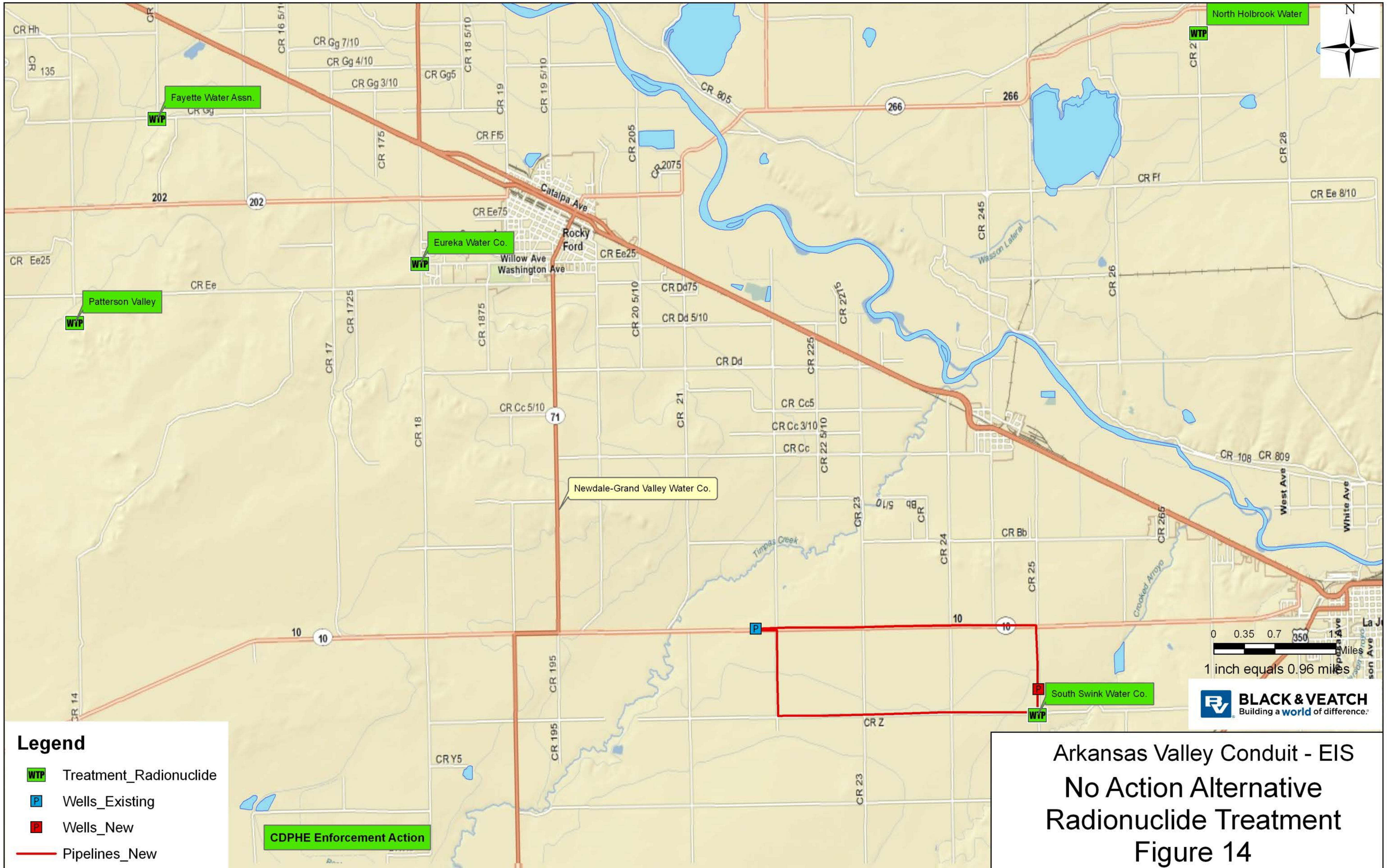
Table 16. Independent Systems Additional Treatment Requirements

Independent Participant	Radionuclides (Health Department Enforcement Actions)	2010 Demand (ac-ft)	2010 Max Day (mgd)	2070 Demand (ac-ft)	2070 Max Day (mgd)	Deep GW Treatment Capacity, All Wells (mgd)	Alluvial Treatment Capacity, All Wells (mgd)	SW Treatment Capacity Max Day (mgd)	Purchased Treatment Capacity Max Day (mgd)	Total Treatment Capacity Max Day (mgd)	Treatment Expansion Max Day (mgd)	Expansion (Percent)	Additional Treatment Facilities
Avondale	No	160	0.34	237	0.51	---	0.87	---	---	0.87	0.00	0%	None
Boone	No	66	0.14	111	0.24	---	0.14	---	---	0.14	0.10	71%	Chlorination
St. Charles Mesa Water District	No	1660	3.56	2698	5.78	---	0.86	4.00	---	4.86	0.92	26%	Additional 2 mgd package treatment module
96 Pipeline	No	56	0.12	52	0.11	---	0.00	---	---	0.00	0.11	92%	Chlorination
Crowley County Water Assn.	No	564	1.21	824	1.77	---	0.79	---	?	0.79	0.98	81%	Chlorination
Crowley	No	27	0.06	65	0.14	---	0.50	---	---	0.50	0.00	0%	None
Ordway	No	250	0.54	414	0.89	---	0.27	---	?	0.27	0.62	115%	Chlorination
Olney Springs	No	40	0.09	60	0.13	---	0.09	---	---	0.09	0.04	44%	Chlorination
Sugar City	No	82	0.18	128	0.27	---	0.50	---	---	0.50	0.00	0%	None
Beehive Water Assn.	No	8	0.02	6	0.01	0.02	---	---	---	0.02	0.00	0%	None
Eureka Water Co.	Yes	74	0.16	86	0.18	0.18	---	---	---	0.18	0.01	5%	Oxidation/HMO/Filtration/Chlorination/Residuals
Fayette Water Assn.	Yes	12	0.03	14	0.03	0.04	---	---	---	0.04	0.00	0%	Oxidation/HMO/Filtration/Chlorination/Residuals
Manzanola	No	39	0.08	37	0.08	0.08	---	---	---	0.08	0.00	0%	None
Newdale-Grand Valley Water Co.	No	57	0.12	60	0.13	1.80	---	---	---	1.80	0.00	0%	None
North Holbrook Water	Yes	7	0.01	8	0.02	0.01	---	---	---	0.01	0.01	100%	Oxidation/HMO/Filtration/Chlorination/Residuals
Patterson Valley	Yes	15	0.03	17	0.04	0.04	---	---	---	0.04	0.00	0%	Oxidation/HMO/Filtration/Chlorination/Residuals
South Side Water Assn.	No	7	0.01	7	0.01	0.02	---	---	---	0.02	0.00	0%	None
South Swink Water Co.	Yes	82	0.18	88	0.19	0.15	---	---	---	0.15	0.04	24%	Oxidation/HMO/Filtration/Chlorination/Residuals
West Holbrook Water	No	14	0.03	18	0.04	0.04	---	---	---	0.04	0.00	9%	None (<10% -- conservation/unaccounted for losses)
Hasty Water Co.	No	32	0.07	33	0.07	0.11	---	---	---	0.11	0.00	0%	None
Las Animas	No	570	1.22	604	1.29	---	1.34	---	---	1.34	0.00	0%	ZLD for RO concentrate disposal
McClave Water Assn.	No	56	0.12	59	0.13	0.15	---	---	---	0.15	0.00	0%	None
Wiley	No	24	0.05	16	0.03	0.05	---	---	---	0.05	0.00	0%	None
Eads	No	250	0.54	232	0.5	---	1.00	---	---	1.00	0.00	0%	None
Total		4,152	8.91	5,874	12.59	2.70	6.36	4.00	---	13.05	---	---	

Key: GW – ground water, SW – surface water


N
Haynes Creek
Baker Ave
Sigler Ave
N Highland Ave
Wilson Ave
Gerard Ave
Boone
E 1st St
Church St
Russell Av
0 0.1 0.2 0.4
Miles
1 inch equals 0.18 miles
BLACK & VEATCH
Building a world of difference.
Legend
IndependentParticipants
Storage_Existing
Treatment_Expansion
Wells_New
Pipelines_New
Arkansas Valley Conduit - EIS
No Action Alternative
Boone
Figure 12


CR 855
Crowley County Water Assn.
WTP
P
Olney Wasteway
Olney Wasteway
Olney Wasteway
N
0 0.05 0.1 0.2 Miles
1 inch equals 0.15 miles
BLACK & VEATCH
Building a world of difference.
Legend
Treatment_Expansion
Wells_New
Pipelines_Existing
Pipelines_New
Arkansas Valley Conduit - EIS
No Action Alternative
Crowley County Water Assn.
Figure 13


Arkansas Valley Conduit - EIS
No Action Alternative
Radionuclide Treatment
Figure 14
Legend
Treatment_Radionuclide
Wells_Existing
Wells_New
Pipelines_New
CDPHE Enforcement Action
Fayette Water Assn.
Eureka Water Co.
Patterson Valley
Newdale-Grand Valley Water Co.
North Holbrook Water
South Swink Water Co.
Rocky Ford
Catalpa Ave
Willow Ave
Washington Ave
0 0.35 0.7 1.4
Miles
1 inch equals 0.96 miles
BLACK & VEATCH
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N
Liberty Ct
Independence Blvd
CR 10
2nd St
3rd St
4th St
Ditch
Mcbride Ave
W 5th St
Peck Ave
W 6th St
N Park Ave
W Amb Thompson Blvd
0 0.035 0.07 0.14
Miles
1 inch equals 0.1 miles
BLACK & VEATCH
Building a world of difference.
Legend
PumpStations_New
Storage_Existing
Treatment_Existing
Pipelines_New
BrineEvapPonds
Arkansas Valley Conduit - EIS
No Action Alternative
Las Animas
Figure 15

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Infrastructure improvements for the independent systems are summarized below.

<u>Avondale</u>

- No improvements would be required.

<u>Boone</u>

- Acquire 15 ac-ft of fully consumable water right at same location as alluvial wells (not included in costs).
- 8 new raw water alluvial wells (average well depth of 70 feet).
- Wells pump directly to existing storage tank (210 ft TDH).
- New conveyance pipeline for new wells to existing storage tank (4" diameter, 4,000 feet long).
- Expand existing chlorination by 0.1 mgd.

<u>St. Charles Mesa Water District</u>

- Expand existing WTP by adding a 2 mgd package treatment module.

<u>96 Pipeline</u>

- Acquire 4 ac-ft of fully consumable water right at same location as alluvial wells (not included in costs).

<u>Crowley County Water Assn.</u>

- Acquire 6 ac-ft of fully consumable water right at same location as alluvial wells (not included in costs).
- 2 new raw water alluvial wells (average well depth of 45 feet).
- Wells pump directly to distribution system (225 ft TDH).
- New conveyance pipeline for new wells to distribution system (12" diameter, 4,760 feet long).
- Expand existing chlorination by 0.98 mgd.

<u>Crowley</u>

- No improvements would be required.

<u>Ordway</u>

- Expand existing chlorination by 0.62 mgd.

<u>Olney Springs</u>

- Expand existing chlorination by 0.04 mgd.

<u>Sugar City</u>

- No improvements would be required.

<u>Beehive Water Assn.</u>

- No improvements would be required.

<u>Eureka Water Co.</u>

- Upgrade existing conventional WTP to use preformed HMO filtration technology.

<u>Fayette Water Assn.</u>

- Upgrade existing conventional WTP to use preformed HMO filtration technology.

<u>Manzanola</u>

- No improvements would be required.

<u>Newdale-Grand Valley Water Co.</u>

- No improvements would be required.

<u>North Holbrook Water</u>

- 1 new raw water deep well (average well depth of 645 feet).
- Well pumps directly to distribution system (765 ft TDH).
- Upgrade existing conventional WTP to use preformed HMO filtration technology.

<u>Patterson Valley</u>

- Upgrade existing conventional WTP to use preformed hydrous HMO filtration technology.

<u>South Side Water Assn.</u>

- No improvements would be required.

<u>South Swink Water Co.</u>

- 1 new raw water deep well (average well depth of 690 feet).
- Well pumps directly to distribution system (810 ft TDH).
- Upgrade existing conventional WTP to use preformed HMO filtration technology.
- A pipeline to convey raw well water to the new treatment facility.
- A pipeline and pump station to convey treated water back to the untreated wells.

<u>West Holbrook Water</u>

- No improvements would be required.

<u>Hasty Water Co.</u>

- No improvements would be required.

<u>Las Animas</u>

- New brine disposal evaporation ponds (8 acres).
- A new pipeline from the WTP to the brine disposal ponds (4” diameter, 5,000 feet long).
- A low head pumping station to pump the brine from the WTP to the brine disposal ponds (0.02 mgd, 20 ft TDH).

<u>McClave Water Assn.</u>

- No improvements would be required.

Wiley

- No improvements would be required.

Eads

- No improvements would be required.

Cost Summary

This section summarizes the conceptual level costs for the No Action Alternative. The conceptual level costs included construction costs and operation, maintenance, and replacement (OM&R) costs.

The one-time costs required to construct the No Action Alternative are called construction costs. Once the alternative is constructed and placed in service, annual costs would be required for operation, maintenance, and periodic replacement of features over a period of time (replacement).

The costs for the No Action Alternative are summarized by each regional system and each independent system. The No Action Alternative would be funded by the participants without any federal cost share. Similar to the Action Alternatives, costs for the facilities are associated with delivery of maximum day demands. Costs that would be incurred under both the Action Alternatives and No Action Alternative, but are individual participant costs outside the scope of the Action Alternatives, have not been included to be consistent in comparing costs to the Appraisal Design Report. These costs for the No Action Alternative include tap fees, water rights acquisition, and decommissioning of contaminated facilities and wells.

Detailed unit quantity cost estimate sheets were prepared for the construction and OM&R costs. The cost estimates are intended for planning and evaluating the No Action Alternative within the EIS. The conceptual level cost estimates are not suitable for construction fund appropriations due to the early stages of project development and limited design data.

The conceptual level cost estimates were generated using industry-wide accepted cost estimate methodology, standards, and practices. The estimates are intended to capture the most current pricing for materials, accepted productivity standards, typical construction practices, procurement methods, current construction economic conditions, and site conditions. The cost estimates were developed from approximate quantities and existing data, as well as from information from field site visits when available.

Reclamation has prepared an appraisal level cost estimate for the action alternatives in the Appraisal Design Report (Reclamation 2012). Where applicable, these unit costs were used for the No Action Alternative cost estimate based on the following:

- Pipelines. A cost of $8 per diameter-inch per foot was used. This cost includes all pipeline site work, excavation, bedding, backfill, pipe materials, and pipe installation.

This cost was based on an average total cost per diameter-inch per foot in the Appraisal Design Report in the 4-inch to 10-inch range.

- The cost for isolation valves, isolation valve manholes, air valve structures, and blow off structures was based on the costs in the Appraisal Design Report.
- The cost for gravel road crossings and paved road crossings was based on the costs in the Appraisal Design Report.

Construction Costs

The construction costs are shown in January 2011 dollars. The detailed cost estimate sheets are included in Attachment A. The methodology, contingencies, and escalation factors are consistent with the contingencies applied to the action alternatives in the Appraisal Design Report (Reclamation 2012). The contingencies and escalation factors are summarized below and any exceptions to those used in the Appraisal Design Report are noted.

- Mobilization – 5 percent of line item cost (same as the Appraisal Design Report).
- Escalation – Costs are escalated from January 2011 to October 2018 at 3 percent per year. Escalation is applied to the line item costs plus mobilization, and also noncontract costs. Escalation is the same as the Appraisal Design Report.
- Design Contingency – 15 percent. The Appraisal Design Report used a 12 percent design contingency (12 percent of line item cost plus mobilization). A higher percentage was selected due to a higher level of design (conceptual level) and the resulting increased number of uncertainties.
- Procurement Strategies Allowance – 0 percent (same as the Appraisal Design Report).
- Construction Contingency – 30 percent. The Appraisal Design Report used a 25 percent construction contingency (30 percent of contract cost). A higher percentage was selected due to a higher level of design (conceptual level) and the resulting increased number of uncertainties.
- Noncontract Costs – Twenty five (25) percent of the field cost was allocated for engineering, permitting and project approvals, legal, and administrative costs. The Appraisal Design Report used approximately 30 percent for noncontract costs. A lower percentage was selected to reflect a smaller scale project and a majority of the noncontract costs completed locally.

Table 17. Summary of Construction Costs

	Line Item Costs w/ Mobilization and Escalation	Design Contingency (15%)	Construction Contingency (30%)	Noncontract Costs w/ Escalation	Total Construction Cost
Regional Systems					
Fowler	$2,965,000	$400,000	$1,000,000	$1,391,000	$5,756,000
Rocky Ford	$7,953,000	$1,200,000	$2,700,000	$3,794,000	$15,647,000
La Junta	$41,554,000	$6,200,000	$14,300,000	$19,600,000	$81,654,000
Lamar	$22,073,000	$3,300,000	$7,600,000	$10,369,000	$43,342,000
				Subtotal 1 – Regional Systems	$147,000,000
Independent Systems					
Avondale	$0	$0	$0	$0	$0
Boone	$1,294,000	$190,000	$450,000	$607,000	$2,541,000
St. Charles Mesa Water District	$1,328,000	$200,000	$460,000	$632,000	$2,620,000
96 Pipeline	$0	$0	$0	$0	$0
Crowley County Water Assn.	$1,223,000	$180,000	$420,000	$582,000	$2,405,000
Crowley	$0	$0	$0	$0	$0
Ordway	$233,000	$30,000	$80,000	$114,000	$457,000
Olney Springs	$186,000	$30,000	$60,000	$89,000	$365,000
Sugar City	$0	$0	$0	$0	$0
Beehive Water Assn.	$0	$0	$0	$0	$0
Eureka Water Co.	$1,036,000	$160,000	$360,000	$493,000	$2,049,000
Fayette Water Assn.	$611,000	$90,000	$210,000	$291,000	$1,202,000
Manzanola	$0	$0	$0	$0	$0
Newdale-Grand Valley Water Co.	$0	$0	$0	$0	$0
North Holbrook Water	$1,106,000	$170,000	$380,000	$518,000	$2,174,000
Patterson Valley	$611,000	$90,000	$210,000	$291,000	$1,202,000
South Side Water Assn.	$0	$0	$0	$0	$0
South Swink Water Co.	$5,050,000	$760,000	$1,740,000	$2,390,000	$9,940,000
West Holbrook Water	$0	$0	$0	$0	$0
Hasty Water Co.	$0	$0	$0	$0	$0
Las Animas	$9,901,000	$1,490,000	$3,420,000	$4,679,000	$19,490,000
McClave Water Assn.	$0	$0	$0	$0	$0
Wiley	$0	$0	$0	$0	$0
Eads	$0	$0	$0	$0	$0
				Subtotal 2 – Independent Systems	$45,000,000
				Total	$192,000,000

Operation, Maintenance and Replacement Costs

OM&R estimates include the computation of the total dollar present worth cost of operating, maintaining, and periodic replacement of a feature(s) over a period of time. These cost estimates are included in Attachment B. The OM&R methodology (including equations for calculating present worth, mobilization percentage, contingencies, and noncontract costs), term, and discount rate are the same as used in the Appraisal Design Report (Reclamation 2012).

The OM&R analysis contains the following three components: (1) a detailed analysis and development of costs for operations, maintenance, and replacement for the feature, (2) the period of time (term) over which these costs would be incurred, and (3) the interest (discount) rate that is applied to future costs to equate them with present day costs.

The first component in an OM&R cost analysis is development of the OM&R costs. OM&R costs for the No Action Alternative includes the following:

- OM&R periodic costs, which include replacement equipment costs calculated in present worth dollars.
- OM&R annual costs, which include daily operational costs and routine maintenance costs. The annual costs are calculated as uniform series present worth costs. Daily operational costs include costs to operate the facility, such as operator wages and benefits, utilities, power consumption (energy costs), etc.
- Routine maintenance costs include costs associated to maintain the facility and equipment in satisfactory condition.

The OM&R costs only include OM&R costs for the new equipment/facilities that were identified in the capital costs. OM&R costs for existing facilities were not included.

The second component of the OM&R analysis is the term. The study period is the period of time over which OM&R expenses are to be evaluated. For this analysis, the period is 50 years.

The third component in the OM&R analysis is the interest rate. For this analysis, the discount rate of 4.125 percent was utilized.

A summary of the total OM&R costs over the term of 50 years are shown in Table 18.

Table 18. Summary of OM&R Present Worth Costs

	Periodic (Replacement) Costs	Annual (Operations and Maintenance) Costs	Total Costs
Regional Systems			
Fowler	$195,000	$762,000	$957,000
Rocky Ford	$623,000	$2,822,000	$3,445,000
La Junta	$1,169,000	$61,639,000	$62,808,000
Lamar	$204,000	$4,458,000	$4,662,000
Subtotal Regional Systems	$2,191,000	$69,681,000	$71,872,000
Independent Systems			
Avondale	$0	$0	$0
Boone	$113,000	$650,000	$763,000
St. Charles Mesa Water District	$0	$382,000	$382,000
96 Pipeline	$0	$0	$0
Crowley County Water Assn.	$44,000	$714,000	$758,000
Crowley	$0	$0	$0
Ordway	$0	$66,000	$66,000
Olney Springs	$0	$54,000	$54,000
Sugar City	$0	$0	$0
Beehive Water Assn.	$0	$0	$0
Eureka Water Co.	$0	$2,137,000	$2,137,000
Fayette Water Assn.	$0	$2,015,000	$2,015,000
Manzanola	$0	$0	$0
Newdale-Grand Valley Water Co.	$0	$0	$0
North Holbrook Water	$13,000	$2,074,000	$2,087,000
Patterson Valley	$0	$2,015,000	$2,015,000
South Side Water Assn.	$0	$0	$0
South Swink Water Co.	$33,000	$2,588,000	$2,621,000
West Holbrook Water	$0	$0	$0
Hasty Water Co.	$0	$0	$0
Las Animas	$198,000	$19,219,000	$19,417,000
McClave Water Assn.	$0	$0	$0
Wiley	$0	$0	$0
Eads	$0	$0	$0
Subtotal Independent Systems	$401,000	$31,914,000	$32,315,000
Total – Regional + Independent	$2,592,000	$101,595,000	$104,187,000

References

Black & Veatch. 2010. Arkansas Valley Conduit Pre-NEPA State and Tribal Assistance Grant (STAG) Final Report. B&V Project Number 142542. August.

Malcolm Pirnie. 2009. CORADS Phase 2 and 3 Summary Report. Prepared for Colorado Department of Public Health and Environment. March. Available at: http://www.cdphe.state.co.us/wq/drinkingwater/pdf/CORADS/FinalCORADSProjReport.pdf.

MWH. 2010. Memorandum: AVC Preliminary Water Demands. December 16.

U.S. Department of the Interior, Bureau of Reclamation (Reclamation). 2012. Arkansas Valley Conduit Appraisal Design Report. Technical Memorandum No. PUB-8140-APP-2011-01.

Attachment A

Detailed Capital Cost Sheets

ESTIMATE WORKSHEET

FEATURE:

Fryingpan-Arkansas Project
Arkansas Valley Conduit
No Action Alternative
Summary Sheet

PROJECT: **Fryingpan-Arkansas Project - Arkansas Valley Conduit**

WOID:

ESTIMATE LEVEL: **Conceptual**

REGION: **GP**

UNIT PRICE LEVEL: **Jan-11**

FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Summary					
		Regional Systems Subtotal					$56,150,000.00
		Independent Systems Subtotal					$17,003,000.00
		Subtotal 1					$73,153,000.00
		Mobilization	5%	+/-			$3,700,000.00
		Subtotal 1 with Mobilization					$76,853,000.00
		Escalation to Notice to Proceed (NTP), from Unit Price Level (Jan. 2011) to NTP (Oct. 2018)					$20,331,000.00
		at	3.0%	per year for	94	months	
		Subtotal 2 = Subtotal 1 with Mobilization + Escalation to NTP					$97,184,000.00
		Design Contingencies	15%	+/-			$14,600,000.00
		Subtotal 3 = Subtotal 2 + Design Contingencies					$111,784,000.00
		Allowance for Procurement Strategies (APS)		+/-			
		Subtotal 4 = Subtotal 3 + APS					$111,784,000.00
		Construction Contingencies	30%	+/-			$33,500,000.00
		Opinion of Total Construction Cost					$145,284,000.00
		Noncontract Costs	25%	+/-			$36,300,000.00
		Escalation of Noncontract Costs to NTP, from Unit Price Level (Jan. 2011) to NTP (Oct. 2018)					$9,603,000.00
		at	3.0%	per year for	94	months	
		Subtotal 5 = Total Construction Cost + Noncontract Costs + Escalation to NTP					$191,187,000.00
		Opinion of Total Project Cost					$191,000,000.00

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Regional Systems Summary Sheet**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID: — **ESTIMATE LEVEL:** **Conceptual**
	REGION: **GP** — **UNIT PRICE LEVEL:** **Jan-11**
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Regional Systems Summary					
		Fowler Regional System					$2,245,200.00
		Rocky Ford Regional System					$5,988,620.00
		La Junta Regional System					$31,261,280.00
		Lamar Regional System					$16,655,100.00
		Subtotal 1					$56,150,000.00
		Mobilization	5%	+/-			$2,800,000.00
		Subtotal 1 with Mobilization					$58,950,000.00
		Escalation to Notice to Proceed (NTP), from Unit Price Level (Jan. 2011) to NTP (Oct. 2018)					$15,595,000.00
		at	3.0%	per year for	94	months	
		Subtotal 2 = Subtotal 1 with Mobilization + Escalation to NTP					$74,545,000.00
		Design Contingencies	15%	+/-			$11,200,000.00
		Subtotal 3 = Subtotal 2 + Design Contingencies					$85,745,000.00
		Allowance for Procurement Strategies (APS)		+/-			
		Subtotal 4 = Subtotal 3 + APS					$85,745,000.00
		Construction Contingencies	30%	+/-			$25,700,000.00
		Opinion of Total Construction Cost					$111,445,000.00
		Noncontract Costs	25%	+/-			$27,900,000.00
		Escalation of Noncontract Costs to NTP, from Unit Price Level (Jan. 2011) to NTP (Oct. 2018)					$7,381,000.00
		at	3.0%	per year for	94	months	
		Subtotal 5 = Total Construction Cost + Noncontract Costs + Escalation to NTP					$146,726,000.00
		Opinion of Total Project Cost					$147,000,000.00

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Fowler Regional System					
		Fowler					
		No Improvements					
		Valley Water Co.					
		Tap Fee From Fowler			ls	10,000	
		Pipeline					
		6" dia. PVC or DIP, Class 150		27,050	lin ft	48	$1,298,400.00
		(Includes sitework and earthwork)					
		Isolation Valve		2	ea	1,300	$2,600.00
		Isolation Valve Manhole		2	ea	7,000	$14,000.00
		Air Valve Stucture		2	ea	6,800	$13,600.00
		Blowoff Structure		2	ea	8,300	$16,600.00
		Gravel Road Crossing		10	ea	10,000	$100,000.00
		Paved Road Crossing		1	ea	25,000	$25,000.00
		Major River Crossing		400	lin ft	1,150	$460,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Standpipe Storage Tank, steel		160,000	gal	1.50	$240,000.00
		Decommission Existing Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment					
		facilities and residuals			ea	100,000	
		SUBTOTAL THIS SHEET					**$2,245,200.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:

Fryingpan-Arkansas Project
Arkansas Valley Conduit
No Action Alternative
Regional Systems

PROJECT: **Fryingpan-Arkansas Project - Arkansas Valley Conduit**

WOID:

ESTIMATE LEVEL: **Conceptual**

REGION: **GP**

UNIT PRICE LEVEL: **Jan-11**

FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Rocky Ford Regional System					
		Rocky Ford					
		No Improvements					
		Hancock Inc.					
		Standpipe Storage Tank, steel		80,000	gal	1.50	$120,000.00
		Decommission Existing Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment					
		facilities and residuals			ea	100,000	
		Hilltop Water Co.					
		Tap Fee From Rocky Ford			ls	10,000	
		Pipeline					
		4" dia. PVC or DIP, Class 150		2,500	lin ft	32	$80,000.00
		(Includes sitework and earthwork)					
		Isolation Valve		2	ea	1,100	$2,200.00
		Isolation Valve Manhole		2	ea	7,000	$14,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Blowoff Structure		1	ea	8,300	$8,300.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		SUBTOTAL THIS SHEET					**$306,300.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Rocky Ford Regional System (Continued)					
		Vroman					
		Tap Fee From Rocky Ford			ls	10,000	
		Pipeline					
		6" dia. PVC or DIP, Class 150		49,260	lin ft	48	$2,364,480.00
		(Includes sitework and earthwork)					
		Isolation Valve		4	ea	1,300	$5,200.00
		Isolation Valve Manhole		4	ea	7,000	$28,000.00
		Air Valve Stucture		6	ea	6,800	$40,800.00
		Blowoff Structure		6	ea	8,300	$49,800.00
		Gravel Road Crossing		10	ea	10,000	$100,000.00
		Paved Road Crossing		1	ea	25,000	$25,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Major Canal Crossing		6	ea	100,000	$600,000.00
		Standpipe Storage Tank, steel		160,000	gal	1.50	$240,000.00
		Decommission Existing Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment					
		facilities and residuals			ea	100,000	
		SUBTOTAL THIS SHEET					**$3,528,280.00**

QUANTITIES		PRICES	
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FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
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	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Rocky Ford Regional System (Continued)					
		West Grand Valley Water Inc.					
		Tap Fee From Rocky Ford			ls	10,000	
		Pipeline					
		4" dia. PVC or DIP, Class 150		19,820	lin ft	32	$634,240.00
		(Includes sitework and earthwork)					
		Isolation Valve		2	ea	1,100	$2,200.00
		Isolation Valve Manhole		2	ea	7,000	$14,000.00
		Air Valve Stucture		2	ea	6,800	$13,600.00
		Blowoff Structure		2	ea	8,300	$16,600.00
		Gravel Road Crossing		5	ea	10,000	$50,000.00
		Paved Road Crossing		1	ea	25,000	$25,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Major Canal Crossing		4	ea	100,000	$400,000.00
		Standpipe Storage Tank, steel		120,000	gal	1.50	$180,000.00
		Hilltop and West Grand Valley Shared Pipeline					
		Pipeline					
		6" dia. PVC or DIP, Class 150		7,500	lin ft	48	$360,000.00
		(Includes sitework and earthwork)					
		Isolation Valve		1	ea	1,300	$1,300.00
		Isolation Valve Manhole		1	ea	7,000	$7,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Blowoff Structure		1	ea	8,300	$8,300.00
		Gravel Road Crossing		1	ea	10,000	$10,000.00
		Paved Road Crossing		2	ea	25,000	$50,000.00
		Major Canal Crossing		1	ea	100,000	$100,000.00
		Hilltop, Vroman and West Grand Valley Shared Booster Pump Station					
		New 0.25 mgd PS @ 215 ft TDH (15 HP)		15	hp	5,000	$75,000.00
		Power Drop for PS		1	ls	75,000	$75,000.00
		Miscellaneous		1	ls	50,000	$50,000.00
		SUBTOTAL THIS SHEET					**$2,154,040.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System					
		La Junta					
		Water Rights					
		Fully consumable water right			af	7,500	
		Admin costs to acquire water right			ls	25,000	
		Wells					
		Alluvial well, shallow, drilling		45	lin ft	500	$22,500.00
		Well pump, motor, and electrical		1	ea	25,000	$25,000.00
		Well Conveyance Pipeline					
		12" dia. PVC or DIP, Class 150		8,660	lin ft	96	$831,360.00
		(Includes sitework and earthwork)					
		Isolation Valve		1	ea	2,500	$2,500.00
		Isolation Valve Manhole		1	ea	7,000	$7,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Arkansas River Crossing		500	lin ft	1,150	$575,000.00
		Railroad Crossing / Hwy 50 Crossing		800	lin ft	1,150	$920,000.00
		Redundant Arkansas River and Ft Lyon Canal Crossings					
		12" dia. PVC or DIP, Class 150		950	lin ft	96	$91,200.00
		(Includes sitework and earthwork)					
		Arkansas River Crossing		500	lin ft	1,150	$575,000.00
		Major Canal Crossing		1	ea	100,000	$100,000.00
		Water Treatment Plant Expansion and Brine Disposal					
		4th Bank of RO Membranes (2.2 mgd)		1	ea	3,400,000	$3,400,000.00
		Brine Disposal Evap Ponds		25	ac	137,000	$3,425,000.00
		RO Concentrate Management Facility		1	ls	2,600,000	$2,600,000.00
		RO Concentrators		2	ea	5,850,000	$11,700,000.00
		4" dia. double contained brine pipe with leak sensors		10,500	lin ft	128	$1,344,000.00
		(Includes sitework and earthwork)					
		Gravel Road Crossing		3	ea	10,000	$30,000.00
		Paved Road Crossing		2	ea	25,000	$50,000.00
		Brine Pump Station					
		New 0.05 mgd PS @ 120 ft TDH (5 HP)		5	hp	10,000	$50,000.00
		Power Drop for PS		1	ls	75,000	$75,000.00
		SUBTOTAL THIS SHEET					**$25,830,360.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	**PROJECT:**
Fryingpan-Arkansas Project	**Fryingpan-Arkansas Project - Arkansas Valley Conduit**
Arkansas Valley Conduit	**WOID:** / **ESTIMATE LEVEL:** Conceptual
No Action Alternative	**REGION:** GP / **UNIT PRICE LEVEL:** Jan-11
Regional Systems	**FILE:** c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System (Continued)					
		La Junta (Continued)					
		Miscellaneous		1	ls	50,000	$50,000.00
		Bents Fort Water Co.					
		No Improvements					
		Cheraw					
		Water Rights					
		Fully consumable water right			af	7,500	
		Admin costs to acquire water right			ls	25,000	
		Tap Fee From La Junta			ls	10,000	
		Pipeline					
		6" dia. PVC or DIP, Class 150		13,270	lin ft	48	$636,960.00
		(Includes sitework and earthwork)					
		Isolation Valve		2	ea	1,300	$2,600.00
		Isolation Valve Manhole		2	ea	7,000	$14,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Blowoff Structure		1	ea	8,300	$8,300.00
		Gravel Road Crossing		1	ea	10,000	$10,000.00
		Paved Road Crossing		2	ea	25,000	$50,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Decommission Existing Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment					
		facilities and residuals			ea	100,000	
		East End Water Assn.					
		Tap Fee From La Junta			ls	10,000	
		Pipeline					
		4" dia. PVC or DIP, Class 150		28,650	lin ft	32	$916,800.00
		(Includes sitework and earthwork)					
		Isolation Valve		3	ea	1,100	$3,300.00
		Isolation Valve Manhole		3	ea	7,000	$21,000.00
		Air Valve Stucture		2	ea	6,800	$13,600.00
		SUBTOTAL THIS SHEET					**$1,808,360.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID: / ESTIMATE LEVEL: Conceptual
	REGION: GP / UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System (Continued)					
		East End Water Assn. (Continued)					
		Blowoff Structure		2	ea	8,300	$16,600.00
		Gravel Road Crossing		4	ea	10,000	$40,000.00
		Major Canal Crossing		3	ea	100,000	$300,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Decommission Existing Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment					
		facilities and residuals			ea	100,000	
		Standpipe Storage Tank, steel		60,000	gal	1.50	$90,000.00
		Holbrook Center Soft Water					
		Water Rights					
		Fully consumable water right			af	7,500	
		Admin costs to acquire water right			ls	25,000	
		Tap Fee From La Junta			ls	10,000	
		Pipeline					
		4" dia. PVC or DIP, Class 150		10,650	lin ft	32	$340,800.00
		(Includes sitework and earthwork)					
		Isolation Valve		2	ea	1,100	$2,200.00
		Isolation Valve Manhole		2	ea	7,000	$14,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Blowoff Structure		1	ea	8,300	$8,300.00
		Gravel Road Crossing		2	ea	10,000	$20,000.00
		Major Canal Crossing		1	ea	100,000	$100,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Decommission Existing Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment					
		facilities and residuals			ea	100,000	
		Standpipe Storage Tank, steel		100,000	gal	1.50	$150,000.00
		SUBTOTAL THIS SHEET					**$1,238,700.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System (Continued)					
		Cheraw, East End, and Holbrook Shared Pipeline					
		Pipeline					
		6" dia. PVC or DIP, Class 150		17,070	lin ft	48	$819,360.00
		(Includes sitework and earthwork)					
		Isolation Valve		3	ea	1,300	$3,900.00
		Isolation Valve Manhole		3	ea	7,000	$21,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Blowoff Structure		1	ea	8,300	$8,300.00
		Gravel Road Crossing		1	ea	10,000	$10,000.00
		Paved Road Crossing		2	ea	25,000	$50,000.00
		Major Canal Crossing		1	ea	100,000	$100,000.00
		Standpipe Storage Tank, steel		400,000	gal	1.50	$600,000.00
		Homestead Improvement Assn.					
		No Improvements					
		Swink					
		Tap Fee From La Junta			ls	10,000	
		Pipeline					
		6" dia. PVC or DIP, Class 150		11,100	lin ft	48	$532,800.00
		(Includes sitework and earthwork)					
		Isolation Valve		2	ea	1,300	$2,600.00
		Isolation Valve Manhole		2	ea	7,000	$14,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Blowoff Structure		1	ea	8,300	$8,300.00
		Gravel Road Crossing		5	ea	10,000	$50,000.00
		Paved Road Crossing		3	ea	25,000	$75,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Decommission Existing Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment					
		facilities and residuals			ea	100,000	
		SUBTOTAL THIS SHEET					**$2,383,860.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:

Fryingpan-Arkansas Project
Arkansas Valley Conduit
No Action Alternative
Regional Systems

PROJECT: Fryingpan-Arkansas Project - Arkansas Valley Conduit

WOID:

ESTIMATE LEVEL: Conceptual

REGION: GP

UNIT PRICE LEVEL: Jan-11

FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Lamar Regional System					
		Lamar					
		Wells					
		Alluvial well, shallow (4 at 80 ft each)		320	lin ft	500	$160,000.00
		Well pump, motor, and electrical		4	ea	25,000	$100,000.00
		Well Conveyance Pipeline					
		12" dia. PVC or DIP, Class 150		49,425	lin ft	96	$4,744,800.00
		(Includes sitework and earthwork)					
		Isolation Valve		5	ea	2,500	$12,500.00
		Isolation Valve Manhole		5	ea	7,000	$35,000.00
		Air Valve Stucture		5	ea	6,800	$34,000.00
		Blowoff Structure		5	ea	8,300	$41,500.00
		Gravel Road Crossing		2	ea	10,000	$20,000.00
		May Valley Water Assn.					
		Tap Fee From Lamar			ls	10,000	
		Expand Lamar's Chlorination Facility		1	ls	175,000	$175,000.00
		Conveyance Pipeline to May Valley					
		10" dia. PVC or DIP, Class 150		101,810	lin ft	80	$8,144,800.00
		(Includes sitework and earthwork)					
		Isolation Valve		8	ea	2,000	$16,000.00
		Isolation Valve Manhole		8	ea	7,000	$56,000.00
		Air Valve Stucture		5	ea	6,800	$34,000.00
		Blowoff Structure		5	ea	8,300	$41,500.00
		Gravel Road Crossing		12	ea	10,000	$120,000.00
		Paved Road Crossing		4	ea	25,000	$100,000.00
		Arkansas River Crossing		500	lin ft	1,150	$575,000.00
		Hwy 50 Crossing		500	lin ft	1,150	$575,000.00
		Railroad Crossing		150	lin ft	1,150	$172,500.00
		Hwy 287 Crossing		250	lin ft	1,150	$287,500.00
		Major Canal Crossing		2	ea	100,000	$200,000.00
		SUBTOTAL THIS SHEET					**$15,645,100.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Lamar Regional System (Continued)					
		May Valley Water Assn. (Continued)					
		Pump Station					
		New 0.5 mgd PS @ 305 ft TDH (50 HP)		50	hp	5,000	$250,000.00
		Power Drop for PS		1	ls	75,000	$75,000.00
		Miscellaneous		1	ls	50,000	$50,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Storage Tank, steel		560,000	gal	1.0	$560,000.00
		Decommission Existing Contamintated Wells					
		Cap existing well with concrete			ea	10,000	
		Decommissioning of contaminated treatment facilities and residuals			ea	100,000	
		SUBTOTAL THIS SHEET					**$1,010,000.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

ESTIMATE WORKSHEET

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Independent Systems Summary Sheet**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID:
	ESTIMATE LEVEL: **Conceptual**
	REGION: **GP**
	UNIT PRICE LEVEL: **Jan-11**
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Independent Systems Summary					
		Avondale					0
		Boone					$974,300.00
		St Charles Mesa					$1,000,000.00
		96 Pipeline					
		Crowley County Water Assn.					$920,660.00
		Crowley					0
		Ordway					$175,000.00
		Olney Springs					$140,000.00
		Sugar City					0
		Beehive Water Assn.					0
		Eureka Water Co.					$780,000.00
		Fayette Water Assn.					$460,000.00
		Manzanola					0
		Newdale Grand Valley					0
		North Holbrook Water					$832,500.00
		Patterson Valley					$460,000.00
		South Side Water Assn.					0
		South Swink					$3,803,600.00
		West Holbrook					0
		Hasty					0
		Las Animas					$7,457,000.00
		McClave					0
		Wiley					0
		Eads					0
		Subtotal 1					$17,003,000.00

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Independent Systems Summary Sheet**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID: / **ESTIMATE LEVEL:** **Conceptual**
	REGION: **GP** / **UNIT PRICE LEVEL:** **Jan-11**
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Independent Systems Summary					
		Subtotal 1					$17,003,000.00
		Mobilization	5%	+/-			$900,000.00
		Subtotal 1 with Mobilization					$17,903,000.00
		Escalation to Notice to Proceed (NTP), from Unit Price Level (Jan. 2011) to NTP (Oct. 2018)					$4,736,000.00
		at	3.0%	per year for	94	months	
		Subtotal 2 = Subtotal 1 with Mobilization + Escalation to NTP					$22,639,000.00
		Design Contingencies	15%	+/-			$3,400,000.00
		Subtotal 3 = Subtotal 2 + Design Contingencies					$26,039,000.00
		Allowance for Procurement Strategies (APS)		+/-			
		Subtotal 4 = Subtotal 3 + APS					$26,039,000.00
		Construction Contingencies	30%	+/-			$7,800,000.00
		Opinion of Total Construction Cost					$33,839,000.00
		Noncontract Costs	25%	+/-			$8,500,000.00
		Escalation of Noncontract Costs to NTP, from Unit Price Level (Jan. 2011) to NTP (Oct. 2018)					$2,249,000.00
		at	3.0%	per year for	94	months	
		Subtotal 5 = Total Construction Cost + Noncontract Costs + Escalation to NTP					$44,588,000.00
		Opinion of Total Project Cost					$45,000,000.00

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Independent Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Avondale					
		No Improvements					
		Boone					
		Water Rights					
		Fully consumable water right			af	7,500	
		Admin costs to acquire water right			ls	25,000	
		Wells					
		Alluvial wells, shallow (8 @ 70 ft each)		560	lin ft	500	$280,000.00
		Well pump, motor, and electrical		8	ea	25,000	$200,000.00
		Well Conveyance Pipeline					
		4" dia. PVC or DIP, Class 150		4,000	lin ft	32	$128,000.00
		(Includes sitework and earthwork)					
		Isolation Valve		2	ea	1,100	$2,200.00
		Isolation Valve Manhole		2	ea	7,000	$14,000.00
		Air Valve Stucture		1	ea	6,800	$6,800.00
		Blowoff Structure		1	ea	8,300	$8,300.00
		Gravel Road Crossing		1	ea	10,000	$10,000.00
		River Crossing		1	ea	100,000	$100,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Water Treatment					
		Chlorination system, 0.24 mgd		1	ls	150,000	$150,000.00
		St Charles Mesa Water District					
		Water Treatment Plant Expansion					
		Package Treatment Module, 2 mgd		1	ea	1,000,000	$1,000,000.00
		96 Pipeline					
		Water Rights					
		Fully consumable water right			af	7,500	
		Admin costs to acquire water right			ls	25,000	
		SUBTOTAL THIS SHEET					**$1,974,300.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Independent Systems	**PROJECT:** Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Crowley County Water Assn.					
		Water Rights					
		Fully consumable water right			af	7,500	
		Admin costs to acquire water right			ls	25,000	
		Wells					
		Alluvial wells, shallow (2 @ 45 ft each)		90	lin ft	500	$45,000.00
		Well pump, motor, and electrical		2	ea	25,000	$50,000.00
		Well Conveyance Pipeline					
		12" dia. PVC or DIP, Class 150		4,760	lin ft	96	$456,960.00
		(Includes sitework and earthwork)					
		Isolation Valve		3	ea	2,500	$7,500.00
		Isolation Valve Manhole		3	ea	7,000	$21,000.00
		Air Valve Stucture		2	ea	6,800	$13,600.00
		Blowoff Structure		2	ea	8,300	$16,600.00
		Gravel Road Crossing		1	ea	10,000	$10,000.00
		Master Meter Vault		1	ea	75,000	$75,000.00
		Water Treatment					
		Chlorination system, 1.77 mgd		1	ls	225,000	$225,000.00
		Crowley					
		No Improvements					
		Ordway					
		Water Treatment					
		Chlorination system, 0.89 mgd		1	ls	175,000	$175,000.00
		Olney Springs					
		Water Treatment					
		Chlorination system, 0.13 mgd		1	ls	140,000	$140,000.00
		Sugar City					
		No Improvements					
		SUBTOTAL THIS SHEET					**$1,235,660.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Independent Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Beehive Water Assn.					
		No Improvements					
		Eureka Water Co.					
		Water Treatment					
		Convert to hydrous manganese oxide filtration		1	ea	780,000	$780,000.00
		Fayette Water Assn.					
		Water Treatment					
		Convert to hydrous manganese oxide filtration		1	ea	460,000	$460,000.00
		Manzanola					
		No Improvements					
		Newdale-Grand Valley Water Co.					
		No Improvements					
		North Holbrook Water					
		Wells					
		Deep well (1 @ 645 ft)		645	lin ft	500	$322,500.00
		Well pump, motor, and electrical		1	ea	50,000	$50,000.00
		Water Treatment					
		Convert to hydrous manganese oxide filtration		1	ea	460,000	$460,000.00
		Patterson Valley					
		Water Treatment					
		Convert to hydrous manganese oxide filtration		1	ea	460,000	$460,000.00
		South Side Water Assn.					
		No Improvements					
		SUBTOTAL THIS SHEET					**$2,532,500.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
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FEATURE:

Fryingpan-Arkansas Project
Arkansas Valley Conduit
No Action Alternative
Independent Systems

PROJECT: **Fryingpan-Arkansas Project - Arkansas Valley Conduit**

WOID:

ESTIMATE LEVEL: **Conceptual**

REGION: **GP**

UNIT PRICE LEVEL: **Jan-11**

FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		South Swink Water Company					
		Wells					
		Deep well (1 @ 690 ft)		690	lin ft	500	$345,000.00
		Well pump, motor, and electrical		1	ea	50,000	$50,000.00
		Water Treatment					
		Convert to hydrous manganese oxide filtration		1	ea	780,000	$780,000.00
		Pipeline from Non-Treated Wells to Treatment Facility and Back					
		6" dia. PVC or DIP, Class 150		45,000	lin ft	48	$2,160,000.00
		(Includes sitework and earthwork)					
		Isolation Valve		4	ea	1,300	$5,200.00
		Isolation Valve Manhole		4	ea	7,000	$28,000.00
		Air Valve Stucture		4	ea	6,800	$27,200.00
		Blowoff Structure		4	ea	8,300	$33,200.00
		Gravel Road Crossing		20	ea	10,000	$200,000.00
		Pump Station to Pump Back to Untreated Well from Treatment					
		New 0.1 mgd PS @ 170 ft TDH (5 HP)		5	hp	10,000	$50,000.00
		Power Drop for PS		1	ls	75,000	$75,000.00
		Miscellaneous		1	ls	50,000	$50,000.00
		West Holbrook Water					
		No Improvements					
		Hasty Water Co.					
		No Improvements					
		SUBTOTAL THIS SHEET					**$3,803,600.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 11/18/11	**PEER REVIEW / DATE**	**DATE PREPARED** 11/18/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Independent Systems	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID: / ESTIMATE LEVEL: Conceptual
	REGION: GP / UNIT PRICE LEVEL: Jan-11
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PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Las Animas					
		Brine Disposal					
		Brine Disposal Evap Ponds		6	ac	137,000	$822,000.00
		RO Concentrate Management Facility		1	ls	1,040,000	$1,040,000.00
		RO Concentrators		2	ea	2,360,000	$4,720,000.00
		4" dia. double contained brine pipe with leak sensors		5,000	lin ft	128	$640,000.00
		(Includes sitework and earthwork)					
		Gravel Road Crossing		1	ea	10,000	$10,000.00
		Paved Road Crossing		2	ea	25,000	$50,000.00
		Brine Pump Station					
		New 0.02 mgd PS @ 20 ft TDH (5 HP)		5	hp	10,000	$50,000.00
		Power Drop for PS		1	ls	75,000	$75,000.00
		Miscellaneous		1	ls	50,000	$50,000.00
		McClave Water Assn.					
		No Improvements					
		Wiley					
		No Improvements					
		Eads					
		No Improvements					
		SUBTOTAL THIS SHEET					$7,457,000.00

QUANTITIES		PRICES	
BY Black & Veatch	CHECKED	BY Black & Veatch	CHECKED
DATE PREPARED 11/18/11	PEER REVIEW / DATE	DATE PREPARED 11/18/11	PEER REVIEW / DATE RJL / 12-15-2011

Attachment B

Detailed OM&R Cost Sheets

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Regional Systems OM&R Summary**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit** **WOID:** / **ESTIMATE LEVEL:** Conceptual **REGION:** GP / **UNIT PRICE LEVEL:** Jan-11 **FILE:** c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

Periodic (Replacement) Costs

		Fowler Regional Sys		Rocky Ford Regional Sys		La Junta Regional Sys		Lamar Regional Sys	
	P/F Factor	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**
Year 5	0.81701								
Year 10	0.6675	$25,000.00	$16,687.50	$75,000.00	$50,062.50	$75,000.00	$50,062.50	$25,000.00	$16,687.50
Year 15	0.54535								
Year 20	0.44555	$25,000.00	$11,138.75	$75,000.00	$33,416.25	$75,000.00	$33,416.25	$25,000.00	$11,138.75
Year 25	0.36402	$121,000.00	$44,046.42	$400,000.00	$145,608.00	$984,000.00	$358,195.68	$128,500.00	$46,776.57
Year 30	0.29741	$25,000.00	$7,435.25	$75,000.00	$22,305.75	$75,000.00	$22,305.75	$25,000.00	$7,435.25
Year 35	0.24298								
Year 40	0.19852	$25,000.00	$4,963.00	$75,000.00	$14,889.00	$75,000.00	$14,889.00	$25,000.00	$4,963.00
Year 45	0.16219								
Year 50	0.13251	$146,000.00	$19,346.46	$475,000.00	$62,942.25	$1,059,000.00	$140,328.09	$153,500.00	$20,340.29
Subtotal, Replacement Costs			$103,617.38		$329,223.75		$619,197.27		$107,341.36
Mobilization (5%)			$5,200.00		$16,500.00		$31,000.00		$5,400.00
Subtotal 1 with Mobilization			$108,817.38		$345,723.75		$650,197.27		$112,741.36
Escalation to NTP									
Subtotal 2 = Subtotal 1 with Mob + Escalation			$108,817.38		$345,723.75		$650,197.27		$112,741.36
Design Contingencies (15%)			$16,300.00		$51,900.00		$97,500.00		$16,900.00
Contract Cost			$125,000.00		$398,000.00		$748,000.00		$130,000.00
Construction Contingencies (25%)			$31,000.00		$100,000.00		$187,000.00		$33,000.00
Field Cost			$156,000.00		$498,000.00		$935,000.00		$163,000.00
Non Contract Costs (25%)			$39,000.00		$125,000.00		$234,000.00		$41,000.00
Total Replacement Present Worth Costs			$195,000.00		$623,000.00		$1,169,000.00		$204,000.00

Annual (Operations and Maintenance) Costs

		Fowler Regional Sys		Rocky Ford Regional Sys		La Junta Regional Sys		Lamar Regional Sys	
	PWA Factor	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**
Operations Costs	21.03006	$18,750.00	$394,313.63	$75,000.00	$1,577,254.50	$112,500.00	$2,365,881.75	$75,000.00	$1,577,254.50
Maintenance Costs	21.03006	$11,200.00	$235,536.67	$32,900.00	$691,888.97	$176,800.00	$3,718,114.61	$83,200.00	$1,749,700.99
RO Brine O&M Costs	21.03006					$2,130,000.00	$44,794,027.80		
Pumping Costs	21.03006			$3,000.00	$63,090.18	$3,000.00	$63,090.18	$17,000.00	$357,511.02
Subtotal Annual (Operation and Maintenance) Costs			$629,850.30		$2,332,233.65		$50,941,114.34		$3,684,466.51
Escalation to NTP									
Subtotal 2 with Escalation			$629,850.30		$2,332,233.65		$50,941,114.34		$3,684,466.51
Design Contingencies (10%)			$63,000.00		$233,200.00		$5,094,100.00		$368,400.00
Subtotal 3 = Subtotal 2 + Design Contingencies			$693,000.00		$2,565,000.00		$56,035,000.00		$4,053,000.00
Non Contract Costs (10%)			$69,000.00		$257,000.00		$5,604,000.00		$405,000.00
Total Operation and Maintenance Present Worth Costs			$762,000.00		$2,822,000.00		$61,639,000.00		$4,458,000.00

FY 2011 planning interest rate 4.125% per year for 50 years.

PWA Factor = P/A = ((1+i)^n-1)/(i*(1+i)^n) = Uniform Series Present Worth Factor (P/A, 4.125%, 50)

PW Factor = P/F = 1/(1+i)^n = Single Payment Present Worth (P/F, 4.125%)

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

ESTIMATE WORKSHEET

FEATURE:

Fryingpan-Arkansas Project
Arkansas Valley Conduit
No Action Alternative
Regional Systems OM&R Costs

PROJECT: **Fryingpan-Arkansas Project - Arkansas Valley Conduit**

WOID:

ESTIMATE LEVEL: **Conceptual**

REGION: **GP**

UNIT PRICE LEVEL: **Jan-11**

FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Fowler Regional System					
		Fowler					
		No Improvements					
		Valley Water Co.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$11,200.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		2	Year 25	500	$1,000.00
				2	Year 50	500	$1,000.00
		Unidentified Repairs		2	Year 25	5,000	$10,000.00
				2	Year 50	5,000	$10,000.00
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	100,000	$100,000.00
				1	Year 50	100,000	$100,000.00
		SUBTOTAL THIS SHEET					**$396,950.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	**PROJECT:**
Fryingpan-Arkansas Project **Arkansas Valley Conduit** **No Action Alternative** **Regional Systems OM&R Costs**	**Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID:
	ESTIMATE LEVEL: **Conceptual**
	REGION: **GP**
	UNIT PRICE LEVEL: **Jan-11**
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Rocky Ford Regional System					
		Rocky Ford					
		No Improvements					
		Hancock Inc.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$600.00
		Replacement Costs					
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	100,000	$100,000.00
				1	Year 50	100,000	$100,000.00
		Hilltop Water Co.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$900.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Unidentified Repairs		1	Year 25	5,000	$5,000.00
				1	Year 50	5,000	$5,000.00
		SUBTOTAL THIS SHEET					**$395,000.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Regional Systems OM&R Costs**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID: / **ESTIMATE LEVEL:** **Conceptual**
	REGION: **GP** / **UNIT PRICE LEVEL:** **Jan-11**
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Rocky Ford Regional System (Continued)					
		Vroman					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$17,600.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		6	Year 25	500	$3,000.00
				6	Year 50	500	$3,000.00
		Unidentified Repairs		4	Year 25	5,000	$20,000.00
				4	Year 50	5,000	$20,000.00
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	100,000	$100,000.00
				1	Year 50	100,000	$100,000.00
		SUBTOTAL THIS SHEET					**$427,350.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Regional Systems OM&R Costs**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit** **WOID:** / **ESTIMATE LEVEL:** Conceptual **REGION:** GP / **UNIT PRICE LEVEL:** Jan-11 **FILE:** c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Rocky Ford Regional System (Continued)					
		West Grand Valley Water Inc.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$7,100.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		2	Year 25	500	$1,000.00
				2	Year 50	500	$1,000.00
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	100,000	$100,000.00
				1	Year 50	100,000	$100,000.00
		Hilltop and West Grand Valley Shared Pipeline					
		Operations and Maintenance Costs					
		Annual Maintenance Cost (0.5% of Capital)			Annual		$2,700.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Hilltop, Vroman and West Grand Valley Shared Booster Pump Station					
		Operations and Maintenance Costs					
		Annual Pumping Costs			Annual		$3,000.00
		Annual Maintenance Cost (2% of Capital)			Annual		$4,000.00
		Replacement Costs					
		PS Unidentified Repair (15% of Capital)		1	Year 25		$30,000.00
				1	Year 50		$30,000.00
		SUBTOTAL THIS SHEET					**$463,550.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems OM&R Costs	**PROJECT:** Fryingpan-Arkansas Project - Arkansas Valley Conduit
WOID:	**ESTIMATE LEVEL:** Conceptual
REGION: GP	**UNIT PRICE LEVEL:** Jan-11
FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System					
		La Junta					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.50	ea	75,000	$37,500.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$129,200.00
		Annual Pumping Costs for new well and brine PS			Annual		$3,000.00
		Annual RO Concentrate / Evap Ponds Maintenance and Operation			Annual		$2,130,000.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		2	Year 25	500	$1,000.00
				2	Year 50	500	$1,000.00
		Unidentified Repairs		1	Year 25	500,000	$500,000.00
				1	Year 50	500,000	$500,000.00
		Bents Fort Water Co.					
		No Improvements					
		Cheraw					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$4,000.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Unidentified Repairs		1	Year 25	5,000	$5,000.00
				1	Year 50	5,000	$5,000.00
		SUBTOTAL THIS SHEET					**$3,375,450.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Regional Systems OM&R Costs	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System (Continued)					
		East End Water Assn.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$6,900.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		2	Year 25	500	$1,000.00
				2	Year 50	500	$1,000.00
		Unidentified Repairs		1	Year 25	5,000	$5,000.00
				1	Year 50	5,000	$5,000.00
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	100,000	$100,000.00
				1	Year 50	100,000	$100,000.00
		Holbrook Center Soft Water					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$3,600.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Unidentified Repairs		1	Year 25	5,000	$5,000.00
				1	Year 50	5,000	$5,000.00
		SUBTOTAL THIS SHEET					**$436,000.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Regional Systems OM&R Costs**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit** **WOID:** / **ESTIMATE LEVEL:** Conceptual **REGION:** GP / **UNIT PRICE LEVEL:** Jan-11 **FILE:** c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System (Continued)					
		Holbrook Center Soft Water (Continued)					
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	100,000	$100,000.00
				1	Year 50	100,000	$100,000.00
		Cheraw, East End, and Holbrook Shared Pipeline					
		Operations and Maintenance Costs					
		Annual Maintenance Cost (0.5% of Capital)			Annual		$8,100.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	200,000	$200,000.00
				1	Year 50	200,000	$200,000.00
		Homestead Improvement Assn.					
		No Improvements					
		SUBTOTAL THIS SHEET					**$879,100.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Regional Systems OM&R Costs**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID: — **ESTIMATE LEVEL:** **Conceptual**
	REGION: **GP** — **UNIT PRICE LEVEL:** **Jan-11**
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		La Junta Regional System (Continued)					
		Swink					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$25,000.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Unidentified Repairs		1	Year 25	5,000	$5,000.00
				1	Year 50	5,000	$5,000.00
		SUBTOTAL THIS SHEET					**$74,750.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	**PROJECT:**
Fryingpan-Arkansas Project	**Fryingpan-Arkansas Project - Arkansas Valley Conduit**
Arkansas Valley Conduit	**WOID:** / **ESTIMATE LEVEL:** Conceptual
No Action Alternative	**REGION:** GP / **UNIT PRICE LEVEL:** Jan-11
Regional Systems OM&R Costs	**FILE:** c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Lamar Regional System					
		Lamar					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.50	ea	75,000	$37,500.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$25,700.00
		Annual Pumping Costs for new wells			Annual		$8,000.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		2	Year 25	500	$1,000.00
				2	Year 50	500	$1,000.00
		May Valley Water Assn.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.50	ea	75,000	$37,500.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$57,500.00
		Annual Pumping Costs for PS			Annual		$9,000.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		5	Year 25	500	$2,500.00
				5	Year 50	500	$2,500.00
		Unidentified Repairs		1	Year 25	5,000	$5,000.00
				1	Year 50	5,000	$5,000.00
		Tank Interior Cleaning		1	Year 10	25,000	$25,000.00
				1	Year 20	25,000	$25,000.00
				1	Year 30	25,000	$25,000.00
				1	Year 40	25,000	$25,000.00
				1	Year 50	25,000	$25,000.00
		Tank Interior and Exterior Recoating		1	Year 25	100,000	$100,000.00
				1	Year 50	100,000	$100,000.00
		SUBTOTAL THIS SHEET					**$557,200.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/09/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/09/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Independent Systems OM&R Summary	**PROJECT:** Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

Periodic (Replacement) Costs

		Boone		St Charles Mesa		Crowley Cty Water		Ordway	
	P/F Factor	Estimated Periodic Costs	Present Worth Costs (Jan 2011)	Estimated Periodic Costs	Present Worth Costs (Jan 2011)	Estimated Periodic Costs	Present Worth Costs (Jan 2011)	Estimated Periodic Costs	Present Worth Costs (Jan 2011)
Year 5	0.81701								
Year 10	0.6675								
Year 15	0.54535								
Year 20	0.44555								
Year 25	0.36402	$120,500.00	$43,864.41			$46,000.00	$16,744.92		
Year 30	0.29741								
Year 35	0.24298								
Year 40	0.19852								
Year 45	0.16219								
Year 50	0.13251	$120,500.00	$15,967.46			$46,000.00	$6,095.46		
Subtotal, Replacement Costs			$59,831.87				$22,840.38		
Mobilization (5%)			$3,000.00				$1,100.00		
Subtotal 1 with Mobilization			$62,831.87				$23,940.38		
Escalation to NTP									
Subtotal 2 = Subtotal 1 with Mob + Escalation			$62,831.87				$23,940.38		
Design Contingencies (15%)			$9,400.00				$3,600.00		
Contract Cost			$72,000.00				$28,000.00		
Construction Contingencies (25%)			$18,000.00				$7,000.00		
Field Cost			$90,000.00				$35,000.00		
Non Contract Costs (25%)			$23,000.00				$9,000.00		
Total Replacement Present Worth Costs			$113,000.00				$44,000.00		

Annual (Operations and Maintenance) Costs

		Boone		St Charles Mesa		Crowley Cty Water		Ordway	
	PWA Factor	Estimated Periodic Costs	Present Worth Costs (Jan 2011)	Estimated Periodic Costs	Present Worth Costs (Jan 2011)	Estimated Periodic Costs	Present Worth Costs (Jan 2011)	Estimated Periodic Costs	Present Worth Costs (Jan 2011)
Operations Costs	21.03006	$18,750.00	$394,313.63			$18,750.00	$394,313.63		
Maintenance Costs	21.03006	$6,400.00	$134,592.38	$15,000.00	$315,450.90	$6,900.00	$145,107.41	$2,600.00	$54,678.16
HMO O&M Costs	21.03006								
Pumping Costs	21.03006	$400.00	$8,412.02			$2,400.00	$50,472.14		
Subtotal Annual (Operation and Maintenance) Costs			$537,318.03		$315,450.90		$589,893.18		$54,678.16
Escalation to NTP									
Subtotal 2 with Escalation			$537,318.03		$315,450.90		$589,893.18		$54,678.16
Design Contingencies (10%)			$53,700.00		$31,500.00		$59,000.00		$5,500.00
Subtotal 3 = Subtotal 2 + Design Contingencies			$591,000.00		$347,000.00		$649,000.00		$60,000.00
Non Contract Costs (10%)			$59,000.00		$35,000.00		$65,000.00		$6,000.00
Total Operation and Maintenance Present Worth Costs			$650,000.00		$382,000.00		$714,000.00		$66,000.00

FY 2011 planning interest rate 4.125% per year for 50 years.

PWA Factor = P/A = ((1+i)^n-1)/(i*(1+i)^n) = Uniform Series Present Worth Factor (P/A, 4.125%, 50)

PW Factor = P/F = 1/(1+i)^n = Single Payment Present Worth (P/F, 4.125%)

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/12/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/12/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	**PROJECT:**
Fryingpan-Arkansas Project **Arkansas Valley Conduit** **No Action Alternative** **Independent Systems OM&R Summary**	**Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

Periodic (Replacement) Costs

		Olney Springs		Eureka		Fayette		North Holbrook	
	P/F Factor	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**
Year 5	0.81701								
Year 10	0.6675								
Year 15	0.54535								
Year 20	0.44555								
Year 25	0.36402								
Year 30	0.29741								
Year 35	0.24298								
Year 40	0.19852								
Year 45	0.16219								
Year 50	0.13251							$50,000.00	$6,625.50
Subtotal, Replacement Costs									$6,625.50
Mobilization (5%)									$300.00
Subtotal 1 with Mobilization									$6,925.50
Escalation to NTP									
Subtotal 2 = Subtotal 1 with Mob + Escalation									$6,925.50
Design Contingencies (15%)									$1,000.00
Contract Cost									$8,000.00
Construction Contingencies (25%)									$2,000.00
Field Cost									$10,000.00
Non Contract Costs (25%)									$3,000.00
Total Replacement Present Worth Costs									$13,000.00

Annual (Operations and Maintenance) Costs

		Olney Springs		Eureka		Fayette		North Holbrook	
	PWA Factor	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**
Operations Costs	21.03006			$18,750.00	$394,313.63	$18,750.00	$394,313.63	$18,750.00	$394,313.63
Maintenance Costs	21.03006	$2,100.00	$44,163.13	$11,700.00	$246,051.70	$6,900.00	$145,107.41	$8,800.00	$185,064.53
HMO O&M Costs	21.03006			$53,550.00	$1,126,159.71	$53,550.00	$1,126,159.71	$53,550.00	$1,126,159.71
Pumping Costs	21.03006							$400.00	$8,412.02
Subtotal Annual (Operation and Maintenance) Costs			$44,163.13		$1,766,525.04		$1,665,580.75		$1,713,949.89
Escalation to NTP									
Subtotal 2 with Escalation			$44,163.13		$1,766,525.04		$1,665,580.75		$1,713,949.89
Design Contingencies (10%)			$4,400.00		$176,700.00		$166,600.00		$171,400.00
Subtotal 3 = Subtotal 2 + Design Contingencies			$49,000.00		$1,943,000.00		$1,832,000.00		$1,885,000.00
Non Contract Costs (10%)			$5,000.00		$194,000.00		$183,000.00		$189,000.00
Total Operation and Maintenance Present Worth Costs			$54,000.00		$2,137,000.00		$2,015,000.00		$2,074,000.00

FY 2011 planning interest rate 4.125% per year for 50 years.

PWA Factor = P/A = ((1+i)^n-1)/(i*(1+i)^n) = Uniform Series Present Worth Factor (P/A, 4.125%, 50)

PW Factor = P/F = 1/(1+i)^n = Single Payment Present Worth (P/F, 4.125%)

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/12/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/12/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Independent Systems OM&R Summary**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit**
	WOID: / **ESTIMATE LEVEL:** Conceptual
	REGION: GP / **UNIT PRICE LEVEL:** Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

Periodic (Replacement) Costs

		Patterson Valley		South Swink		Las Animas			
	P/F Factor	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**
Year 5	0.81701								
Year 10	0.6675								
Year 15	0.54535								
Year 20	0.44555								
Year 25	0.36402			$22,000.00	$8,008.44	$210,500.00	$76,626.21		
Year 30	0.29741								
Year 35	0.24298								
Year 40	0.19852								
Year 45	0.16219								
Year 50	0.13251			$72,000.00	$9,540.72	$210,500.00	$27,893.36		
Subtotal, Replacement Costs					$17,549.16		$104,519.57		
Mobilization (5%)					$900.00		$5,200.00		
Subtotal 1 with Mobilization					$18,449.16		$109,719.57		
Escalation to NTP									
Subtotal 2 = Subtotal 1 with Mob + Escalation					$18,449.16		$109,719.57		
Design Contingencies (15%)					$2,800.00		$16,500.00		
Contract Cost					$21,000.00		$126,000.00		
Construction Contingencies (25%)					$5,000.00		$32,000.00		
Field Cost					$26,000.00		$158,000.00		
Non Contract Costs (25%)					$7,000.00		$40,000.00		
Total Replacement Present Worth Costs					$33,000.00		$198,000.00		

Annual (Operations and Maintenance) Costs

		Patterson Valley		South Swink		Las Animas			
	PWA Factor	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**	**Estimated Periodic Costs**	**Present Worth Costs (Jan 2011)**
Operations Costs	21.03006	$18,750.00	$394,313.63	$18,750.00	$394,313.63	$37,500.00	$788,627.25		
Maintenance Costs	21.03006	$6,900.00	$145,107.41	$26,800.00	$563,605.61	$37,300.00	$784,421.24		
HMO/RO O&M Costs	21.03006	$53,550.00	$1,126,159.71	$53,550.00	$1,126,159.71	$680,000.00	$14,300,440.80		
Pumping Costs	21.03006			$2,600.00	$54,678.16	$500.00	$10,515.03		
Subtotal Annual (Operation and Maintenance) Costs			$1,665,580.75		$2,138,757.10		$15,884,004.32		
Escalation to NTP									
Subtotal 2 with Escalation			$1,665,580.75		$2,138,757.10		$15,884,004.32		
Design Contingencies (10%)			$166,600.00		$213,900.00		$1,588,400.00		
Subtotal 3 = Subtotal 2 + Design Contingencies			$1,832,000.00		$2,353,000.00		$17,472,000.00		
Non Contract Costs (10%)			$183,000.00		$235,000.00		$1,747,000.00		
Total Operation and Maintenance Present Worth Costs			$2,015,000.00		$2,588,000.00		$19,219,000.00		

FY 2011 planning interest rate 4.125% per year for 50 years.

PWA Factor = P/A = ((1+i)^n-1)/(i*(1+i)^n) = Uniform Series Present Worth Factor (P/A, 4.125%, 50)

PW Factor = P/F = 1/(1+i)^n = Single Payment Present Worth (P/F, 4.125%)

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/12/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/12/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:

Fryingpan-Arkansas Project
Arkansas Valley Conduit
No Action Alternative
Independent Systems OM&R Costs

PROJECT: **Fryingpan-Arkansas Project - Arkansas Valley Conduit**

WOID:

ESTIMATE LEVEL: **Conceptual**

REGION: **GP**

UNIT PRICE LEVEL: **Jan-11**

FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Avondale					
		No Improvements					
		Boone					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$4,100.00
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$2,300.00
		Annual Pumping Costs for new wells			Annual		$400.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Unidentified Repairs		2	Year 25	5,000	$10,000.00
				2	Year 50	5,000	$10,000.00
		Replace Well Pump and Motor		4	Year 25	25,000	$100,000.00
		(Half every 25 years)		4	Year 50	25,000	$100,000.00
		St Charles Mesa Water District					
		Operations and Maintenance Costs					
		Annual Maintenance Cost (1.5% of Capital)			Annual		$15,000.00
		96 Pipeline					
		No additional OM&R Costs					
		SUBTOTAL THIS SHEET					**$281,550.00**

QUANTITIES		PRICES	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/12/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/12/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:

Fryingpan-Arkansas Project
Arkansas Valley Conduit
No Action Alternative
Independent Systems OM&R Costs

PROJECT: **Fryingpan-Arkansas Project - Arkansas Valley Conduit**

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ESTIMATE LEVEL: **Conceptual**

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UNIT PRICE LEVEL: **Jan-11**

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PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Crowley County Water Assn.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$3,500.00
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$3,400.00
		Annual Pumping Costs for new wells			Annual		$2,400.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		2	Year 25	500	$1,000.00
				2	Year 50	500	$1,000.00
		Unidentified Repairs		2	Year 25	5,000	$10,000.00
				2	Year 50	5,000	$10,000.00
		Replace Well Pump and Motor		1	Year 25	25,000	$25,000.00
		(Half every 25 years)		1	Year 50	25,000	$25,000.00
		Crowley					
		No Improvements					
		Ordway					
		Operations and Maintenance Costs					
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$2,600.00
		Olney Springs					
		Operations and Maintenance Costs					
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$2,100.00
		Sugar City					
		No Improvements					
		Beehive Water Assn.					
		No Improvements					
		SUBTOTAL THIS SHEET					**$124,750.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
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ESTIMATE WORKSHEET

FEATURE: **Fryingpan-Arkansas Project** **Arkansas Valley Conduit** **No Action Alternative** **Independent Systems OM&R Costs**	**PROJECT:** **Fryingpan-Arkansas Project - Arkansas Valley Conduit**
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	REGION: **GP** / **UNIT PRICE LEVEL:** **Jan-11**
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PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Eureka Water Co.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$11,700.00
		Annual HMO Maintenance and Operation			Annual		$53,550.00
		Fayette Water Assn.					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$6,900.00
		Annual HMO Maintenance and Operation			Annual		$53,550.00
		Manzanola					
		No Improvements					
		Newdale-Grand Valley Water Co.					
		No Improvements					
		North Holbrook Water					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$1,900.00
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$6,900.00
		Annual HMO Maintenance and Operation			Annual		$53,550.00
		Annual Pumping Costs for new well			Annual		$400.00
		Replacement Costs					
		Replace Well Pump and Motor			Year 25	50,000	
		(Half every 25 years)		1	Year 50	50,000	$50,000.00
		SUBTOTAL THIS SHEET					**$294,700.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/12/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/12/11	**PEER REVIEW / DATE** RJL / 12-15-2011

FEATURE:	PROJECT:
Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Independent Systems OM&R Costs	Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
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PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Patterson Valley					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$6,900.00
		Annual HMO Maintenance and Operation			Annual		$53,550.00
		South Side Water Assn.					
		No Improvements					
		South Swink Water Company					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.25	ea	75,000	$18,750.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$15,100.00
		Annual Maintenance Cost, Treatment (1.5% of Capital)			Annual		$11,700.00
		Annual HMO Maintenance and Operation			Annual		$53,550.00
		Annual Pumping Costs for new well and PS			Annual		$2,600.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		4	Year 25	500	$2,000.00
				4	Year 50	500	$2,000.00
		Unidentified Repairs		2	Year 25	5,000	$10,000.00
				2	Year 50	5,000	$10,000.00
		Replace Well Pump and Motor			Year 25	50,000	
		(Half every 25 years)		1	Year 50	50,000	$50,000.00
		West Holbrook Water					
		No Improvements					
		Hasty Water Co.					
		No Improvements					
		SUBTOTAL THIS SHEET					**$274,900.00**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Black & Veatch		Black & Veatch	
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
12/12/11		12/12/11	RJL / 12-15-2011

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ESTIMATE WORKSHEET

FEATURE: Fryingpan-Arkansas Project Arkansas Valley Conduit No Action Alternative Independent Systems OM&R Costs	**PROJECT:** Fryingpan-Arkansas Project - Arkansas Valley Conduit
	WOID:
	ESTIMATE LEVEL: Conceptual
	REGION: GP
	UNIT PRICE LEVEL: Jan-11
	FILE: c:\pw_working\cngpw\d0210074\[AVC Estimate Worksheet_No Action Costs_1Feb12.xlsx]Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Las Animas					
		Operations and Maintenance Costs					
		Annual Operations Staff (Staff and Vehicle)		0.50	ea	75,000	$37,500.00
		Annual Maintenance Cost (0.5% of Capital)			Annual		$37,300.00
		Annual Pumping Costs for new brine PS			Annual		$500.00
		Annual RO Concentrate / Evap Ponds Maintenance and Operation			Annual		$680,000.00
		Replacement Costs					
		Pipe Break		1	Year 25	10,000	$10,000.00
				1	Year 50	10,000	$10,000.00
		Air Valve Replacement		1	Year 25	500	$500.00
				1	Year 50	500	$500.00
		Unidentified Repairs		1	Year 25	200,000	$200,000.00
				1	Year 50	200,000	$200,000.00
		McClave Water Assn.					
		No Improvements					
		Wiley					
		No Improvements					
		Eads					
		No Improvements					
		SUBTOTAL THIS SHEET					**$1,176,300.00**

QUANTITIES		**PRICES**	
BY Black & Veatch	**CHECKED**	**BY** Black & Veatch	**CHECKED**
DATE PREPARED 12/12/11	**PEER REVIEW / DATE**	**DATE PREPARED** 12/12/11	**PEER REVIEW / DATE** RJL / 12-15-2011

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Appendix B.4 – Existing and Reasonably Foreseeable Actions

Introduction

This memorandum discusses existing conditions, reasonably foreseeable actions and other actions considered but eliminated as reasonably foreseeable actions for the Arkansas Valley Conduit Environmental Impact Statement. For purposes of this memorandum, all actions are summarized into the following categories:

- General Water Related Activities
- Water Administration
- Districts and Organizations
- Water Development Projects
- Excess Capacity Contracts
- Agricultural to Municipal Transfers
- Flooding and Flood Control
- Hydropower and Energy Projects
- Transportation Projects

Existing Conditions

The time frame considered for the existing conditions generally corresponds to either the time that the Notice of Intent (NOI) was issued or 2010, although some more recent events are also described. In addition to natural characteristics, past and present water, land, and urban development projects help define the existing conditions for each resource. A summary of these actions is shown in Table 1.

Table 1. Summary of Past and Existing Activities that Affect the Natural and Human Characteristics of the Study Area

Activity	Description
General Water Related Activities	
Agriculture	Agriculture in the Arkansas River Basin, and more specifically irrigated agriculture, developed in the mid to late 1800s. There are approximately 428,000 irrigated acres in the Arkansas River Basin (including areas outside of the study area), with an irrigation water requirement of approximately 995,000 acre-feet per year, or 2.3 acre-feet per acre (Colorado Water Conservation Board 2011).
Climate Change	Based on review of technical information by Reclamation, all areas of Reclamation's Great Plains region have become more temperate. These areas experienced a general increase in annual precipitation and a decline in spring snowpack, including reduced snowfall to winter precipitation ratios and earlier snowmelt runoff (Reclamation 2009a). Climate change has contributed to existing conditions for several resources, including streamflow, water quality, geomorphology, wildlife habitat, wetlands, vegetation, aquatic life, recreation, cultural resources, and socioeconomics.
Mining	Hard-rock mining, including gold, silver and molybdenum, has been active in the Upper Arkansas River Basin since the mid to late 1800s. This mining has resulted in acid mine drainage into tributaries to the Arkansas River. California Gulch, near Leadville, was added to the National Priorities List of Superfund Sites in 1983. Two treatment plants were constructed to remediate acid mine waste drainage into the groundwater and, ultimately, into the Arkansas River.
Non-Consumptive Water Uses	Nonconsumptive water uses include environmental and recreational water uses that result in little or no net consumptive use of water. The Colorado Water Conservation Board recently found that there are 40 nonconsumptive on-going projects and studies, 86 natural lakes, and 190 decreed, pending or recommended instream flow water rights in the Arkansas Basin. In addition, several other general programs are on-going in the basin (Colorado Water Conservation Board 2011).
Urban and Suburban Development in Chaffee, Fremont, El Paso, Pueblo, Crowley, Otero, Bent, Prowers, and Kiowa Counties and growth of military installations	Rapid population growth and land development since the 1950s have resulted in urban, suburban and rural development. This resulted in hydrologic changes due to increased runoff from impervious surfaces as well as use, discharge, and reuse of municipal water supplies. Some of this developed area, such as Colorado Springs, is outside of the study area. However, because Colorado Springs and surrounding communities in Fountain Creek are upstream of the study area, hydrologic changes resulting from development affect the study area. Overall, municipal and industrial water use in the Arkansas River Basin (including areas outside of the study area) is approximately 196,000 acre-feet per year serving a population of 948,000. Basin-wide per capita use is 185 gallons per capita per day, while the statewide average is 172 gallons per capita per day (Colorado Water Conservation Board 2011). Urban growth and development has also affected other resources, such as vegetation, wildlife, visual quality, noise, ground water, water quality, and socioeconomics.
Water Administration	
Arkansas River Compact	The Arkansas River Compact, which governs the use and distribution of water in the Arkansas River between Colorado and Kansas, was signed by the states in December 1948 and approved by Congress and the President in 1949 (US 63 Stat. 145-152). In 1985, Kansas brought suit against Colorado claiming injury under the Compact (U.S. Supreme Court, *Kansas v Colorado* No. 105, Orig.). A final opinion was issued by the Supreme Court in 2009. As a result of the lawsuit, several rules were implemented governing water use within the Arkansas River Basin. See discussion of the Arkansas River Compact in Surface Water Hydrology, below.

Activity	Description
Arkansas River Irrigation Improvement Rules	In 2010 the Colorado State Engineer implemented rules in accordance with Rule 11 of the Arkansas River Basin Compact that requires irrigators to obtain permits from the State Engineer's office for irrigation efficiency improvements in the Arkansas River Basin. These permits are intended to ensure improvements do not materially deplete the waters of the Arkansas River in violation of Article IV-D of the Arkansas River Compact (Irrigation Improvement Rules website; Colorado Division of Water Resources 2010). In addition, the 1996 "Amended Rules and Regulations Governing the Diversion and Use of Tributary Ground Water in the Arkansas River Basin, Colorado" require groundwater users to replace depletions of surface water.
Minimum Flows and Flow Management Programs	In addition to programs shown separately in this table, several other minimum flow water rights and flow management programs influence water operations in the basin. Additional information on these water rights and flow programs is provided in Appendix D.1.
Pueblo Flow Management Program	Six-party intergovernmental agreements were signed in 2004 to manage flows in the Arkansas River from Pueblo Dam to Fountain Creek primarily for recreational purposes. See description of the program in Appendix D.1.
Recovery-of-Yield Storage Contract	A cooperative multi-party agreement to develop off-channel storage to recapture un-exchangeable return flows and other water supplies that would have otherwise been lost due to inadequate streamflow for exchanges (developed in principle in 2004, first used in 2005 using Holbrook Reservoir).
Upper Arkansas Voluntary Flow Management Program	This program was established in 1990 to manage flows for the protection of the fishery and summer recreational boating in the Arkansas River upstream of Pueblo Reservoir. See description of the program in Appendix D.1
Well use and groundwater rules	In the 1950s and 1960s, irrigators began to install wells to use groundwater for irrigation. The Colorado legislature eventually required that these wells be included in the prior appropriation system with the "Water Rights Determination Act of 1969". All well owners had to obtain a decree from the District Court establishing a priority date, use, diversion rate and place of use. To prevent well use from injuring the more senior surface water rights, the State Engineer enacted rules governing the use of the wells in 1973 (Colorado State Engineer's Office 1973). In 1996, the State Engineer amended the Rules (1996 Amended Rules and Regulations Governing the Diversion and use of Tributary Groundwater in the Arkansas River Basin, Colorado) and required that the well users annually submit for approval a "Rule 14 Plan" which identifies the amounts of allowable pumping, the resulting depletions, and the sources of water used to replace the depletions (Colorado State Engineer's Office 1996). Several augmentation groups formed in the Lower Arkansas River Basin to assist irrigators with augmentation and Compact compliance (Lower Arkansas Water Management Association, Arkansas Groundwater Users Association, and the Colorado Water Protective and Development Association). These groups provide replacement water to allow their members to operate their wells under the 1973 Rules and Rule 14 plans.
Districts and Organizations	
Lower Arkansas Valley Water Conservancy District	The Lower Arkansas Valley Water Conservancy District was formed in November and December of 2002 when voters in Pueblo, Otero, Crowley, Bent and Prowers counties approved an initiative forming the district. The district acquires, retains and conserves water resources within the Lower Arkansas River Valley (Lower Arkansas Valley Water Conservancy District 2011).
Pueblo Conservancy District	The Pueblo Conservancy District was established following the 1921 floods in Pueblo as the contracting entity for levees constructed by the U.S. Army Corps of Engineers along the Arkansas River through Pueblo to the Otero County line. The District subsequently extended levee protection along Fountain Creek within Pueblo. The District is currently performing levee maintenance and repairs as described below.

Activity	Description
Purgatoire River Water Conservancy District	The Purgatoire River Water Conservancy District was created in the 1960s as a legal entity capable of contracting with the United States for repayment of the irrigation, municipal and industrial component assigned to the Trinidad Project (see below) and to provide a management entity to oversee the Trinidad Project. (Purgatoire River Water Conservancy District 2011).
Southeastern Colorado Water Conservancy District	The Southeastern Colorado Water Conservancy District was created in 1958 for the purpose of developing and administering the Fryingpan-Arkansas Project. The District extends along the Arkansas River from Buena Vista to Lamar, and along Fountain Creek from Colorado Springs to Pueblo. Additional information is contained in Chapter 1 of the EIS.
Upper Arkansas Water Conservancy District	The Upper Arkansas Water Conservancy District was founded in 1979 by state statute for the purpose of protecting and securing water in the Upper Arkansas Valley. It administers an augmentation plan in which a person or business can purchase a water augmentation right through the Upper Arkansas Water Conservancy District (2011). These plans affect surface water flow on the Arkansas River.
Water Development Projects	
Blue River Project	The Blue River Project is a transmountain project that diverts water from the upper reaches of the Blue River into Colorado Springs' local system. Water is diverted out of several tributary streams to the Blue River and the Blue River headwaters, through a series of pipelines and tunnels to the Hoosier Tunnel. The Hoosier Tunnel conveys water beneath the Continental Divide to Montgomery Reservoir in the South Platte River Basin. From Montgomery Reservoir, water flows by gravity through the Blue River Pipeline to North Catamount Reservoir on the north slope of Pike's Peak, where it is then conveyed to Colorado Springs water treatment plants. By decree, water diverted through the Blue River system must be reused to extinction by Colorado Springs. Therefore, although its direct imports do not affect the study area, the reusable return flows resulting from its use do affect the study area.
Busk-Ivanhoe System	The Busk-Ivanhoe System is a transmountain diversion project that diverts water from the upper reaches of Ivanhoe Creek in the Colorado River Basin to Turquoise Lake. Diversions are made through the Ivanhoe Tunnel, also known as the Carlton Tunnel, which is a converted railroad tunnel. However, due to the condition of the tunnel, it cannot carry the full transmountain supply. The Board of Water Works of Pueblo has contracted with Reclamation to carry a portion of the supply through the Boustead Tunnel, although they have not done so since 2003. The Board of Water Works of Pueblo and the city of Aurora have equal ownership of the system, including 10,000 acre-feet of storage in Turquoise Lake.
Columbine, Ewing, and Wurtz Ditches	Columbine, Ewing and Wurtz Ditches are smaller transmountain diversion ditches that divert water from the Colorado River Basin to the Arkansas River Basin near Tennessee and Fremont Passes north of Leadville. The Board of Water Works of Pueblo owns the Ewing and Wurtz diversion structures and their associated water rights. The Board of Water Works of Pueblo sold the Columbine Ditch in 2009 to Fremont Pass Ditch Co.
Fry-Ark Project	As discussed in other sections of the EIS, this project is a transbasin water diversion and delivery project to serve both agricultural and municipal entities. It was authorized in 1962, with construction commencing in 1964 and continuing through the mid 1980s. Additional information on the project is contained in the EIS and Appendix D.
Fountain Valley Conduit	This 45-mile conduit was constructed in 1985 to convey water for municipal use from Pueblo Reservoir to members of the Fountain Valley Authority, which include Colorado Springs, Fountain, Security, Widefield and Stratmoor Hills.

Activity	Description
Homestake Project	The Homestake Project is a municipal transmountain diversion project owned jointly by the cities of Colorado Springs and Aurora. The project includes a Western Slope diversion system in the Homestake Creek watershed, Homestake Reservoir on the Western Slope, the Homestake Tunnel, which diverts water from Homestake Reservoir into Turquoise Reservoir, and the Otero Pump Station and Homestake Pipeline. The Homestake Pipeline conveys Homestake Project water as well as several other sources of water to Spinney Mountain Reservoir in the South Platte River Basin for Aurora and Rampart Reservoir on the north slope of Pikes Peak for Colorado Springs.
John Martin Reservoir	John Martin Reservoir is located in the Lower Arkansas Valley on the Arkansas River between Las Animas and Lamar. The dam was constructed in the early to mid 1940s by the U.S. Army Corps of Engineers, and is used for flood control, irrigation, recreation, and for administration of the Arkansas River Compact. Reservoir capacity at the top of the flood control gates is 603,500 acre-feet. The maximum recreation and conservation storage is 343,960 acre-feet, although the storage volume at the top of the conservation pool is 333,912 acre-feet. Up to 10,000 acre-feet in the permanent pool (water for fish, wildlife and recreation) is allowed to be stored in flood control space, accounting for the difference in the maximum conservation storage and conservation pool (USACE 2011).
Trinidad Project, Dam and Reservoir	Trinidad Dam and Reservoir, constructed in the 1970s, is the main feature of the Trinidad Project. The dam and reservoir are located several miles west of the City of Trinidad, on the Purgatoire River in Las Animas County. The reservoir has a total capacity of 125,967 ac-ft and is used for flood control, municipal and industrial water, recreation and fisheries. The repayment portion of the Trinidad Project is managed by Reclamation (Purgatoire River Water Conservancy District 2011). The Purgatoire River is tributary to the Arkansas River at Las Animas, thus the Trinidad Project affects surface water hydrology in the study area.
Twin Lakes Project	This is a transbasin water diversion and delivery project initially constructed in the 1930s to serve agricultural water uses. Since the 1950s, water use from this system has gradually transitioned to primarily municipal and industrial use.
Excess Capacity Contracts	
Board of Water Works of Pueblo Long-Term Storage Contract	This 25-year excess capacity contract allows the Board of Water Works of Pueblo to store non-Fry-Ark Project water in Pueblo Reservoir (began in 2001). Annual storage amounts are presented in Appendix D.1.
City of Aurora Long-Term Storage Contract	Reclamation completed an Environmental Assessment and Finding of No Significant Impact in March 2007 that resulted in a long-term excess capacity storage contract with Aurora for storage of up to 10,000 ac-ft of non-Fry-Ark Project water in Pueblo Reservoir, and contract exchanges between Pueblo Reservoir, Turquoise Lake and Twin Lakes.
Pueblo West Metropolitan District Excess Capacity Conveyance Contract	Pueblo West currently has two conveyance contracts with Reclamation. The first is a 40-year contract beginning in 1984 for conveyance of up to 18.94 cfs through the South Outlet Works of Pueblo Dam. The second is a 5-year excess capacity conveyance contract beginning in 2007 to convey up to 30.94 cfs (or an additional 15.06 cfs) of non Fry-Ark Project water in the south outlet works of Pueblo Dam using space currently allocated to the Arkansas Valley Conduit.
Southern Delivery System Excess Capacity Contract	Southern Delivery System participants and Reclamation executed temporary excess capacity contracts for water in Pueblo Reservoir for 2011. Amounts of those contracts are 400 acre-feet for the City of Fountain, 9,000 acre-feet for Pueblo West, 200 acre-feet for Security, and 17,000 acre-feet for Colorado Springs Utilities. Because these contracts are already in place, the temporary excess capacity portion of the Southern Delivery System project is treated as an existing condition in this EIS. Future long-term 40-year contracts associated the project are discussed in Table 2.

Activity	Description
Temporary Excess Capacity Contracts	Beginning in 1986, these contracts allow storage of non Fry-Ark Project water in Fry-Ark Project reservoirs for use at a later date to more efficiently use infrastructure for temporary municipal, industrial, irrigation, fishery and recreation uses. Temporary excess capacity contracts have been issued to some Master Contract participants in the recent past. For some of the alternatives evaluated in the EIS, Master Contract participants would replace their short-term contracts with long-term contracts as part of the Master Contract. A list of historical short-term contract amounts is presented in later sections of this appendix. NEPA compliance is required for each contract. The most recent NEPA documents are available at http://www.usbr.gov/gp/nepa/quarterly.cfm (Reclamation 2011a).
Winter Water Storage Program	Initiated in 1977, this program allows specific agricultural water rights to be stored in Pueblo Reservoir from November to March for use during the peak agricultural demand season. This program, along with the 1980 Operating Plan for John Martin Reservoir, also provides for storage of "winter water" in John Martin Reservoir and off-channel irrigator owned reservoirs.
Agricultural to Municipal Transfers [1]	
Agricultural to Municipal Water Transfers	Many historical agricultural water rights in the Arkansas River Basin have been transferred to municipal entities to meet growing M&I demands. In addition to those discussed in the remainder of this table and subsequent tables in this appendix, several smaller transfers have occurred throughout the basin. Water rights from several ranches in the Upper Arkansas River Basin and Grape Creek area have been purchased and transferred to municipal uses. Additionally, most large ditches in the study area have had at least a small portion of their shares transferred to municipal and industrial uses.
Colorado Canal	Since the 1980s, municipal and industrial entities have transferred approximately 90% of the shares in the Colorado Canal companies to municipal use. The Colorado Canal System is comprised of the Colorado Canal Company, the Lake Meredith Company and the Lake Henry Company. The Colorado Canal diverts water from the Arkansas River near Boone, downstream of Pueblo. The Colorado Canal conveys water either directly to agricultural water users or to storage in Lake Meredith and Lake Henry. Water is then released back to the Arkansas River from Lake Meredith and Lake Henry to be exchanged upstream for use by municipal and industrial shareholders.
Highline Canal Leases – City of Aurora	Aurora has signed agreements with the Southeastern Colorado Water Conservancy District that allows negotiations of short-term leases with Arkansas Valley ditches in the reach between the Rocky Ford Ditch and Pueblo Reservoir. The lease program limits the leases to no more than three years out of every 10-year period beginning in 2006, with a maximum annual lease of no more than 10,000 ac-ft. Aurora has recently entered into a lease contract with the Highline Canal Company to divert up to 10,000 acre-feet of water at a rate commensurate with historical irrigation consumptive use (Aurora Water Supply Fact Book; Aurora Water 2011).
Rocky Ford Ditch Transfers	Since the early 1990s, the city of Aurora has purchased and transferred to municipal and industrial use about 93 percent of Rocky Ford Ditch shares. The Rocky Ford Ditch diverts water from the Arkansas River between Manzanola and Rocky Ford, and formerly irrigated approximately 8,000 acres of land surrounding the town of Rocky Ford. The Rocky Ford Ditch has an appropriation date of May 15, 1874, making it one of the most senior water rights in the Arkansas River system. Aurora shares are run through the ditch system and released back to the Arkansas River through augmentation stations, where they are then exchanged to Pueblo Reservoir. If exchange potential is unavailable, water is stored in the Colorado Canal system reservoirs or Recovery-of-Yield storage.
Wastewater, Flooding and Flood Control Projects	
Fountain Creek Recovery Project	A Colorado Springs project constructed in 2007 to capture sanitary sewer spills to Fountain Creek and keep spills from reaching downstream communities.

Activity	Description
Fountain Creek Watershed Greenway and Flood Control District	The district was formed to manage, administer, and fund the capital improvements necessary in the Fountain Creek Watershed to mitigate flooding, erosion and sedimentation; address water quality issues; improve drainage; fund the protection of open space; and develop public recreational opportunities including open space.
Multiple flood events including 1965, 1993, 1999, 2005, 2011	These flood events caused washed out bridges, trails, and roads, and eroded stream banks. During some events, homes and agricultural areas were flooded along the Lower Arkansas River and Fountain Creek, and sewer lines broke in Fountain Creek.
Pueblo levee maintenance	The Pueblo Conservancy District is currently performing levee maintenance and repairs during low water conditions on the Arkansas River. In early 2011, repairs on the levee through the kayak course were performed to prevent erosion by installing drains at the base of the concrete levees. Work will continue on a concrete cap that is securing the levee between structures No. 4 and No. 5 on the kayak course (Woodka 2011a).
Hydropower and Energy Projects	
Comanche Station Unit 3 Power Plant Expansion – Xcel Energy	Xcel Energy recently began operating an 850-megawatt expansion (Unit 3) to its coal-fired Comanche Generating Station in Pueblo, which increases the station's capacity to 1,500 megawatts. Unit 3 began producing electricity in July 2010. This power plant uses water (primarily leased from the Board of Water Works of Pueblo from the Arkansas River) for cooling. Annual use for the entire plant is approximately 10,000 acre-feet (Xcel Energy – Comanche Station website; Xcel Energy 2010).
Transportation Projects	
Replacement of 4th Street Bridge over the Arkansas River in Pueblo – Colorado Department of Transportation	The old 4th Street Bridge, which crosses the Arkansas River in Pueblo, had structural deficiencies and was replaced by the Colorado Department of Transportation. The new bridge is located slightly north of the old bridge. The ribbon-cutting ceremony for the bridge took place on December 17, 2010, and the bridge is fully operational (4th Street Bridge Project website; Colorado Department of Transportation 2010a).

Notes:
(1) The existing conditions table only includes major transfers that have been purchased and fully transferred to municipal and industrial use. Those transfers that have been purchased but not transferred are discussed in other locations in this document.

Reasonably Foreseeable Actions

The time frame considered for the EIS effects analyses generally extends from the past to 2070, which is the planning horizon for the AVC and likely terms of the repayment contracts. Each of the resource sections in the EIS provide a cumulative effects analysis, including evaluations of the effects of reasonably foreseeable future actions combined with the AVC alternatives. For the cumulative effects analysis, a list of potential reasonably foreseeable actions was developed. The following criteria were used to define reasonable foreseeable actions:

- It is expected to be implemented or to occur between now and 2070 (i.e., AVC EIS study period)
- If required, a known source of funding has been identified or is reasonably certain (not applied as a stand-alone criterion)
- It is judged to contribute measurably to cumulative effects in the geographic area and on the resources that would be affected by the AVC EIS alternatives

- It has sufficient information available to define the activity and conduct a meaningful analysis
- If required, a permit application would be submitted to a federal, state, or local agency with jurisdiction over the activity, and the outcome of the permitting process is well enough defined to draw qualitative or quantitative conclusions regarding its cumulative effects.

For purposes of this appendix, the cumulative effects geographic area has been defined fairly broadly to incorporate actions that could potentially affect the EIS study area. A more detailed description of the cumulative effects by geographic area is defined in the EIS for each resource.

The reasonably foreseeable future actions occurring through 2070 are described in Table 2.

Table 2. Reasonably Foreseeable Actions

Action	Description
General Water Related Activities	
Climate Change	Climate change is expected to continue in the future, and may have cumulative effects on streamflow, water quality, geomorphology, wildlife habitat, wetlands, vegetation, aquatic life, recreation, cultural resources, and socioeconomics. Discussions of climate studies that pertain to the study area are documented in Chapter 4 and Appendix C, and cumulative effects evaluations for all resources discuss how climate change may affect the resource.
Urban and Suburban Development in Chaffee, Fremont, El Paso, Pueblo Crowley, Otero, Bent, Prowers, and Kiowa counties	Population growth is expected in each of the counties where the participants are located, with the exception of Kiowa County, where population is expected to remain flat. (Population Forecasts; Colorado Department of Local Affairs 2010). The cumulative effects analysis considers the following actions due to urban development within the study area: • Land use effects for AVC participants, Master Contract participants, and other municipal entities within the study area • Increased water demand for other municipal entities within the study area, or for those entities that affect water resources within the study area (such as Colorado Springs Utilities and the city of Aurora) • Increased surface water runoff in Colorado Springs due to more impervious area and subsequent increased flows in Fountain Creek Future water demand for AVC and Master Contract participants is considered in the direct effects analysis, rather than cumulative effects analysis.
Water Development Projects	
Fountain Water Supply Project	Fountain is expanding its Fountain Creek wellfield to meet projected maximum day demand through the year 2046 through the use of 17 new wells in Fountain (Black & Veatch 2007). A new untreated water reservoir and microfiltration water treatment plant will be constructed. This new treatment plant will be located on the west side of Fountain. Treatment brine will be evaporated and waste separated, resulting in no liquid waste discharge. Treated water will be conveyed through new transmission pipelines and pump stations. Small storage facilities for potable water and return flows will be included (Fountain Water Plan; Black & Veatch 2007). The project may have cumulative effects on groundwater levels or surface water flow.
Southern Delivery System	Southern Delivery System is a regional project that will convey water through a 62-mile underground pipeline from Pueblo Reservoir to Colorado Springs, Fountain, Security, and Pueblo West, including a connection to Pueblo Dam, pump stations, water treatment plant, two reservoirs (Upper Williams Creek and Williams Creek), and a long-term excess capacity contract in Pueblo Reservoir for 42,000 acre-feet. The Bureau of Reclamation issued its record of decision for Southern Delivery System on March 20, 2009. The Pueblo Board of County Commissioners unanimously approved a resolution to issue a 1041 land-use permit for the Southern Delivery System preferred alternative on April 21, 2009 (SDS website; Colorado Springs Utilities 2010). Construction began on Southern Delivery System in 2011. The Southern Delivery System will have cumulative effects on streamflow, reservoir levels, water quality, geomorphology, wetlands and several other resources within the AVC EIS study area.
Excess Capacity Contracts	
Short-Term Excess Capacity Contracts	Short-term excess capacity contracts are granted by Reclamation to various entities throughout the Arkansas River Basin on an annual basis. These contracts generally allow the contract holder to store non Fry-Ark Project water in Fry-Ark storage space (typically Pueblo Reservoir). The duration of these contracts is generally from 1 to 3 years, but they are renewed annually. Continued issuance of these contracts is reasonably foreseeable.

Action	Description
Southern Delivery System Excess Capacity Contracts	The Southern Delivery System will include long-term excess capacity contracts in Pueblo Reservoir for 42,000 acre-feet. Colorado Springs Utilities will be issued a contract for 28,000 acre-feet annually, Pueblo West for 10,000 acre-feet, Security for 1,500 acre-feet and Fountain for 2,500 acre-feet annually.
Wastewater, Flooding and Flood Control Projects	
Cherokee Metropolitan District - New Wastewater Treatment Facility	Cherokee Metropolitan District (located adjacent to the eastern side of Colorado Springs) is constructing a new wastewater treatment facility, which will change the discharge point for its wastewater effluent from the Fountain Creek Basin to the Upper Black Squirrel Creek Basin, which drains to the Lower Arkansas River Basin (Cherokee Metro Wastewater website; Cherokee Metropolitan District 2010). Construction on the facility is essentially complete.
Pueblo West Metropolitan District - Wastewater Discharge Pipeline (Wild Horse Dry Creek)	As part of agreements reached with Pueblo County and Southern Delivery System participants, Pueblo West Metropolitan District is proposing to construct a pipeline from its wastewater treatment facility to the Arkansas River generally following Wild Horse Dry Creek. This water would then be exchanged upstream to Pueblo Reservoir. As part of the agreement, Colorado Springs would provide up to 900 acre-feet annually to Pueblo West through contract exchanges if water is lost due to the Pueblo Flow Management Program.
Agricultural to Municipal Transfers	
Lower Arkansas Valley Super Ditch Company	The Lower Arkansas Valley Super Ditch Company (Super Ditch) was formed in 2008 by shareholders of six irrigation districts as an agent to facilitate temporary leases and transfers of irrigation water between the Company and other water users, primarily municipal water users (Lower Arkansas Valley Water Conservancy District website; Lower Arkansas Valley Water Conservancy District 2010). Super Ditch supplies are being considered by several AVC and Master Contract participants. The effects of Super Ditch transfers to AVC and Master Contract participants, and for specified irrigation improvement and seep ditch augmentation uses, are evaluated within this EIS. Additional information is provided in the EIS and Appendix D. Table 3 provides additional information on those portions of the Super Ditch not included as reasonably foreseeable in the AVC EIS.
Transportation Projects	
State Highway 194 overlay	An overlay is planned for State Highway 194 in 2013 from approximately milepost 0 to milepost 10. Current AVC alignment alternatives consider paralleling State Highway 194 from approximately milepost 10 to milepost 20 (Colorado Department of Transportation 2010b).
US 287 at Lamar project	The Colorado Department of Transportation initiated a feasibility study for an alternate truck route around the City of Lamar in early 1999. As a result of this study, a preferred corridor was selected and presented to the public in the Spring 2000. The preferred corridor is located on the east side of Lamar extending approximately nine miles from the southern end near County Road C-C north across the Arkansas River and connecting to State Highway 196 north of Lamar. The project also includes improvements to Main Street in Lamar. The Colorado Department of Transportation is currently developing an environmental assessment (EA) for the project. The EA will build on the feasibility study, detail proposed corridor alternative designs, and evaluate potential environmental impacts of these proposed alternatives. A final EA and finding of no significant impact (if applicable) is expected in 2011. Based on this schedule, it is reasonable that the project would be permitted in 2012, and would be constructed within the AVC planning horizon of 2070 (US 287 at Lamar website; Colorado Department of Transportation 2010c).

Action	Description
Peak to Prairie-Fountain Creek Conservation Project – Colorado Open Lands	The Peak to Prairie Project is a large-scale conservation initiative focusing on key resources in El Paso, Pueblo, Lincoln and Crowley counties. The project involves many partners and stretches from Cheyenne Mountain in the west to the western half of Lincoln and Crowley counties in the east, from the City of Colorado Springs in the north to the City of Pueblo and the Arkansas River in the south. The project covers over 2.1 million acres of prairie, creek, mountain and plains. Within this region are valuable resources such as working agricultural operations, scenic vistas, threatened wildlife habitat, intact prairie ecosystems, military assets, and open space. The goal of the project is to preserve and protect these resources by knitting together and protecting public and private lands. Implementation began in 2008 (Peak-to-Prairie website; Colorado Open Lands 2010).

A number of actions were considered in this analyses but will not be considered in the cumulative effects analysis because the action did not meet one or more of the criteria necessary to be deemed reasonably foreseeable. Many of these activities lacked funding, government action, or NEPA compliance in a reasonable time frame. A summary of these projects is presented in Table 3.

Table 3. Actions Considered but Determined Not To Be Reasonably Foreseeable Actions

Action	Description
Water Development Projects	
Box Creek Reservoir – City of Aurora	The Box Creek Reservoir site is located in the Upper Arkansas River Basin between Turquoise Lake and Twin Lakes. Box Creek Reservoir is still in the feasibility phase, and various alternatives for delivering water into and out of the proposed reservoir are being considered (Aurora Water Supply Fact Book; Aurora Water 2011). Aurora has decreed water rights for exchange into the reservoir (99CW170, Division 2). It is likely that this site will require NEPA compliance, as exchanges would be made from Aurora's excess capacity account in Pueblo Reservoir which is contracted through Reclamation.
Preferred Storage Options Plan	The Preferred Storage Options Plan, sponsored by Southeastern, would involve renewing operation of space in Pueblo Reservoir and other Fry-Ark facilities, and enlargement of Pueblo Reservoir. For the project to proceed, changes to federal legislation, NEPA compliance, and funding are required. It is unlikely that environmental permitting and funding would be acquired in a reasonable timeframe for consideration in the AVC EIS.
Stonewall Springs Reservoir	Stonewall Springs Reservoir is a potential future gravel pit complex located on the Arkansas River near the Excelsior Ditch diversion east of Pueblo. Up to three reservoirs could be constructed with a total storage capacity of about 25,000 acre-feet. There are current gravel mining operations at these sites operated under permit no. M2008052 from the Colorado Division of Minerals and Geology for 1,030 acres. Woodmoor Water and Sanitation District has contracted with the developers of the site (Stonewall Springs Quarry, LLC) for 8,300 acre-feet of storage (Tetra Tech 2010, Woodka 2010a, Woodka 2010b). The reservoir is also listed as an exchange point in the Lower Arkansas Valley Water Conservancy District Super Ditch water rights application. It is unknown when the project would be constructed.
Agricultural to Municipal Transfers	
Bessemer Ditch Transfer to Municipal Use	The Board of Water Works of Pueblo has recently purchased about 5,400 shares (or 28%) of the Bessemer Ditch. The Board of Water Works of Pueblo anticipates that these shares will ultimately be used for municipal purposes within its system. However, it is not known at this time how much of the land will be permanently dried and how much may be incorporated into a rotational fallowing scheme that would sustain agriculture on the lands. Because of the uncertainty regarding timing and implementation of this project, it is unclear how this project may affect the study area (Woodka 2011b). It is likely that this action will require NEPA compliance, as exchanges would be made to Pueblo's excess capacity account in Pueblo Reservoir which is contracted through Reclamation. St. Charles Mesa Water District owns approximately 2057.744 shares in the Bessemer Ditch, or about 10.4% (some of which has already been dried up and transferred, and is considered in existing conditions). Transfer and use of these shares are analyzed in the EIS, as described in Appendix A.
Lower Arkansas Valley Super Ditch Company	The Lower Arkansas Valley Super Ditch Company (Super Ditch) transfers not specifically identified as part of the Master Contract account (including, but not limited to, potential water users such as Colorado Springs, Aurora, Board of Water Works of Pueblo, upper Fountain Creek entities, or other entities outside of Southeastern boundaries) are not considered reasonably foreseeable. Storage in Pueblo Reservoir has been identified as a necessary component of the Super Ditch Company activities, which would require a separate NEPA process. Currently, there are no NEPA activities related to the Super Ditch other than those through the AVC EIS.

Action	Description
GP Water Pipeline Project	GP Water is proposing to construct a $350 million potable water pipeline project from Lamar to yet undetermined locations in Elbert and/or El Paso County. The pipeline would deliver 8,000 to 10,000 acre-feet of water transferred from water rights owned by GP Water on the Lamar Canal (which total approximately 40% of the water rights on the canal). Approximately 4,000 acres currently using Lamar Canal for irrigation would be dried up. However, approximately 2,000 acres would be "reirrigated" using alluvial groundwater augmented by shares in the Lower Arkansas Water Management Association. The project would include a reverse osmosis-type water treatment plant with either "zero liquid discharge" or deep well injection of liquid brine. The project could be constructed and operational by 2018. However, the project proponent has yet to secure agreements with potential water users, and the water court process for changing use of the Lamar Canal shares from agricultural to municipal use has not yet begun (which presents a substantial "unknown" in the schedule). Additionally, several 1041 land-use permits would need to be secured from the counties affected by the project, Other potential local, state and federal permits may be required as well.
Pure Cycle Corporation	High Plains A&M originally purchased about 23% of the shares in the Fort Lyon Canal and associated farms in 2001. However, the company lost a water court case to change the water rights to municipal and industrial use in 2004, which was upheld by the Colorado Supreme Court in 2005. Pure Cycle Corporation purchased these shares from High Plains in 2006. Since that time, most of the land and water has remained in agriculture through leases to farmers. Ultimately, Pure Cycle intends to transfer the water to municipal and industrial use. However, water rights applications to do so have not been filed, the methods by which transfers would be done have not been determined, and the time frame for making the transfers has not been identified.
Woodmoor Water and Sanitation District Renewable Water Plan	The Woodmoor Water and Sanitation District is currently implementing its Renewable Water Plan. The District is in the process of purchasing water rights associated with the JV Ranch in the Fountain Creek basin, and the Holbrook Ditch. Woodmoor recently dropped plans to purchase shares in the Rocky Ford Highline and Excelsior ditches. Woodmoor currently has water rights applications in the water court process (filed December 2009) to change the use of the Holbrook rights to municipal use, and exchange water to several locations including Stonewall Springs Reservoir and other gravel lakes on the Arkansas River. The project could include a pipeline and water treatment plant to deliver water from Fountain Creek below the city of Fountain to Woodmoor (Tetra Tech 2010, Woodka 2010a, Woodka 2010b, Woodka 2011c). It is unknown when the water rights will be adjudicated or the project would be constructed.
Wastewater, Flooding and Flood Control Projects	
Fountain Creek Flood Control Reservoir	The Fountain Creek Watershed Flood Control and Greenway District is currently studying a flood control dam and reservoir on Fountain Creek (Woodka 2010c; Woodka 2011d). This project is currently only in the planning phase – the project has not received any funding except for the study. Additionally, a Notice of Intent or other formal action to initiate NEPA permitting has been received by federal agencies.

Action	Description
Stormwater Enterprise Activities – City of Colorado Springs	The Colorado Springs City Council established a storm water enterprise in 2005 and an associated fee to property owners in 2007 as the funding mechanism for the design and construction of capital improvement projects, the operations and maintenance of existing storm water infrastructure, administration of the City's federally-mandated municipal storm water discharge permit, and the engineering and technical review staff. The city council voted to end the storm water enterprise and its associated fee in 2009. The remaining fee revenue will be used to complete projects underway and fund 2010 programs and activities required by the City's municipal storm water discharge permit. The dissolution of the enterprise moves the responsibility for stormwater management back into the general fund as part of the City's Engineering Division. Long-term activities originally anticipated using Stormwater Enterprise funding are not considered reasonably foreseeable. (http://www.springsgov.com/SectionIndex.aspx?SectionID=34).
Wastewater Discharge Pipeline (Pueblo Reservoir) – Pueblo West Metropolitan District	Pueblo West had previously considered changing the discharge point for its wastewater effluent to Golf Course Draw, which is tributary to Pueblo Reservoir (Reclamation 2008). As part of agreements reached with Pueblo County and Southern Delivery System participants, Pueblo West is no longer proposing to construct this pipeline.
Hydropower and Energy Projects	
Eastern Plans Transmission Project – Western Area Power Administration	The Eastern Plains Transmission Project is a proposed new transmission project for about 1,000 miles of new high-voltage transmission lines and related facilities in eastern Colorado and western Kansas, expansions at existing substations, and construction of new substations, access roads, and fiber optic communication facilities. The Western Area Power Administration canceled preparation of an EIS in September 2008 due to changes in the project scope (Eastern Plains Transmission Project website; Western Area Power Administration 2010). Based on this, it is unknown when the project would be fully permitted for construction.
Nuclear Power Plant near Pueblo	A proposal was received in 2010 from a private developer to construct a 3,000 megawatt nuclear power plant southeast of Pueblo (Woodka 2010d). In April 2011, Pueblo County Commissioners voted 3-0 to deny use of 24,000 acres in eastern Pueblo County for a clean energy park which would have included the nuclear power plant (Strescino 2011).
Xcel Energy Power Plant	Xcel Energy purchased a majority of the Las Animas Consolidated Ditch in the 1980s. A power plant has never been built, and most water continues to be leased to irrigators. It is unknown when a new power plant would be constructed.
Tri-State Power Plant	The Tri-State Generation and Transmission Association, Inc. has purchase approximately 49 percent of the Amity Canal, or about 20,000 acre-feet of water, to be used for a new power plant. The association would continue to lease water for agricultural use until the power plant is constructed (Woodka 2008). Tri-State filed a water rights application for change of use and exchange of the water in 2007. It is unclear when a new power plant would be constructed.

Action	Description
Pueblo Dam Renewable Energy Development – Hydropower	A recent Reclamation Hydropower Resources Assessment (Reclamation 2011b) rated Pueblo Dam among the top ten opportunities for cost-effective future hydropower development. Reclamation received a Lease of Power Privilege request to develop hydropower at Pueblo Dam in October 2010. Following a request for clarification of power development jurisdiction with the Federal Energy Regulation Commission, Reclamation filed a Notice of Intent on April 20, 2011 soliciting hydropower development proposals. Proposals were due and were received on or before October 21, 2011, and subsequently evaluated. Based upon this evaluation process, a partnership consisting of Southeastern, the Board of Water Work of Pueblo, and Colorado Springs Utilities has been issued a Preliminary Permit to plan and study the proposed project. Assuming typical negotiation and process timelines, and following execution of a contract with Reclamation, the successful applicant must complete the permitting (including NEPA compliance), licensing, and construction process within seven years (Reclamation 2009b). Based on this schedule, it is possible that a contract could be executed with Reclamation by 2013, with hydropower construction completed at Pueblo Dam as soon as 2020. However, because NEPA compliance has not been initiated, inadequate information is available to evaluate cumulative effects.
South Slope Pump Storage Project	The South Slope Hydropower Project (Federal Energy and Regulatory Commission Project No. 12714) is proposed by H2O Providers, LLC. as a 430 Megawatt pump-storage hydropower project on Brush Hollow Creek near Penrose. This project has reduced in scope from the original project, formally referred to as the Phantom Canyon Pumped Storage Project, to eliminate potential project-related environmental impacts. On July 17, 2009, H2O Providers, LLC filed its request to use the Traditional Licensing Process and provided public notice of its request. In a letter dated August 18, 2009, the Director, Division of Hydropower Licensing, approved H2O Providers, LLC's request to use the Traditional Licensing Process. H2O Providers has initiated a Section 7 consultation with the Service, Section 106 consultation with the Colorado State Historic Preservation Office, and the 50 CFR 600.920 consultation with National Oceanic and Atmospheric Administration Fisheries (U.S. Federal Energy Regulatory Commission 2009). Based on preliminary information and FERC decision to allow use of the Traditional Licensing Process, the project would likely not contribute measurably to cumulative effects in the AVC EIS study area.
Transportation Projects	
Reconstruction of I-25 at Pueblo – Colorado Department of Transportation and Federal Highway Administration	The Colorado Department of Transportation is proposing to improve an 8-mile segment of I-25 near Pueblo, between Eagleridge and Pueblo Boulevard/Lake Avenue. The two action alternatives for the project involve widening the freeway to six lanes, either in the existing alignment or a new alignment (New Pueblo Freeway website, Colorado Department of Transportation 2010d). The final EIS and Record-of-Decision for the I-25 reconstruction project are scheduled for completion in 2012. Additionally, funding for the improvements has not yet been identified or secured, and the project is not anticipated to contribute to cumulative effects in the AVC Study area.

Action	Description
US 50 Corridor East Improvements	The Federal Highway Administration and the Colorado Department of Transportation are proposing to improve US 50 between Pueblo and the vicinity of the Kansas State line in southeastern Colorado. This includes preparation of a Tier 1 EIS, evaluating alternative corridor locations for future improvements and the No Action Alternative (i.e. "no changes or improvements to the current highway alignment"). The Tier 1 draft EIS is currently scheduled for release in 2011. Once the Tier 1 final EIS is prepared, a Tier 2 NEPA project-level analysis that focuses on specific sections identified in Tier 1 will begin. At this point, it is unknown when the Tier 2 NEPA study would commence, and ultimately, and which projects (if any) would be funded for construction. Based on this schedule, it is unknown how this project may contribute to cumulative effects in the AVC EIS study area (US 50 East website; Colorado Department of Transportation 2010e).

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Appendix B.5 – Best Management Practices and Mitigation Measures

This appendix describes best management practices (Table 1) and mitigation (Table 2). The following definitions apply to best management practices and mitigation in this EIS.

Best Management Practices

Methods intended to avoid or reduce general construction-related effects while an action of this nature is being implemented. These methods are not intended to avoid specific environmental effects evaluated in this EIS.

Mitigation

Methods or plans to reduce, offset, or eliminate adverse project effects. Action taken to avoid, reduce the severity of, or eliminate an adverse effect. Mitigation could include one or more of the following:

- Avoiding effects.
- Minimizing effects by limiting the degree or magnitude of an action.
- Rectifying effects by restoration, rehabilitation, or repair of the affected environment.
- Reducing or eliminating effects over time.
- Compensating for the effect by replacing or providing substitute resources or environments to offset the loss.

All of the best management practices shown in Table 1 would be implemented as part of an action alternative that includes construction of AVC. The table also indicates whether the practices were assumed to be implemented in the No Action Alternative, and how the practice would be implemented (either through construction contract documents between Reclamation and construction contractors, or through Reclamation contracts directly with project participants). Practices were assumed to be implemented in the No Action Alternative if the practice is required by Federal, State or Local laws, or if the practice is typically included as part of municipal water infrastructure projects as determined using best professional judgment.

Table 1. Best Management Practices

Resource	Best Management Practices	Included in No Action Alternative [1]	Implementation Mechanism [2]
General	Construction activities would comply with all appropriate Federal, State, and local laws and regulations.	Yes	Construction Contract Documents
	To the extent practicable, construction would avoid wetlands; federal, state, and local wildlife areas and refuges; designated critical habitats; migratory bird habitat during the nesting brood-rearing season; known cultural resources and historic sites; hazardous material sites; and other resource sensitive areas noted below.	Yes	Construction Contract Documents
	Construction limits would be clearly marked with stakes or fencing prior to beginning ground disturbing activities. No disturbance would occur beyond these limits other than non-destructive protection measures for erosion/sediment control.	Yes	Construction Contract Documents
	Construction would typically occur during daylight hours Monday through Friday, although these hours may be extended if needed for certain aspects of the work.	Yes	Construction Contract Documents
	Material and equipment storage would be only within well-defined, designated staging areas placed outside of wetlands and other sensitive areas.	Yes	Construction Contract Documents
	Structures affected by pipeline construction, including utilities, roads, highways, rivers, canals, railroads, agricultural irrigation facilities, fences, and other structures, would be replaced, repaired, or restored to their current condition or better after construction.	Yes	Construction Contract Documents
	Construction debris would be hauled from the work site to a disposal location approved by the Contracting Officer or his/her representative.	Yes	Construction Contract Documents
Surface Water	Participants would continue voluntary commitment to operations of the Fry-Ark Project and any other non-Project water supplies in accordance with the Upper Arkansas Flow Management Program.	Yes	Reclamation Contracting Process
	Participants would commit to operations of non-Project water supplies in accordance with the Pueblo Flow Management Program.	Varies by Participant	Reclamation Contracting Process
Groundwater	Established groundwater monitoring wells would be avoided. However, if any monitoring wells are inadvertently damaged or affected during construction they would be repaired and the Colorado Division of Water Resources, USGS or other agency responsible for the well would be contacted.	Yes	Construction Contract Documents

Table 1. Best Management Practices (continued)

Resource	Best Management Practices	Included in No Action Alternative [1]	Implementation Mechanism [2]
Water Quality	As part of the National Pollution Discharge Elimination System permitting requirement, a stormwater pollution prevention plan would be developed and approved by Reclamation and submitted to the Colorado Water Quality Control Division prior to commencing construction activities.	Yes	Construction Contract Documents
	The stormwater pollution prevention plan would include erosion control measures to prevent or reduce erosion, soil loss, and nonpoint source pollution. These practices may include, but are not limited to, silt fencing, filter fabric, sediment logs, hay bales, temporary sediment ponds, check dams, and/or immediate mulching of exposed areas to minimize sedimentation and turbidity effects as a result of construction activities. The placement and specific measures used would be dictated by site specific conditions. Erosion control measures would be inspected regularly and repaired as needed.	Yes	Construction Contract Documents
	In-stream flows would be maintained during stream crossing construction. Spoil, debris piling, construction materials, and any other obstructions would be removed from stream crossings to preserve normal water flow.	Yes	Construction Contract Documents
	Stream crossings would be routed, as practicable, to minimize disturbance.	Yes	Construction Contract Documents
	Intermittent streams would be crossed only during low-flow periods and preferably when streambeds are dry.	Yes	Construction Contract Documents
	Disturbed portions of the stream banks and beds of rivers, streams, and other waterways would be protected by rock riprap of adequate size and type to minimize erosion and scour. Any slopes greater than 3:1 would be protected with erosion-control blankets after seeding.	No	Construction Contract Documents
Aquatic Life	To minimize effects on fisheries and stream habitat, any stream identified as a fishery, based upon recommendations from the Division of Parks and Wildlife, that cannot be directionally bored would be avoided during spawning periods and during high flow and crossed when flows are low.	No	Construction Contract Documents
	Identified potential habitat for state threatened, endangered, and special concern species would be avoided if feasible, especially for Arkansas darters in tributary streams.	Yes	Construction Contract Documents
	In-stream flows would be maintained during stream crossing construction. Water would be allowed to flow around or past stream crossings to preserve normal water flow downstream from construction.	Yes	Construction Contract Documents

Table 1. Best Management Practices (continued)

Resource	Best Management Practices	Included in No Action Alternative (1)	Implementation Mechanism (2)
Wetlands/Riparian Areas	Permanent and temporary effects on jurisdictional wetlands would be avoided to the extent practicable in compliance with Section 404 of the Clean Water Act.	Yes	Construction Contract Documents
	Identified perennial river or stream crossings would be performed by horizontal directional drilling operations, which would not disturb the stream channel or the adjacent wetlands.	No	Construction Contract Documents
	Erosion control measures would be employed as appropriate and at stream crossings prior to construction activities. In addition: • Preserve, if feasible, existing trees along the stream bank • Stabilize, control erosion, restore, and re-vegetate streambeds and embankments as soon as a stream crossing is completed, following vegetation best management practices, and maintain until stable • Replant riparian, as necessary, woody shrubs and trees appropriate to ecological characteristics of the site to preserve shading characteristics of the watercourse and the aesthetic nature of the stream bank	Yes	Construction Contract Documents
	Any equipment used previously in a water body or wetland would be disinfected to prevent the spread of invasive aquatic species. Disinfection methods would follow Corps section 404 requirements.	No	Construction Contract Documents
	Where open trench crossing of stream is required, the stream channel would be reestablished following pipe installation.	Yes	Construction Contract Documents
	All temporarily disturbed jurisdictional and non-jurisdictional wetlands and riparian areas would be reestablished following construction by doing the following: • Restore contours to previous elevations • Compact trenches sufficiently to prevent drainage along the trench or via bottom seepage • Salvage and replace topsoil • Backfill in such a manner as to not drain wetland or stream • Reestablish wetlands to similar type of wetland and wetland function	Yes	Construction Contract Documents
	Permanent and temporary effects on wetlands and riparian areas would be avoided to the extent practicable in compliance with Section 404 of the Clean Water Act.	Yes	Construction Contract Documents

Table 1. Best Management Practices (continued)

Resource	Best Management Practices	Included in No Action Alternative (1)	Implementation Mechanism (2)
Vegetation	Sensitive vegetation communities, native prairie, or areas with sensitive plant species would be avoided to the extent possible. However, if these areas are disturbed during pipeline construction, topsoil would be replaced and re-vegetation plans would be specifically designed for these areas to ensure re-establishment of a similar type and quality of native vegetation.	No	Construction Contract Documents
	Vegetated areas temporarily disturbed by construction (except cropland) would be revegetated with species appropriate to ecological conditions of the surrounding area, and in a manner that prevents erosion and noxious weed invasion. Revegetation would occur as soon as practicable after construction and would follow all pertinent local and state regulations. Temporary seeding may be required when areas remain disturbed for more than 30 days.	Yes	Construction Contract Documents
	All areas with existing landscape cover or mulch would be replaced with similar size and type of cover materials. A turf seed mix would be used for established lawns.	Yes	Construction Contract Documents
	Topsoil would be removed and stockpiled separately from surface soils for reapplication following construction.	No	Construction Contract Documents
	Topsoil, soil amendments, fertilizers, and mulches would be reapplied selectively as appropriate, prior to revegetation during favorable plant establishment climate conditions to match site conditions and revegetation goals.	No	Construction Contract Documents
	Revegetation success would be monitored and areas reseeded as needed.	Yes	Construction Contract Documents
	To prevent introduction of, and minimize spread of, nonnative vegetation and noxious weeds, the following measures would be implemented during construction: • Survey noxious weed within a year before construction to establish type, size, and location of noxious weed populations. • Minimize soil disturbance. • Pressure washed and/or steam clean construction equipment before entering construction zones from off-site locations. • Cover haul trucks bringing fill materials to prevent seed transport. • Park vehicles and equipment only in construction sites or approved staging areas. • Survey staging areas for noxious weeds and treat appropriately before use. • Use fill, rock, and topsoil that is weed-free. • Minimize fertilizer in seeded areas. • Use certified weed-free seed and mulch. • Use weed-free straw bales for erosion control. • Monitor and follow-up on treatment of exotic vegetation after construction. • Follow Colorado Department of Agriculture Noxious Weed Management Guidelines as well as local regulations.	Weed control per Colorado Noxious Weed Act as administered by individual counties.	Construction Contract Documents

Table 1. Best Management Practices (continued)

Resource	Best Management Practices	Included in No Action Alternative [(1)]	Implementation Mechanism [(2)]
Wildlife	Identified potential habitat for federal or state threatened, endangered, and sensitive species would be avoided if feasible.	Yes	Construction Contract Documents
	Construction would be prohibited within ½ mile of designated piping plover or Interior least tern breeding areas during the breeding season (April 15 through August 31) when these species are present.	No	Construction Contract Documents
	If threatened or endangered species are identified and encountered during construction, all ground-disturbing activities in the immediate area would be stopped to consult with the U.S. Fish and Wildlife Service and determine appropriate steps to avoid affecting the species.	Yes	Construction Contract Documents
	Effects on migratory birds would be avoided and minimized by implementation of a Migratory Bird Management Plan. The management plan would include a number of measures, including removal of vegetation prior to migratory bird breeding season (which is typically between April 1 and August 15 in Colorado) or conducting clearance surveys immediately prior to construction. The Migratory Bird Management Plan would be developed in consultation with Colorado Parks and Wildlife and made a part of the Fish and Wildlife Mitigation Plan.	No	Construction Contract Documents
	Seasonal Restrictions and Buffer Zones for Raptors. Avoidance and mitigation options for nesting raptors sites consists of: 1) conducting nest surveys prior to construction, 2) establishing reasonable site-specific buffers and seasonal restrictions, 3) implementing seasonal restrictions to avoid and minimize disturbance, and 4) from the construction footprints or other areas of long-term effects.	Yes	Construction Contract Documents
	Construction would be timed to minimize effects and disruption to parks and trails during the peak recreation season (May through September) where feasible.	Yes	Construction Contract Documents
Noise and Vibration	Construction and operation activities would comply with state and local noise ordinances.	Yes	Construction Contract Documents
	Night construction would be avoided near residential and populated areas.	Yes	Construction Contract Documents
Visual Resources	As noted for vegetation, short-term disturbances associated with constructing facilities would be revegetated and/or landscaped.	Yes	Construction Contract Documents
	Existing topographic grades would be restored following pipeline excavation.	Yes	Construction Contract Documents
	Constructed facilities would be designed to blend with the architectural characteristics of surrounding structures	Yes	Construction Contract Documents
	Valve boxes would be left above grade in a cultivated field if agreeable to the landowner, or moved to the nearest fence or right-of-way. Valves would not be located adjacent to or in close proximity to a paved or graveled road and would be painted a neutral color that blends with the background, reduces visibility, and maintains the viewshed.	Yes	Construction Contract Documents
	Construction lighting during night work would be directed downward onto the construction activity to minimize effects near occupied homes and businesses, and to the night sky.	Yes	Construction Contract Documents

Table 1. Best Management Practices (continued)

Resource	Best Management Practices	Included in No Action Alternative [(1)]	Implementation Mechanism [(2)]
Traffic	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	Yes?	Construction Contract Documents
	Crossings of interstate or divided highways and railroads would be performed by a bore and jack method of operations, which would not disturb or interrupt traffic.	Yes	Construction Contract Documents
	Night work would be considered at select locations to minimize traffic effects, where work could be performed without affecting nearby residences;	Yes	Construction Contract Documents
	Boring under larger and busier roadways such as highways and major collector streets; or construction within existing rights-of-way or easements that are part of or adjacent to roadways would also be used to reduce effects on traffic.	No	Construction Contract Documents
	No more than two city blocks would be unavailable for general traffic at any time.	Yes	Construction Contract Documents
	Construction contractors would coordinate with the Colorado Department of Transportation, county, and local jurisdictions on traffic plans, lane closures, and detours.	Yes	Construction Contract Documents
Socio-economics	Landowners would be compensated for crop damage and hay loss caused by construction activities.	Yes	Reclamation Contracting Process
	Structures damaged or disturbed during construction would be repaired, replaced, or the landowners compensated.	Yes	Construction Contract Documents

Table 1. Best Management Practices (continued)

Resource	Best Management Practices	Included in No Action Alternative (1)	Implementation Mechanism (2)
Cultural Resources	Direct disturbance to historical properties would be avoided to the extent feasible.	Yes	Construction Contract Documents
	Previously disturbed utility rights-of-way would be used for placement of pipelines and facilities, where feasible, to diminish the probability of encountering any undisturbed historical properties.	No	Construction Contract Documents
	All known burials or cemeteries would be avoided to the extent possible. If a burial or cemetery cannot be avoided or is encountered during construction, Reclamation would comply with the Native American Graves Protection and Repatriation Act if graves are discovered on Federal or trust lands or within reservation boundaries. If on state or private land, Reclamation would comply with the State unmarked burial law and the Section 106 programmatic agreement with SHPO and tribes.	Yes	Construction Contract Documents
	If unrecorded cultural resources or traditional cultural properties are encountered during construction, all ground disturbance activity within the area would be stopped, Reclamation and appropriate authorities would be notified, and all applicable stipulations of the NHPA would be followed. Activities in the area would resume only when compliance has been completed.	No	Construction Contract Documents
	All appropriate cultural resource compliance activities would be completed prior to the commencement of ground-disturbing activities, including Class III surveys and consultation with the SHPO. All cultural resources would be avoided if their significance cannot be established prior to disturbance. If the No Action is implemented, cultural resource compliance would follow applicable state and local preservation statutes, if any. If avoidance is not practicable, Reclamation, in consultation with the SHPO, would determine if the site is eligible for nomination to the National Register of Historic Places [36CFR800.4(c) and 36CFR60.4]. If the site is determined to be a historic property, initially Reclamation, SHPO, and other interested parties, depending on the type of property, would consult to determine a plan of mitigation. If an adverse effect cannot be avoided, the Advisory Council on Historic Preservation would be contacted. All ensuing activities would comply with the NHPA, as amended, and the Archaeological Resource Protection Act.	Only per applicable state and local preservation statutes.	Construction Contract Documents
Air Quality	A fugitive dust control plan would be developed and implemented to minimize particulate and dust emissions from the construction site.	Yes	Construction Contract Documents
	Construction equipment/vehicles would not be allowed to idle longer than 15 minutes when not in use.	No	Construction Contract Documents
	All construction equipment would be maintained in proper working order.	Yes	Construction Contract Documents
Floodplains	No structures would be constructed that would raise flood water surface elevations.	Yes	Construction Contract Documents

Table 1. Best Management Practices (continued)

Resource	Best Management Practices	Included in No Action Alternative [1]	Implementation Mechanism [2]
Hazardous Materials	A Hazardous Spill Plan or Spill Prevention, Control and Countermeasures Plan, whichever is appropriate, would be in place, stating what actions would be taken in the event of a spill, notification measures, and preventive measures to be implemented, such as the placement of refueling facilities, storage, and handling of hazardous materials.	Yes	Construction Contract Documents
	All equipment would be maintained in a clean and well-functioning operating condition to avoid or minimize contamination from automotive fluids. All equipment would be checked daily and any leaks would be immediately repaired upon discovery. Oil, hydraulic fluids, antifreeze or other chemicals would not be drained to the ground.	Yes	Construction Contract Documents
	Before construction, a more detailed hazardous materials assessment in conformance with the scope and limitations of American Society for Testing Materials (ASTM) 1527-05: “Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process” would be conducted to identify sites with soil and/or groundwater contamination not documented in readily ascertainable agency files (ASTM 2005).	No	Construction Contract Documents
	Any known solid waste disposal areas identified in the construction sites would be avoided or removed and properly disposed at a permitted solid waste disposal facility	No	Construction Contract Documents
	Equipment or vehicles would not be refueled within 100 feet of rivers, streams, or identified wetlands. If on-site fuel tanks are used, approved containment devices would be required.	Yes	Construction Contract Documents
	Identified evidence of hazardous materials, petroleum product spills, or other contamination would be avoided or excavated and properly disposed at a permitted waste disposal facility.	Yes	Construction Contract Documents
	If soil and/or groundwater contamination is encountered during construction, mitigation procedures would be implemented to minimize the risk to construction workers and to future operations.	Yes	Construction Contract Documents
Unique and Prime Farmland/ Agricultural Lands	To the extent feasible, construction activities on irrigated lands would be avoided during the growing season.	Yes	Construction Contract Documents
	Cropland disturbed by construction would be restored with topsoil to the depth, quality, grade, and relative density, as the original surface as described for soils below. Pipelines crossing agricultural fields would be backfilled and compacted to prevent settling when the field is irrigated.	Yes	Construction Contract Documents
	Long-term effects on prime and unique farmland would be avoided to the extent feasible. If avoidance is not possible, Reclamation would complete and submit a Farmland Conversion Form (AD-1006) to the Natural Resources Conservation Service in compliance with the Farmland Protection Policy Act for any long-term change in land use.	Yes	Construction Contract Documents

Notes:
(1) Includes construction activities under the Master Contract Only alternative.
(2) Construction Contract Documents include design drawings and construction specifications that would be implemented by the contractor. The Reclamation Contracting Process includes measures that Reclamation would address directly.

Table 2. Mitigation Measures

Resource	Mitigation Measures
Surface Water Hydrology, Water Quality, Aquatic Life	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 will assist the participants annually in reserving water in Pueblo Reservoir or upstream storage facilities that can be released to maintain flows in the Arkansas River downstream from Pueblo Reservoir. The amount of water/storage to be reserved would be evaluated during development of the Fish and Wildlife Mitigation Plan, and would provide a reasonable amount of streamflow to meet water quality and aquatic life goals, but would have minimal effect on water supply yield. Supplies could include various types of water supply to be determined by Reclamation and Southeastern on an annual basis. Releases would be coordinated with the Division Engineer and basin water users to minimize losses to water users' water supply yield and maximize instream benefits of the releases.
Water Quality	No significant adverse effects on water quality were found. However, a monitoring plan would be established by the Environmental Review Team to determine whether AVC or Master Contract operations are causing violations of discharge permits or stream water quality standards. If so, exchanges of non Fry-Ark Project water may be curtailed during these times. There would be no requirement for Fry-Ark Project water or non-Fry-Ark Project water releases to meet target flows at permitted discharge locations, although individual non-Fry-Ark Project water owners could voluntarily make releases for this purpose at their own discretion.
Aquatic Life	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.
	The Environmental Review Team will monitor storage contents and aquatic life conditions at Holbrook Reservoir. If it is determined that adverse aquatic life conditions are being caused by AVC or Master Contract operations, the Environmental Review Team will coordinate with CPW to determine the level of mitigation that is warranted. Such mitigation will be limited to assistance with restocking aquatic species.
Recreation	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.
Vegetation and Wetlands	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.
	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.
Wildlife	Pipelines, water treatment plants, and pump station facilities would be realigned, where feasible, to avoid sensitive wildlife habitat.
	Preconstruction surveys would identify sensitive habitats and wildlife use before construction to allow implementing best management practices, including implementation of a Migratory Bird Management Plan and working with Colorado Parks and Wildlife to develop and implement a Fish and Wildlife Mitigation Plan.
	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.

Table 2. Mitigation Measures (continued)

Resource	Mitigation Measures
Human Environment	Provide land owners sufficient advance notice of land use disruptions prior to 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.
	Construction methods with the minimum vibratory disturbance would be used near sensitive structures.
	Vibration monitors would be placed near sensitive structures to monitor and correct potential effects.
	Traffic delays or detours from construction activities would be announced in advance of work to minimize disruption in traffic patterns.
	Residential, business, and emergency vehicles access would be maintained at all times.
	Provide incentives and disincentives for construction contractors to expedite completion in areas where traffic effects would be greatest.
	Provide land owners sufficient advance notice of land use disruptions prior to construction or maintenance activities.
Cultural Resources	Compliance with Section 106 of the National Historic Preservation Act would be completed prior to construction by finishing remaining inventory, eligibility determinations, and determinations of effect, in consultation with the State Historic Preservation Office and interested Tribes. This includes conducting a field survey of the preferred alternative to identify unrecorded historic properties that may be affected by construction activities and development of avoidance or mitigation measures. 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.
	Where feasible, all historic properties would be avoided by ground disturbing actions, using existing right-of-ways where ground disturbance has already taken place. Historic properties that cannot be avoided would be subject to mitigation prior to construction.
	Reclamation is preparing a programmatic agreement that gives guidance for following Section 106 once the NEPA process has been completed. Reclamation is preparing a programmatic agreement in consultation with the State Historic Preservation Office and interested tribes. The Advisory Council on Historic Preservation has been invited to participate in the agreement. The agreement would guide compliance with the National Historic Preservation Act, including mitigating historic properties that would be affected by constructing the preferred alternative, if an action alternative is selected in the record of decision. The programmatic agreement would require identifying historic properties, mitigating affected historic properties, and include a plan for actions for unexpected buried archaeological site discovery.
	Mitigation plans would be written in consultation between Reclamation, the State Historic Preservation Office, the Advisory Council on Historic Preservation, and participating Native American Tribes, and would comply with the Archaeological Resources Protection Act, if on federal or trust lands. Actions to avoid cemeteries would be used to the extent feasible. Any unexpected discoveries of human remains on federal or trust lands would be mitigated under provisions of the Native American Graves Protection and Repatriation Act. In the event of an inadvertent discovery of human remains on non-federal lands, Colorado Statute 18-4-509: (Colorado's Historical, Prehistorical, and Archaeological Resources Act) 24-80, Part 13 would be followed.
	A Historic American Building Survey would mitigate unavoidable impacts to historic buildings. The level of effort would be on a case-by-case basis, and would consider the building's overall importance (whether national, state, or local). Typically these records include photographs; a written history built by research, and drawing(s) if the building is architecturally important. Similarly, a Historic American Engineering Record would mitigate unavoidable impacts to engineered historic structures such as railroad, canal, ditch, or road segments, which, depending on importance, would include a measured drawing, photographs, and a written history. Under most circumstances, impacts to engineered historic structures would be avoidable by boring beneath the resource. Although the preferred mitigation measure is avoidance, if effects on historic resources would be unavoidable, Reclamation, in consultation with SHPO, would determine the appropriate mitigation measures, which would be outlined in a memorandum of agreement that would be developed by Reclamation and agreed upon between SHPO and participating signatories, if any.
	Archaeological resources, whether prehistoric or historic, would be mitigated by excavation. A data recovery plan would be written in consultation with Reclamation, the State Historic Preservation Office, and participating Native American Tribes; and would be implemented before construction.

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Appendix B.6 – Master Contract Costs

Introduction

The Appraisal Design Report by Reclamation (2012) developed appraisal-level construction, operation, maintenance and replacement costs for the AVC EIS action alternatives (Comanche South, Pueblo Dam South, JUP North, Pueblo Dam North and River South alternatives). The No Action Alternative study (Appendix B.3) developed construction, operation, maintenance and replacement costs for the alternatives that do not include AVC (No Action and Master Contract Only alternatives). Neither of these studies included costs associated with storage, conveyance and/or exchange of non-Fry-Ark water in Fry-Ark facilities under short-term contracts (also referred to as “temporary” or If/When contracts) or long-term contracts, which include the Master Contract. This appendix estimates these costs by participant for inclusion in the total alternative cost estimates. However, it should be noted that rates for excess capacity storage are unknown at this time and will be determined in the contract negotiation process. Nothing in this EIS will influence the price that is determined in the contract negotiation process.

Methods

Many Master Contract participants currently have 1 year short-term excess capacity storage contracts with Reclamation (see Appendix D.1). These contracts have an excess capacity charge that is reviewed annually. The charge in 2012 was $22.04 per acre-foot for irrigation use, $23.98 per acre-foot for wildlife, fishery and recreation use, and $27.79 per acre-foot for municipal and industrial uses. These rates reflect excess capacity storage used within Southeastern Colorado Water Conservancy District boundaries and the Arkansas River Basin. The out-of-district rate was $53.32 per acre-foot. In addition, Reclamation has long-term excess capacity storage contracts, including a contract with the Board of Water Works of Pueblo for $17.35 per acre-foot (Contract 00XX6C0049, signed July 11, 2000). However, recently executed contracts are about twice that rate and the current temporary contract rate is higher than the Board of Water Works of Pueblo rate.

Reclamation is currently developing market pricing criteria for the Fry-Ark Project. This initiative to develop a temporary Directive and Standard, which includes public review, would be incorporated into a permanent Directive and Standard to be applied throughout Reclamation. It is assumed that Master Contract participant rates, regardless if for short-term contracts or long-term excess capacity storage contracts, would be at rates developed through this market pricing criteria. However, rates at this time are unknown, and therefore, it is difficult to analyze effects of the No Action Alternative verses the action alternatives with any certainty.

Prior to undertaking development of market pricing criteria, Reclamation recently negotiated Fry-Ark excess capacity storage contracts for the Southern Delivery System Project. The excess capacity charge negotiated was $36.00 per acre-foot for the year 2011 with a 1.79 percent annual increase. The rate for year 2012 was $36.64 per acre-foot of excess capacity storage.

Because future short-term and long-term contracts would be negotiated with Reclamation based on market pricing criteria described above, and the outcomes of these negotiations are unknown, a range of potential costs for an excess capacity storage rate was used in this EIS, with the upper and lower ends of the range based on recent rates. The lower end of the range for short-term and long-term contracts in this EIS assumes the current municipal short-term rate of $27.79 per acre-foot. The upper end of the range for short-term and long-term contracts in this EIS assumes the current 2012 Southern Delivery System Project rate of $36.64 per acre-foot, however the actual rate that would be negotiated could be higher. Both rates displayed in Table 1 are increased annually, consistent with the terms of the Southern Delivery System contract (1.79 percent).

Contracts are assumed to commence in 2014, and be issued for a 40-year term. Costs were discounted to 2011 present worth using a discount rate of 4.125% to be consistent with the Appraisal Design Report (Reclamation 2012). A summary of estimated annual unit cost per acre-foot of excess capacity storage is shown in Table 1.

Table 1. Estimated Annual Cost Per Acre-Foot of Excess Capacity Storage Contracts

Year	Incremental Year from 2012	Year of Contract	Annual Payment ($/ac-ft) (1)		Present Worth Annual Payment ($/ac-ft) (2)	
			Short-Term Contract Rate (Lower End of Range) ($)	Long-Term Contract Rate (Upper End of Range) ($)	Short-Term Contract Rate (Lower End of Range) ($)	Long-Term Contract Rate (Upper End of Range) ($)
2011	1		$27.30	$36.00	$27.30	$36.00
2012	2		$27.79	$36.64	$26.69	$35.19
2013	3		$28.29	$37.30	$26.09	$34.40
2014	4	1	$28.79	$37.96	$25.51	$33.63
2015	5	2	$29.31	$38.64	$24.93	$32.87
2016	6	3	$29.83	$39.33	$24.37	$32.14
2017	7	4	$30.37	$40.04	$23.83	$31.42
2018	8	5	$30.91	$40.76	$23.29	$30.71
2019	9	6	$31.46	$41.49	$22.77	$30.02
2020	10	7	$32.03	$42.23	$22.26	$29.35
2021	11	8	$32.60	$42.98	$21.76	$28.69
2022	12	9	$33.18	$43.75	$21.27	$28.05
2023	13	10	$33.78	$44.54	$20.80	$27.42
2024	14	11	$34.38	$45.33	$20.33	$26.80
2025	15	12	$35.00	$46.14	$19.87	$26.20
2026	16	13	$35.63	$46.97	$19.43	$25.62
2027	17	14	$36.26	$47.81	$18.99	$25.04
2028	18	15	$36.91	$48.67	$18.57	$24.48
2029	19	16	$37.57	$49.54	$18.15	$23.93
2030	20	17	$38.25	$50.43	$17.74	$23.39
2031	21	18	$38.93	$51.33	$17.35	$22.87
2032	22	19	$39.63	$52.25	$16.96	$22.36
2033	23	20	$40.34	$53.18	$16.58	$21.86
2034	24	21	$41.06	$54.13	$16.20	$21.36
2035	25	22	$41.79	$55.10	$15.84	$20.89
2036	26	23	$42.54	$56.09	$15.49	$20.42
2037	27	24	$43.30	$57.09	$15.14	$19.96
2038	28	25	$44.08	$58.12	$14.80	$19.51
2039	29	26	$44.87	$59.16	$14.47	$19.07
2040	30	27	$45.67	$60.21	$14.14	$18.65
2041	31	28	$46.49	$61.29	$13.83	$18.23
2042	32	29	$47.32	$62.39	$13.52	$17.82
2043	33	30	$48.17	$63.51	$13.21	$17.42
2044	34	31	$49.03	$64.64	$12.92	$17.03
2045	35	32	$49.91	$65.80	$12.63	$16.65
2046	36	33	$50.80	$66.98	$12.34	$16.27
2047	37	34	$51.71	$68.18	$12.07	$15.91
2048	38	35	$52.63	$69.40	$11.80	$15.55
2049	39	36	$53.58	$70.64	$11.53	$15.20
2050	40	37	$54.54	$71.90	$11.27	$14.86
2051	41	38	$55.51	$73.19	$11.02	$14.53
2052	42	39	$56.51	$74.50	$10.77	$14.20
2053	43	40	$57.52	$75.83	$10.53	$13.89
Total paid per acre-foot, 2014-2053			**$1,662.18**	**$2,191.52**	**$678.27**	**$894.27**

Notes:
(1) Includes annual rate increase of 1.79%.
(2) Present worth calculated for 2011 dollars using a discount rate of 4.125%.

Results

Estimated 2011 present worth costs for Master Contract participants are presented in Table 2. Total project costs assume a 40-year contracting period from 2014 through 2053. Note that rates and other contract terms provided and used in this analysis are for illustration purposes only and in no way should it be assumed that these rates will be reflected in any future excess capacity contracts that are yet to be negotiated.

Table 2. Range of Present Worth Annual and Total Excess Capacity Storage Contract Costs

	No Master Contract Alternatives (Short-term)	Master Contract Alternatives
Excess Capacity Storage (ac-ft)		
Master Contract Only Participants	4,625	21,700
AVC Participants	500	8,238
Total	5,125	29,938
Range of Annual Cost ($ million) (1)		
Master Contract Only Participants	0.13 - 0.17	0.59 - 0.78
AVC Participants	0.01 - 0.02	0.22 - 0.30
Total	0.14 - 0.19	0.81 - 1.08
Range of Total Contract Cost ($ million 2011 Present Worth) (1)		
Master Contract Only Participants	3.1 - 4.1	14.7 - 19.4
AVC Participants	0.3 - 0.4	5.6 - 7.4
Total	3.4 - 4.5	20.3 - 26.8

Note:
(1) Costs are present worth 2011 dollars.

The excess capacity storage contract costs presented in Appendix B.6 do not include a separate charge for conveyance of non-project water in the Arkansas Valley Conduit or the Interconnect. However, this in no way implies that the excess capacity and/or conveyance contract would not have a separate charge for conveyance. This will be determined during contract negotiations.

Appendix B.7 – Southeastern Colorado Water Conservancy District Water Conservation Plan

Southeastern's water conservation plan is still under development. The information in this document is preliminary information only, and was used in the development of demand information in Chapter 1 and Appendix A.

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Memorandum

To: Jean Van Pelt, Southeastern Colorado Water Conservancy District

From: Tracy Bouvette, Great Western Institute

Subject: Passive Saving Impacts on Future Water Use Demands of the AVC Participants

Date: December 3, 2010

At the request of the Southeastern Colorado Water Conservancy District (hereafter the "District"), Great Western Institute performed an evaluation of future water demands for the Arkansas Valley Conduit (AVC) participants. The evaluation performed utilized data from various sources including:

- Current participant water demands and current and future participant populations served (i.e., 2010 and 2070) from Table 4 of "Arkansas Valley Conduit Population Projections" by Reclamation.
- Amended current populations served for Fowler and Las Animas from Table 2 of "Preliminary Water Demands" Memorandum dated November 15, 2010 by MWH.
- Passive savings estimates in residential settings from the CWCB Report "SWSI Conservation Levels Analysis Report", Great Western Institute (2010)).

The analyses presented herein characterize future water demands for all the AVC participants based on the following assumptions:

- Future water demands can be reasonably estimated using the product of current (i.e., 2010) per capita water use and predicted future population served, based on 2010 per capita water use reported by the AVC participants and summarized by Reclamation;
- The impact of passive savings[1] can be estimated by developing an adjusted per capita water use using the methodology presented in the SWSI Conservation Levels Report. The passive savings are related to the natural replacement of only toilets, clothes washers and dish washers in single family and multi-family residences. The replacement of other water saving devices is not accounted for in this analysis for those reasons detailed in the CWCB report.

A summary of the methodology used and the results of the analyses are provided below.

[1] Passive (or naturally-occurring) water conservation savings are defined as water savings that result from the impacts of plumbing codes, ordinances, and standards that improve the efficiency of water use. These conservation savings are called "passive" savings because water utilities do not actively fund or implement programs that produce these savings. In contrast, water conservation savings from utility-sponsored water conservation programs are referred to as "active" savings (SWSI I, Appendix E, (CDM, 2004)).

Methodology

Estimating passive savings using the methodology contained in the SWSI Conservation Levels Report hinges on determining the population served by each local water provider, or in this case AVC participant, in three key years – 1994, 2005 and 2015. These times relate to when key federal or state legislation impacted (or will impact) the availability of water conserving fixtures and/or appliances.

To estimate the populations served by each of the AVC participates in 1994, 2005 and 2015, the flowing methodology was used:

1. The ratio of current (i.e., 2010) population served by each AVC participant to the current county population within which each resides was calculated.
2. The relevant County populations for 1994 and 2005 were obtained from the SWSI Conservation Levels Report (which utilized the SWSI Phase I Report and the State Demographers Office as sources for past population data).
3. The ratio developed in Step 1 was multiplied by the 1994 and 2005 relevant County population to estimate the AVC participant population served in 1994 and 2005.
4. The Reclamation estimate of AVC participant population was obtained for 2070.
5. A straight-line interpolation of the AVC participant population from 2010 to 2070 was developed to estimate the 2015 population for all AVC participants.

Table 1 presents the population estimates for each of these three key years for all of the AVC participants. Table 1 also presents the per capita water use reported by each of the AVC participants in 2010[2].

Once the key year service populations were estimated, the estimates of annual demand adjustments were developed. The demand adjustments were obtained by multiplying the subject population for each AVC participant by the reduced gallons per capita per day (gpcd) associated with each of three different passive water conservation actions:

- After 1994, only low flow toilets (1.6 gallons per flush (gpf)) could be purchased by residential water users.
- After 2005, only Energy Star clothes washers and dish washers could be purchased by residential water users[3].
- After 2015, only 1.28 gpf toilets will be available on the market in response to California's "point-of-sales" laws that will require these types of toilets be installed prior to any property sale that takes place.

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[2] The per capita water use for those AVC participants that receive water from Crowley County (i.e., 96 Pipeline, Crowley County Water Association, the Town of Crowley, and the Town of Ordway) was estimated to be the 2010 water delivery by the Crowley County Commissioners (890 AF) divided by the total population served by the four entities receiving the water (4,160) resulting in a per capita water use of approximately 191 gallons per capita per day.

[3] Energy Star clothes and dishwashers, which were developed in association with California State laws that required energy use reductions by all residential customers, included substantial reductions in appliance water use.

Given the size of the California market, changes in California State laws that affect the supply chain in that state, affect the supply chain in all western states, including Colorado.

A high and low passive saving estimates of the adjustment to future water demand was calculated based on the following:

- Passive savings change over time depending on the rate at which the fixtures and appliances are replaced. For toilets, the replacement rate was estimated to be between 25 and 83 years (Great Western Institute (2010)). For clothes washers and dishwashers, the replacement rate was estimated to be between 12 and 15 years (Great Western Institute (2010)).
- The change to the gpcd associated with the gradual replacement of the subject fixtures and appliances was obtained from the SWSI Conservation Levels Report.
- The gradual decrease in future water demand for each AVC participant was estimated by multiplying the reduced gpcd associated with each type of passive retrofit (i.e., toilet, clothes washer, dish washer) by the target population.
- The decreased water demand for all three fixtures and appliances were summed and the difference between the water demands for each water provider was determined for the period from 2010 to 2070.

Note that in accordance with the SWSI Conservation Levels Report, both a high and low passive savings estimate was calculated for 2070. The difference between the two scenarios chiefly address expected differences in replacement rates for the fixtures and appliances in question and the variability of water use between different models of the new fixtures and appliances.

Results

The results of the passive savings estimates are presented in Table 2, which contains the 2070 forecasted demand without passive savings and the 2070 forecasted demand with both high and low estimates of passive savings. Overall the passive savings were estimated to range from about 7 to 9 percent of total forecasted 2070 water demand; however, on a per participant basis the variability was found to be substantially larger – varying from as little as 1.9% to as large as 33% depending on the age of the housing stock[4], the predicted growth rate of the service population, and the current per capita water use. For example, entities with large per capita water use have a smaller percentage change in future demand associated with the impacts from passive savings as compared to those with low per capita water usage.

Overall, the reduction in forecasted 2070 water demand associated with passive savings is estimated to be between 1,000 and 1,300 AF for all the AVC participants combined.

[4] Population was used as a surrogate parameter for housing stock.

Table 1 – Target Populations and Per Capita Water Use in 2010

		Estimated Target Year Population			
	County	1994	2005	2015	gpcd[1]
Hasty Water Company	Bent	244	289	291	100
Las Animas, City of2	Bent	3,768	4,470	4,496	116
McClave Water Assoc.	Bent	376	446	449	114
96 Pipeline Co.	Crowley	53	75	168	191
Crowley County Commissioners	Crowley	1,293	1,820	4,091	-
Crowley County Water Assoc.	Crowley	839	1,181	2,654	191
Crowley, Town of	Crowley	66	93	210	191
Olney Springs, Town of	Crowley	110	155	349	108
Ordway, Town of	Crowley	421	593	1,332	191
Sugar City, Town of	Crowley	79	111	250	308
Eads, Town of	Kiowa	719	655	626	357
Beehive Water Assn	Otero	176	169	169	43
Bents Fort Water Co.	Otero	962	924	922	62
Cheraw, Town of	Otero	206	198	198	222
East End Water Assn.	Otero	80	77	77	131
Eureka Water Co.	Otero	353	339	338	200
Fayette Water Assn.	Otero	64	62	62	179
Fowler, Town of	Otero	1,818	1,745	1,741	110
Hancock Inc.	Otero	160	154	154	101
Hilltop Water Co.	Otero	304	292	291	141
Holbrook Center Soft Water	Otero	53	51	52	321
Homestead Improvement Assn.	Otero	72	69	69	93
La Junta, City of1	Otero	7,593	7,291	7,270	256
Manzanola, Town of	Otero	509	489	487	73
Newdale-Grand Valley Water Co.	Otero	495	475	474	110
North Holbrook Water	Otero	43	41	41	156
Patterson Valley	Otero	103	99	99	139
Rocky Ford, City of	Otero	4,270	4,100	4,089	199
South Side Water Assoc. (La Junta)	Otero	51	49	49	130
South Swink Water Co.	Otero	652	626	624	120
Swink, Town of	Otero	710	682	680	51
Valley Water Co.	Otero	347	334	333	104
Vroman	Otero	160	154	154	190
West Grand Valley Water Inc.	Otero	90	86	86	266
West Holbrook Water	Otero	25	24	24	543
Lamar, City of	Prowers	8,255	8,468	8,282	262
May Valley Water Assoc.	Prowers	1,516	1,555	1,520	244
Wiley, Town of	Prowers	438	450	440	49
Avondale	Pueblo	1,566	1,862	2,131	71
Boone, Town of	Pueblo	254	302	346	182
St. Charles Mesa Water District3	Pueblo	8,563	10,182	11,654	135

[1] gpcd – gallons per capita per day in 2010

Table 2 – Forecasted 2070 Water Demands with and without Passive Savings Impacts

		Forecasted 2070 Demands (AF)		
		Without Passive	Minimum Passive Savings	Maximum Passive Savings
Hasty Water Company	Bent	40	34	33
Las Animas, City of[2]	Bent	713	628	604
McClave Water Assoc.	Bent	70	62	59
96 Pipeline Co.	Crowley	54	53	52
Crowley County Commissioners	Crowley	-	-	-
Crowley County Water Assoc.	Crowley	859	836	824
Crowley, Town of	Crowley	68	66	65
Olney Springs, Town of	Crowley	64	61	60
Ordway, Town of	Crowley	431	420	414
Sugar City, Town of	Crowley	131	129	128
Eads, Town of	Kiowa	250	236	232
Beehive Water Assn	Otero	10	7	6
Bents Fort Water Co.	Otero	81	61	55
Cheraw, Town of	Otero	62	58	57
East End Water Assn.	Otero	15	13	13
Eureka Water Co.	Otero	95	88	86
Fayette Water Assn.	Otero	16	15	14
Fowler, Town of	Otero	269	232	222
Hancock Inc.	Otero	22	19	18
Hilltop Water Co.	Otero	58	51	50
Holbrook Center Soft Water	Otero	23	22	22
Homestead Improvement Assn.	Otero	9	7	7
La Junta, City of[1]	Otero	2,615	2,459	2,417
Manzanola, Town of	Otero	50	39	37
Newdale-Grand Valley Water Co.	Otero	73	63	60
North Holbrook Water	Otero	9	8	8
Patterson Valley	Otero	19	17	17
Rocky Ford, City of	Otero	1,144	1,056	1,032
South Side Water Assoc. (La Junta)	Otero	9	8	7
South Swink Water Co.	Otero	105	91	88
Swink, Town of	Otero	49	34	30
Valley Water Co.	Otero	48	41	39
Vroman	Otero	42	38	37
West Grand Valley Water Inc.	Otero	33	31	30
West Holbrook Water	Otero	18	18	18
Lamar, City of	Prowers	2,788	2,614	2,567
May Valley Water Assoc.	Prowers	476	444	435
Wiley, Town of	Prowers	28	18	16
Avondale	Pueblo	284	248	237
Boone, Town of	Pueblo	118	112	111
St. Charles Mesa Water District[3]	Pueblo	2,955	2,760	2,698
	TOTAL =	**14,201**	**13,197**	**12,902**

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Appendix C.1 - Climate Change Literature Review

Introduction

Appendix C.1 aims to further the understanding of climate change and describe the potential impacts and environmental effects of climate variability on resource areas evaluated in this EIS. This appendix is a literature review of existing scientific studies regarding the effects of potential climate change on Arkansas and Colorado River Basins hydrology. The Upper Colorado River Basin supplements the Arkansas River via the Fryingpan-Arkansas Project and other transmountain diversion projects. Climate altered hydrologic modeling was not performed for the AVC EIS.

Much of the western United States (U.S.) has warmed during the 20th century and is projected to warm further during the 21st century. Temperatures in many major river basins have warmed approximately 2 degrees Fahrenheit (°F) over recent decades, and could continue to increase by 5 to 7 °F (Reclamation 2011a). However, trends for precipitation are less clear. Additionally, warming and associated loss of snowpack has occurred and is projected to persist over much of the western U.S. (Reclamation 2011a).

The historical temperature trend is very likely attributable, at least in part, to long-term warming, although some part may have been played by decadal scale variability, including shifts in the Pacific Decadal Oscillation in the late 1970’s. Where present, shifts to earlier snowmelt peaks and reduced summer and fall low flows are very likely to continue (U.S. Climate Change Science Program. 2008).

Losses in snowpack will be greatest where the baseline climate is closer to freezing thresholds, such as in lower lying valley areas and lower altitude mountain ranges. In high-altitude, high latitude areas, cool-season snowpack could increase during the 21st century (Reclamation 2011a). This shows that not all locations in this region are expected to experience the exact same impacts and that high uncertainty is still involved in many existing analyses.

The southwestern U.S. to the southern Rocky Mountains may experience runoff declines during the 21st century (Reclamation 2011a). Without changes to overall precipitation quantity, changes in snowpack dynamics (i.e., cool season accumulation and warm season melt) would lead to increases in cool season rainfall-runoff and decreases in warm season snowmelt runoff.

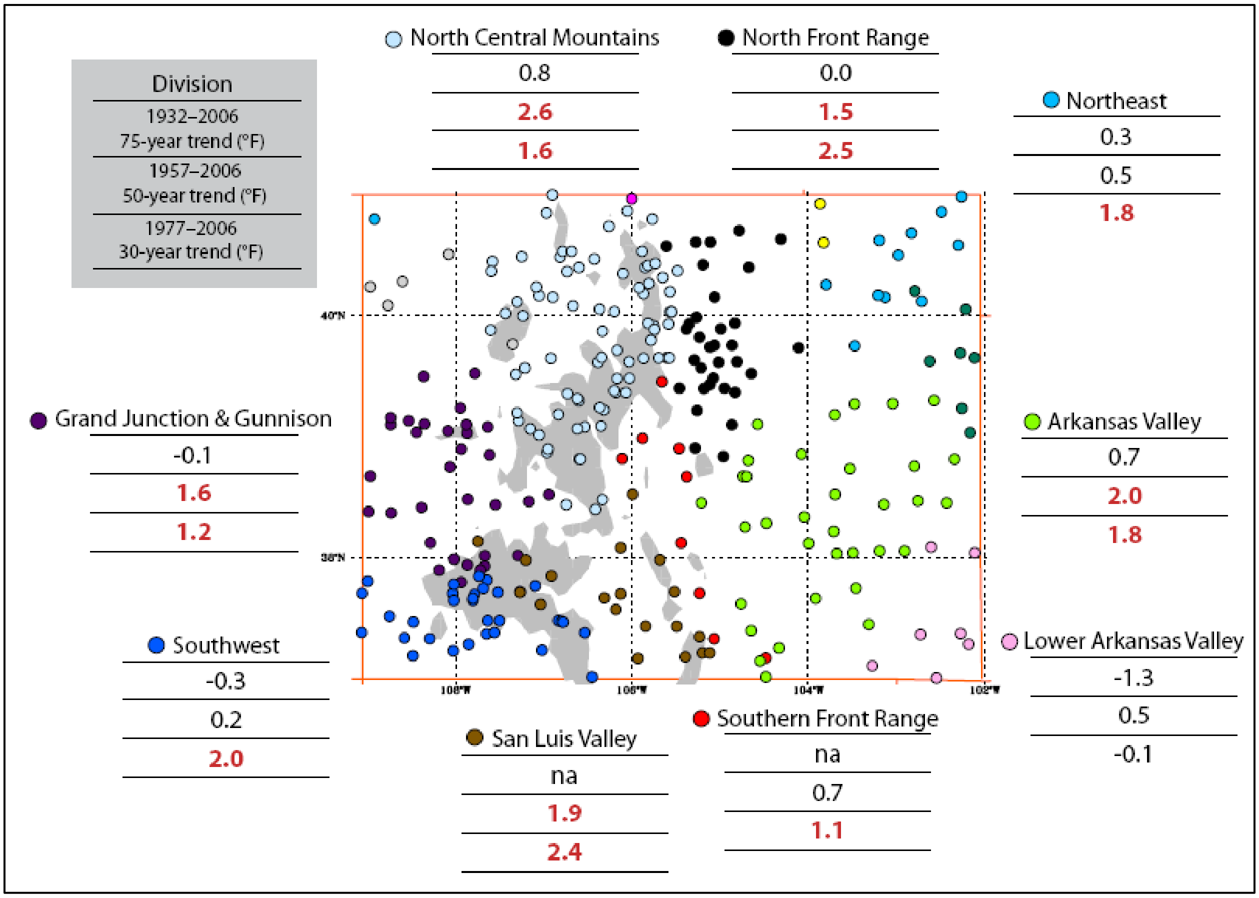
Historical Climate

Two sources of information are used to describe historical climate in Colorado and the western U.S. Climate records have been kept since the 1800s and can be used to examine recent climate trends. Natural, physical features (e.g. tree rings) can be used to assess ancient climate conditions.

Recent Trends

Reclamation (2011a, 2011c) provides an overview of hydroclimatic changes across the western U.S. Much of the western U.S. has warmed during the 20th century and is projected to warm further during the 21st century. Many major river basins in the western U.S. have warmed approximately 2° F over recent decades, and the warming trends appear to have shifted cool season precipitation towards more rain and less snow. This leads to increased rainfall-runoff volume during the cool season and subsequent decreased snowpack accumulation. Other historical trends for precipitation are less apparent. These generalizations reflect regionally averaged changes. Data available from the Western Climate Mapping Initiative indicate that the 11-year mean temperature has increased during the 20th century and is roughly 1.2° C (2.2º F) warmer for the Upper Colorado River Basin and 1.7° C (3.1º F) warmer for the Lower Colorado River Basin than it was a hundred years ago (difference computed is 1996-2006 mean minus 1896-1906 mean, Reclamation 2009).

Groups of stations with similar climates (Figure 1) comprise the divisions indicated by colored circles; there are no delineated geographic boundaries. Gray shading indicates terrain at an elevation higher than 9850 feet. The tables show temperature changes for the 30-, 50-, and 75-year periods ending in 2006, as determined from linear trend analysis. Statistically significant trends (>95 percent) are shown in red (warming). Insufficient data were available to calculate 75-year trends for the San Luis Valley and the Southern Front Range divisions. Statistically significant warming is evident in most divisions in the past 30 and 50 years (Western Water Assessment 2008).



Source: Western Water Assessment 2008

Figure 1. Regional Trends in Annual Average Temperature (°F) for Experimental Climate Divisions in Colorado

Spring shows minimum temperatures demonstrate greater overall warming than maximum temperatures in the last 50 years, including the Arkansas Valley (green circles). Spring shows the greatest increase in temperatures for the Arkansas Valley (Table 1). This finding is consistent with Knowles et al. (2006) who also found large and widespread warming trends in the intermountain west in March over a similar period.

Table 1. Seasonal Temperature Trends (1957-2006, 50-year) in the Arkansas River Valley

Location	Statistic	Temperature Trend [(1)]				
		Winter	Spring	Summer	Autumn	Annual
Arkansas River Valley	Maximum Temperature	+2.1	*+3.8*	+0.4	1.0	*+1.8*
	Minimum Temperature	*+3.2*	*+3.0*	*+1.4*	*+1.4*	*+2.2*

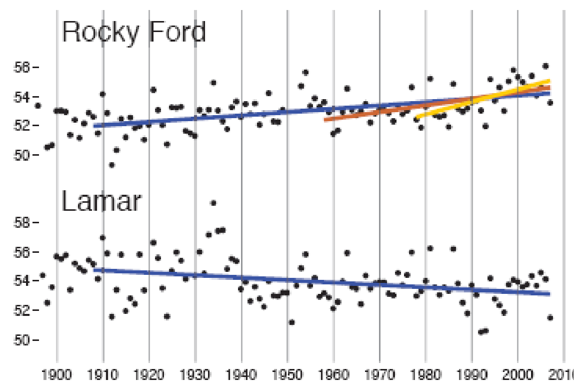
Source: Western Water Assessment 2008
Note:
(1) Statistically significant warning trends are shown in red and italics.

The Lower Arkansas Valley (pink circles) reflects a -1.3 °F change since 1932, and a -0.1 °F change during the recent 30-year period of 1977-2006. Western Water Assessment (2008) notes that the 75-year period begins during the Dust Bowl years, one of the hottest periods on record. Pielke et al. (2002 and 2007) also notes problems with the observational record at this time that may have introduced bias. Western Water Assessment (2008) notes that by using a larger selection of National Weather Service Cooperative Observer Program COOP stations in this division in Colorado and in neighboring states yields the linear trends for the Lower Arkansas River Valley shown in Table 2.

Table 2. Corrected Linear Trend for Lower Arkansas River Valley

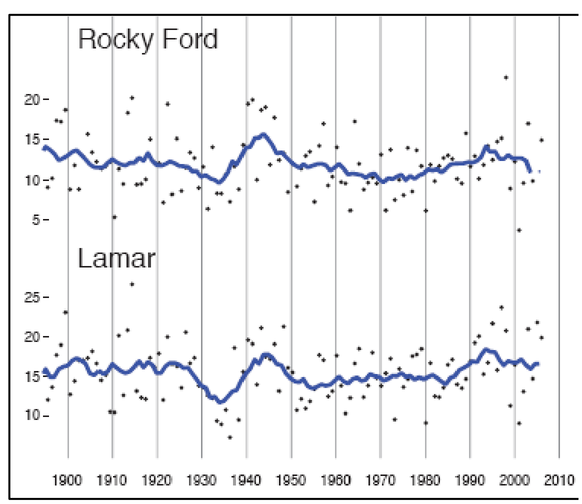
Division	Trend
75-year trend 1932-2006:	-1.4°F
50-year trend 1957-2006:	+0.1°F
30-year trend 1977-2006:	+0.7°F

Western Water Assessment (2008) examined 30-, 50-, and 100-year temperature trends of nine representative Colorado weather stations with 90-year or longer records in both temperature and precipitation, and with comparatively few identified problems with station relocation, instrument changes, and missing observations compared to Colorado's other stations. Two weather stations are in communities associated with the study area – Rocky Ford and Lamar. The temperature analysis at Rocky Ford and Lamar showed detectable trends with statistically significant changes (Figure 2). Rocky Ford's trends show increasing temperature, consistent with most other locations in Colorado. In contrast to the other locations, Lamar showed a trend for decreasing temperature; the reasons for this are unknown. Western Water Assessment (2008) emphasizes that trends at a single station are not definitive because of local effects and that general conclusions of temperature trends need to be considered across multiple stations to develop regional generalizations. The 100-, 50- and 30-year linear trends shown in blue, red and yellow, respectively, are statistically significant (>97.5 percent); linear trends not significant are not shown in Figure 2.



Source: Western Water Assessment 2008
Figure 2. Daily Average Temperature (°F) at Lamar and Rocky Ford Colorado

Western Water Assessment (2008) also looked at precipitation at the same nine stations with higher quality data, including the Rocky Ford and Lamar stations (Figure 3). The findings reveal that overall, long-term trends are not detectable at these stations, which aligns with Reclamation's (2011b) view that historical precipitation trends lack clarity. In Figure 3, the ten-year moving average of available data (solid blue line) is shown to emphasize decadal variations. Shorter-term changes, such as the droughts of the 1930s, 1950s and early 2000s, are apparent at some stations.



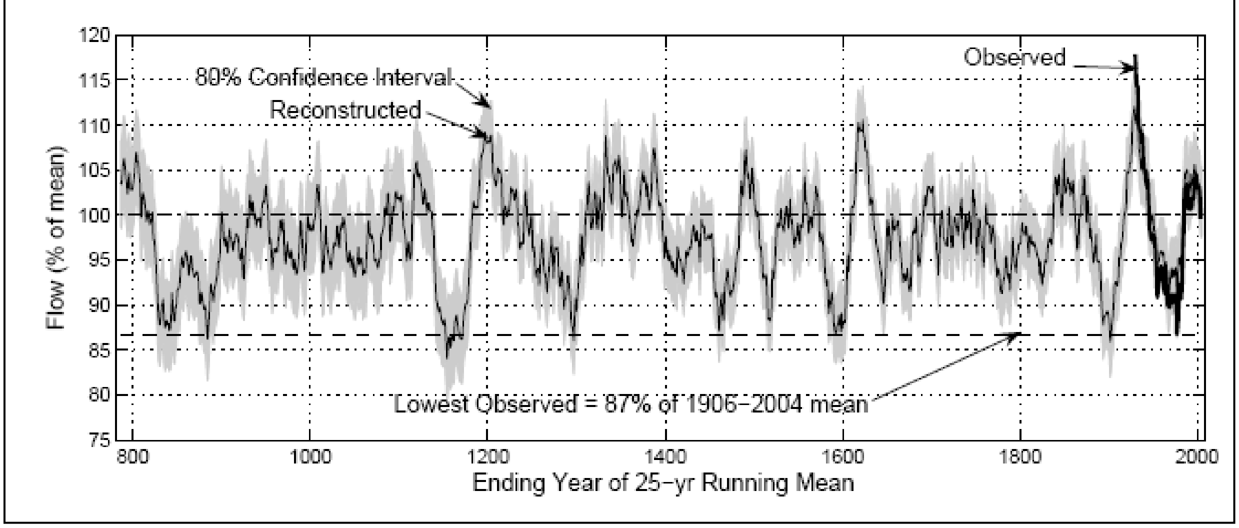
Source: Western Water Assessment 2008
Figure 3. Water Year Precipitation (inches) at Rocky Ford and Lamar, Colorado

Paleoclimate

Paleoclimate is historical or ancient climate. Paleoclimatic data can be reconstructed through such methods as ice core and tree ring analysis.

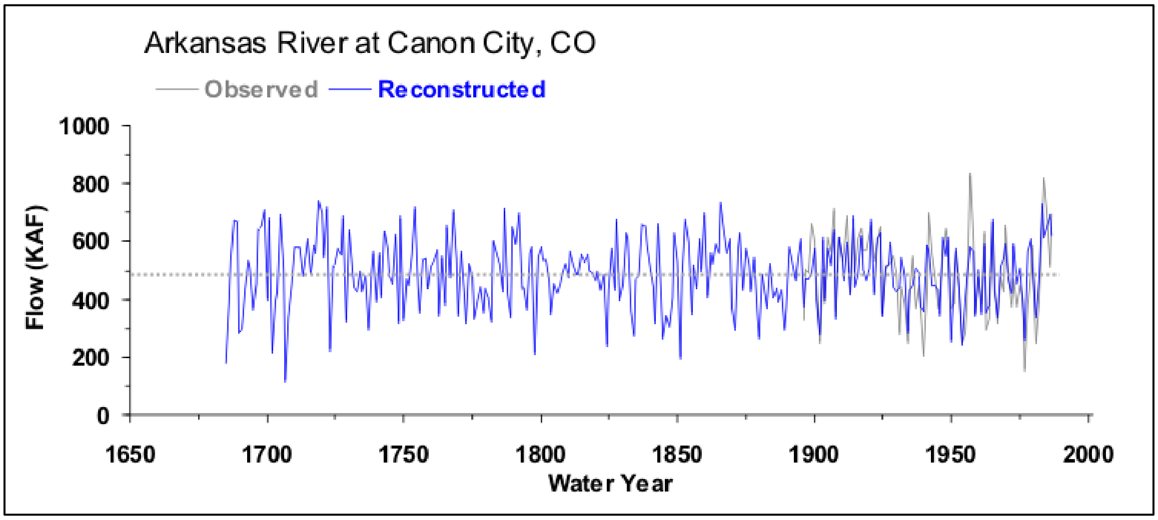
Examining ancient historical climate also reveals hydrologically relevant characterizations. The growth of trees in many parts of Colorado closely reflects annual moisture variability, enabling the tree rings to be used to reconstruct annual streamflow beyond the beginning of instrumental records. The reconstructions indicate that more severe and sustained droughts occurred in the centuries prior to 1900 than those seen in gaged records (Western Water Assessment 2008). In the Upper Colorado River basin, tree-ring data have been used to reconstruct streamflow over the past five centuries and longer using dendrochronological techniques. Reconstructions on the Colorado River based on statistically calibrating tree-ring data with natural flow records was first done by Stockton in 1975. Since then several reconstructions have been done on the Colorado River at Lees Ferry, Arizona. The most recent efforts extend the reconstruction back to AD 762 (Meko et al. 2007). The Meko, 2007 reconstruction shows several extreme and sustained droughts (Figure 4).

Woodhouse (2004) reconstructed the Arkansas River at Cañon City gage historical flow based on tree-ring data. The Arkansas River at Cañon City gage has one of the longest and most complete record sets in the basin. The reconstruction extends only through 1987 because the model was calibrated prior to the updating of key chronology (Van Bibber) that ends in 1987.



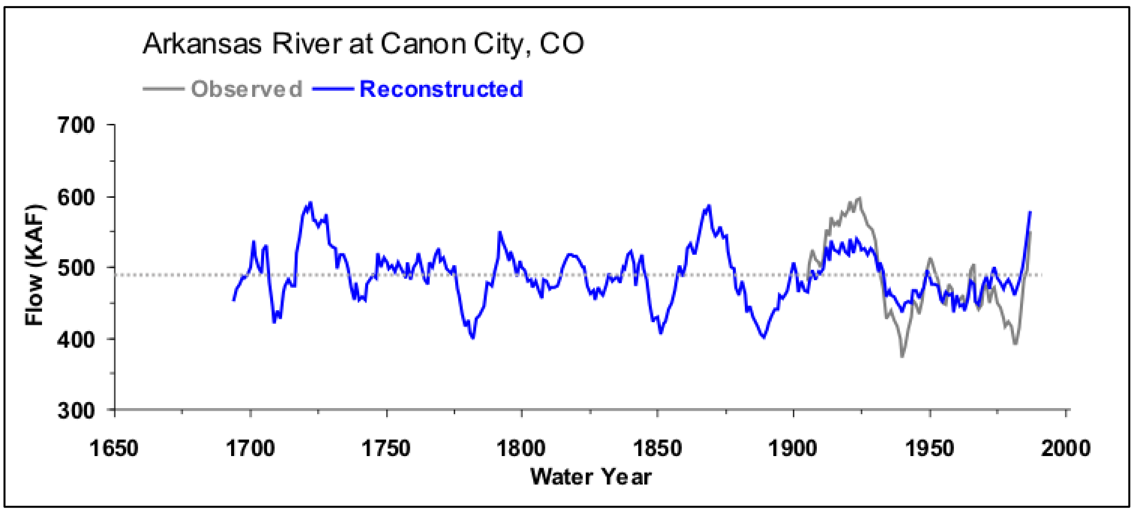
Source: Meko et al., 2007
Figure 4. Reconstruction of Lees Ferry Streamflow

Figure 5 shows observed streamflow for the last 90 years and reconstructed streamflow for the last 300 years for the Arkansas River at Cañon City gage. The dashed line is the long-term reconstructed mean streamflow at the gage. The reconstructed record is extended into the gaged time period to show, in general, how well the reconstructed data calibrates. In general, the observed record has lower lows and higher highs than the reconstructed record. This is not entirely unexpected as the observed record for the Arkansas River at Cañon City gage includes the transport of west slope water brought over by transmountain diversions en route to Pueblo Reservoir and downstream water users. Furthermore, the tree ring data reflects an averaged response to moisture conditions whereas the gaged record responds immediately to extreme weather events. Reconstructions in other parts of Colorado typically show the extreme minimums and maximums in the reconstructed model. The 10-year running mean for 200 years appears in Figure 6. In these figures, distinct spells of time when the flows are above or below the mean can be seen. Spells information is useful for interpreting whether paleo droughts are more/less sustained than observed droughts.



Data Source: Woodhouse 2004

Figure 5. Reconstructed Annual Flow for the Arkansas River at Cañon City Gage (1685-1987)



Data Source: Woodhouse 2004

Figure 6. The 10-year Running Mean (Plotted on Final Year) of Reconstructed Arkansas River at Cañon City Gage Streamflow (1685-1987)

Climate Change Analyses

The following sections discuss climate change analyses by Reclamation and other organizations. This review is not meant to be all inclusive of every study available, rather it is a synopsis of major studies with potential implications on AVC EIS proposed actions. The individual study documents should be referenced for a complete description of methodology, assumptions, conclusions, and applicability.

Reclamation Climate Change Analyses

In meeting its mission, Reclamation's planning and operations rely upon assumptions of present and future water supplies based on climate. Climate information influences the evaluation of resource management strategies through assumptions or characterization of future potential temperature, precipitation, and runoff conditions, among other weather information. Water supply estimates are developed by determining what wet, dry, and normal periods may be like in the future, and by including the potential for hydrologic extremes that could create flood risks and droughts. Several Reclamation studies have assessed climate information and its effects on water supply.

Secure Water Act

Acknowledging the uncertainties associated with future climate and associated potential impacts, Congress passed the Omnibus Public Land Management of 2009 (Public Law 111-11) Subtitle F – SECURE Water. This act authorized Reclamation to continually evaluate and report on the risks and impacts from a changing climate and to identify appropriate adaptation and mitigation strategies utilizing the best available science in conjunction with stakeholders (Reclamation 2011a).

Reclamation published the *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011* report (2011a), which assessed climate change risks and how these risks could impact water operations, hydropower, flood control, and fish and wildlife in the western U.S.. It represents the first consistent and coordinated assessment of effects of and risks from climate change to future water supplies across eight major Reclamation river basins, including the Colorado, Rio Grande and Missouri river basins. The SECURE Water Act report was supported by Reclamation's *West Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections* study (2011b), which analyzed changes in hydroclimatic variables, such as precipitation, temperature, snow water equivalent, and streamflow, across major Reclamation river basins. Downscaled climate data using the West Wide Climate Risk Assessment methodology was used in the climate change analysis of AVC yield (see Appendix C.2).

The SECURE Water Act report and West Wide Climate Risk Assessments study are based on projections of future temperature and precipitation projections from multiple climate models and various projections of future greenhouse gas emissions, technological advancements, and global population estimates. Reclamation recognizes that further information is likely needed to inform local level decision making. Reclamation plans to develop reports that will build upon the level of information currently available and use the rapidly developing science to address how changes in supply and demands will impact water management. One such initiative includes the WaterSMART Basin Studies; however, the Arkansas River is not presently included in this study set (Reclamation 2012).

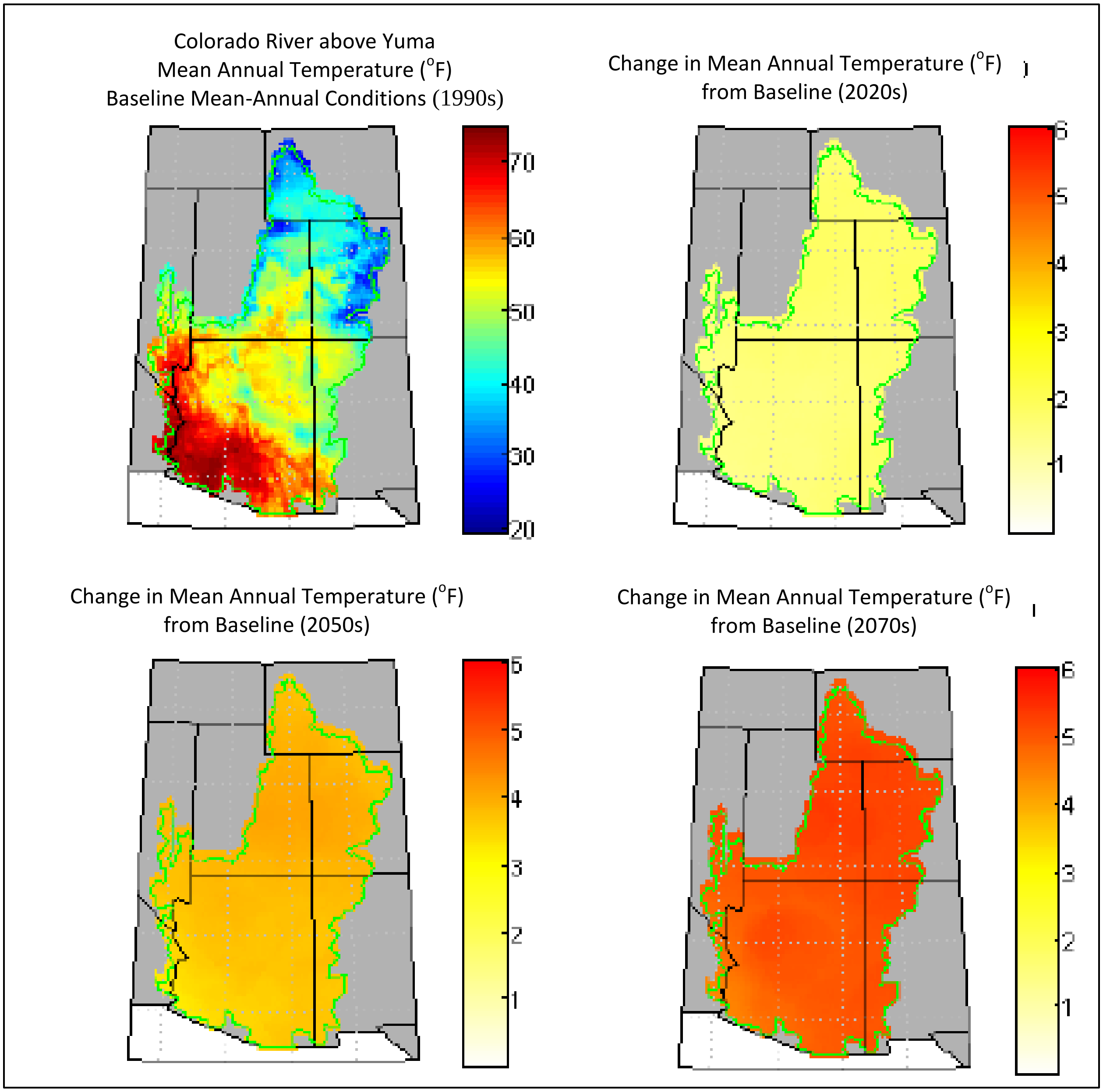
The Secure Water Act report findings show increased climate change risks to the western U.S. and water resources during the 21st century. General findings include the following:

- a temperature increase of 5-7º F
- a precipitation increase over the northwestern and north-central portions of the western United States
- a decrease over the southwestern and south-central areas
- a decrease for almost all April 1st snowpack, a standard benchmark measurement used to project river basin runoff
- an 8 percent to 20 percent decrease in average annual stream flow in several river basins, including the Colorado, the Rio Grande, and the San Joaquin

The report notes that projected changes in temperature and precipitation are likely to impact the timing and quantity of stream flows in all western basins, which could impact water available to farms and cities, hydropower generation, fish and wildlife, and other uses such as recreation (Reclamation 2011a). Because of its geographic proximity to other basins in the study (i.e., Colorado River Basin), it is likely that the Arkansas River Basin would be subject to similar risks. Furthermore, the Arkansas River system would be influenced by the results in the Colorado River Basin by transmountain diversion projects such as the Fry-Ark Project, which moves west slope Upper Colorado River Basin water to the east slope.

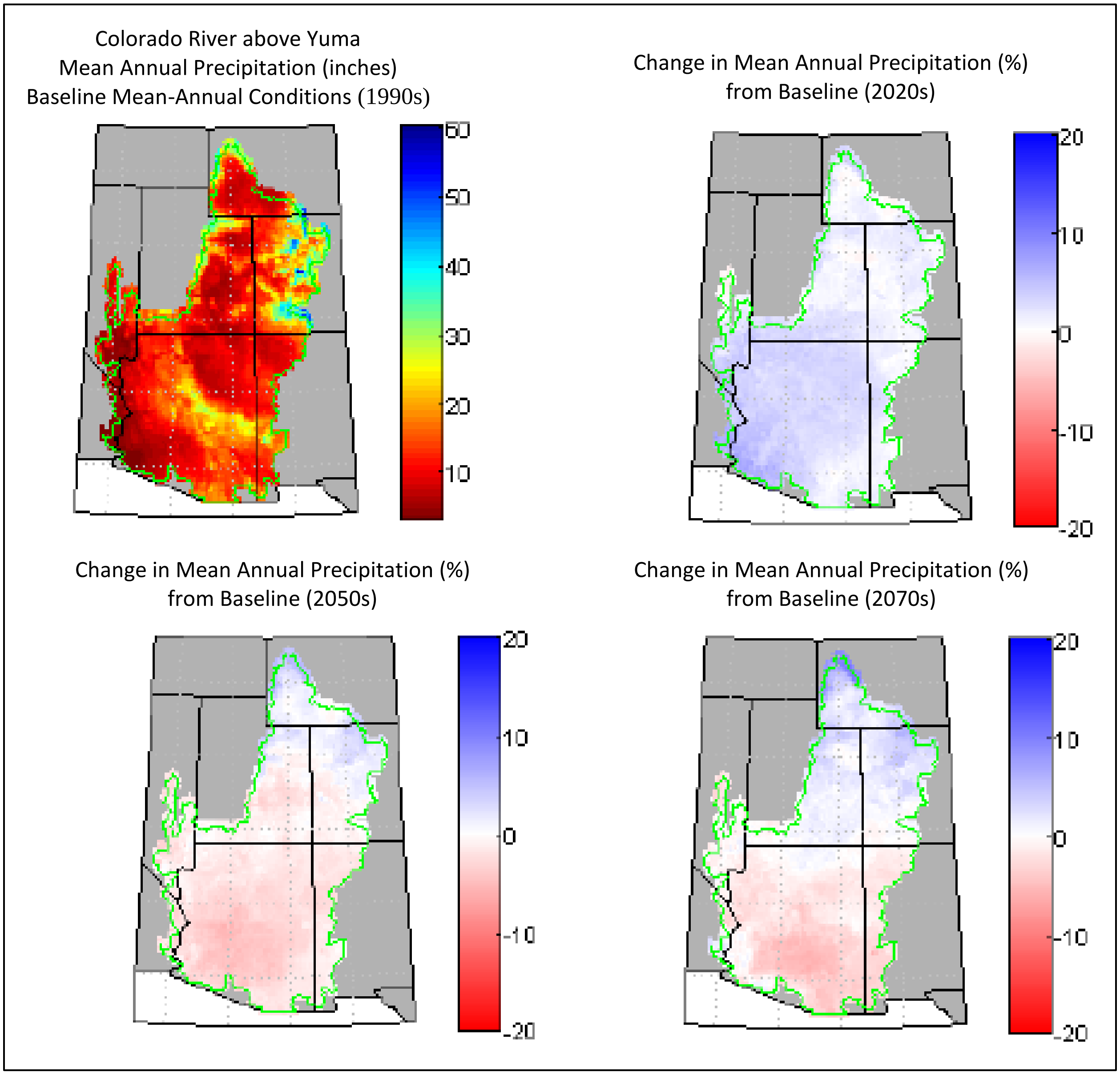
Findings from the Secure Water Act report for the Upper Colorado Basin in the 21st century are shown in Figure 7 through Figure 9. Mapped values for baseline conditions (1990s) are median-values from the collection of climate simulations. Mapped changes (next three panels) are median changes from the collection of climate simulations, or ensembles. General climate change risks for the Upper Colorado Basin include the following:

- basin-average mean annual temperature is projected to increase approximately 6-7^{o}F
- precipitation is projected to increase in the headwater areas
- warming trends, rather than precipitation trends, are expected to dominate climate change effects on snowpack
- low elevation snowpack is projected to decrease; high elevation snowpack effects are projected to be minimal
- winter season (December–March) runoff shows an increasing trend; spring–summer season (April–July) runoff shows a decreasing trend



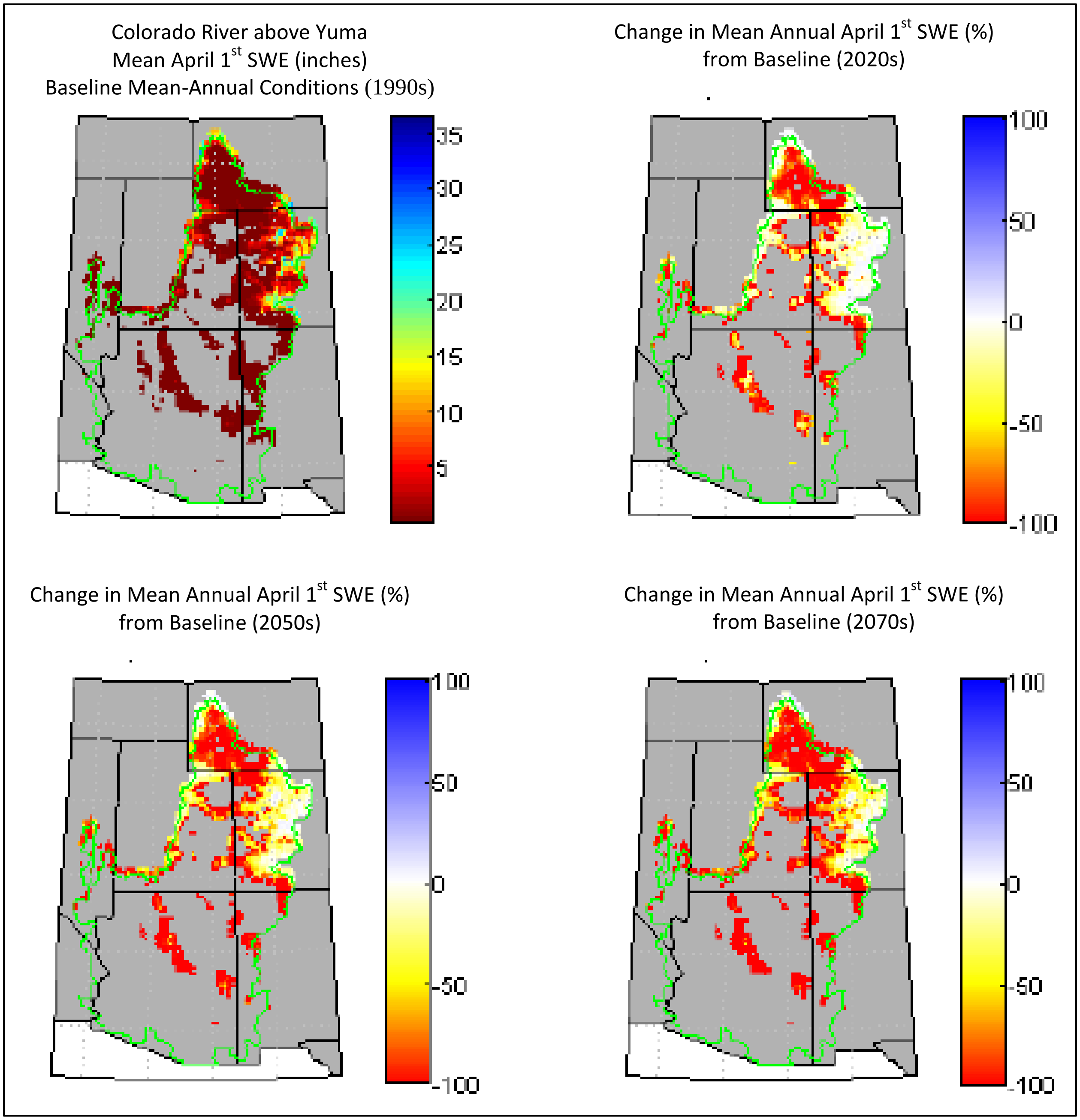
Source: Reclamation 2011a

Figure 7. Simulated Decade-mean Temperature Over the Colorado River Basin



Source: Reclamation 2011a

Figure 8. Simulated Decade-mean Precipitation Over the Colorado River Basin



Source: Reclamation 2011a

Figure 9. Simulated Decade-mean April 1st Snowpack Over the Colorado River Basin

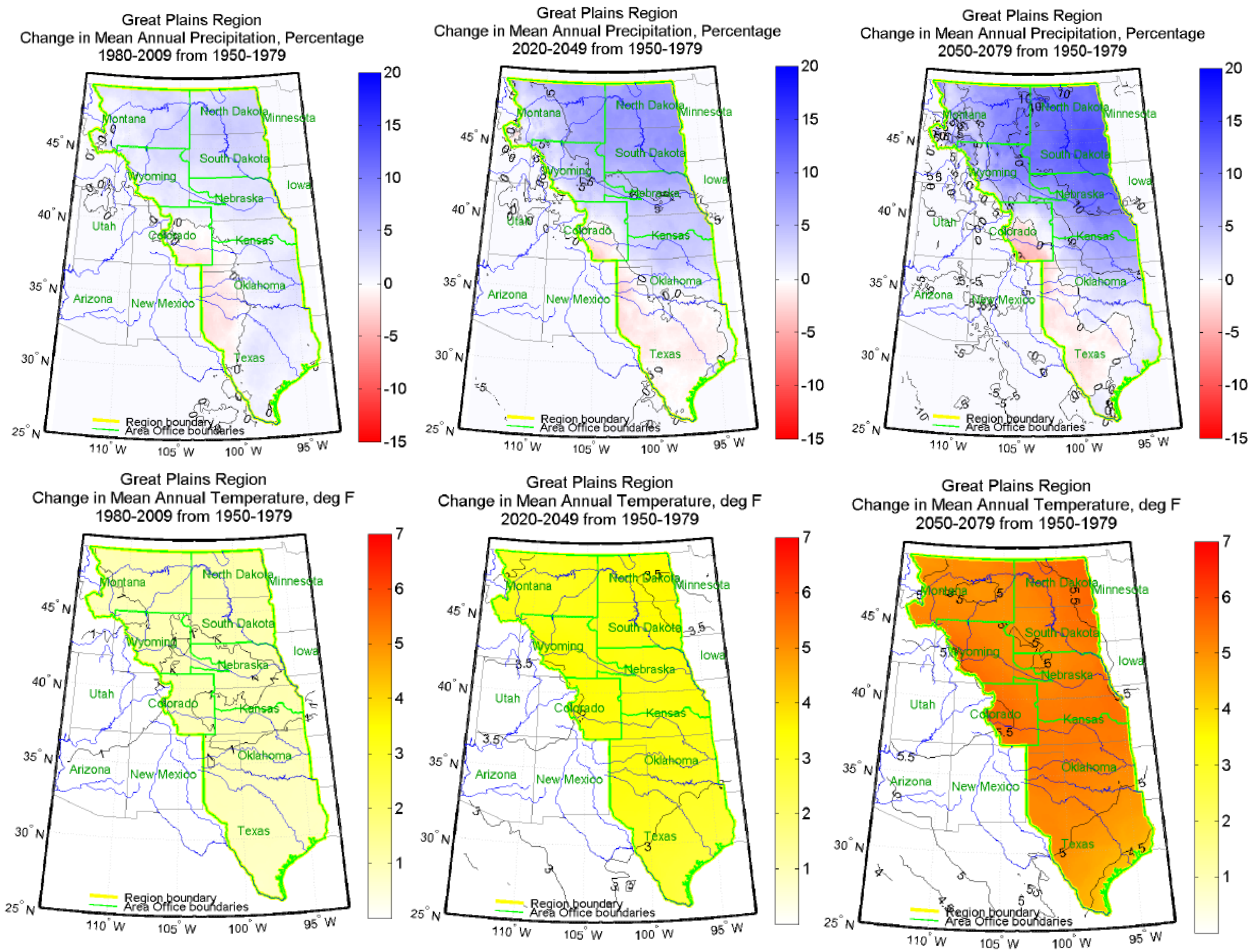
Reclamation Great Plains Region Climate Change Analyses

The World Climate Research Programme's Coupled Model Intercomparison Project phase 3 multi-model dataset (World Climate Research Programme 2007) has been bias corrected and downscaled for translation into climate and hydrologic runoff projections in the western United States, including the Colorado River and Arkansas River Basins. This climate data was used in Reclamation 2011a (SECURE report, Figure 7 and Figure 8) and for the graphical analysis in Reclamation 2011c. Figure 10 presents Reclamations' forecasts for the Region, inclusive of the Arkansas Basin (Reclamation 2011c). These projections also served as the fundamentals of the Intergovernmental Panel on Climate Change Fourth Assessment Report (2007). The projections reflect decadal moving changes in 30-year mean precipitation and temperature relative to a simulated 1950-1979 base period. They have been bias-corrected to be statistically consistent with 50-year climatology (1950-1999), but have not been constrained to reproduce observed frequency characteristics, such as the timing and occurrence of drought spells. At any projection time-stage, the middle condition among projected conditions can be used to develop a sense about mean climate state. If middle change is tracked through time, the presence or absence of climate trends may be determined. (Reclamation 2011c)

Southern and southwestern portions of Reclamation's Great Plains region are projected to have a tendency for drier conditions in the 21st century (Figure 10); this applies especially to southeastern Colorado and the Arkansas Basin. Mean-annual temperature is projected to warm uniformly across the region in the 21st century (Figure 10; Reclamation 2011c). World Climate Research Programme's projections documented by Reclamation (2011c) appear to be in generally the same magnitude of change as Tetra Tech's (2010) results outlined in Table 3 for the Arkansas Basin (see below).

Other Reclamation Literature Reviews

Recently, several literature reviews on the science of climate change have been prepared. The Climate Technical Work Group Report (Reclamation 2007), prepared a literature review as Appendix U for the *Final Environmental Impact Statement, Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead,* including a comprehensive literature review of climate science in the Colorado River Basin. Reclamation's Research and Development Office commissioned the Technical Service Center Water Operations and Planning Support Group to conduct a comprehensive literature review and synthesis that was region-specific within the United States to enable efficient and consistent discussion of climate change implications in planning documents (Reclamation 2009, 2011c). The 2011 review updates the 2009 report. Updates of this "living document" are expected to occur annually. The 2011 document addresses concerns about climate change impacts for specific resources and geographic areas (e.g., climate change impacts on ecosystems and water demands and climate change impacts for the eastern Great Plains Region).



Source: Reclamation 2011c

Figure 10. Downscaled Precipitation and Temperature Change Projections in Reclamation's Great Plains Region

Other Climate Change Studies

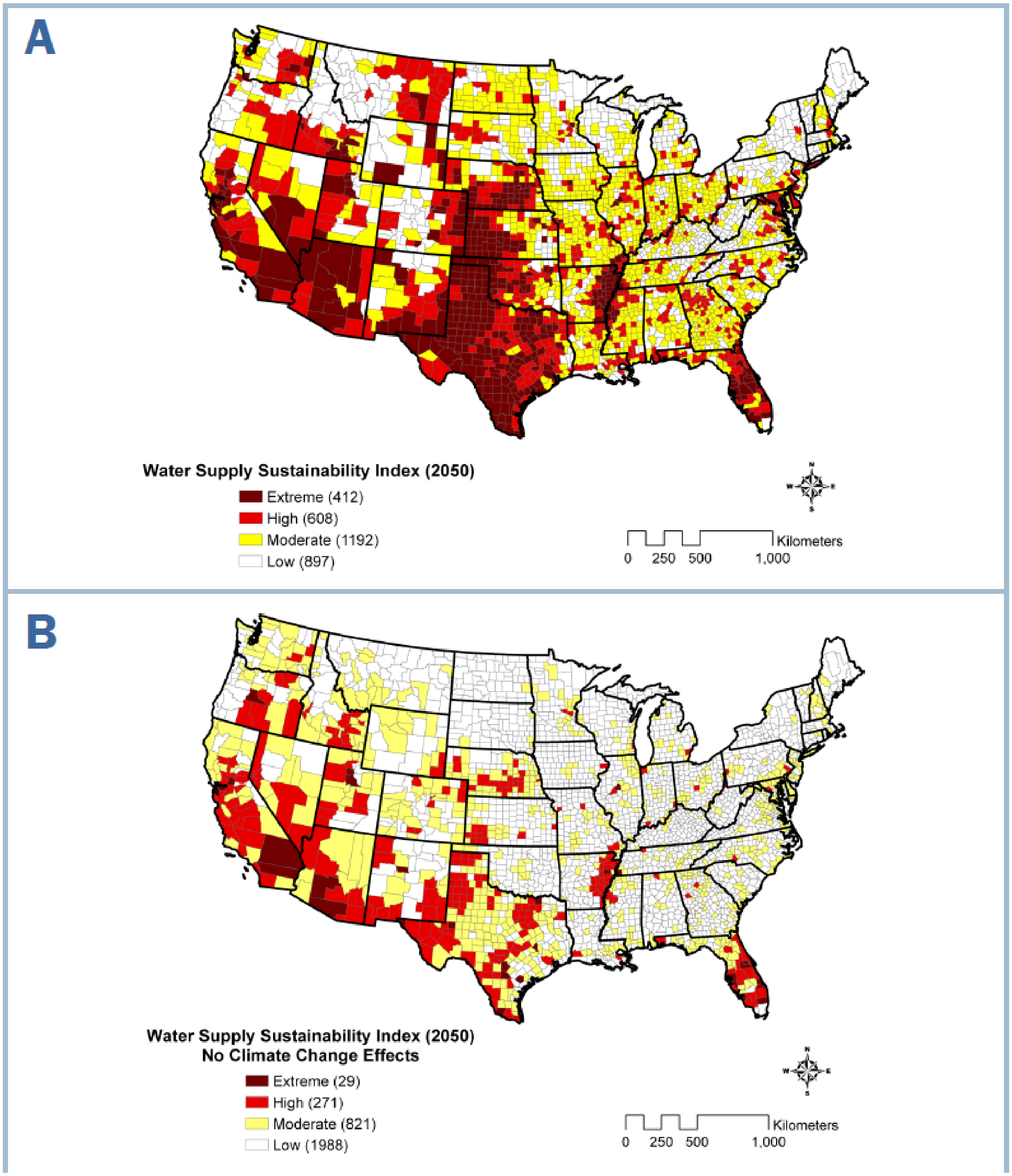
Several other climate change studies specific to Colorado and the western U.S. have been completed in the last decade, and are summarized in this sections.

Tetra Tech / National Resource Defense Council Projections

Tetra Tech (2010) performed a study to define the significance of climate change and its forecasting to water supplies. More than one-third of counties in the continental U.S. could face higher risks of water shortages by mid-century as the result of global warming, as shown in Figure 11. These conclusions are based on publicly available water-use data from across the U.S. and estimated future demands using business-as-usual scenarios of growth, compared with simulated future renewable water supply based on a set of 16 global climate model projections of temperature and precipitation (Tetra Tech 2010). These projections are the same as used in the Intergovernmental Panel on Climate Change, and as previously described regarding Reclamation's graphical analyses (Reclamation 2011a and 2011c).

By 2050, fourteen states face an extreme or high risk to water sustainability, or are likely to see limitations on water availability as demand exceeds supply (Tetra Tech 2010). This water sustainability index considers natural available precipitation, the extent of water development already in place, dependence on groundwater, susceptibility to drought, projected increases in water use, and changes in storage (the difference between peak summer demand and available precipitation). These water supply limitations were found to be applicable to all states west of the Missouri River, except for the Dakotas, Utah, Oregon, and Washington. States potentially impacted by water shortages include states in all eight of Reclamations major river basins. Over 400 counties (one-third of all counties, 14 times the previous estimate) are identified as being at the greatest risk.

The risks from climate change are related to changes in precipitation and the likelihood of increased demands in some regions. Estimated water withdrawal as a percentage of available precipitation may exceed 100 percent in some arid regions such as the southwestern U.S., compounding climate change impacts. Climate change could have major impacts on the available precipitation and the sustainability of water withdrawals in future years under the present water use scenario (Tetra Tech 2010).



Source: Tetra Tech 2010

Notes:

(1) With available precipitation computed using projected climate change

(2) With available precipitation corresponding to 20th century conditions, i.e., 1934-2000. The risks to water sustainability are classified into four categories from Extreme to Low. The numbers in parentheses are the numbers of counties in each category.

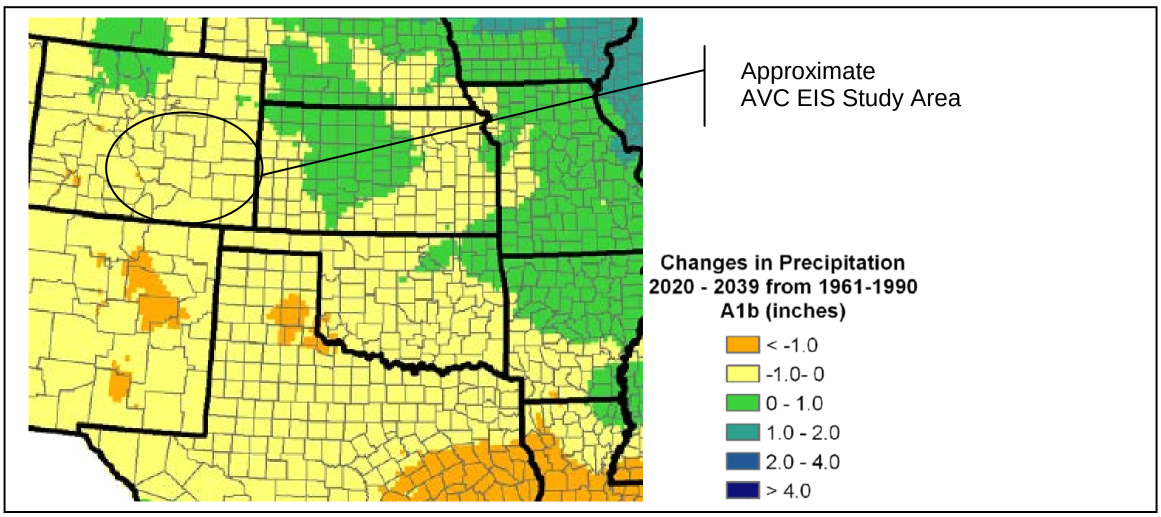
Figure 11. Water Supply Sustainability Index in 2050

The Tetra Tech (2010) study provides a summary of temperature and precipitation predictions from the A1b emissions scenario, which reflects a middle emissions path. Precipitation in this study accounted for losses due to potential evapotranspiration. It used years 1961-1990 as a baseline, and developed projections for 2020-2039 and 2040-2059. Tetra Tech's study period differs from those used in Reclamation 2011a and 2011c due to period choices in characterizing climate change. General projections for the majority of the Arkansas Basin in Colorado are outlined in Table 3 and Figure 12 through Figure 15. Findings are in general agreement with World Climate Research Programme conclusions (World Climate Research Programme 2007) and documented by Reclamation (2011c).

Table 3. Projections of Climatic Change for Majority of Arkansas River Basin in Colorado

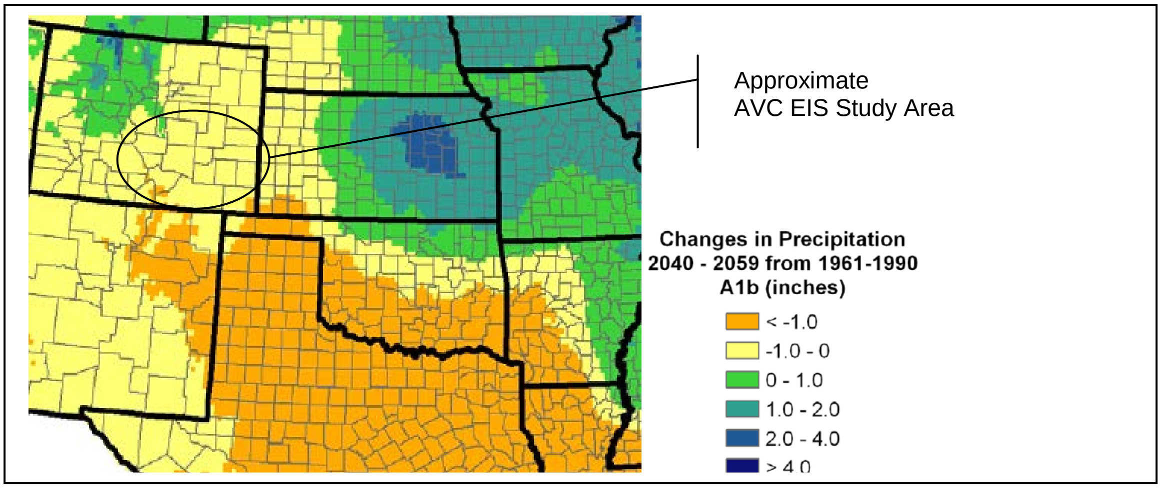
Parameter	Time Period	Change from ca. 1961-1990
Mean Annual Precipitation (less potential evapotranspiration)	2020-2039	0 to -1.0 in.
Mean Annual Precipitation (less potential evapotranspiration)	2040-2059	0 to -1.0 in.
Mean Annual Temperature	2020-2039	+1.50 to +1.75 °C (2.7 to 3.15 °F)
Mean Annual Temperature	2040-2059	+2.75 to +3.00 °C (4.95 to 5.40 °F)

Source: Tetra Tech 2010



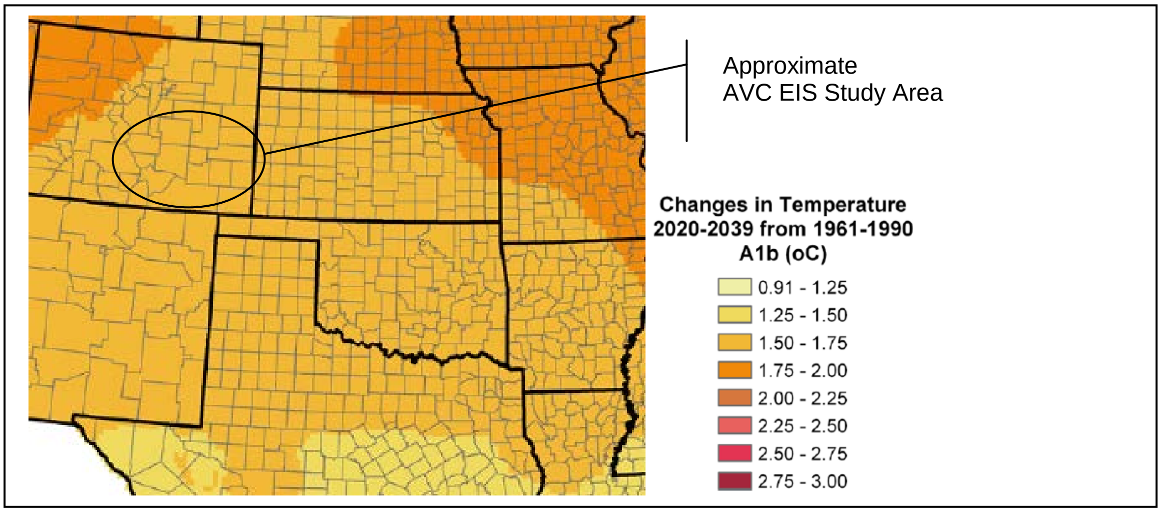
Source: Tetra Tech 2010

Figure 12. Predicted Changes in Mean Annual Precipitation from 1961-1990 to 2020-2039 (median of 20-year means computed from the 16 global climate models)



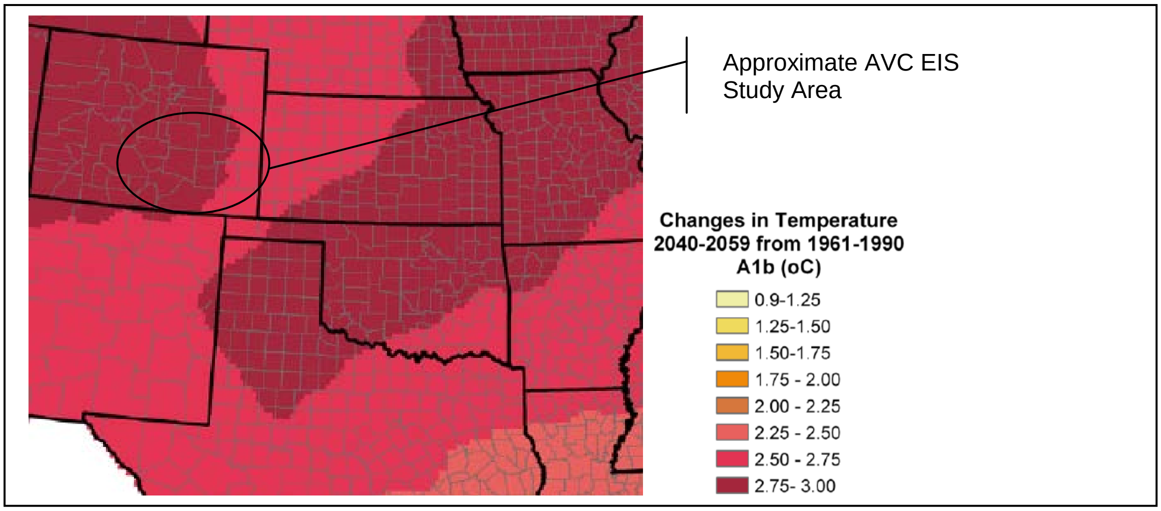
Source: Tetra Tech 2010

Figure 13. Predicted Changes in Mean Annual Precipitation from 1961-1990 to 2040-2059 (median of 20-year means computed from the 16 global climate models)



Source: Tetra Tech 2010

Figure 14. Predicted Changes in Mean Temperature from 1961-1990 to 2020-2039 (median of 20-year means computed from the 16 global climate models)



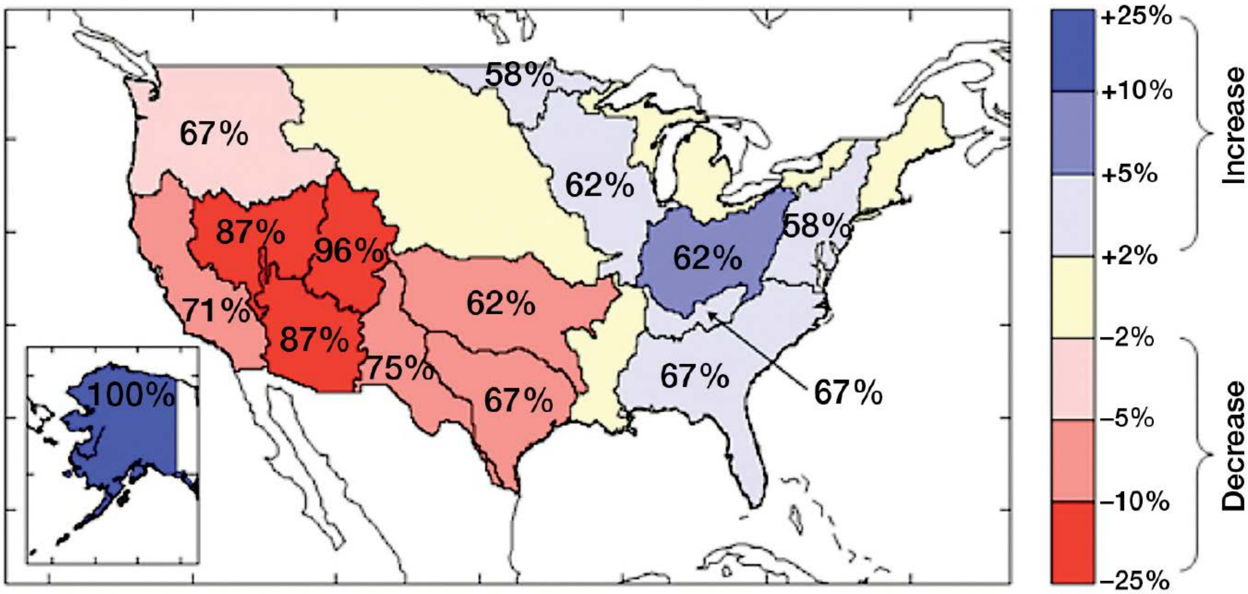
Source: Tetra Tech 2010

Figure 15. Predicted Changes in Mean Temperature for the Period of 1961-1990 to 2040-2059 (median of 20-year means computed from the 16 global climate model)

Colorado Foundation for Water Education/U.S. Geological Survey Projections

The Intergovernmental Panel on Climate Change (2007) projects global warming of about 0.7 F over the next 20 years, regardless of greenhouse gas emissions during the period. The warming in the interior of North America and Colorado will be substantially more than the global average. Summer warming is expected to be greater than winter warming, partially because of increased evaporation and reduced soil moisture. Additionally, precipitation is expected to significantly decrease in March, April, and May, which may indicate an earlier transition to spring, a shorter snow season, and earlier runoff. Additionally, runoff is projected to decrease because of increased evapotranspiration. This decreased runoff is projected to lead to reductions in average streamflow at 2050 ranging from 5 percent to 50 percent (Colorado Foundation for Water Education 2008). In a 2006 study by Christensen and Lettenmaier, less than a 1 percent change in total annual precipitation was predicted by the year 2100 in the Colorado River Basin. However, substantial warming results in significant declines in April 1 snowpack. Slight shifts towards more winter precipitation held declines in runoff to approximately 10 percent (Christensen and Lettenmaier 2006, as found in Colorado Foundation for Water Education 2008).

Beyond Reclamation's eight major river basins, most other river basins in Colorado remain generally unforecasted. The U.S. Geological Survey developed future runoff changes for the entire U.S. by river basin using multiple global climate models (Milly et al. 2005). The Arkansas River basin could realize 5 percent to 10 percent reductions in runoff by 2050 where the Upper Colorado River basin could realize 10 to 25 percent reductions (Milly et al. 2005), as shown by Figure 16.



Notes:
(1) Percentages shown on map are fraction of simulations for which differences between simulated baseline and future runoff had same sign as the median change in runoff.
(2) Source: Milly et al. 2005.

Figure 16. Projected Median Changes in Runoff by 2050 Interpolated to U.S.GS Water Resources Regions

Western Water Assessment Projections

The topography of Colorado complicates the accuracy and subsequent application of global climate models to micro-regions, such as along a specific river basin with severe elevation changes like the Arkansas River. The global climate models do not account for elevation changes. Subsequently, the accuracy of forecasts for temperature and precipitation changes may be affected. Thus, examining analyses that account for elevation changes is important when considering climate change forecasts for Colorado and its river basins, including those supplying the Arkansas Valley Conduit and Master Contract such as the Upper Colorado and the Arkansas River Basins.

In efforts to perform a Colorado-specific analysis the Western Water Assessment (2008) developed some insights for the Colorado Water Conservation Board into general trends of climate in Colorado. The synthesis of findings in the report suggests the following general themes for Colorado by the mid-21st century:

- Reduction in total water supply
- Decline in runoff for most river basins

The report drills deeper into these characterizations for Colorado, and provides some specific insight related to the climate of both the Upper Colorado and Arkansas River basins. For instance, with regards to Colorado, the synthesis identified the following key points from its research and use of pertinent references to keep in mind for water resources planning in Colorado:

- Colorado's highly variable climate is a consequence of high elevations and a complex topography of mountains, plains, and plateaus. Climate varies spatially and temporally, and different climatic variables fluctuate in distinct ways.

- Average river runoff and water availability are projected to decrease at mid-latitudes such as the western U.S.

- Changes in the quantity and quality of water may occur due to warming even in the absence of precipitation changes. Combined with related changes in evaporation and soil moisture suggests a decline and seasonal shift of runoff for most of Colorado's river basins by the mid-21st century.

- Climate models project Colorado will warm 2.5 °F (+1.5 to +3.5 °F) by 2025 and 4 °F (+2.5 to +5.5 °F) by 2050, relative to the 1950-1999 baseline. The 2050 projections show summers warming by +5 °F (+3 to +7 °F), and winters by +3 °F (+2 to + 5 °F). These projections also suggest that typical summer monthly temperatures will be as warm or warmer than the hottest 10 percent of summers that occurred between 1950 and 1999. By way of illustration, mid-21st century summer temperatures on the Eastern Plains of Colorado are projected to shift westward and upslope, bringing into the Front Range temperature regimes that today occur near the Kansas border.

- In all seasons mountain climate is expected to migrate upward in elevation, and the climate of the desert southwestern U.S. is expected to progress up into the West Slope valleys of Colorado.

- Winter projections show fewer extreme cold months, more extreme warm months, and more strings of consecutive warm winters. Typical, projected winter monthly temperatures are between the 10th and 90th percentiles of the historical record. Between 2008 and 2050, January climate of the Eastern Plains of Colorado is expected to shift northward by about 150 miles.

- In all parts of Colorado, no consistent long-term trends in annual precipitation have been detected over the last 100 years. Variability is high, which makes detecting trends difficult. Climate model projections do not agree whether annual mean precipitation will increase or decrease in Colorado by 2050. The multi-model average projection shows little change in annual mean precipitation, although a seasonal shift in precipitation to slightly more winter and less summer precipitation is projected.

- In Colorado, it is unlikely that widespread and large increases in precipitation falling as rain rather than snow, and subsequent reduction in snow water equivalent, will occur in significant amounts (Knowles et al. 2006). The widespread reduction in snowpack found in the lower elevation mountains of the western U.S. (i.e., California) has not been detected in Colorado. Most of Colorado's snowpack accumulates in temperatures well below freezing and above an elevation of 8200 feet (Regonda et al. 2005). Modest declines (10-20 percent) in snowpack are projected for Colorado's high-elevation (above 8200 ft) snowpack.

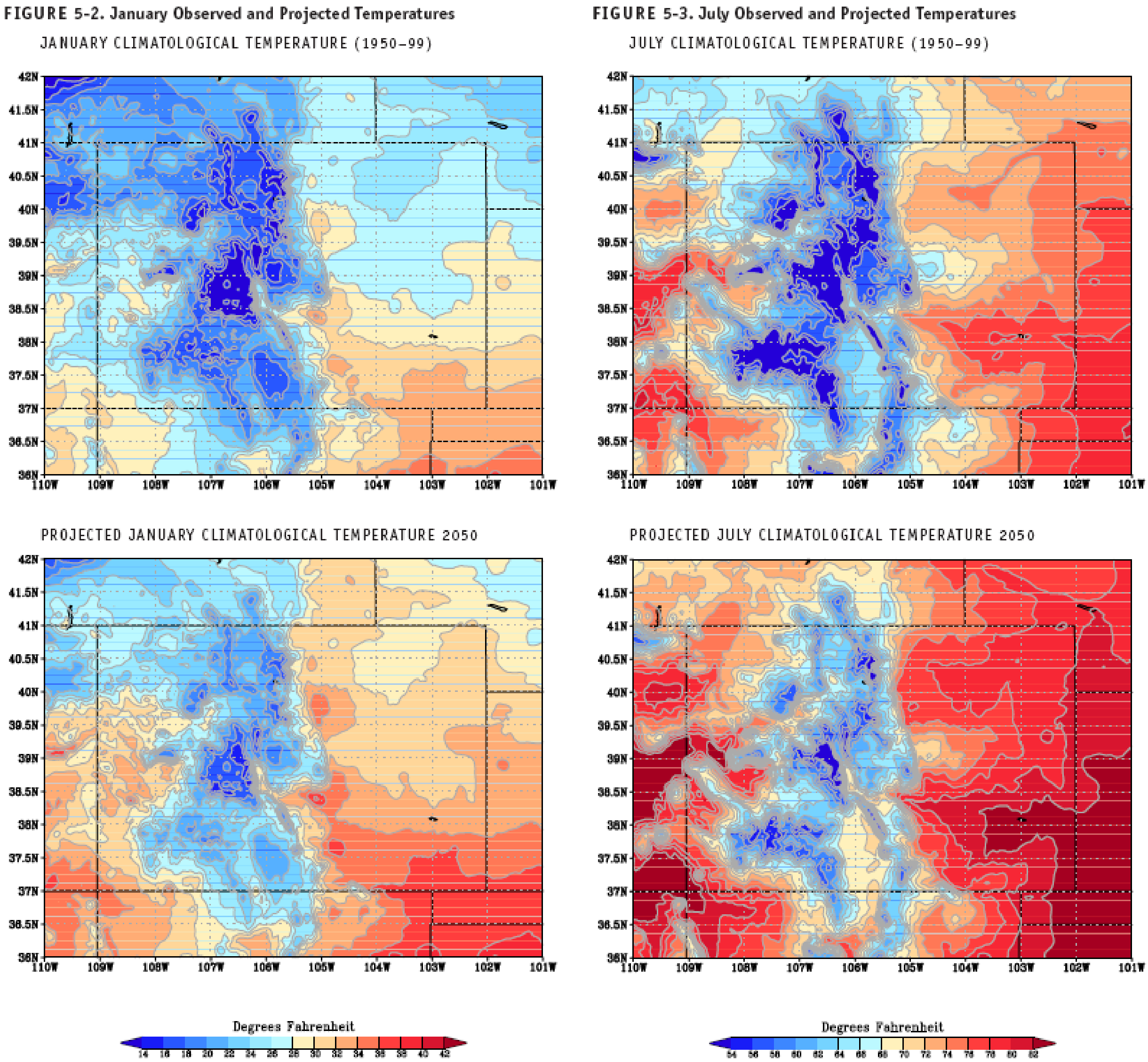
- Between 1978 and 2004, spring runoff (the onset of streamflows from melting snow) in Colorado has shifted earlier by two weeks (Clow 2007). Several studies suggest that shifts in timing and intensity of spring runoff are related to warming spring temperatures. The timing of spring runoff is projected to continue shifting earlier in the spring (Stewart et al. 2005, Hamlet et al. 2005). Late-summer flows may be reduced. These changes are projected to occur regardless of changes in precipitation.

- Recent hydrology projections suggest declining streamflow for most of Colorado's river basins in the 21st century. However, the impact of climate change on streamflow in the Rio Grande, Platte, and Arkansas Basins has not been studied as extensively as the Colorado River Basin. In general, warmer temperatures and increased evaporation will lead to lower river levels (EPA 2007). Heavily utilized groundwater-based systems in the southwestern U.S. are likely to experience additional stress from climate change that leads to decreased recharge (Field et al. 2007).

- The Western Water Assessment also notes that the lowest five-year period of Colorado River natural flow since records began in the late 1800s occurred in 2000 to 2004. Recent hydrological studies of the Upper Colorado River Basin project multi-model average decreases in runoff ranging from 6 percent to 20 percent by 2050 compared to the 20th century average. This is important to note since the Colorado River is the primary source of water for the Fry-Ark Project and a future AVC.

- Global climate models do not represent the complexity of Colorado's topography, so downscaling and other techniques are needed to study processes that affect Colorado water resources.

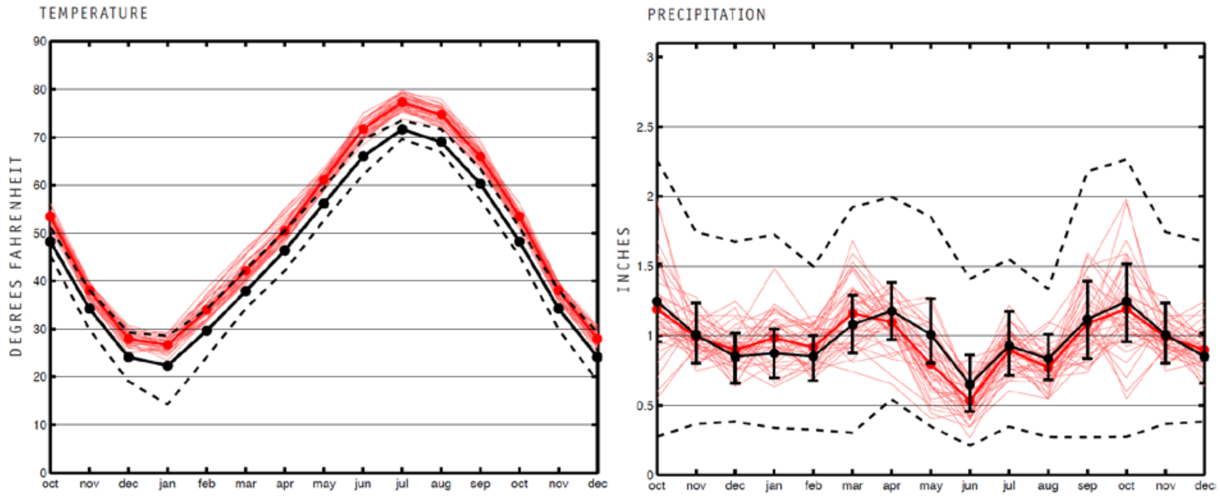
Comparing current temperatures and projected temperature changes can be useful to see how temperatures could change in the Upper Colorado and Arkansas River basins. Using the same climate projection data as used in Reclamation 2011a and Reclamation 2011c, Figure 17 shows that in January, winter temperatures shift northward on the plains by 2050 by a distance greater than half the state of Colorado. They will also increase in the mountains in all seasons. In July, summer temperatures are projected to shift by 2050 westward on the plains of Colorado and upslope, bringing the temperatures of the Kansas border to the Front Range.



Source: Western Water Assessment 2008

Figure 17. January and July Observed and Projected Temperatures for 2050

In Figure 18, the projected monthly climatologies (thin red lines) are from the multi-modal ensemble for the 20-year period centered on 2040. The projection average is shown as a heavy red line. Data are derived from bias-corrected and downscaled climate model output and gridded observations (Maurer 2007). For precipitation, the 10th and 90th percentile values of historical 20-year averages, estimated from nearby station data with approximately 100 year records, are shown (vertical bars). The projected temperature change is consistently comparable or greater the historical record; however, this is not the case for precipitation showing projections above and below the historical average (Western Water Assessment 2008).



Source: Western Water Assessment 2008

Figure 18. Observed Monthly Average Temperature (°F) and Precipitation (inches) Compared with Projections for 2050 Over a 30 x 40 Mile Region Near La Junta

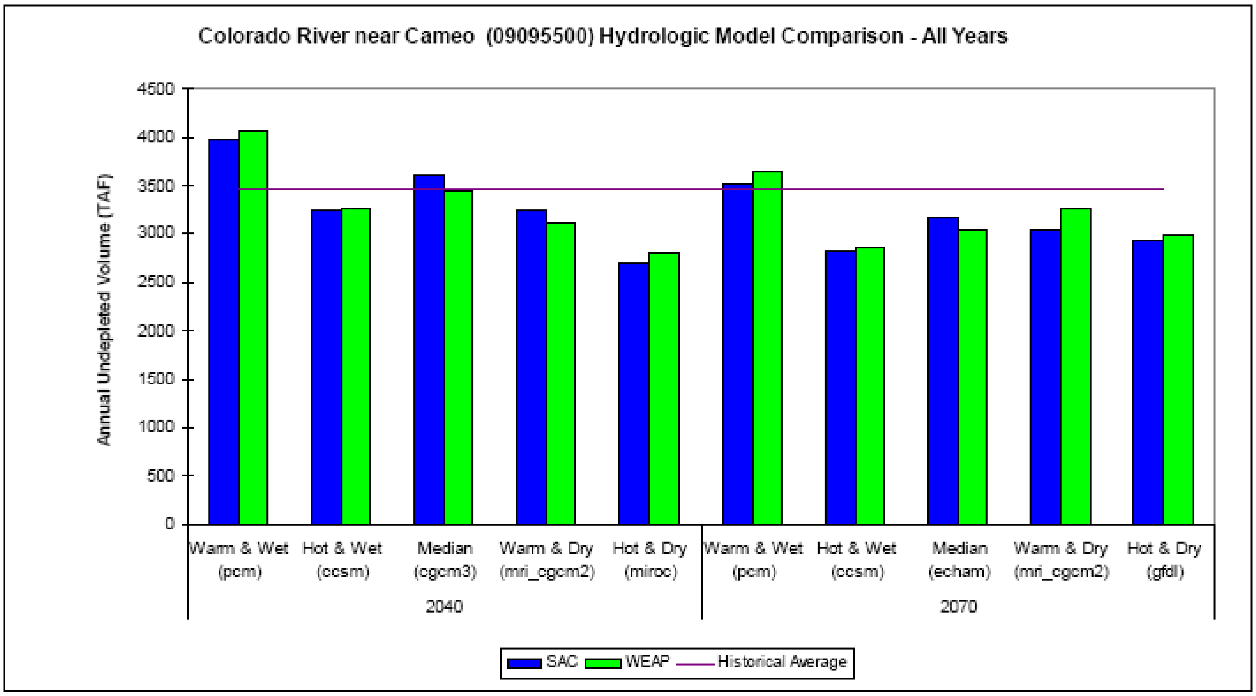
Joint Front Range Climate Change Vulnerability Study

The Joint Front Range Climate Change Vulnerability Study is a joint study facilitated by the Water Research Foundation between water utilities along Colorado's Front Range, the Colorado Water Conservation Board, the Western Water Assessment, and other principal investigators (Water Research Foundation 2012). The study objective was to assess climate change effects on several Colorado watersheds, including the Upper Colorado, South Platte, Arkansas, Cache la Poudre, St. Vrain, Boulder Creek, and Big Thompson river basins. The study approach included selecting various climate projections representative of the range of outputs of various climate models, constructing altered climate inputs for two hydrologic models. The climate data were the same as previously described and utilized in Reclamation 2011a and Reclamation 2011c, as well as other studies. The hydrologic models included the Stockholm Environmental Institute's (SEI) Water Evaluation and Planning (WEAP) model and the Sacramento Soil Moisture model coupled with the Snow-17 model (Sac Model) to estimate change in runoff, and simulate the hydrologic response. The WEAP model has been used in several climate change analysis in the country. The SAC model is often used by the National Weather Service for both short- and long-term operational streamflow forecasting. The Joint Front Range Climate Change Vulnerability Study report has further details on the assumptions and sensitivities of the projections and hydrologic models (Water Research Foundation 2012).

Five climate projects for 2040 and 2070 time periods were selected that encompassed various combinations of hot, warm, dry, and wet climate patterns. The general climate characteristics of the projections include the following:

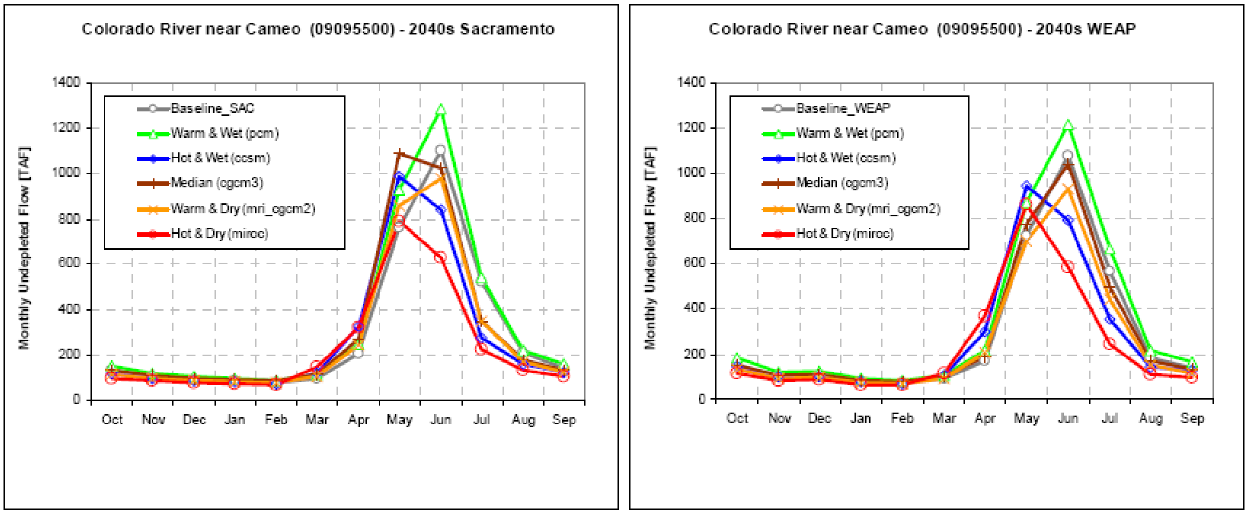
- Average annual temperature could increase from 2°F to 10°F for the 2070 time period
- Average annual percent change in precipitation could range between 18 percent decrease to a 28 percent increase for the 2070 time period

Colorado River streamflow volume near Cameo in 2070 could decrease 18 percent or increase up to 5 percent, depending on climate change projection and hydrologic model (Figure 19). Model projections also show a shift in peak flows from June to May (Figure 20), which could present unique challenges to existing operations and infrastructure. Similar results in changes to streamflow volume and timing are seen in the Arkansas River Basin (Figure 21 and Figure 22), with annual streamflows changes ranging from 5 percent increase to 21 percent decrease.



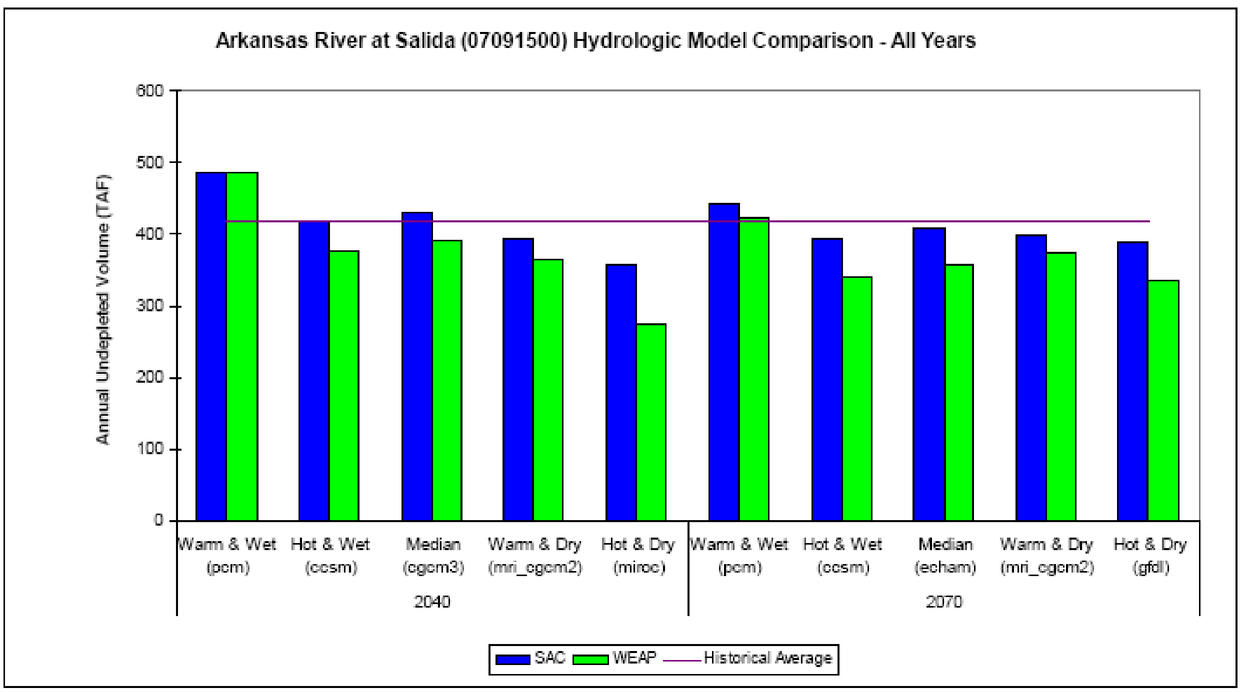
Source: Water Research Foundation 2012

Figure 19. 2070 Simulated Average Annual Undepleted Streamflow Volume for Colorado River near Cameo



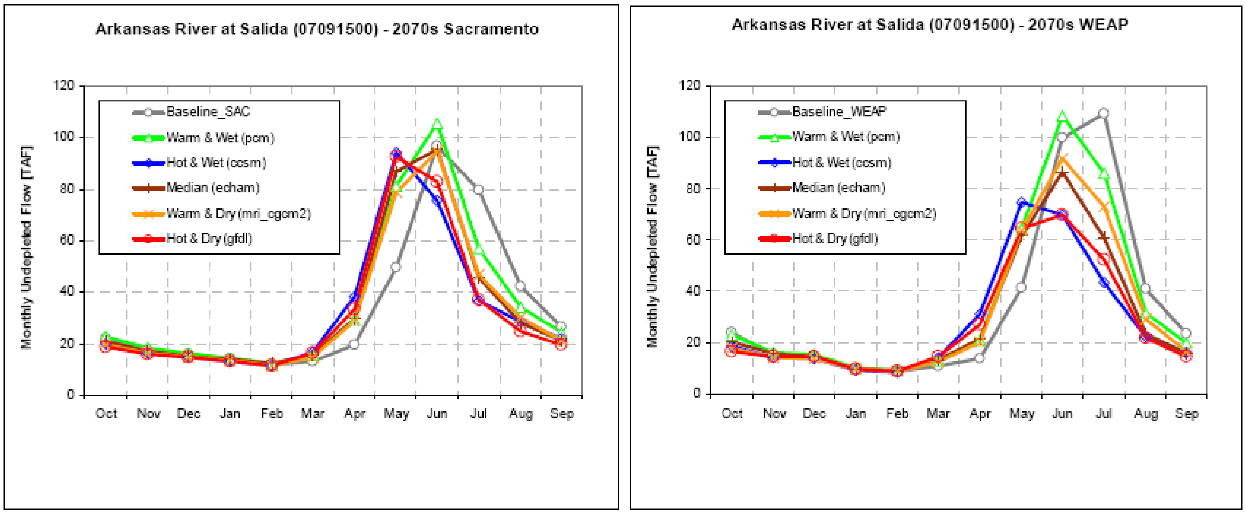
Source: Water Research Foundation 2012

Figure 20. 2070 Simulated Average Monthly Streamflow for Colorado River near Cameo



Source: Water Research Foundation 2012

Figure 21. 2070 Simulated Average Annual Undepleted Streamflow Volume for Arkansas River at Salida



Source: Water Research Foundation 2012

Figure 22. 2070 Simulated Average Monthly Streamflow for Arkansas River at Salida

Colorado River Water Availability Study

The Colorado River Water Availability Study was authorized by the Colorado General Assembly in Senate Bill (SB) 07-122 and House Bill (HB) 08-1346. The General Assembly directed the Colorado Water Conservation Board, in cooperation with the Interbasin Compact Committee and the state's river basin roundtables, to study Colorado River water availability in light of current and potential future consumptive and non-consumptive needs (CWCB 2012). The study area includes major Colorado River tributary river basins in the state, such as the Yampa and White, Upper Colorado, Gunnison, and San Juan/Dolores basins.

Phase I of the study was performed between 2008 and 2012, and combines the data and models developed by the Colorado Water Conservation Board and the Division of Water Resources with new information on paleohydrology and potential climate change conditions. Phase I is expected to lead to subsequent work that will evaluate water availability for proposed water supply projects and additional non-consumptive water needs (CWCB 2012). The Colorado River Water Availability Study is also expected to allow assessment of climate change effects at the water user and water rights level, and effects on reservoir use and operations (CWCB 2012).

Phase I of the Colorado River Water Availability Study used five climate projections for each 2040 and 2070 planning horizons (CWCB 2012). This study was initially coordinated with the Joint Front Range Climate Change Vulnerability Study, previously described, in that both studies adopted common assumptions for representing available climate projections (i.e. both using the 2040 and 2070 time-frames, and both using a small set of climate change scenarios to represent change possibilities for each time frame). The Colorado River Water Availability Study coordinated with Joint Front Range Climate Change Vulnerability Study for the 2040 scenarios throughout the study. However, for 2070, the Colorado River Water Availability Study eventually deviated to better serve their study goals on representing future runoff uncertainty during that period. The Variable Infiltration Capacity (VIC) hydrology model was then used to develop natural flows in the river basin in response to climate projections. Colorado's consumptive use model, StateCU, was then used to assess crop water needs in response to higher temperatures and longer growing seasons (CWCB 2012). General climate results of the Phase I report include the following for the study area (CWCB 2012):

- 2070 average annual temperatures could increase 4.8 °F to 8.1 °F
- 2070 winter average precipitation could become 99 percent to 127 percent of historical
- 2070 April through October precipitation average could become 93 percent to 99 percent of historical

Modeling results show that streamflow changes in 2070 in the Colorado River near Glenwood Springs could range from a 24 percent decrease to a 13 percent increase. Even small decreases or increases in precipitation could still result in streamflow decreases because temperature increases affect evapotranspiration, runoff, and crop irrigation requirements (CWCB 2012). Furthermore, temperature increases could shift peak runoff periods to April and May, which could affect transmountain diversions, reservoir, and irrigation operations.

The Colorado River Water Availability Study also assessed streamflow and diversion associated with the Fry-Ark Project's Boustead Tunnel. Results found that peak flows in future scenarios shift from June to May because of warmer temperatures melting the snowpack. Boustead Tunnel supplies could decrease by as much as 33,000 acre-feet per year, on average, because of the shift in peak flows.

Conclusions

The Arkansas Valley Conduit depends on streamflows in both basins, for Fryingpan-Arkansas project supply in the Colorado Basin and non-project supply in the Arkansas Basin. This review has examined existing climate changes analyses for the Arkansas River and Upper Colorado River basins. Generally, temperatures are projected to rise in the western U.S., which has a direct effect on runoff and streamflow. This is especially evident in a potential shift of peak streamflow to earlier in the spring as seen in the Colorado Basin. This shift in peak streamflow is a consistent projection of most studies. Precipitation, however, is more variable across the basins and across global climate models. Uncertainty remains regarding the effects of precipitation changes on streamflows and potential water supplies.

Studies in the Arkansas Basin consistently project warmer temperatures. Like the Colorado Basin, precipitation projections vary among studies and climate projections. Many studies show that warmer temperatures would translate into decreases in streamflow, regardless of the magnitude of change in precipitation because of increased evapotranspiration in the riparian areas. Earlier peak runoff in the Colorado Basin would translate to lower streamflows in the Arkansas Basin during most months of the year as the transbasin deliveries would likely decrease, limiting their conveyance down the Arkansas. These decreases would impact the potential to exchange water from lower in the basin to storage and diversion locations located higher in the basin, as is common practice for many Arkansas Basin municipal supply providers.

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Appendix C.2 - Climate Change Yield Analysis

This appendix presents average and firm yield of AVC under long-term hydrology with current runoff and reduced runoff scenarios projected using climate change analyses. The appendix contains the following sections.

Introduction

The purpose of the climate change analysis is to investigate the sensitivity of AVC water supplies, including Fryingpan-Arkansas (Fry-Ark) transmountain diversions, native East Slope water rights, and non-Fry-Ark supplies, to changes in runoff due to climate change.

The World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset has been translated into hydrologic runoff projections throughout the western United States, including the Colorado River and Arkansas River Basins (Reclamation 2011). The Bias Corrected and Downscaled WCRP CMIP3 Climate and Hydrology Projections web-site (Projections website) allows hydrologic projections (including basin runoff) in monthly and daily form to be downloaded (WCRP CMIP3 2012). These data were used as a basis for climate change hydrologic projections in this analysis.

Methods

This analysis uses and builds upon the spreadsheet model developed for the AVC yield analysis, which is more fully described in Appendix D.2. The spreadsheet model was initially developed to analyze long-term AVC operations and yield for AVC using historical hydrology. As part of the climate change analyses, inputs to this model were modified to include sets of “climate change hydrology” developed from statistically downscaled climate projections. The spreadsheet model only considers Fry-Ark supplies and non-Fry-Ark supplies for AVC participants. The spreadsheet model does not simulate full Fry-Ark operations, nor does it simulate any other water users or uses in the basin. It was specifically developed to analyze AVC operations; with broad-level assumptions about other operations in the basin that may affect AVC operations (see Appendix D.2).

This section describes development of five key hydrologic input data sets for use in the spreadsheet model: Fry-Ark West Slope yield (Boustead Tunnel diversions), Fry-Ark East Slope yield, non-Fry-Ark supply, exchange potential, and reservoir evaporation. Three ensembles of climate change runoff projections were selected for this analysis, resulting in three climate change analysis scenarios.

Projection Selection

Since 2007, Reclamation has collaborated with federal and nonfederal entities to provide monthly precipitation and temperature data for 112 projections of future climate based on 16 global circulation models (GCMs) and the B1, A1B and A2 emission scenarios (Coupled Model Intercomparison Project Phase 3 (CMIP3)). These data were downscaled using a statistical method of bias correction to 1/8^{o} latitude X 1/8^{o} longitude (approximately 12 X 12 kilometers). In 2011, Reclamation collaborated with the University of Washington and the Colorado Basin River Forecast Center (CBRFC) of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) to generate 1/8^{o} gridded hydrologic projections using the variable infiltration capacity (VIC) macroscale hydrology model (Liang et al., 1994). The bias-corrected spatially downscaled, or BCSD-CMIP3 hydrologic projections are available on the Climate Projections Web site along with nine other relevant water balance variables including precipitation and temperature (Gangopadhyay 2011, Reclamation 2011). The following sections describe the methods utilized to develop three future hydrologic scenarios at two key locations in the Upper Colorado River basin and the Arkansas River basin. Figure 1 below summarizes these methods.

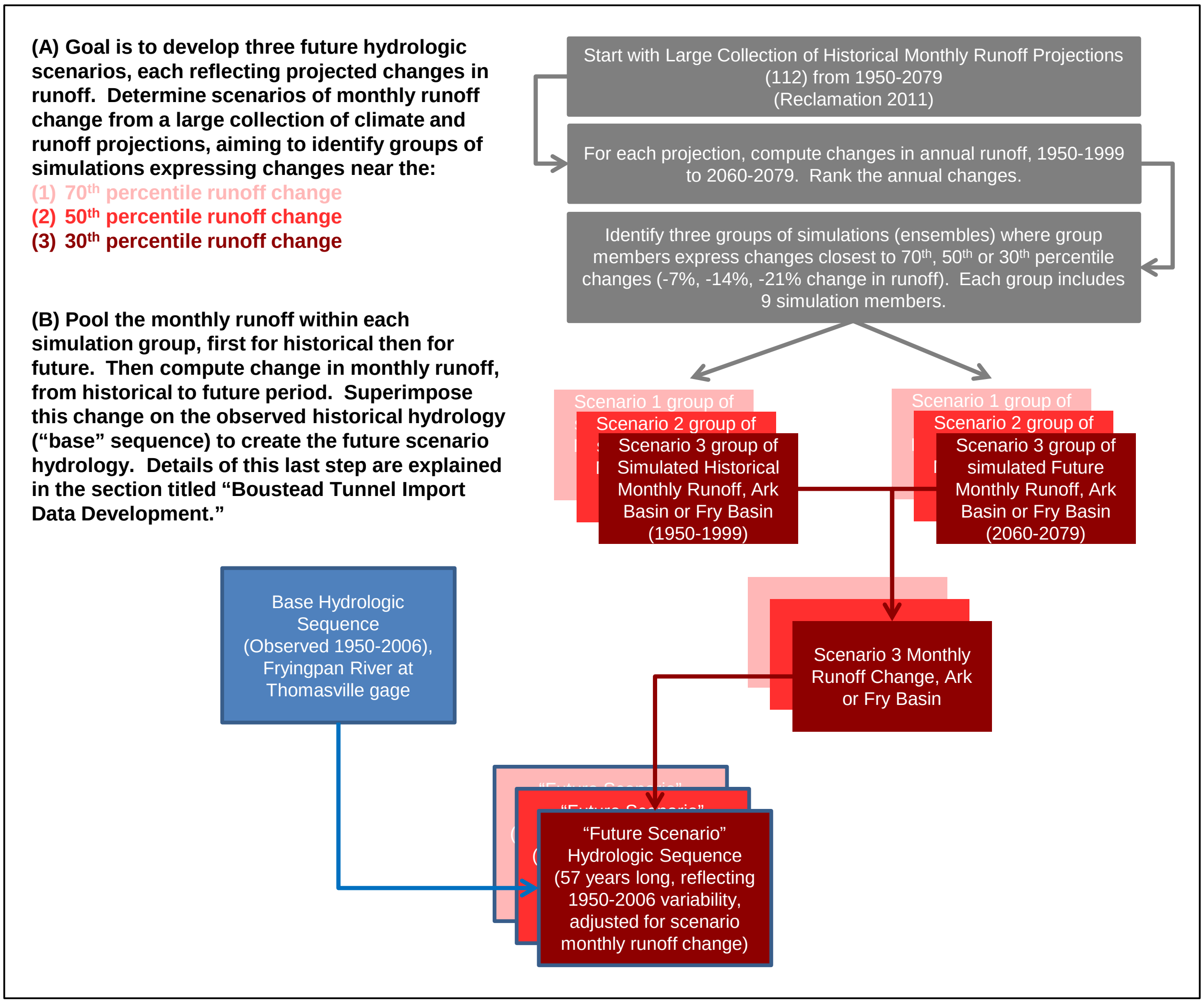
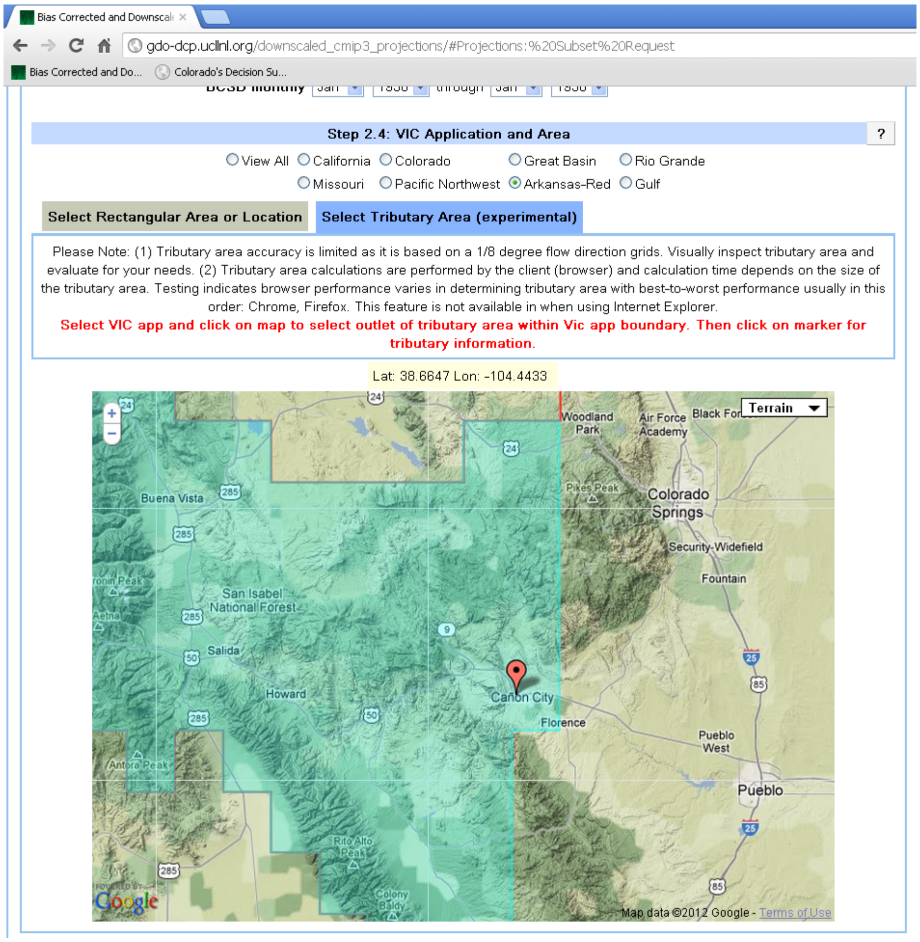


Figure 1. Summary of Methods Used to Develop Future Hydrologic Scenarios

Bureau of Reclamation Runoff Projections

Monthly simulated runoff projections for two "pour point" locations, the Arkansas River near the Arkansas River at Cañon City gage and the Fryingpan River upstream from the Fryingpan River near Thomasville gage, were downloaded from the Projections website for all climate projection models and all 3 emissions scenarios (112 projections). A "pour point" represents a single point location on a map and a polygon defined by the contributing area to the selected pour point for the VIC application output. An example of the Cañon City pour point appears in Figure 2.



Source: Web site: http://gdo-cp.ucllnl.org/downscaled_cmip3_projections. Google Earth™ imagery ©Google Inc. Used with permission.

Figure 2. Variable Infiltration Capacity (VIC) Grid Cells (area shaded in turquoise) Contributing to a Downstream "Pour" Point near the Arkansas River at Cañon City Gage (pinpoint on the map)

Data were averaged from 1950-1999 to represent current conditions hydrology and from 2060-2079 to represent future conditions at the end of the AVC EIS study period (2070) on an annual basis. A shorter time period was chosen for the future conditions to provide a more conservative approach for the sensitivity analysis between the historical conditions and the project planning horizon of 2070. Percent change between the two time periods was calculated for all projections. Statistics for changes in temperature, precipitation and runoff for all 112 projections at both locations are in Table 1. Figure 3 and Figure 4 show the simulated changes in runoff for all model runs at each location. To assess the potential changes during the middle of the project planning horizon (2040), the percent change between runoff averaged from 1950-1999 and 2030-

2049 was also looked at for the Fryingpan River near the Thomasville gage. The simulated change in runoff for the 2040 period is shown in Figure 5. As shown, the median change in runoff is -10% versus the -14% seen with the 2070 period.

Table 1. Statistics for 112 Climate Projections (2060-2079 compared to1950-1999)

Statistic	Fryingpan River Point			Arkansas River Point		
	Change in Temp. °F	*Change in Precip. inches*	*Change in Runoff*	*Change in Temp. °F*	*Change in Precip. inches*	*Change in Runoff*
Median	5.5	0.4	-14%	5.4	-0.3	-15%
90th Percentile	7.9	4.2	5%	7.8	2.3	5%
70th Percentile	6.7	1.6	-7%	6.5	0.4	-8%
30th Percentile	4.7	-0.6	-21%	4.6	-0.8	-21%
10th Percentile	3.7	-2.4	-30%	3.6	-2.7	-29%

Source: Web site: http://gdo-cp.ucllnl.org/downscaled_cmip3_projections

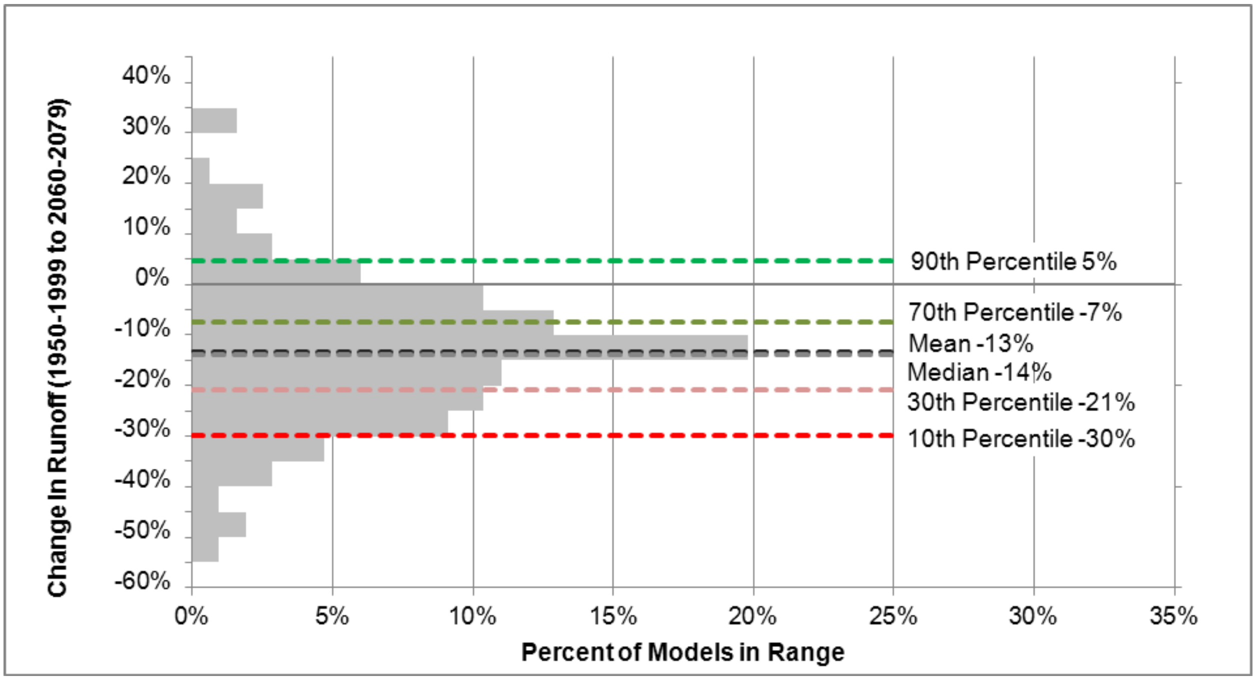


Figure 3. Summary of Simulated Annual Change in Runoff at the Fryingpan River near Thomasville Gage (1950-1999 compared with 2060-2079; Reclamation 2011)

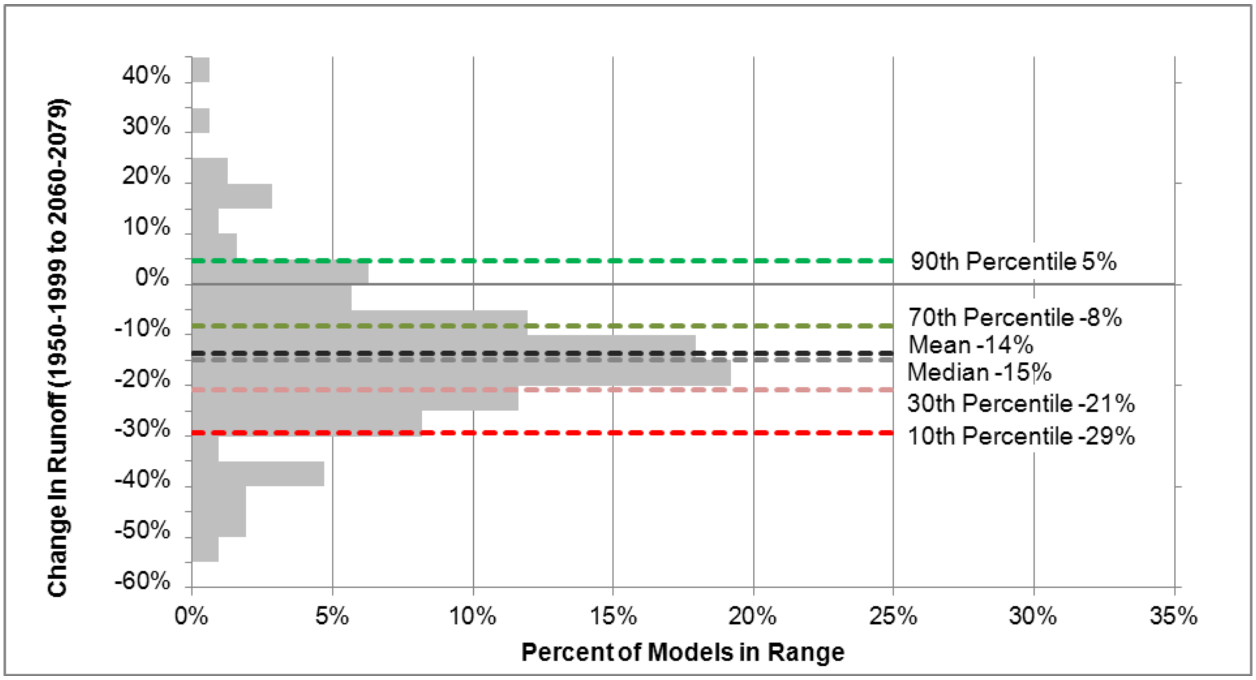


Figure 4. Summary of Simulated Annual Change in Runoff on the Arkansas River near the Arkansas River near Cañon City gage (1950-1999 compared with 2060-2079; Reclamation 2011)

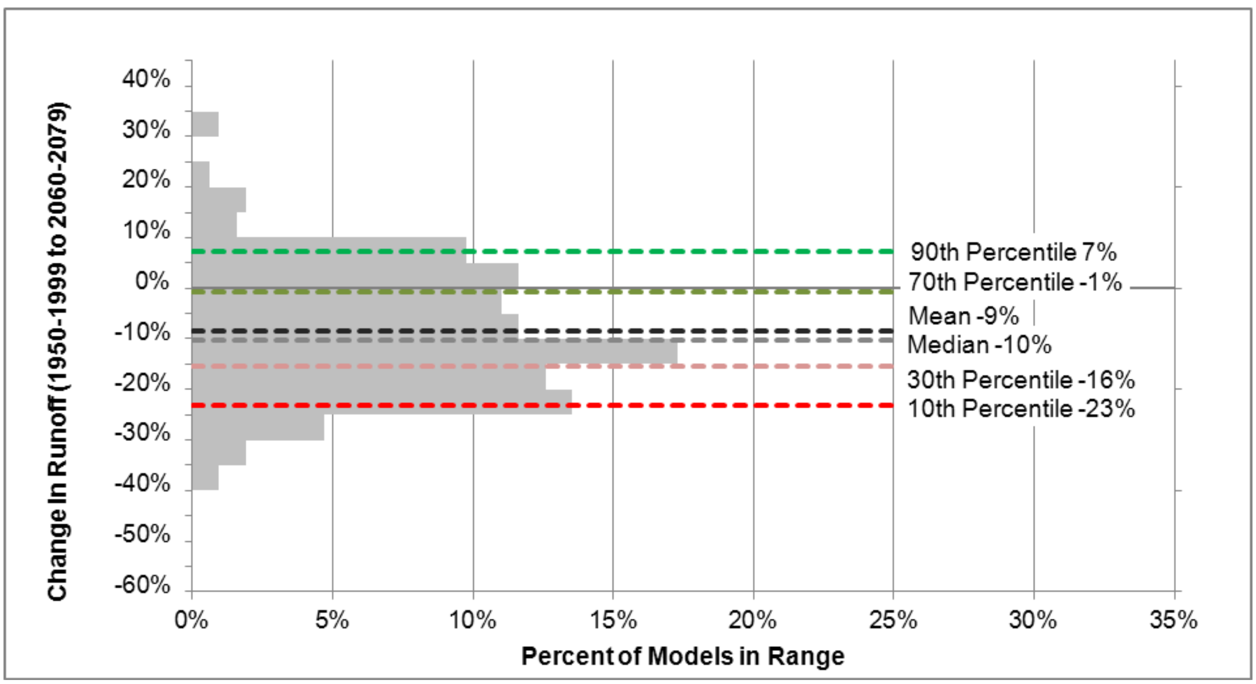


Figure 5. Summary of Simulated Annual Change in Runoff at the Fryingpan River near the Thomasville gage (1950-1999 compared with 2030-2049; Reclamation 2011)

Selection of West-Wide Climate Risk Assessment (WWCRA) Hydrologic Projections

Three ensembles of runoff change projections, consisting of nine projections each, were selected from the Projections website for use in this analysis based on the projected runoff data at the Fryingpan River upstream from the Fryingpan River near Thomasville Gage. Runoff projections were selected that best represented mean annual runoff changes in the 70th percentile (around 7% reduced runoff), median (around 14% reduced runoff), and 30th percentile (around 21% reduced runoff) see Figure 3 above. These percentiles were chosen to analyze a range of possible runoff changes without focusing on the more extreme percentiles where there is less confidence that the changes seen are due to global warming and not merely natural climate variability. The nine projections in the ensemble were chosen based on the proximity of the representative projection's percent change in runoff to the target percent change (7%, 14% and 21%). For the remainder of this document, these projections are referred to as the 7% Reduced Scenario, 14% Reduced Scenario and the 21% Reduced Scenario (70th, 50th and 30th percentiles). Associated temperature, precipitation and runoff statistics for the chosen projections appears in Table 2 below. Representative projection and emissions scenario denote the name of the model and version of the individual projection utilized and the type of emissions scenario run through the global circulation model to attain the temperature and precipitation results. These statistics are provided for informational purposes only and were not considered in selecting the projections for the ensembles. It may be noted, however, that for approximately the same percent change in runoff, many projections had considerable warming with little change or small increases in precipitation while some others had less warming with decreased precipitation. This was particularly evident in the -21 percent reduced ensemble.

Table 2. Selected Model Projection Changes (2060-2079 compared to 1950-1999)

	Arkansas River Point			Representative Projection (model, version. run. emission scenario)	Emissions Scenario Utilized by Projection
	Temp. (°F)	Precip. (inches)	Runoff (%)		
7% Reduced Scenario	6.7	2.8	-6.1	cccma_cgcm3_1.4.sresa2	Higher emissions path
	4.6	0.8	-9.0	cccma_cgcm3_1.4.sresb1	Lower emissions path
	6.0	2.2	-5.7	cccma_cgcm3_1.5.sresa1b	Middle emissions path
	4.3	1.0	-7.1	cccma_cgcm3_1.5.sresb1	Lower emissions path
	4.1	0.7	-8.1	csiro_mk3_0.1.sresa2	Higher emissions path
	6.2	1.9	-7.7	ipsl_cm4.1.sresb1	Lower emissions path
	3.8	0.5	-8.8	mri_cgcm2_3_2a.4.sresb1	Lower emissions path
	5.0	1.3	-6.3	mri_cgcm2_3_2a.5.sresa2	Higher emissions path
	5.5	1.4	-8.2	ncar_ccsm3_0.7.sresb1	Lower emissions path
14% Reduced Scenario	3.5	-0.8	-14.2	bccr_bcm2_0.1.sresb1	Lower emissions path
	5.9	0.2	-13.8	cccma_cgcm3_1.1.sresa1b	Middle emissions path
	6.5	1.1	-14.0	cccma_cgcm3_1.3.sresa2	Higher emissions path
	4.3	-0.1	-14.6	cccma_cgcm3_1.3.sresb1	Lower emissions path
	6.5	1.4	-13.5	cccma_cgcm3_1.5.sresa2	Higher emissions path
	5.1	0.3	-12.8	mpi_echam5.1.sresb1	Lower emissions path
	5.1	0.0	-13.7	mri_cgcm2_3_2a.1.sresa1b	Middle emissions path
	7.3	1.6	-14.0	ncar_ccsm3_0.2.sresa2	Higher emissions path
	4.6	0.1	-13.9	ncar_ccsm3_0.2.sresb1	Lower emissions path
21% Reduced Scenario	7.3	-0.5	-21.6	gfdl_cm2_1.1.sresa1b	Middle emissions path
	4.8	-1.3	-20.0	gfdl_cm2_1.1.sresb1	Lower emissions path
	8.4	-0.1	-20.3	ipsl_cm4.1.sresa1b	Middle emissions path
	7.0	-0.8	-21.5	mpi_echam5.1.sresa2	Higher emissions path
	5.3	-1.6	-21.2	mri_cgcm2_3_2a.2.sresa1b	Middle emissions path
	6.9	-0.1	-19.5	ncar_ccsm3_0.1.sresa1b	Middle emissions path
	7.0	-0.4	-21.0	ncar_ccsm3_0.2.sresa1b	Middle emissions path
	5.0	-1.4	-21.6	ncar_ccsm3_0.6.sresb1	Lower emissions path
	5.5	-0.2	-19.9	ukmo_hadcm3.1.sresb1	Lower emissions path

Source: Web site: http://gdo-cp.ucllnl.org/downscaled_cmip3_projections

Fry-Ark Supplies

The Southeastern Colorado Water Conservancy District (Southeastern) owns water rights on both the East and West slopes of the Continental Divide. West Slope water rights are imported through the Boustead Tunnel, and are subsequently referred to as Boustead Tunnel imports. East Slope water rights are native Arkansas River water rights decreed in 1962 and 1969 with a 1939 priority date (thus these rights are occasionally referred to as "native yield;" see Appendix D.2 for more information on the Fry-Ark Project).

Boustead Tunnel Import Data Development

The Boustead Tunnel diverts water from the Roaring Fork and Fryingpan River basins on the West Slope of the Continental Divide in the Sawatch Range. Grand River Consulting Corporation maintains a daily model to evaluate potential Boustead Tunnel diversions based on historical streamflow data. Runoff change projection "deltas" were developed in this study for Grand River Consulting Corporation in order to simulate potential Boustead Tunnel imports for the Fry-Ark Project under the three selected climate projection scenarios. The "deltas" represent the monthly change in the historical streamflow record due to the predicted changes in runoff. These "deltas" were applied to the native flows used in Grand River Consulting Corporation's model to produce climate altered data for Boustead Tunnel diversions under the three selected projection scenarios (GRC 2012, Attachment 1). Although some Boustead Tunnel yield comes from the Hunter Creek Basin, this analysis focuses on the Fryingpan River diversions. It is assumed that similar runoff and yield relationships would occur in the Hunter Creek basins.

To develop the "deltas", the monthly runoff projections for the Fryingpan River upstream from the Fryingpan River near Thomasville gage for the three ensembles of chosen projections were used. Native monthly historical flow for the Fryingpan River near Thomasville was obtained from Grand River Consulting Corporation (GRC 2012). To calculate the change in streamflow between the projection ensembles and the native historical flow, a percentile approach was utilized similar to the "Ensemble Hybrid-Delta" (HDe) described in Reclamation 2010.

For each ensemble grouping, monthly runoff projection data was summed by calendar year. Thus, each year within the ensemble contained nine data points (one for each projection within the ensemble). Annual runoff projection data values for the current conditions (1950-1999) and the future conditions (2060-2079) were distributed into 101 separate percentile "bins" from the 0th to 100th percentile. The percent change in value between the future conditions and current conditions was then calculated for each percentile bin to represent an annual "delta" for the respective percentile. Figure 6 through Figure 8 show the flow distribution for the 1950-1999 average and the 2060-2079 average annual flows, for the three ensembles. The space between the curves represents the "deltas" at each flow percentile.

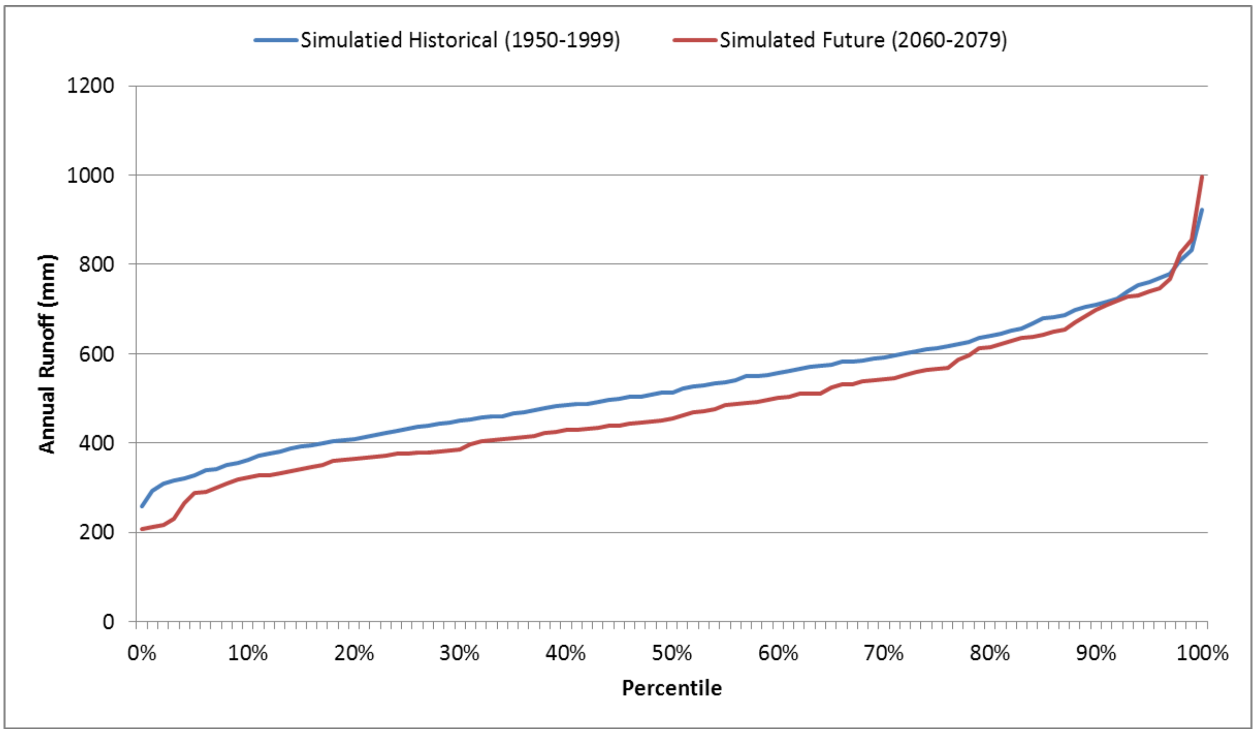


Figure 6. Annual Flow Distribution for 7% Reduced Scenario, Fryingpan River

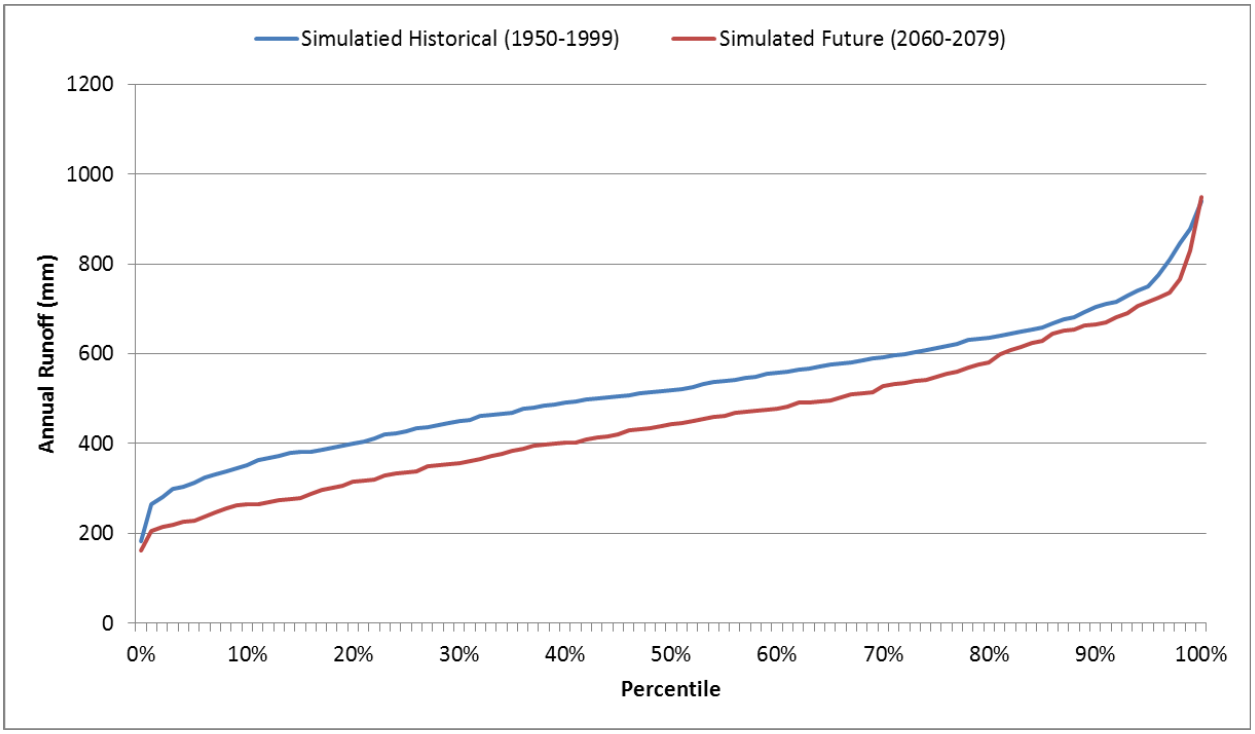


Figure 7. Annual Flow Distribution for 14% Reduced Scenario, Fryingpan River

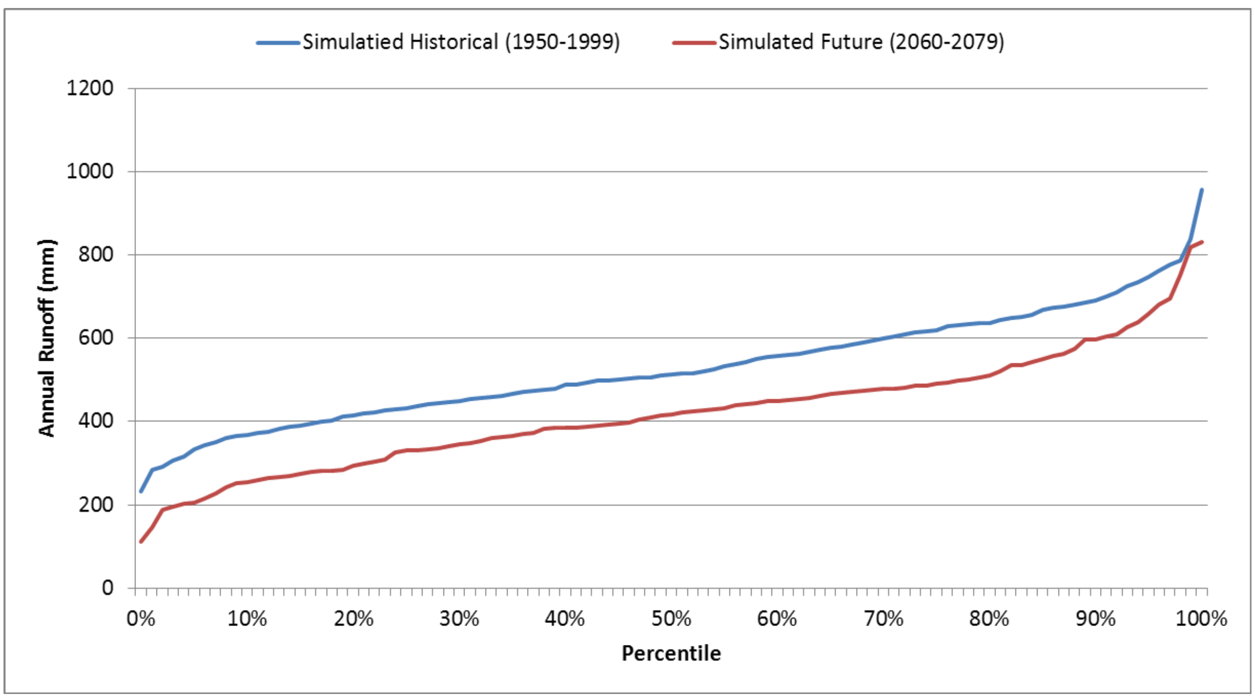


Figure 8. Annual Flow Distribution for 21% Reduced Scenario, Fryingpan River

In addition to changes in annual runoff, the runoff projections also show a shift in runoff to earlier in the year by about 1-month. To capture the shift in runoff, annual 1950-1999 historical streamflow, 1950-1999 simulated historical runoff and 2060-2079 simulated future runoff (for each runoff projection) were classified into 5% bins. The average monthly runoff distribution within each bin was calculated. The historical monthly distribution percentage for each month in each bin was then adjusted based on the ratio of the simulated future to simulated historical monthly distribution percentage. The monthly values in each bin were normalized so that the sum of monthly percentages equals 1.

The annual historical flow for each percentile was modified by the corresponding climate projections data percentile "delta." The monthly future distribution was then applied to the annual flow, based on the corresponding percentile bins. This calculated climate projection hydrology was then compared back to the historical native flows on the Fryingpan River to calculate the monthly "delta" for use in Grand River Consulting Corporation's Boustead Import model. The average monthly native streamflow for the Fryingpan River near Thomasville gage appears in Figure 9. The total reduction and shift in monthly runoff for the climate projections can be seen in the graph. As shown, the peak runoff shifts one month earlier and is much greater than the historical peak runoff. Also, the decline in flows after the peak is more rapid and more pronounced. The Fry-Ark bypass requirements were negotiated based on historical flows. It is possible that these requirements could be readjusted in the future if such a shift in the hydrograph does occur. No change in the bypass requirements was made for this study.

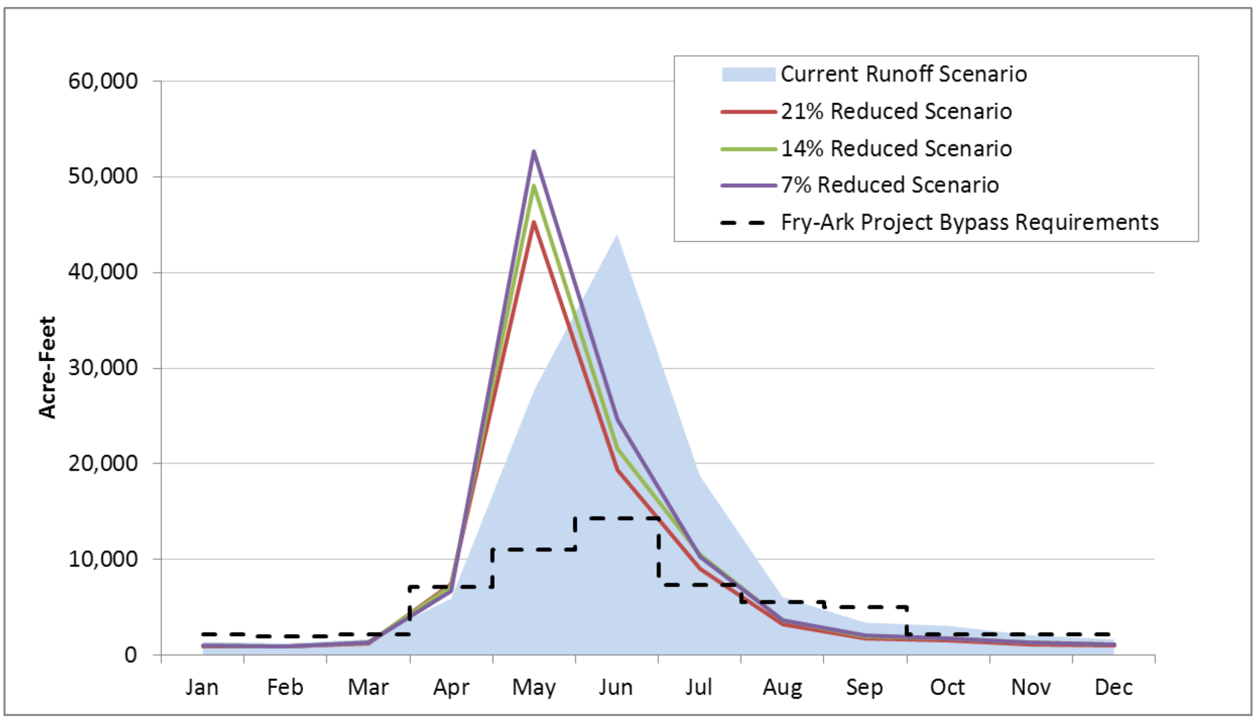


Figure 9. Average Monthly Native Fryingpan River Streamflow

Grand River Consulting Corporation calculated potential Fry-Ark yield for four scenarios; the Current Runoff Scenario and three climate projection scenarios based on the streamflow "deltas" described above. The Current Runoff Scenario represents current Fry-Ark yield based on historical Fryingpan River flows. The Current Runoff Scenario yield is estimated to average about 60,000 acre-feet (ac-ft). This value is slightly higher than the average of potential imports by Grand River Consulting Corporation used in Appendix D.2. due to a change in the way they calculated native streamflow and unrestricted Fry-Ark diversions from native streamflow in their latest estimates. The climate projection yields averaged between about 42,500 ac-ft and 51,000 ac-ft, which represent a 16 percent to 30 percent decrease in yield compared to the Current runoff scenario. Table 3 shows Fry-Ark yield compared to streamflow changes for the four scenarios. Table 5 shows the annual Boustead Tunnel yield in acre feet as developed by Grand River Consulting Corporation and used in this study.

Table 3. Summary of Streamflow and Yield

	Fryingpan River Streamflow		Fry-Ark Yield	
Scenario	Annual Change (%)	May-July Change (%)	Annual Average (ac-ft)	Annual Change (%)
Current Runoff Scenario	---	---	60,686	--
7% Reduced Scenario	-10	-5	51,163	-16
14% Reduced Scenario	-15	-13	47,083	-22
21% Reduced Scenario	23	-22	42,459	-30

Source: GRC 2012

Table 4. Annual Boustead Tunnel Yield

Water Year	Boustead Tunnel Yield (ac-ft)				Water Year	Boustead Tunnel Yield (ac-ft)			
	Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario		Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario
1950	51,209	40,804	36,676	35,341	1980	58,032	43,296	41,387	36,448
1951	63,278	45,546	44,274	41,808	1981	49,205	46,272	37,942	37,354
1952	101,034	104,040	98,819	91,864	1982	72,239	64,220	57,968	47,356
1953	53,016	30,722	29,480	26,906	1983	97,128	78,051	75,805	68,558
1954	12,201	6,398	6,520	2,739	1984	120,000	113,935	103,358	94,078
1955	33,835	26,145	17,809	15,652	1985	76,301	74,362	70,184	54,045
1956	49,122	37,792	32,522	30,918	1986	75,026	69,825	63,508	48,976
1957	120,000	120,000	109,253	112,684	1987	46,151	43,133	39,407	36,175
1958	57,911	44,626	43,867	43,366	1988	43,067	38,444	30,713	24,996
1959	46,594	39,704	32,651	26,084	1989	15,184	12,016	9,010	8,725
1960	48,102	38,057	33,115	30,099	1990	41,439	31,036	24,537	20,386
1961	33,618	25,333	18,275	14,756	1991	62,963	45,676	45,140	43,297
1962	93,205	85,472	84,710	67,274	1992	51,225	45,907	41,000	37,057
1963	18,165	13,378	9,566	7,748	1993	98,333	82,170	81,038	72,626
1964	47,200	39,892	33,056	26,828	1994	49,818	43,542	38,096	36,486
1965	98,349	85,465	86,368	67,986	1995	112,011	101,639	98,017	98,153
1966	29,593	27,985	20,188	16,505	1996	87,955	83,641	80,653	63,875
1967	47,311	35,886	28,590	25,833	1997	101,468	104,357	100,853	94,952
1968	55,793	37,717	31,725	32,838	1998	67,996	64,182	56,885	48,865
1969	54,414	44,120	43,264	41,540	1999	69,882	48,296	51,168	45,172
1970	77,203	57,781	53,626	47,945	2000	62,850	55,935	52,401	49,714
1971	60,782	56,166	52,981	47,002	2001	47,465	43,583	35,844	38,697
1972	45,376	36,089	31,107	31,952	2002	12,742	7,397	7,492	6,059
1973	75,956	58,720	55,598	50,210	2003	60,333	39,196	40,136	38,113
1974	59,657	52,540	49,349	47,527	2004	25,228	21,310	15,201	11,654
1975	61,160	44,403	42,742	38,011	2005	50,606	38,176	32,251	34,288
1976	33,974	27,704	20,487	17,727	2006	65,217	63,333	58,141	48,248
1977	11,484	7,968	8,247	2,338	2007	56,250	52,679	48,957	47,530
1978	73,609	52,019	52,020	45,797	2008	97,609	85,213	80,115	73,345
1979	73,226	46,679	43,670	44,453	2009	81,033	59,824	57,226	50,559
					Average	60,686	51,163	47,083	42,459

Source: GRC 2012

The difference between the annual streamflow changes and the annual changes in Fry-Ark yield can mostly be attributed to streamflow bypass requirements. Diversions from the Fryingpan River portion of the Fry-Ark Project are curtailed by specified streamflow bypasses at the Fryingpan River near Thomasville gage (Table 5). It is during the May through July snowmelt runoff when the current runoff hydrology would exceed the bypass requirements, enabling Fry-Ark diversions to occur (Figure 9). The greatest bypass requirement occurs in June, which is when the current runoff hydrology peaks. The reduced runoff hydrologies would peak in May and would have lower flows in June, making it less likely that the flow would exceed the bypass requirement and could be diverted. For use in the Yield Model, the same percentage of Fry-Ark entity yield was applied to the Boustead yield estimates as was used in Appendix D.2.

Table 5. Fry-Ark Bypass Requirements – Fryingpan River near Thomasville

Month	Flow Rate (cfs)	Flow Rate (ac-ft/month)
January	30	1,845
February	30	1,666
March	30	1,845
April	100	5,951
May	150	9,223
June	200	11,901
July	100	6,149
August	75	4,612
September	70	4,165
October	30	1,845
November	30	1,785
December	30	1,845

Source: GRC 2012

East Slope Water Rights Data Development

Native Arkansas basin East Slope water rights are decreed junior water rights occasionally available for storage in East Slope Fry-Ark facilities. When the East Slope water rights are in priority, the Fry-Ark Project is allowed to store native Arkansas basin water with the stipulation that the conservation pool at John Martin Reservoir is also full and/or spilling. To estimate East Slope yield with respect to the climate projections data, monthly simulated runoff projections for the Arkansas River near Cañon City were downloaded from the Projections website for the three selected climate projections. Also, historical monthly flow for the Arkansas River at Cañon City gage was obtained from CDSS (CDSS 2012). Historical records and climate projections data were then summed by year and placed in percentile "bins" in the same manner as was done for the Fryingpan River data described in the Transmountain Import Data Development section of this document. This methodology does not address changes in operations of Fry-Ark facilities, and is very coarse estimate of flows, limited to the very basic methodologies described previously.

As described in Appendices D.1 and D.2, East Slope Fry-Ark water rights have a junior water right priority and are historically available during less than 4 months every 10 years. Additionally, these water rights are only available when John Martin Reservoir is full or spilling, which is a function of long-term hydrologic conditions. Therefore, a simple reduction in yield based upon changes in streamflow is not applicable for these rights. To assess availability of East Slope water rights, a method developed in the Colorado Springs Utilities Raw Water Yield Study (MWH 2005) was used. This method analyzes long-term streamflow at the Arkansas River at Cañon City gage to estimate years when East Slope rights may be in priority. For each projection, East Slope Fry-Ark water rights were in priority when both the annual flow at Cañon City was greater than 650,000 ac-ft and the three-year average flow at Cañon City was greater than 650,000 ac-ft, or if the annual flow at Cañon City was greater than 800,000 ac-ft. When either condition was met, a regression (developed from historical data) was applied to projected annual flow at Cañon City of the reduced runoff scenarios to calculate annual East Slope yield. To distribute the yield by month, the average monthly East Slope yield was estimated from historical distributions of East Slope yield. This assumption was made due to the perceived complexity of Arkansas basin water rights with respect to climate altered hydrology during these rare high flow events. Monthly percentages were applied to the annual yield for the three projections. Average annual East Slope yield appears in Table 6 for the Current Runoff Scenario and the reduced runoff scenarios. The Current Runoff Scenario, developed with the annual regression, is used in the Yield Model rather than actual historical East Slope yield (which was used in Appendix D.2) so that the differences between the scenarios would not be influenced by the methodology of the East Slope calculation. The same percentage of Fry-Ark entity yield was applied to the East Slope yield estimates in the Yield Model as was used in Appendix D.2.

Table 6. Annual Fry-Ark East Slope Yield Estimates

Water Year	Fry-Ark East Slope Yield (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario	Water Year	Fry-Ark East Slope Yield (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario
1950	0	0	0	0	1980	0	0	0	0
1951	0	0	0	0	1981	0	0	0	0
1952	0	0	0	0	1982	0	0	0	0
1953	0	0	0	0	1983	0	0	0	0
1954	0	0	0	0	1984	245,527	221,455	217,971	236,246
1955	0	0	0	0	1985	197,812	176,385	175,859	149,118
1956	0	0	0	0	1986	157,976	136,583	0	0
1957	241,688	219,676	208,215	0	1987	145,359	0	0	0
1958	0	0	0	0	1988	0	0	0	0
1959	0	0	0	0	1989	0	0	0	0
1960	0	0	0	0	1990	0	0	0	0
1961	0	0	0	0	1991	0	0	0	0
1962	0	0	0	0	1992	0	0	0	0
1963	0	0	0	0	1993	0	0	0	0
1964	0	0	0	0	1994	0	0	0	0
1965	0	0	0	0	1995	254,393	282,805	217,880	0
1966	0	0	0	0	1996	0	0	0	0
1967	0	0	0	0	1997	160,459	148,583	0	0
1968	0	0	0	0	1998	0	0	0	0
1969	0	0	0	0	1999	0	0	0	0
1970	0	0	0	0	2000	0	0	0	0
1971	0	0	0	0	2001	0	0	0	0
1972	0	0	0	0	2002	0	0	0	0
1973	0	0	0	0	2003	0	0	0	0
1974	0	0	0	0	2004	0	0	0	0
1975	0	0	0	0	2005	0	0	0	0
1976	0	0	0	0	2006	0	0	0	0
1977	0	0	0	0	2007	0	0	0	0
1978	0	0	0	0	2008	0	0	0	0
1979	0	0	0	0	2009	0	0	0	0
					Average	23,387	19,758	13,665	6,423

Exchange Potential Calculations

Exchange potential is the minimum flow in the river between the exchange points, after considering senior demands, flow management programs, and instream flow rights (see Appendix D.2 for further discussion). Exchange potential was calculated from Daily Model results and a regression with annual Arkansas River at Cañon City gage flow. Exchange potential between Fountain Creek and Pueblo Reservoir (the constraining reach in the basin east of Pueblo Reservoir) was summarized by month from 1976 through 2009 from Daily Model results for direct and cumulative effects. Simulated exchanges by the larger entities (Colorado Springs, Fountain, Security, Aurora, Pueblo and Pueblo West) moving water upstream into existing excess capacity accounts were subtracted from the exchange potential in the reach between exchange points to estimate exchange potential for the AVC participants Current Runoff Scenario in the Yield Model. This allows for a more conservative estimate of exchange potential because all exchanges by AVC entities are treated as junior to the larger entities. However, Fry-Ark return flow exchanges would fall under a senior decree, and return flows would be exchanged during most years.

A regression between annual simulated exchange potential Arkansas River near Cañon City streamflow was developed for both the direct effects analysis and the cumulative effects analysis. The cumulative effects analysis exchange potential is lower than the direct effects because it considers exchanges at 2070 by all major entities within the basin, most notably Colorado Springs Utilities. The direct effects only consider AVC and Master Contract participants at 2070 exchanges and all others at current conditions exchanges. The regressions were applied to historical flows at the Arkansas River at Cañon City gage for the current runoff scenario and climate projection flows at the Arkansas River at Cañon City gage for the reduced runoff scenarios. Historical monthly distributions were applied to the annual values. It was assumed that the timing of releases from Pueblo Reservoir would not change substantially from current conditions, but that releases would generally be lower according to the reduced runoff hydrology. Therefore the exchange potential monthly distribution would be similar to historical. Figure 10 below shows the average monthly estimated exchange potential used in the Yield Model, while Table 7 shows the average annual estimates for direct effects. Table 8 shows the average annual estimated exchange potential for cumulative effects.

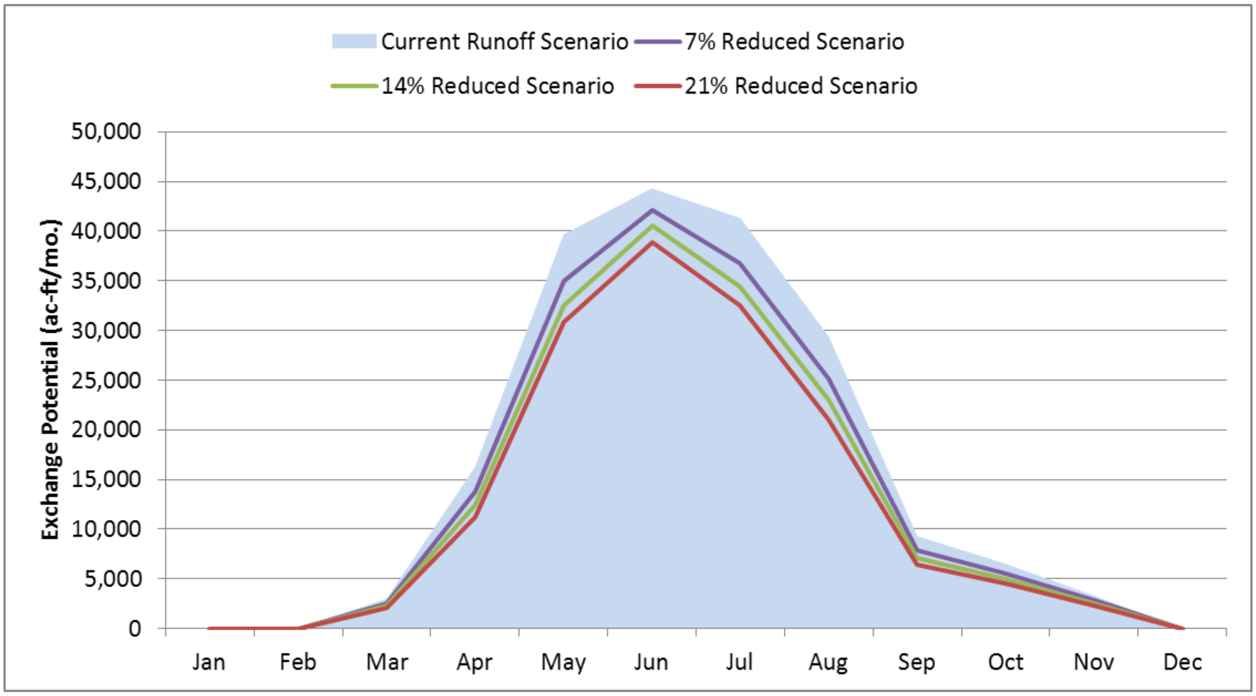


Figure 10. Estimated Exchange Potential

Table 7. Annual Estimated Exchange Potential – Direct Effects

Water Year	Exchange Potential (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario	Water Year	Exchange Potential (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario
1950	168,926	136,735	127,704	95,773	1980	240,905	230,735	228,710	221,289
1951	192,449	163,969	151,211	142,101	1981	117,474	65,596	45,376	37,265
1952	227,452	218,012	213,440	201,635	1982	206,835	194,311	183,015	176,520
1953	195,898	172,185	159,733	151,322	1983	250,694	247,019	243,016	236,238
1954	95,146	30,808	28,962	0	1984	264,781	258,288	257,348	262,278
1955	129,420	84,889	57,907	47,687	1985	251,911	246,131	245,989	238,776
1956	175,375	142,621	129,801	115,574	1986	241,165	233,254	230,823	221,565
1957	263,746	257,808	254,717	248,756	1987	237,549	226,635	223,338	212,117
1958	222,355	211,933	206,210	198,701	1988	160,657	125,546	108,058	73,682
1959	163,977	131,297	125,504	87,989	1989	183,834	154,008	139,585	131,408
1960	205,884	194,139	182,412	175,611	1990	153,592	124,008	96,666	71,809
1961	189,990	163,672	146,207	139,925	1991	183,375	149,882	136,289	129,740
1962	239,523	228,510	227,227	215,176	1992	183,155	147,449	131,547	130,686
1963	127,882	82,553	55,455	43,306	1993	226,068	216,349	211,300	200,792
1964	155,708	125,272	97,655	72,980	1994	201,996	189,853	175,249	165,496
1965	248,469	243,643	240,643	230,351	1995	267,173	274,837	257,324	250,510
1966	197,072	180,305	165,934	155,432	1996	219,061	209,965	202,399	197,787
1967	162,155	125,744	114,427	73,413	1997	241,835	238,631	229,339	219,416
1968	209,846	197,330	188,027	187,453	1998	200,439	187,077	174,092	162,599
1969	205,539	194,623	182,442	174,326	1999	219,180	209,964	202,851	195,899
1970	245,778	242,306	235,741	226,185	2000	191,367	163,895	150,762	141,449
1971	213,418	202,010	196,848	190,833	2001	180,650	147,892	131,571	124,144
1972	192,639	164,997	151,620	143,974	2002	24,132	0	0	0
1973	218,398	208,991	202,087	197,011	2003	122,473	76,976	51,169	39,300
1974	190,015	162,997	148,248	140,129	2004	131,065	91,239	58,602	50,020
1975	216,938	207,687	200,944	194,621	2005	147,944	120,554	74,697	73,073
1976	175,250	143,316	129,907	113,644	2006	181,859	150,891	131,292	126,543
1977	54,853	0	0	0	2007	211,488	199,997	194,338	188,942
1978	184,366	156,829	139,335	133,520	2008	241,280	234,290	231,185	220,325
1979	221,565	211,968	204,734	197,508	2009	213,778	202,439	197,976	190,747
					Average	193,129	171,748	160,150	149,756

Table 8. Annual Estimated Exchange Potential – Cumulative Effects

Water Year	Exchange Potential (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario	Water Year	Exchange Potential (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario
1950	117,187	77,028	64,281	32,881	1980	198,420	190,096	188,750	180,927
1951	140,852	113,092	97,461	84,602	1981	52,048	6,228	0	0
1952	187,913	176,781	170,996	156,059	1982	162,639	143,158	129,168	123,458
1953	146,489	119,878	109,489	97,618	1983	206,306	204,849	200,966	193,756
1954	32,328	0	0	0	1984	211,890	209,316	208,943	210,897
1955	66,704	23,268	0	0	1985	206,788	204,497	204,441	195,851
1956	122,513	85,337	67,242	50,370	1986	198,734	191,772	190,155	181,277
1957	211,479	209,126	207,900	205,538	1987	194,627	187,370	183,520	169,322
1958	182,276	169,090	161,848	152,347	1988	110,358	61,236	43,732	13,370
1959	113,099	69,353	61,176	26,006	1989	130,182	101,410	81,051	69,510
1960	161,436	142,945	128,421	122,708	1990	100,822	59,065	33,670	11,715
1961	137,807	112,847	90,399	81,532	1991	129,614	95,585	76,399	67,155
1962	196,753	188,617	187,764	173,193	1992	129,342	92,151	69,706	68,491
1963	64,532	21,204	0	0	1993	186,975	174,677	168,288	154,993
1964	103,809	60,849	34,543	12,750	1994	156,517	137,637	122,409	114,354
1965	205,424	201,723	198,103	189,842	1995	212,838	215,875	208,934	206,233
1966	149,088	126,585	114,716	103,419	1996	178,109	166,599	157,026	150,668
1967	111,594	61,516	49,357	13,132	1997	199,542	195,677	189,168	178,558
1968	166,449	149,657	135,376	134,665	1998	154,546	134,199	121,454	111,961
1969	161,000	143,669	128,458	121,647	1999	178,259	166,598	157,598	146,492
1970	204,299	200,110	193,425	187,071	2000	139,512	113,032	96,828	83,683
1971	170,969	156,534	148,591	138,850	2001	126,869	92,777	69,740	59,257
1972	141,087	113,941	98,039	87,247	2002	0	0	0	0
1973	177,270	165,367	156,632	148,953	2003	56,899	16,279	0	0
1974	137,838	112,290	93,280	81,819	2004	69,026	28,877	50	0
1975	175,422	163,717	155,185	143,665	2005	92,849	54,768	14,266	12,832
1976	122,410	86,318	67,392	48,665	2006	127,869	97,009	69,346	62,643
1977	0	0	0	0	2007	168,527	153,988	143,191	136,509
1978	130,841	105,391	80,699	72,491	2008	198,872	192,461	190,396	179,708
1979	181,277	169,133	159,981	150,053	2009	171,424	157,078	151,088	138,745
					Average	144,509	122,827	110,517	100,658

Non-Fry-Ark Supplies

To be eligible for analysis in the EIS and subsequent contracting processes covered by this EIS, non-Fry-Ark supplies identified by participants had to be quantifiable shares of a specified ditch that were either purchased, or soon to be purchased, by the participant[1]. Identified ditch shares also had to be eligible for exchange to and storage in Pueblo Reservoir. Approximately 4,200 ac-ft of annual non-Fry-Ark supply have been identified by various AVC participants (see Appendix D.2 for more detail). The historical headgate yield for all identified ditch shares was

[1] Ultimately, any non-Fry-Ark water supplies used in AVC or stored in the Master Contract would need to be fully purchased and decreed before a contract for its use could be signed with Reclamation.

summed by year. These years were indexed to the historical annual flow at the Arkansas River at Cañon City gage. The historical annual flow was then matched to the annual climate projection flows at the Arkansas River at Cañon City gage for the reduced runoff scenarios. The corresponding indexed year for yield was then assigned to the projection flow. If the projection flow was lower than the lowest historical flow, the yield assigned was that of the storage rights (2,922 acre feet) included in the non-Fry-Ark supply portfolio. The storage rights of 2,922 were reduced by 7 percent, 14 percent and 21 percent based on the reduced hydrology simulation being analyzed. This yield is assumed to be constant throughout the study period. Annual yields were disaggregated into monthly yield using the historical average monthly distribution, as it was assumed the timing of headgate diversions would not change substantially in the future since these diversions depend on crop growth needs rather than river flow. Table 9 shows the annual non-Fry-Ark yield developed for this analysis.

Table 9. Annual Estimated Non-Fry-Ark Yield

Water Year	Non-Fry-Ark Yield (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario	Water Year	Non-Fry-Ark Yield (ac-ft) Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario
1950	4,430	3,619	3,771	3,394	1980	5,704	4,965	4,760	4,840
1951	4,905	4,563	4,240	3,210	1981	3,906	3,605	3,278	3,073
1952	5,169	4,543	3,943	5,140	1982	5,965	4,624	3,804	3,383
1953	4,452	4,225	3,581	4,035	1983	6,322	5,499	5,505	4,556
1954	4,008	3,482	3,278	2,308	1984	4,791	5,165	4,960	4,756
1955	4,526	3,605	3,400	3,073	1985	5,370	5,499	5,295	5,267
1956	3,996	3,619	4,116	3,394	1986	5,856	4,965	4,760	4,879
1957	6,606	5,165	4,960	5,260	1987	5,880	5,748	5,075	4,693
1958	5,484	5,102	4,746	3,902	1988	4,595	3,976	3,599	3,196
1959	4,321	3,619	3,771	3,196	1989	5,502	4,737	3,414	3,210
1960	5,155	4,624	3,804	3,383	1990	4,941	3,976	3,599	3,196
1961	4,941	4,563	3,414	3,210	1991	4,148	4,445	3,414	3,912
1962	5,830	4,965	5,544	3,591	1992	4,799	3,619	3,414	3,912
1963	3,979	3,605	3,400	3,073	1993	5,953	4,000	4,427	5,140
1964	3,990	3,976	3,599	3,196	1994	5,848	4,211	4,021	3,708
1965	5,874	5,709	5,421	4,556	1995	5,904	5,700	4,960	5,260
1966	4,516	3,792	3,912	4,327	1996	6,235	4,632	5,439	3,902
1967	4,767	3,976	3,599	3,196	1997	5,914	5,676	4,760	4,840
1968	4,836	4,311	4,006	3,802	1998	5,754	4,211	4,021	4,154
1969	5,041	4,624	3,804	3,816	1999	5,454	4,632	5,439	3,838
1970	5,704	5,709	4,760	5,339	2000	5,641	4,563	4,240	3,210
1971	4,352	5,644	4,043	3,220	2001	4,962	3,619	3,414	3,567
1972	4,829	4,117	4,240	3,210	2002	3,687	2,717	2,513	2,308
1973	5,362	5,761	5,439	3,838	2003	4,180	3,605	3,278	3,073
1974	3,833	4,563	4,240	3,210	2004	3,823	3,605	3,400	3,073
1975	4,748	5,761	5,345	4,215	2005	4,649	3,702	3,400	3,196
1976	4,147	3,619	4,116	3,394	2006	4,213	4,445	3,414	3,567
1977	3,809	2,717	2,513	2,308	2007	5,307	4,311	4,420	3,802
1978	4,415	3,786	3,414	3,210	2008	5,154	4,965	4,760	4,840
1979	5,493	5,102	5,439	3,902	2009	4,204	5,644	4,107	3,220
					Average	4,970	4,459	4,146	3,775

Evaporation Data

Evaporation decreases the available yield of Fry-Ark supplies. Evaporative losses from reservoirs vary with surface area and atmospheric conditions. In the yield analysis, evaporation losses were simplified to monthly Pueblo Reservoir evaporation rates and were applied to the sum of the previous month's account storage and current month's account inflow. Evaporation rates were developed using average evaporation rates by month as calculated by the Daily Model.

The Projections website has data for simulated potential evaporation for an open water surface with fixed albedo (analogous to pan evaporation). These were downloaded for the three selected climate projections. Annual averages for the current conditions time period (1950-1999) and the future conditions (2060-2070) were compared. Future conditions evaporation projections showed a less than 1 percent change for the three climate projections between future and current conditions. Based on this evaluation, evaporation rates were not altered for this analysis.

Table 10. Simulated Pan Evaporation

Scenario	Average Pan Evaporation (ft/year)		Percent Change
	1950-1999	2060-2079	1950-1999 to 2060-2079
7% Reduced Scenario	6.88	6.89	0.9
14% Reduced Scenario	6.87	6.88	0.3
21% Reduced Scenario	6.87	6.98	0.8

Source: WCRP CMIP3 2012

Results

Firm and average yield analyses were performed for the No Acton Alternative and an AVC Alternative for the Current Runoff Scenario data and the three climate projection reduced runoff scenarios for direct and cumulative effects. The AVC Alternative generally represents an alternative that includes both the AVC and Master Contract (Comanche South, Pueblo Dam South, Pueblo Dam North, River South). Although there are hydrologic differences in these alternatives as simulated by the Daily Model, for purposes of this yield analysis, differences are minor and within the accuracy of the simulations.

It was found that shortages occur in the 14% and the 21% Reduced scenario for the No Action Alternative, and in all of the reduced scenarios for the AVC Alternative. Results for the AVC Alternative would likely be the same for all alternatives, except the Master Contract Only alternative. Shortages 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, temporary leases. Environmental effects of securing these additional supplies were not analyzed in this EIS.

In the original AVC Yield Analysis (Appendix D.2), several scenarios were considered to calculate the yield of supplies identified for AVC use. These scenarios were grouped into the following categories.

- Category A: Firm Yield of Existing Supplies
- Category B: Full AVC Demand
- Category C: Alternate Supply Combinations

For this analysis, only categories A and B were evaluated for the No Action Alternative and the AVC Alternative. Category A examined the firm yield of existing AVC supplies as simulated in the Daily Model (the annual AVC demand varies between all runs to evaluate firm yield). Category B was an average yield run and examined the ability of requested AVC supplies to meet the projected annual AVC demand of 10,260 ac-ft (i.e. the annual AVC demand is the same in all runs). This demand is higher than the original demand of 9,200 ac-ft per year used in Appendix D.2 due to the yield analysis findings in D.2 and further investigation of participant needs. The annual demand of 10,260 was used in the Daily Model effects analysis (Appendix D.4).

The No Action Alternative was represented by the Fry-Ark Allocation Only scenario. Only the Fry-Ark deliveries to the AVC participants were evaluated. For the purpose of this analysis, it was assumed that all future well pumping and use would remain the same in the future. Additional pumping may be an option for participants to supplement supplies in the future if shortages occur, but was not simulated. The AVC Alternative was represented by the Fry-Ark + Existing Non-Fry-Ark Supplies scenario. This analysis assumed that non-Fry-Ark supplies, including those stored in Master Contract storage space, were used in preference to Fry-Ark supplies. This assumption was made based on the thought that entities would choose to use non-Fry-Ark supplies first to reduce the chances that these supplies could be spilled from Master Contract storage space, and because Fry-Ark supplies would be considered supplemental supplies. This is consistent with the approach taken in the AVC yield analysis (Appendix D.2) and the Daily Model effects analysis (Appendices D.3 and D.4). The model run settings for the No Action Alternative and the AVC Alternative appears in Table 11 and are the same as the original analysis (Appendix D.2).

Table 11. Yield Model Run Settings

Setting	No Action Alternative A1: Fry-Ark Allocation Only	AVC Alternative A4: FryArk + Existing Non-Fry-Ark Supplies
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	0.0	34.5
Master Contract Storage (ac-ft)	0	9,838
East of Pueblo Carryover Space Used (ac-ft)	37,400	37,400

Category A – Firm Yield of Existing Supplies

Firm yield in this analysis is the maximum annual demand that could be met 100 percent of the time during the analysis period (water years 1950-2009). The critical period is the period of time where shortages first occur as demand rises, and defines the firm yield under a given set of supplies. In other words, the critical period is the point where any additional demand cannot be fully met with the analyzed supplies. The firm yield was calculated by running the Yield Model at 10 ac-ft demand increments for each alternative and scenario until no shortage in deliveries was seen. No restrictions on deliveries were made due to AVC conveyance capacity.

Table 12 shows the firm yield results for the direct effects. As shown, the No Action Alternative firm yield would decrease from the base condition by 18 percent to 36 percent in the scenarios with the climate projections. The No Action Alternative would have much lower firm yield than the AVC Alternative, as only Fry-Ark allocations were considered and no non-Fry-Ark supplies were utilized. The scenario with the current runoff hydrology could utilize 6,710 ac-ft per year of Fry-Ark supplies for well augmentation. The climate projection scenarios could utilize between 4,300 and 5,500 ac-ft per year of Fry-Ark supplies. No Fry-Ark return flows were utilized in these scenarios. For the AVC Alternative, climate projection firm yield would be 15 percent to 34 percent lower than that of the current runoff scenario. Firm yield for the climate projection scenarios would be less than the AVC demand of 10,260 ac-ft per year for the AVC Alternative.

Table 12. Yield Model Results---Firm Yield, Direct Effects

Scenario	No Action Alternative A1: Fry-Ark Allocation Only		AVC Alternative A4: FryArk + Existing Non-Fry-Ark Supplies	
	Firm Yield (ac-ft)	% Change from Base	Firm Yield (ac-ft)	% Change from Base
Current Runoff Scenario	6,710	---	11,610	---
7% Reduced Scenario	5,500	-18	9,850	-15
14% Reduced Scenario	5,090	-24	9,150	-21
21% Reduced Scenario	4,300	-36	7,680	-34

Annual Fry-Ark and Master Contract storage for the AVC Alternative three climate projection scenarios appears in Figure 11 through Figure 13. As shown, 1978 and/or 1982 would be the critical periods for all scenarios, as this was when carryover storage would be lowest. Because non-Fry-Ark supply was utilized first, very little water would be available for carryover storage in the Master Contract account and only a few hundred acre feet of the almost 10,000 acre foot account occasionally shows carryover storage. The 21% Reduced Scenario Fry-Ark account fills less frequently than the other alternatives (Figure 13). This is because the Fry-Ark East Slope water rights come into priority less often under the 21% Reduced Scenario.

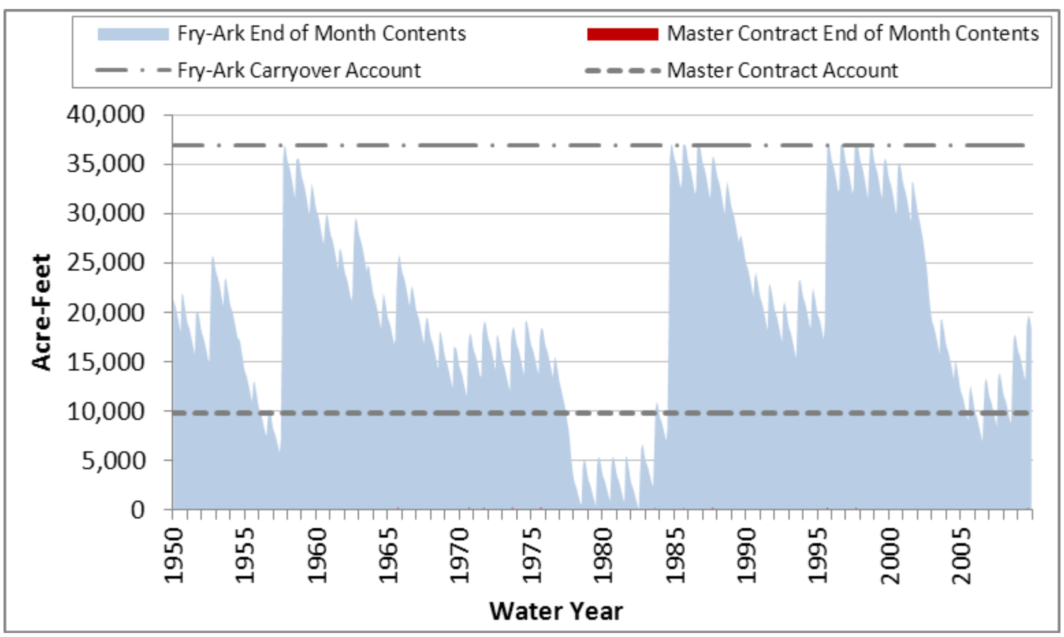


Figure 11. Direct Effects Annual AVC Fry-Ark and Master Contract Storage—AVC Alternative 7% Reduced Scenario, Firm Yield (model run A4)

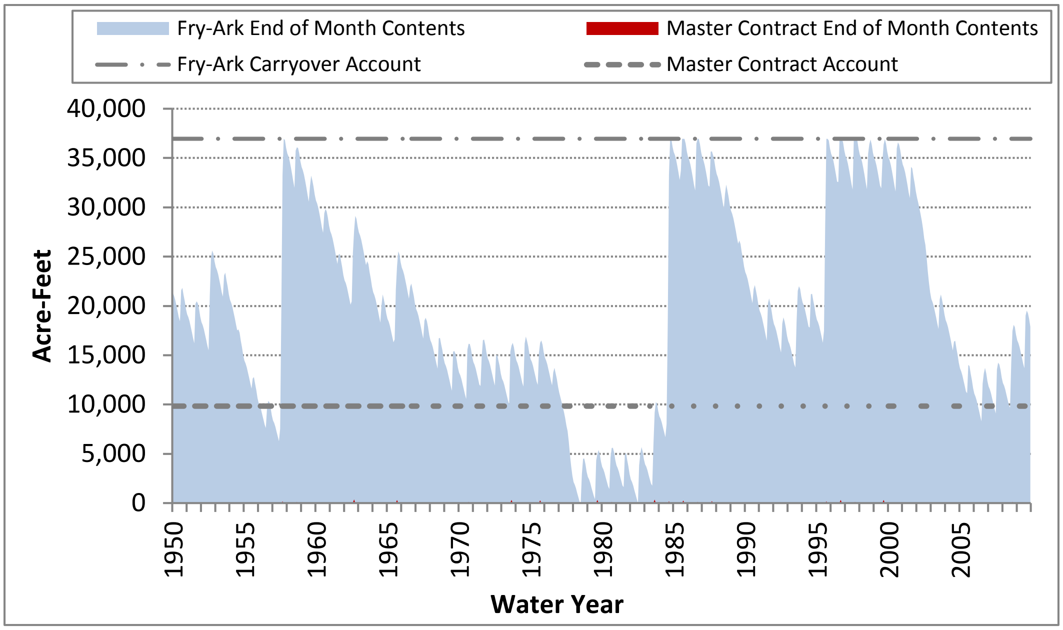


Figure 12. Direct Effects Annual AVC Fry-Ark and Master Contract Storage—AVC Alternative 14% Reduced Scenario, Firm Yield (model run A4)

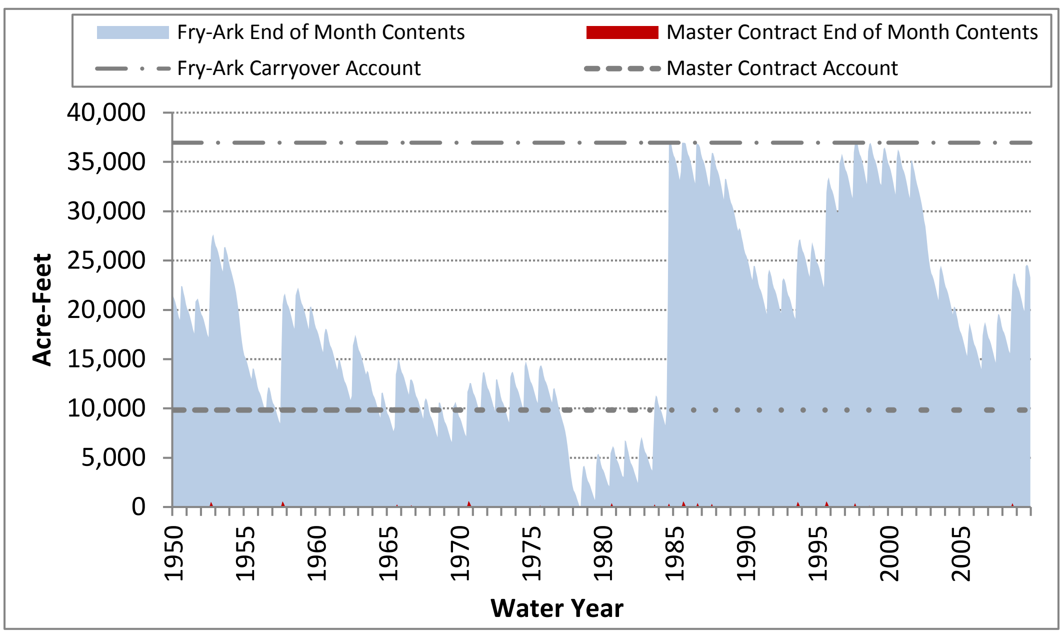


Figure 13. Direct Effects Annual AVC Fry-Ark and Master Contract Storage—AVC Alternative 21% Reduced Scenario, Firm Yield (model run A4)

Table 13 shows the firm yield results for the cumulative effects. Like the direct effects analysis, the firm yield would decrease from the Current Runoff Scenario as the representative projection hydrology is reduced. The cumulative effects for the climate projection scenarios would have lower firm yield for the AVC Alternative than the direct effects because the exchange potential under cumulative effects would be less than in the direct effects. There would be no difference in the firm yield for the No Action Alternative because there would be nothing to be exchanged in the No Action Alternative (no Master Contract account in Pueblo reservoir to exchange to). The cumulative effects exchange potential dataset considered all exchangers in the Arkansas basin as operating under 2070 conditions, where the direct effects only simulated the AVC participants as operating under 2070 conditions (see Appendix D.4). The No Action Alternative firm yield would decrease from the base condition by 18 percent to 36 percent in the scenarios with reduced runoff. For the AVC Alternative, reduced runoff firm yield would be 13 percent to 33 percent lower than that of the Current Runoff Scenario.

Table 13. Yield Model Results---Firm Yield, Cumulative Effects

Scenario	No Action Alternative A1: Fry-Ark Allocation Only		AVC Alternative A4: FryArk + Existing Non-Fry-Ark Supplies	
	Firm Yield (ac-ft)	% Change from Base	Firm Yield (ac-ft)	% Change from Base
Current Runoff Scenario	6,710	---	11,220	---
7% Reduced Scenario	5,500	-18	9,810	-13
14% Reduced Scenario	5,090	-24	8,750	-22
21% Reduced Scenario	4,300	-36	7,470	-33

Cumulative effects annual Fry-Ark and Master Contract storage for the AVC Alternative three climate projection scenarios are in Figure 14 through Figure 16. Again, 1978 and/or 1982 would be the critical periods for all scenarios. Like the direct effects, due to full non-FryArk water usage, nothing would be available for carryover storage in the Master Contract account.

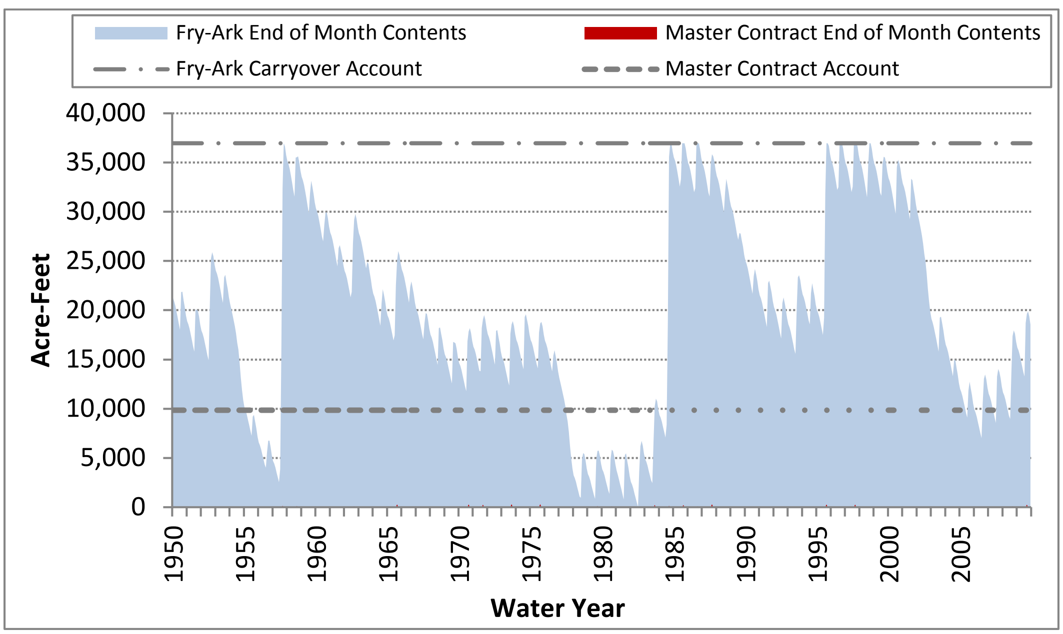


Figure 14. Cumulative Effects Annual AVC Fry-Ark and Master Contract Storage—AVC Alternative 7% Reduced Scenario, Firm Yield (model run A4)

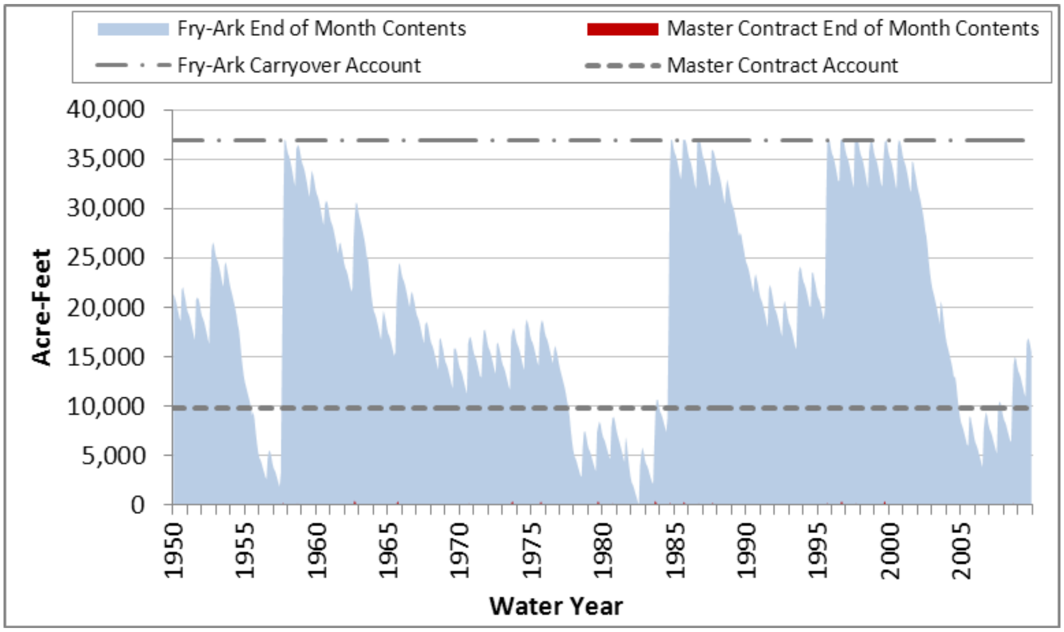


Figure 15. Cumulative Effects Annual AVC Fry-Ark and Master Contract Storage—AVC Alternative 14% Reduced Scenario, Firm Yield (model run A4)

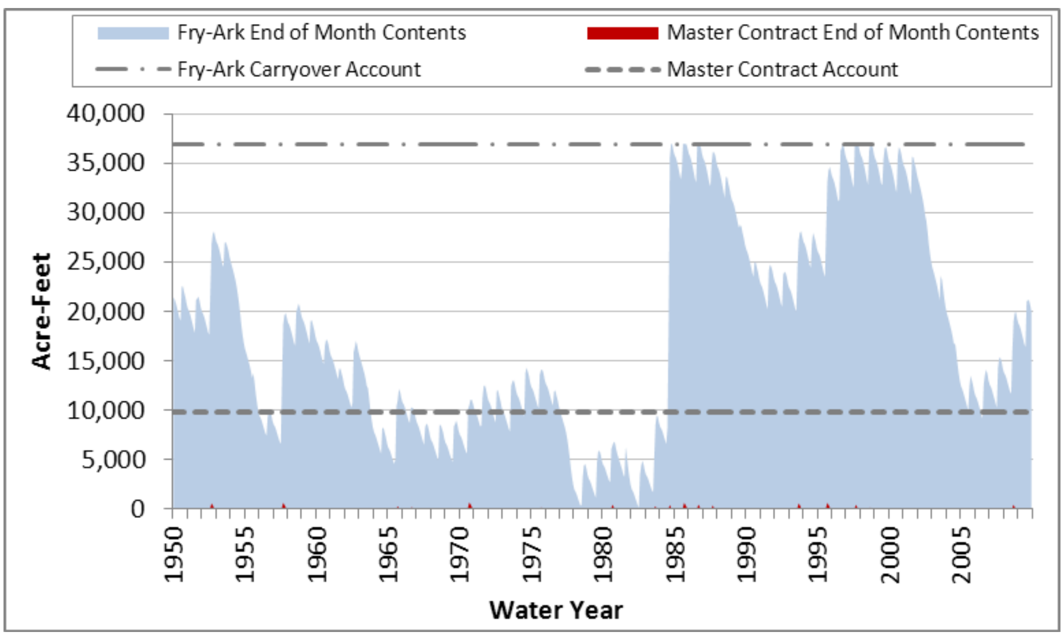


Figure 16. Cumulative Effects Annual AVC Fry-Ark and Master Contract Storage—AVC Alternative 21% Reduced Scenario, Firm Yield (model run A4)

Category B – Full AVC Demand

The AVC participants include a variety of water providers such as cities, towns, and rural water districts throughout the Lower Arkansas River Basin. Water users served by these providers include residential, commercial, and industrial customers. The AVC demand would be approximately 10,260 ac-ft per year for the AVC Alternative. The No Action Alternative demand would be 5,130 ac-ft per year. The No Action Alternative demand represents the Fry-Ark water needed for well augmentation by the participants that would be released from Pueblo Reservoir. This demand was calculated as the total annual alluvial pumping demand minus the non-Fry-Ark supplies to be utilized for augmentation with a 10 percent increase for transit loss from Pueblo Reservoir to the entities.

Average yield for the Current Runoff Scenario and the three reduced runoff scenarios was run at the AVC demand of 5,130 ac-ft per year for the No Action Alternative, and 10,260 ac-ft per year for the AVC Alternative, and is presented in Table 14 for direct effects. For the No Action Alternative, the Fry-Ark Project could deliver the entire 5,130 ac-ft demand level for well augmentation under Current Runoff Scenario hydrology. For the 21% Reduced Scenario, which represents the greatest decrease in streamflow, about 4,844 ac-ft per year of Fry-Ark water could be delivered from Pueblo Reservoir. The shortfall in supply versus demand would have to be met by other sources of water such as additional water leases or new non-Fry-Ark supplies. Additional groundwater pumping may also be an option for additional supply.

For the AVC Alternative, the average annual shortage would be about 1,316 ac-ft per year for the 21% Reduced Scenario, where the monthly maximum shortage would be 1,439 ac-ft. AVC participants would need to purchase or lease additional water supplies to fulfill 2070 demand. Figure 17 through Figure 19 show the AVC Alternative annual deliveries and shortages for the three climate projection scenarios at the average demand level of 10,260 ac-ft per year. As shown, the 7% Reduced Scenario would have shortages 5 of 60 simulated years, the 14% Reduced Scenario would have shortages in 6 of 60 years and the 21% Reduced Scenario would have shortages during 29 of 60 simulated years. There are no Fry-Ark deliveries during some years for the reduced scenarios because there is not enough simulated flow during those years to produce simulated exchange potential; however, sometimes (e.g. 2002) there is enough carryover storage from the previous year that no shortages occur.

The median reduced runoff, mid-way through the project planning horizon (2040), is a 10% reduction in runoff (Figure 5). It can be inferred that at this point in time, it is likely that average annual shortages would be somewhere between those seen in the 7% Reduced scenario and the 14% Reduced scenario, or about 195 acre feet of average annual shortages. Likewise, the firm yield would be about 9,500 acre feet at the 50^{th} percentile flow reduction if you infer between the 7% Reduced and 14% Reduced scenarios from Table 12.

Table 14. Yield Model Results---Average Yield, Direct Effects (model run B4)

Alternative	Scenario			
	Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario
No Action Alternative				
Demand				
Annual AVC Demand (ac-ft)	5,130	5,130	5,130	5,130
Annual AVC Demand Shortage (ac-ft)	0	0	8	286
Maximum Monthly Shortage (ac-ft)	0	0	383	711
Deliveries				
Fry-Ark Allocation (ac-ft)	5,130	5,130	5,122	4,844
Fry-Ark Return Flows (ac-ft)	0	0	0	0
Non-Fry-Ark (ac-ft)	0	0	0	0
Total Deliveries (ac-ft)	5,130	5,130	5,122	4,844
AVC Alternative				
Demand				
Annual AVC Demand (ac-ft)	10,260	10,260	10,260	10,260
Annual AVC Demand Shortage (ac-ft)	0	106	284	1,316
Maximum Monthly Shortage (ac-ft)	0	990	1,426	1,439
Deliveries				
Fry-Ark Allocation (ac-ft)	5,264	5,666	5,724	5,143
Fry-Ark Return Flows (ac-ft)	729	738	764	659
Non-Fry-Ark (ac-ft)	4,267	3,751	3,488	3,142
Total Deliveries (ac-ft)	10,260	10,154	9,976	8,944

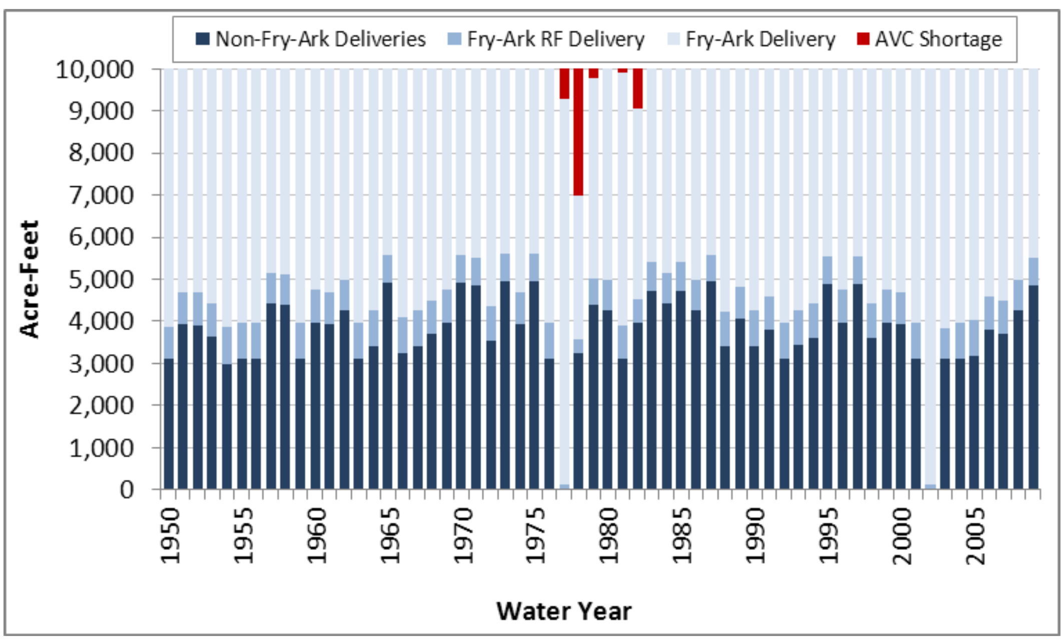


Figure 17. Direct Effects Annual Deliveries and Shortages - AVC Alternative 7% Reduced Scenario, Average Yield (model run B4)

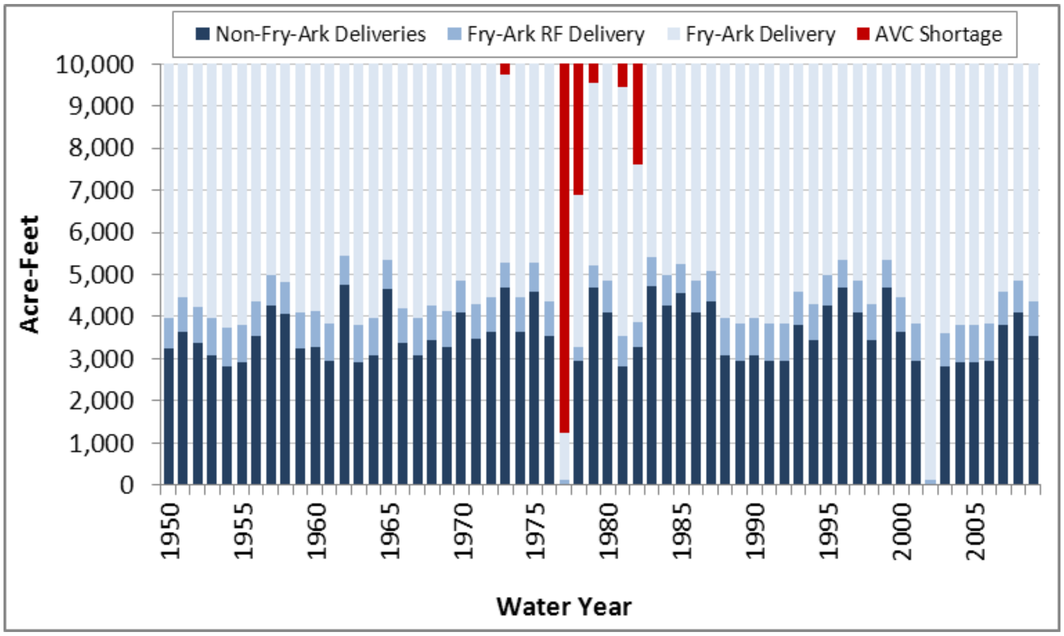


Figure 18. **Direct Effects Annual Deliveries and Shortages AVC Alternative 14% Reduced Scenario, Average Yield (model run B4)**

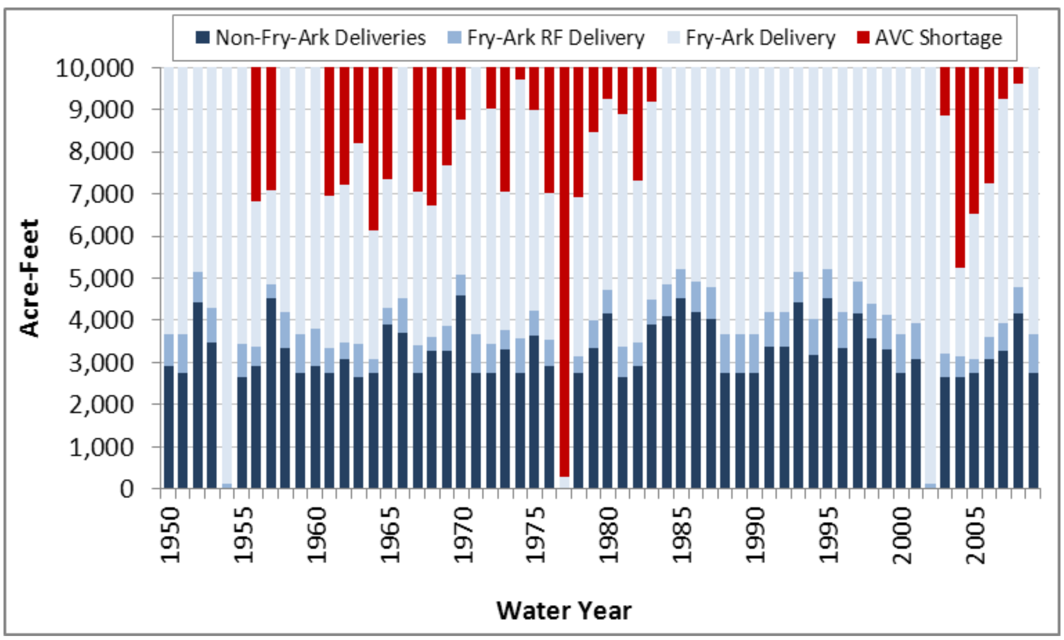


Figure 19. **Direct Effects Annual Deliveries and Shortages AVC Alternative 21% Reduced Scenario, Average Yield (model run B4)**

Average yield for the Current Runoff Scenario and the three climate projections is presented in Table 15 for cumulative effects. In the cumulative effects, the No Action Alternative average yield would be the same for all alternatives as for direct effects. This is because only the exchange potential dataset is different in the cumulative effects runs and no exchanges would take place in the No Action Alternative analysis.

For the AVC Alternative, the average annual shortage would be 682 ac-ft per year for the 21% Reduced Scenario, with a maximum monthly shortage of 1,439 ac-ft. In 1977 and 2002, there were no non-Fry-Ark deliveries for this scenario because flows were too low to allow exchange potential (Figure 22). AVC participants would need to find more non-Fry-Ark supplies or lease additional supplies from willing parties to fulfill 2070 demand. Cumulative effects deliveries and shortages for the three climate projections are in Figure 20 through Figure 22. As shown, the 7% Reduced Scenario has shortages in 5 of 60 years simulated, the 14% Reduced Scenario has shortages in 8 of 60 years and the 21% Reduced Scenario has shortages in 30 of 60 simulated years.

Table 15. Yield Model Results---Average Yield, Cumulative Effects (model run B4)

Alternative	Scenario			
	Current Runoff Scenario	7% Reduced Scenario	14% Reduced Scenario	21% Reduced Scenario
No Action Alternative				
Demand				
Annual AVC Demand (ac-ft)	5,130	5,130	5,130	5,130
Annual AVC Demand Shortage (ac-ft)	0	0	8	286
Maximum Monthly Shortage (ac-ft)	0	0	383	711
Deliveries				
Fry-Ark Allocation (ac-ft)	5,130	5,130	5,122	4,844
Fry-Ark Return Flows (ac-ft)	0	0	0	0
Non-Fry-Ark (ac-ft)	0	0	0	0
Total Deliveries (ac-ft)	5,130	5,130	5,122	4,844
AVC Alternative				
Demand				
Annual AVC Demand (ac-ft)	10,260	10,260	10,260	10,260
Annual AVC Demand Shortage (ac-ft)	0	104	288	1,318
Maximum Monthly Shortage (ac-ft)	0	875	1,426	1,439
Deliveries				
Fry-Ark Allocation (ac-ft)	5,299	5,672	5,726	5,143
Fry-Ark Return Flows (ac-ft)	723	734	759	657
Non-Fry-Ark (ac-ft)	4,238	3,750	3,487	3,142
Total Deliveries (ac-ft)	10,260	10,156	9,972	8,942

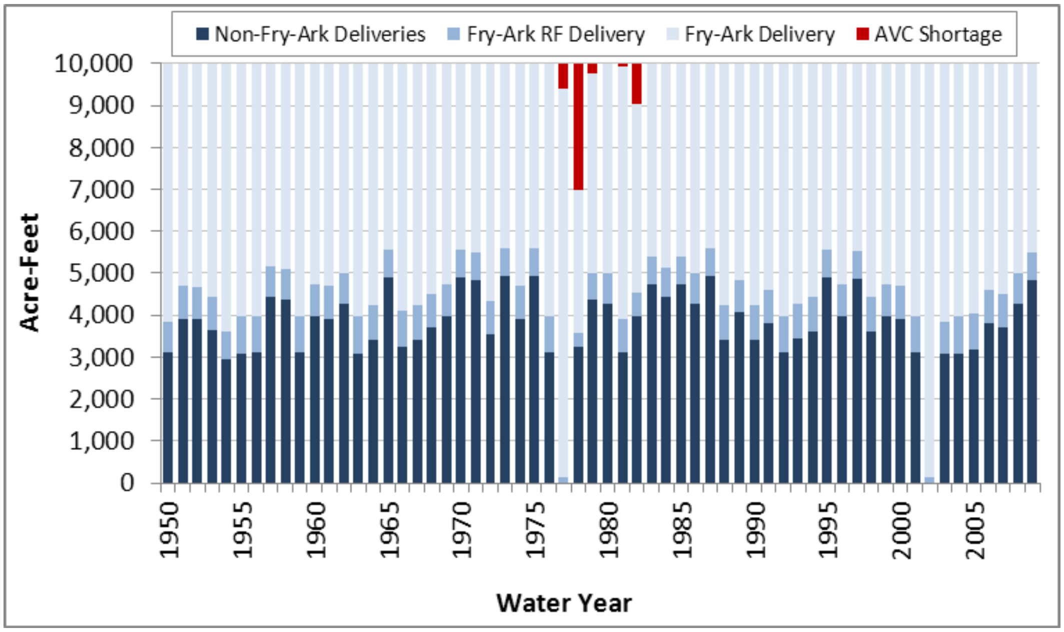


Figure 20. **Cumulative Effects Annual Deliveries and Shortages AVC Alternative 7% Reduced Scenario, Average Yield (model run B4)**

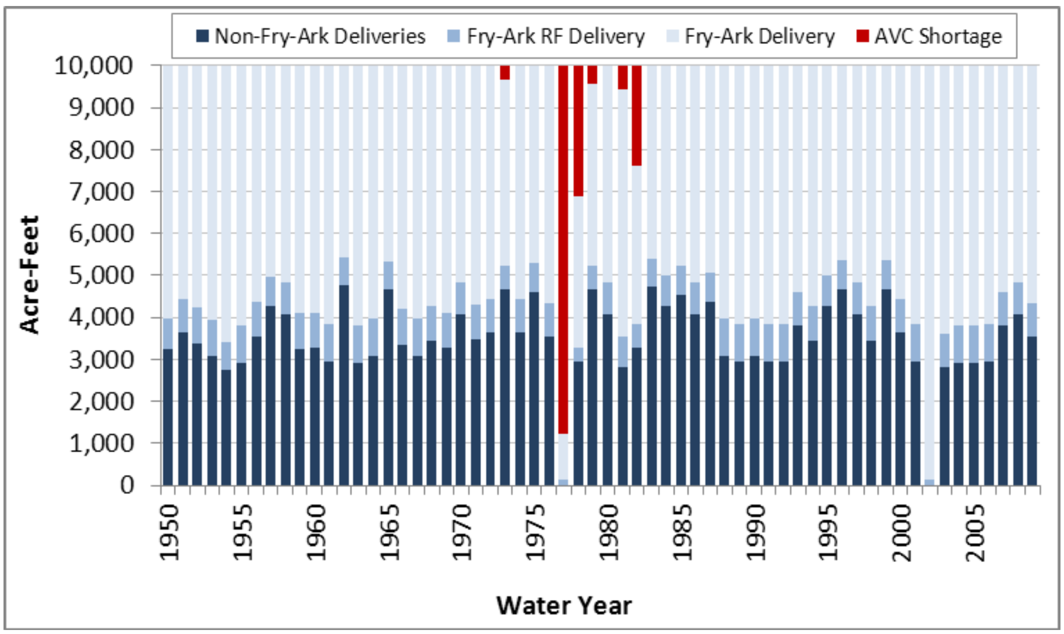


Figure 21. **Cumulative Effects Annual Deliveries and Shortages AVC Alternative 14% Reduced Scenario, Average Yield (model run B4)**

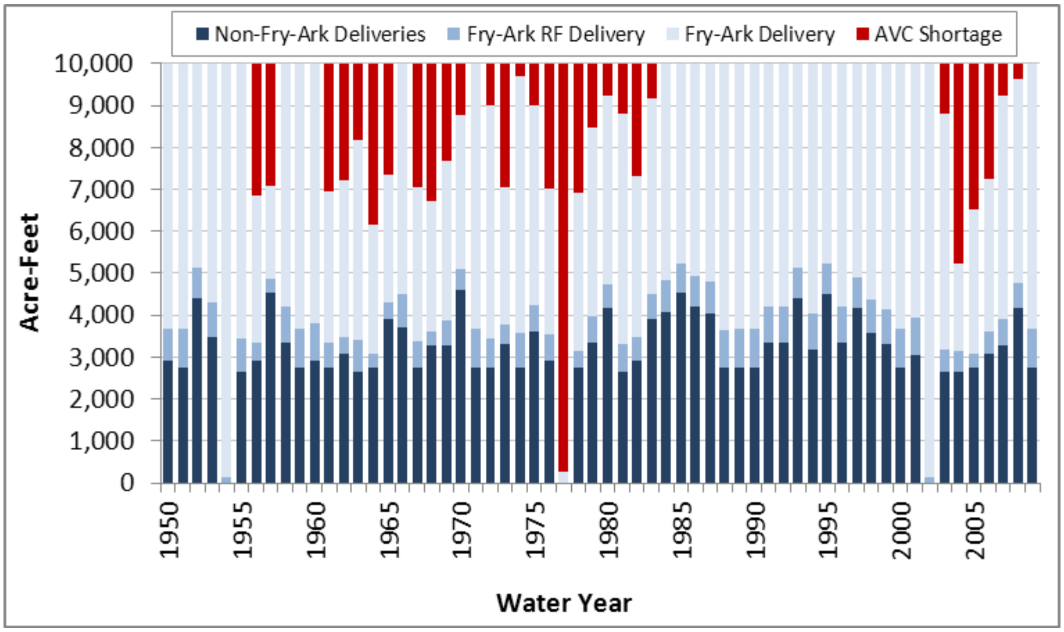


Figure 22. Cumulative Effects Annual Deliveries and Shortages AVC Alternative 21% Reduced Scenario, Average Yield (model run B4)

Conclusion

Firm and average yield runs were conducted for the No Action Alternative and the AVC Alternative for direct and cumulative effects under current runoff hydrology and three reduced hydrologies based on results from three climate projection ensemble outputs of the VIC model available on the Projections website (Reclamation 2011). Similar results were seen for both direct effects and cumulative effects with slightly lower yields in the cumulative effects.

Fry-Ark releases for the No Action Alternative would be less than historical hydrology in the 14% Reduced and 21% Reduced scenarios (Table 14). 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 historical hydrology scenario in all climate change scenarios for the AVC Alternative (Table 14). 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 where 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 supply would be more applicable. The 21% Reduced Scenario would have shortages in 29 of 60 simulated years. The magnitude of this shortage is great in the simulated 1977 year; nearly the entire demand is unable to be met, with shortages during 11 months. This year follows a year where Fry-Ark storage contents are depleted. During this dry year there is no exchange potential for non-Fry-Ark supplies. Therefore, no non-Fry-Ark supplies are used. In this case, access to a more permanent long-term supply would be more appropriate. Environmental effects of securing additional supplies were not analyzed in this EIS. The use of 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 in times when Fry-Ark supply is depleted and there is no exchange potential in the river.

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Attachment 1

MEMORANDUM

GrandRiver
Consulting Corporation

DATE: July 9, 2012

TO: Lisa Fardal

FROM: Tyler Benton

SUBJECT: Estimated Climate Adjusted Fryingpan-Arkansas Project Yield: 1950-2009
REVISED DRAFT

This memorandum updates our previous draft dated May 23th 2012. Grand River was contacted by Gerald Gibbens on June 12th to update the Boustead Tunnel yield estimates based upon revised monthly climate change deltas. The changes associated with these revised deltas are reflected below.

Per your request, we have completed a climate adjusted yield analysis of the Fryingpan-Arkansas Project (Fry-Ark Project). The Fry-Ark Project is a U.S. Bureau of Reclamation project that diverts water from tributaries of the upper Roaring Fork River watershed including Hunter Creek and Fryingpan Rivers. Water is collected through a series of intakes, pipelines and tunnels before being gravity fed beneath the continental divide through the Boustead Tunnel to the Arkansas River watershed.

The yield estimates described below consider projected changes in stream flow due to climate for the study period 1950-2009. Three climate change scenarios were analyzed to understand the potential variability associated with the projections, including the 30th, 50th, and 70th percentiles (Attachment 1). These three climate change scenarios relate to your projections of how Fryingpan River streamflow near Thomasville is expected to change from the historical record. These monthly climate change deltas were revised and provided by you in a July 3rd email. This memo reflects the updated hydrology associated with the revised deltas.

BACKGROUND INFORMATION

In 2004 Grand River Consulting was contracted by Aurora Water to model unconstrained Fry-Ark Project diversions for a 1950-2003 study period. This assessment required estimating unconstrained diversions of the Fry-Ark Project for a time period before Fryingpan River stream gages were installed (1950-1973). To reconstruct available diversions of the Fry-Ark Project for this ungaged period, a regression was developed between historical Twin Lakes and Fry-Ark Project diversion records. From this relationship, total available Fry-Ark Project diversions were calculated for the ungaged period.

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In 2009 Grand River Consulting was contracted to update the previous assessment to include the 2006-2008 period. This update was based on actual and simulated unconstrained Fry-Ark Project yield estimates and upon native Fryingpan River near Thomasville stream flow from the 2004 analysis. Please note that unconstrained Fry-Ark Project diversions for the 2004-2005 time period were not included in the 2004 update as historical diversions were assumed to equal unconstrained diversions.

METHODS

Historically, Fry-Ark Project diversions have been curtailed by the minimum bypass requirement downstream of the collection system on the Fryingpan River near Thomasville (Attachment 2). To estimate unconstrained Fry-Ark Project diversions under climate change scenarios, regressions were developed between native stream flow at Thomasville and the simulated unconstrained Fry-Ark Project yield estimates from our 2004 analysis (Figure 1).

The 2004 analysis generated a native stream flow record of the Fryingpan River near Thomasville for the years 1974-1999. To extend this native stream flow record back to the year 1950, regressions were developed utilizing the 1974–1999 Fryingpan River near Thomasville native stream flow and the Roaring Fork River at Glenwood Springs stream flow (Figure 2). Roaring Fork River stream flow was adjusted for diversions by both Twin Lakes and the Fry-Ark Project. However, stored and released water from Ruedi Reservoir was not included in this analysis and may help to explain some noise in the regressions. Please note, if for a given day, Roaring Fork River stream flow was low enough that Fryingpan River stream flow near Thomasville was calculated to be less than 19 cfs, then 19 cfs was assumed. Nineteen cfs was recorded as the lowest stream flow level during base flow of the 2002 drought and was used as a conservative estimate. This approach was deemed appropriate for this level of study. If in the future a more detailed analysis is required, incorporating the effects of Ruedi Reservoir may help to refine the relationship.

The native stream flow record of the Fryingpan River near Thomasville was extended from the year 2000 to 2009 by summing Colorado Division of Water Resources Fryingpan River near Thomasville stream gage data, and the Fryingpan River portion of Fry-Ark Project diversions.

After reconstructing the native stream flow of the Fryingpan River near Thomasville for the study period (1950-2009), the monthly climate change deltas provide by you were applied to simulate future stream flow conditions at Thomasville. Fry-Ark Project yield estimates were then calculated on a daily basis using the relationship described above (Figure 1) for the four data sets; a Base Condition and three climate scenarios (70^{th}, 50^{th} and 30^{th} percentiles). The rising limb equation was used from April through June 6 (Base Condition), and the falling limb equation was used from June 7 (Base Condition) through March of the following water year. Daily diversions were limited to the minimum of the following:

(1) Calculated available diversion (If native stream flow of the Fryingpan River near Thomasville was low enough that diversions were precluded, then the March 31^{st} diversion value was used.)

(2) Native Fryingpan River stream flow near Thomasville less the monthly bypass requirement (Attachment 2)

(3) Boustead Tunnel capacity (950 cfs)

RESULTS AND OBSERVATIONS

Estimated annual Fry-Ark Project yield was calculated for four scenarios; a base condition, and three climate scenarios (70th, 50th and 30th percentiles). These three climate scenarios bracket the variability expected in future streamflow conditions for the upper Fryingpan River, which were provided by you. Figure 3 shows how annual yield may differ between these scenarios for the 1950-2009 study period. Current potential yield of the Fry-Ark Project (Base Condition) is estimated to average about 61,000 acre feet (AF). Under the climate scenarios, simulated potential annual yield ranges from about 42,500 AF to 51,200 AF (30th percentile to 70th percentile), with the 50th percentile scenario resulting in an average annual Fry-Ark Project yield of about 47,000 AF. Table 1 depicts how the three climate scenarios are projected to change stream flow and the annual Fry-Ark Project yield.

TABLE 1
Summary of Stream Flow and Yield

	Native Fryingpan River Stream Flow near Thomasville			Fry-Ark Project Yield	
	Oct-Sep (1950-2009)	May-July (1950-2009)	Peak Flow Day (1950-2009)	Oct-Sep (1950-2009)	
	(%)	(%)	(Day)	(AF)	(%)
Base Condition	-	-	6-Jun	60,865	-
70th %ile Climate Scenario	-10%	-5%	May 24 (-13 Days)	51,217	-16%
50th %ile Climate Scenario	-15%	-13%	May 24 (-13 Days)	47,083	-23%
30th %ile Climate Scenario	-23%	-22%	May 24 (-13 Days)	42,459	-30%

The Fry-Ark Project can be curtailed by specified stream flow bypasses at the Thomasville gage on the Fryingpan River (Attachment 2). These stream flow bypasses vary by month and were included in the Congressional legislation authorizing construction of the Fry-Ark Project. Though annual stream flow at the Thomasville Gage is reduced by 10 % to 23 % under the climate scenarios, May through July stream flow is reduced 5 % to 22 %. It is typically during the May through July snowmelt runoff when stream flow at the Thomasville gage exceeds the bypass requirements enabling Fry-Ark Project diversions to occur. The decrease in stream flow during the May through July snowmelt period results in a decrease of Fry-Ark Project yield ranging from 16 % to 30 %. Fry-Ark Project yield is summarized by month for the 1950-2009 study period in Attachment 3.

In the Base Condition, stream flow peaks on June 6th on average. This date was calculated from the native Fryingpan River streamflow near Thomasville, and was used as the divider between the rising and falling limbs on the hydrograph. Between April and June 6th we used the rising limb equation (Figure 1) to calculate Fry-Ark Project yield. From June 7th to March of the following water year we used the falling limb equation. Under the climate change scenarios the average peak flow date moves earlier in the year by 13 days under each climate scenario.

This analysis indicates a shift in peak snowmelt runoff to earlier in the year, by about 13 days under the climate scenarios. We wanted to understand how the monthly Thomasville bypass requirements affect

Fry-Ark Project yield with the climate scenarios, and to understand if shifting the monthly bypass amounts to an earlier date would affect the Fry-Ark Project diversions under these climate scenarios. Our assessment reflects that if the distribution of the monthly Thomasville bypass requirements are shifted two weeks earlier in the year, in a manner consistent with the projected shift in peak flow under the climate scenarios, average annual yield of the project would decrease by a lesser amount, and may yield the Fry-Ark Project an additional 1,500 AF under each scenario. This change is largely occurs by extending the diversion season to later in the year. We understand that changing the bypass requirements in amount or timing would require legislative approval.

We hope this assessment is in-line with your expectations. Please let us know if you have any comments or concerns.

TJB

Enclosures

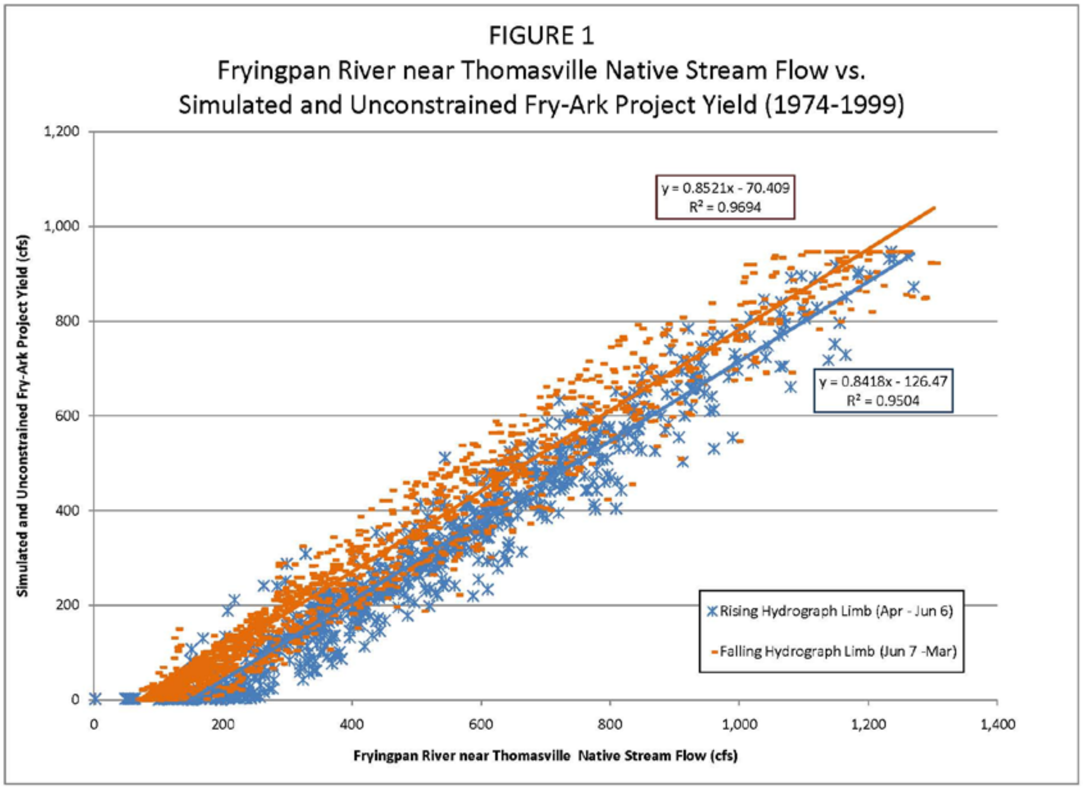
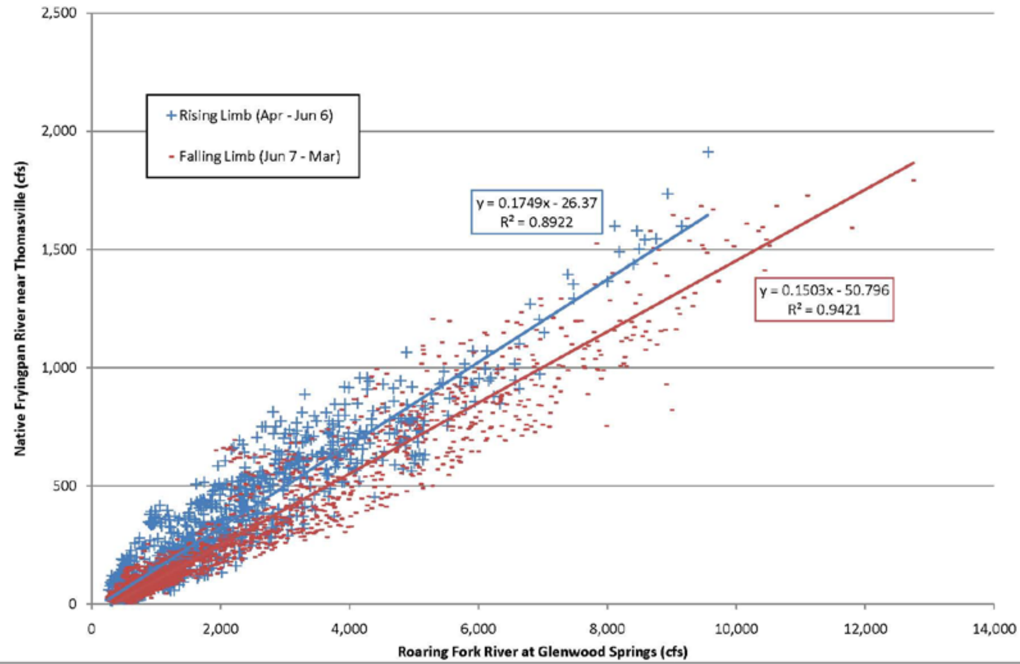


FIGURE 1
Fryingpan River near Thomasville Native Stream Flow vs.
Simulated and Unconstrained Fry-Ark Project Yield (1974-1999)
y = 0.8521x - 70.409
R² = 0.9694
y = 0.8418x - 126.47
R² = 0.9504
Rising Hydrograph Limb (Apr - Jun 6)
Falling Hydrograph Limb (Jun 7 -Mar)
Simulated and Unconstrained Fry-Ark Project Yield (cfs)
Fryingpan River near Thomasville Native Stream Flow (cfs)
0
200
400
600
800
1,000
1,200
1,400

FIGURE 2
Fryingpan River near Thomasville Native Stream Flow vs. Roaring Fork River at Glenwood Springs



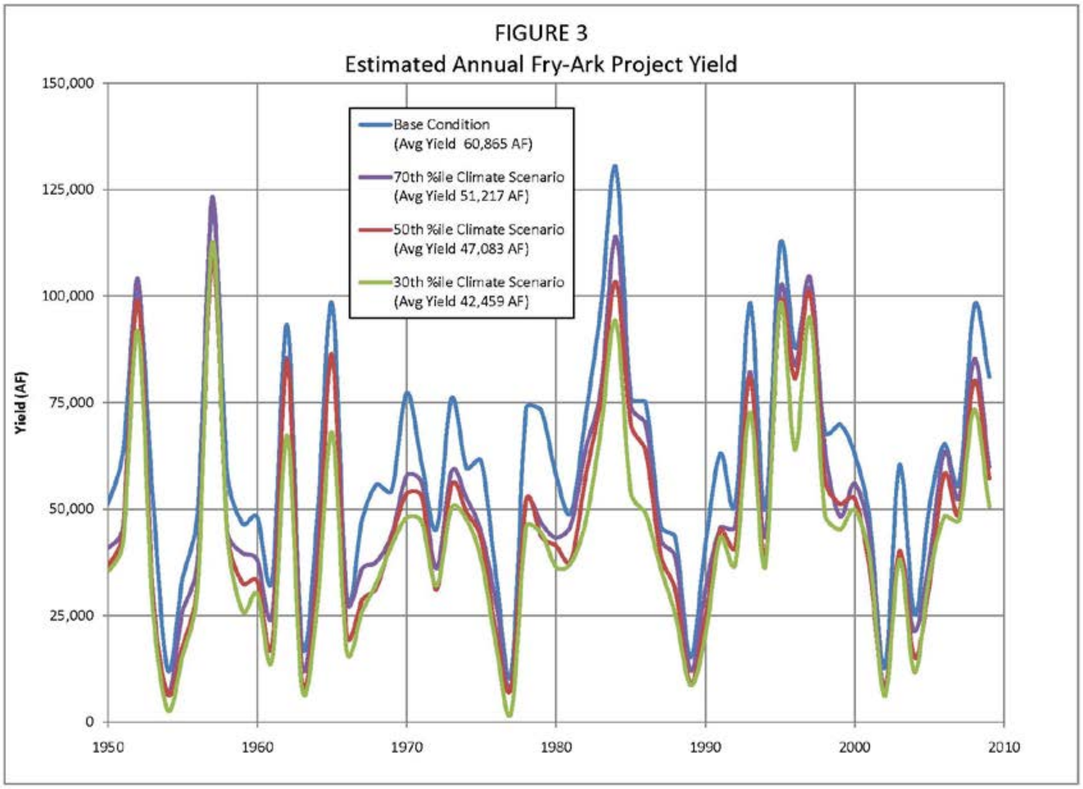


FIGURE 3
Estimated Annual Fry-Ark Project Yield
Yield (AF)
150,000
125,000
100,000
75,000
50,000
25,000
0
1950
1960
1970
1980
1990
2000
2010
Base Condition (Avg Yield 60,865 AF)
70th %ile Climate Scenario (Avg Yield 51,217 AF)
50th %ile Climate Scenario (Avg Yield 47,083 AF)
30th %ile Climate Scenario (Avg Yield 42,459 AF)

ATTACHMENT 1 - A
Monthly Climate Change Deltas for the Fryingpan River near Thomasville
50th Percentile Climate Change Scenario

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1950	-56%	-50%	-40%	-34%	-30%	-6%	22%	109%	-64%	-70%	-58%	-70%
1951	-47%	-50%	-58%	-50%	-36%	-29%	5%	139%	-68%	-58%	-62%	0%
1952	-13%	5%	40%	6%	-2%	80%	-46%	82%	-38%	-20%	-27%	-38%
1953	-19%	-40%	-47%	-34%	-30%	-12%	119%	160%	-69%	-68%	-82%	-53%
1954	4%	-24%	-21%	-21%	-16%	-10%	65%	-25%	-37%	-48%	-10%	-35%
1955	-29%	-4%	-11%	-20%	-19%	-12%	-3%	11%	-47%	-55%	-61%	73%
1956	8%	-25%	-12%	-19%	-17%	-12%	34%	-15%	-55%	67%	12%	46%
1957	-25%	-25%	-19%	-25%	-25%	-17%	5%	297%	-44%	-66%	-45%	-41%
1958	-75%	-74%	-76%	-62%	-37%	-28%	14%	53%	-71%	47%	39%	1%
1959	-53%	-50%	-37%	-35%	-30%	-13%	-16%	56%	-49%	-19%	-22%	-34%
1960	-66%	-49%	-7%	-15%	-12%	-33%	-5%	54%	-59%	-6%	-17%	42%
1961	63%	2%	-13%	-23%	-22%	-15%	70%	-3%	-51%	6%	-4%	-73%
1962	-62%	-43%	-25%	-18%	-21%	-10%	-10%	76%	-37%	-30%	-5%	65%
1963	-56%	-44%	-28%	-29%	-25%	3%	33%	-25%	-41%	-9%	-33%	-42%
1964	-32%	-32%	-36%	-36%	-31%	-14%	21%	5%	-29%	-50%	-53%	-27%
1965	106%	17%	-11%	-13%	-1%	-4%	125%	147%	-39%	-51%	-45%	-53%
1966	-85%	-74%	-61%	-44%	-38%	-23%	-20%	-9%	-27%	-23%	-13%	31%
1967	-26%	-29%	-27%	-23%	-20%	-14%	75%	44%	-55%	-46%	-52%	-42%
1968	43%	45%	52%	6%	15%	56%	129%	160%	-74%	-63%	-80%	-30%
1969	-64%	-63%	-59%	-52%	-38%	-31%	-42%	71%	-56%	-50%	-47%	-55%
1970	-58%	-29%	-26%	-4%	-2%	-23%	-2%	100%	-60%	-54%	-53%	-77%
1971	-49%	-42%	-44%	-40%	-32%	-17%	-8%	106%	-40%	-40%	-12%	-41%
1972	-29%	-37%	-42%	-43%	-33%	-31%	20%	122%	-71%	-51%	-31%	-56%
1973	-47%	-51%	-47%	-52%	-50%	-35%	52%	187%	-62%	-71%	-71%	-39%
1974	-43%	-50%	-48%	-34%	-33%	-39%	12%	42%	-53%	-36%	-47%	-54%
1975	-39%	-12%	22%	5%	-23%	-19%	92%	138%	-48%	-69%	-39%	-43%
1976	-54%	-51%	-45%	-43%	-39%	-21%	28%	1%	-43%	-40%	-52%	-45%
1977	-23%	10%	15%	30%	24%	35%	90%	4%	-44%	-30%	-45%	-29%
1978	21%	37%	29%	32%	33%	34%	97%	94%	-55%	-48%	-27%	18%
1979	17%	12%	3%	-2%	-1%	-7%	10%	159%	-68%	-60%	-55%	-37%
1980	-43%	-36%	-22%	-31%	-30%	-19%	46%	92%	-60%	-41%	13%	-22%
1981	-23%	-35%	-46%	-37%	-25%	-10%	68%	91%	-59%	-61%	-87%	-91%
1982	-61%	-35%	-35%	-27%	-23%	-10%	33%	158%	-55%	-32%	-32%	-44%
1983	-54%	-46%	-42%	-31%	-26%	-22%	256%	387%	-41%	-64%	-56%	-36%
1984	-71%	-61%	-57%	-51%	-45%	-44%	63%	120%	-34%	-37%	-40%	-49%
1985	-63%	-60%	-55%	-51%	-40%	-15%	15%	108%	-51%	-38%	-34%	-6%
1986	-53%	-50%	-42%	-41%	-40%	-52%	17%	146%	-53%	-46%	-49%	-54%
1987	-74%	-65%	-53%	-25%	-41%	-33%	52%	55%	-64%	-56%	-54%	-45%
1988	-56%	-53%	-50%	-42%	-41%	-46%	-33%	16%	-41%	-12%	-16%	-46%
1989	-24%	-34%	-38%	-28%	-19%	-30%	-29%	8%	-42%	-51%	-40%	-26%
1990	-35%	-36%	-32%	-25%	-19%	-26%	23%	63%	-58%	-40%	-29%	-36%
1991	-59%	-34%	-13%	-16%	-20%	-4%	82%	94%	-62%	-47%	-53%	-76%
1992	-47%	-44%	-42%	-27%	-20%	-27%	-6%	26%	-38%	-40%	-39%	-58%
1993	-26%	-40%	-35%	-32%	-32%	-31%	80%	103%	-40%	-51%	2%	-42%
1994	-65%	-52%	-43%	-37%	-38%	-37%	63%	42%	-70%	-43%	-29%	-34%
1995	2%	4%	-11%	-2%	-10%	18%	67%	387%	-29%	-66%	-56%	-48%
1996	-43%	-41%	-57%	-47%	-38%	-52%	86%	34%	-48%	12%	34%	-7%
1997	-41%	-40%	-32%	-35%	-29%	-34%	-14%	67%	-36%	-8%	-12%	-42%
1998	-45%	-62%	-56%	-51%	-48%	-44%	26%	73%	-47%	-32%	-29%	-13%
1999	-17%	-16%	1%	1%	-9%	-15%	178%	71%	-49%	-29%	-55%	-50%
2000	-49%	-36%	-43%	-43%	-47%	-39%	-39%	34%	-53%	-3%	-25%	-58%
2001	-4%	-15%	-11%	-22%	3%	33%	40%	30%	-62%	-44%	-69%	-50%
2002	-49%	-53%	-52%	-42%	-40%	-17%	-23%	-17%	-38%	11%	19%	-53%
2003	-48%	-22%	-14%	-22%	-26%	-16%	21%	62%	-59%	-30%	-35%	-79%
2004	21%	-25%	-27%	-25%	-16%	-61%	-22%	-9%	-34%	-40%	-39%	-8%
2005	-45%	-35%	-29%	-29%	-25%	-11%	109%	62%	-68%	-69%	-58%	-44%
2006	-39%	-64%	-56%	-48%	-38%	-37%	-51%	27%	-46%	44%	42%	1%
2007	-65%	-50%	-45%	-43%	-35%	-59%	-36%	65%	-56%	-22%	-51%	-61%
2008	-43%	-34%	-36%	-32%	-30%	-17%	48%	151%	-48%	-51%	-9%	-2%
2009	24%	2%	-24%	-37%	-25%	-45%	-12%	66%	-65%	-42%	-44%	-24%
Average	-33%	-33%	-30%	-28%	-24%	-18%	35%	83%	-51%	-36%	-34%	-32%

ATTACHMENT 1 - B
Monthly Climate Change Deltas for the Fryingpan River near Thomasville
30th Percentile Climate Change Scenario

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1950	-61%	-61%	-50%	-43%	-37%	-13%	25%	123%	-74%	-75%	-60%	-75%
1951	-35%	-43%	-52%	-41%	-25%	-9%	46%	95%	-68%	-46%	-59%	25%
1952	-34%	-10%	31%	2%	-2%	78%	-42%	41%	-30%	-35%	-28%	-36%
1953	-30%	-54%	-56%	-44%	-39%	-20%	120%	173%	-77%	-74%	-83%	-61%
1954	-34%	-47%	-42%	-41%	-34%	-20%	48%	-55%	-65%	-68%	-43%	-49%
1955	-37%	-14%	-16%	-24%	-22%	-15%	46%	9%	-57%	-64%	-67%	55%
1956	-9%	-30%	-14%	-20%	-16%	-13%	33%	-22%	-54%	67%	10%	33%
1957	9%	-10%	-7%	-13%	-14%	6%	21%	303%	-20%	-79%	-53%	-53%
1958	-69%	-69%	-72%	-55%	-26%	-7%	59%	26%	-71%	89%	52%	28%
1959	-48%	-46%	-32%	-28%	-24%	-7%	32%	85%	-72%	-50%	-55%	-60%
1960	-72%	-53%	-11%	-18%	-14%	-36%	-9%	39%	-59%	-8%	-21%	26%
1961	41%	-11%	-21%	-30%	-27%	-21%	150%	-8%	-62%	-18%	-22%	-77%
1962	-68%	-53%	-41%	-36%	-39%	-31%	-9%	90%	-67%	-45%	-37%	-4%
1963	-72%	-60%	-48%	-46%	-42%	-9%	67%	-32%	-62%	-38%	-50%	-57%
1964	-23%	-24%	-29%	-27%	-22%	-5%	97%	29%	-60%	-68%	-72%	-55%
1965	74%	-6%	-31%	-33%	-25%	-28%	123%	162%	-68%	-62%	-64%	-73%
1966	-79%	-62%	-47%	-27%	-23%	-4%	18%	-9%	-49%	-42%	-32%	-1%
1967	-40%	-36%	-31%	-27%	-23%	-19%	66%	27%	-55%	-48%	-55%	-49%
1968	-16%	-14%	1%	-26%	-18%	12%	99%	183%	-77%	-67%	-82%	-38%
1969	-56%	-58%	-53%	-43%	-28%	-12%	-20%	40%	-56%	-36%	-42%	-44%
1970	-49%	-28%	-25%	0%	2%	-17%	15%	52%	-65%	-48%	-31%	-67%
1971	-51%	-47%	-46%	-42%	-33%	-9%	-2%	94%	-48%	-44%	-26%	-51%
1972	-58%	-62%	-61%	-60%	-52%	-50%	5%	142%	-74%	-56%	-36%	-60%
1973	-34%	-49%	-46%	-50%	-47%	-28%	80%	122%	-67%	-67%	-57%	-9%
1974	-57%	-60%	-59%	-47%	-46%	-52%	0%	41%	-55%	-42%	-50%	-47%
1975	-37%	-12%	26%	9%	-23%	-16%	88%	144%	-60%	-71%	-41%	-40%
1976	-34%	-28%	-23%	-24%	-23%	-1%	92%	2%	-60%	-54%	-62%	-58%
1977	-59%	-37%	-31%	-19%	-20%	-1%	41%	-49%	-74%	-65%	-71%	-54%
1978	15%	24%	23%	27%	32%	46%	109%	81%	-61%	-52%	-39%	-3%
1979	-6%	-4%	-8%	-9%	-5%	-8%	2%	119%	-61%	-60%	-45%	-22%
1980	-41%	-36%	-20%	-28%	-31%	-17%	42%	96%	-69%	-47%	8%	-19%
1981	-32%	-48%	-55%	-45%	-32%	-16%	73%	106%	-70%	-67%	-88%	-93%
1982	-54%	-18%	-19%	-14%	-9%	3%	42%	120%	-61%	-42%	-46%	-52%
1983	-66%	-55%	-46%	-35%	-29%	-24%	205%	339%	-45%	-68%	-61%	-39%
1984	-65%	-62%	-59%	-53%	-49%	-41%	53%	83%	-23%	-69%	-59%	-67%
1985	-77%	-70%	-63%	-58%	-50%	-24%	11%	138%	-79%	-69%	-71%	-63%
1986	-70%	-62%	-52%	-50%	-50%	-57%	14%	183%	-80%	-73%	-77%	-82%
1987	-78%	-67%	-54%	-23%	-40%	-32%	-10%	13%	-33%	-33%	-38%	-29%
1988	-51%	-48%	-45%	-36%	-35%	-41%	7%	40%	-67%	-45%	-51%	-67%
1989	-50%	-52%	-54%	-44%	-36%	-36%	-7%	0%	-61%	-66%	-54%	-44%
1990	-10%	-9%	-9%	-4%	1%	-9%	79%	60%	-71%	-55%	-45%	-52%
1991	-69%	-48%	-31%	-33%	-36%	-26%	60%	92%	-64%	-53%	-55%	-73%
1992	-45%	-44%	-40%	-23%	-19%	-23%	-7%	30%	-52%	-45%	-41%	-56%
1993	-47%	-51%	-42%	-38%	-37%	-35%	49%	77%	-46%	-57%	-11%	-46%
1994	-70%	-54%	-43%	-35%	-35%	-34%	-1%	6%	-43%	-10%	-3%	-13%
1995	-20%	-7%	-13%	-1%	-6%	22%	89%	294%	-17%	-71%	-54%	-44%
1996	-51%	-52%	-66%	-58%	-52%	-63%	88%	46%	-72%	-11%	-11%	-46%
1997	-56%	-49%	-36%	-38%	-30%	-35%	-7%	29%	-28%	-25%	-12%	-40%
1998	-33%	-50%	-42%	-40%	-36%	-33%	40%	53%	-53%	-40%	-41%	-22%
1999	-21%	-24%	-4%	-3%	-11%	-8%	194%	59%	-57%	-34%	-63%	-60%
2000	-59%	-46%	-49%	-48%	-51%	-41%	-44%	11%	-44%	-6%	-11%	-48%
2001	-43%	-48%	-40%	-45%	-25%	-2%	25%	44%	-66%	-49%	-71%	-54%
2002	-66%	-65%	-64%	-55%	-52%	-23%	1%	-22%	-58%	-21%	-8%	-64%
2003	-61%	-38%	-32%	-38%	-41%	-35%	7%	60%	-62%	-38%	-38%	-76%
2004	1%	-37%	-36%	-33%	-24%	-65%	11%	-16%	-50%	-55%	-52%	-22%
2005	-53%	-39%	-30%	-28%	-24%	-9%	23%	18%	-41%	-52%	-43%	-27%
2006	-29%	-55%	-44%	-38%	-26%	-28%	-47%	9%	-54%	24%	14%	-13%
2007	-71%	-57%	-51%	-47%	-37%	-59%	-40%	40%	-47%	-22%	-40%	-51%
2008	-58%	-45%	-40%	-35%	-32%	-19%	28%	127%	-51%	-56%	-17%	-6%
2009	50%	4%	-23%	-34%	-22%	-41%	2%	26%	-70%	-33%	-18%	11%
Average	-40%	-40%	-35%	-32%	-28%	-19%	40%	70%	-58%	-44%	-41%	-39%

ATTACHMENT 1 - C
Monthly Climate Change Deltas for the Fryingpan River near Thomasville
70th Percentile Climate Change Scenario

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1950	-51%	-46%	-37%	-32%	-30%	-11%	-20%	160%	-66%	-71%	-57%	-70%
1951	-25%	-26%	-45%	-40%	-27%	-20%	17%	158%	-76%	-52%	-64%	-13%
1952	-21%	9%	55%	19%	8%	98%	-45%	83%	-26%	-26%	-35%	-44%
1953	-9%	-36%	-45%	-33%	-31%	-17%	43%	222%	-71%	-70%	-82%	-52%
1954	-25%	-48%	-46%	-45%	-38%	-33%	-12%	-26%	-25%	-40%	-7%	-36%
1955	-27%	0%	-7%	-17%	-15%	-11%	12%	53%	-45%	-50%	-48%	144%
1956	5%	-21%	-1%	-9%	-4%	0%	51%	-23%	-40%	116%	43%	49%
1957	36%	22%	20%	6%	2%	6%	-16%	274%	-7%	-70%	-33%	-26%
1958	-64%	-61%	-68%	-54%	-28%	-18%	28%	66%	-79%	69%	34%	-12%
1959	-38%	-36%	-20%	-19%	-13%	4%	7%	83%	-43%	-19%	-30%	-39%
1960	-68%	-48%	2%	-6%	-1%	-27%	4%	35%	-45%	18%	3%	41%
1961	66%	6%	-11%	-21%	-19%	-15%	96%	33%	-51%	16%	26%	-62%
1962	-64%	-43%	-27%	-22%	-27%	-17%	10%	80%	-34%	-43%	-20%	23%
1963	-48%	-32%	-15%	-19%	-16%	18%	70%	-14%	-23%	7%	-25%	-32%
1964	-10%	-11%	-18%	-20%	-14%	3%	56%	25%	-20%	-50%	-58%	-33%
1965	95%	14%	-15%	-18%	-10%	-13%	171%	148%	-37%	-61%	-54%	-65%
1966	-80%	-63%	-46%	-25%	-21%	-3%	-21%	8%	-13%	-6%	17%	68%
1967	-27%	-24%	-16%	-12%	-6%	-2%	101%	32%	-38%	-29%	-38%	-40%
1968	17%	12%	19%	-16%	-7%	22%	72%	219%	-73%	-61%	-79%	-29%
1969	-49%	-46%	-47%	-41%	-30%	-23%	-36%	84%	-68%	-43%	-49%	-61%
1970	-50%	-12%	-9%	16%	15%	-9%	-17%	96%	-52%	-48%	-34%	-66%
1971	-58%	-53%	-52%	-48%	-42%	-23%	-2%	180%	-55%	-44%	-17%	-50%
1972	-42%	-51%	-54%	-55%	-46%	-46%	-10%	171%	-70%	-48%	-27%	-55%
1973	-38%	-40%	-36%	-43%	-42%	-24%	27%	178%	-55%	-68%	-59%	-10%
1974	-64%	-67%	-65%	-54%	-53%	-61%	-14%	78%	-62%	-46%	-57%	-56%
1975	-18%	8%	44%	17%	-17%	-16%	61%	172%	-49%	-71%	-42%	-47%
1976	-36%	-31%	-24%	-23%	-22%	-2%	25%	19%	-32%	-26%	-36%	-29%
1977	-45%	-26%	-23%	-11%	-11%	-2%	-1%	0%	-35%	-21%	-44%	-31%
1978	-2%	9%	8%	13%	11%	22%	106%	158%	-67%	-52%	-32%	-2%
1979	-22%	-27%	-28%	-27%	-22%	-27%	-21%	187%	-65%	-60%	-54%	-37%
1980	-23%	-20%	-8%	-23%	-24%	-15%	23%	121%	-61%	-46%	7%	-28%
1981	-11%	-28%	-43%	-33%	-23%	-12%	14%	145%	-60%	-62%	-87%	-91%
1982	-62%	-33%	-29%	-20%	-14%	1%	7%	136%	-33%	-38%	-35%	-48%
1983	-59%	-43%	-38%	-28%	-24%	-22%	228%	392%	-36%	-65%	-61%	-44%
1984	-49%	-41%	-39%	-34%	-29%	-31%	24%	97%	3%	-49%	-31%	-39%
1985	-66%	-58%	-53%	-49%	-39%	-16%	-30%	121%	-40%	-48%	-34%	-15%
1986	-56%	-47%	-38%	-37%	-38%	-52%	-27%	167%	-41%	-54%	-49%	-57%
1987	-74%	-66%	-54%	-24%	-39%	-34%	2%	43%	-36%	-36%	-32%	-11%
1988	-41%	-38%	-35%	-27%	-26%	-34%	-13%	40%	-33%	-11%	-24%	-49%
1989	-12%	-22%	-28%	-19%	-12%	-22%	-11%	21%	-27%	-45%	-34%	-14%
1990	-13%	-13%	-10%	-3%	1%	-10%	17%	86%	-51%	-29%	-7%	-21%
1991	-74%	-57%	-40%	-41%	-44%	-39%	41%	146%	-69%	-55%	-61%	-77%
1992	-27%	-30%	-31%	-17%	-12%	-22%	-20%	47%	-38%	-44%	-42%	-60%
1993	-35%	-37%	-32%	-30%	-31%	-32%	63%	102%	-36%	-52%	-10%	-50%
1994	-64%	-53%	-42%	-34%	-34%	-36%	14%	35%	-44%	-14%	7%	9%
1995	-9%	7%	-2%	10%	-1%	30%	70%	386%	-17%	-68%	-61%	-53%
1996	-44%	-40%	-57%	-48%	-41%	-55%	133%	41%	-44%	-7%	16%	-29%
1997	-48%	-39%	-27%	-29%	-24%	-30%	-14%	64%	-26%	-16%	-23%	-48%
1998	-46%	-60%	-51%	-45%	-41%	-36%	4%	61%	-21%	-37%	-31%	-17%
1999	-32%	-33%	-14%	-13%	-23%	-21%	194%	130%	-62%	-34%	-58%	-58%
2000	-66%	-59%	-60%	-58%	-59%	-53%	-56%	47%	-49%	-4%	-24%	-59%
2001	-22%	-34%	-30%	-38%	-16%	4%	6%	59%	-61%	-40%	-67%	-49%
2002	-50%	-52%	-53%	-45%	-44%	-21%	-18%	-21%	-33%	8%	11%	-54%
2003	-68%	-50%	-42%	-46%	-49%	-47%	-8%	102%	-68%	-42%	-47%	-80%
2004	20%	-24%	-27%	-25%	-15%	-62%	-12%	22%	-35%	-36%	-22%	26%
2005	-44%	-37%	-30%	-27%	-23%	-12%	42%	51%	-43%	-55%	-38%	-9%
2006	-42%	-63%	-52%	-43%	-31%	-31%	-60%	15%	-22%	31%	35%	-6%
2007	-76%	-67%	-61%	-58%	-48%	-67%	-53%	84%	-53%	-21%	-49%	-61%
2008	-47%	-28%	-30%	-27%	-25%	-14%	42%	162%	-42%	-51%	-15%	-11%
2009	42%	24%	-9%	-25%	-14%	-37%	-27%	59%	-59%	-36%	-23%	10%
Average	-33%	-32%	-28%	-26%	-23%	-18%	22%	98%	-44%	-33%	-31%	-29%

ATTACHMENT 2

Fry-Ark Project Bypass Requirements at Fryingpan River near Thomasville

Month	Flow Rate (cfs)
October	30
November	30
December	30
January	30
February	30
March	30
April	100
May	150
June	200
July	100
August	75
September	70

ATTACHMENT 3 - A
Estimated Fry-Ark Project Diversions (AF)
Base Conditions

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1950	163	147	171	153	152	187	880	9,772	31,259	8,025	152	147	51,209
1951	163	147	171	153	152	187	201	12,900	30,321	16,502	2,234	147	63,278
1952	163	147	171	153	152	187	3,991	25,081	48,425	16,972	5,201	391	101,034
1953	163	147	171	153	152	187	169	8,052	35,020	7,279	1,376	147	53,016
1954	163	147	171	153	152	187	147	7,849	2,139	793	152	147	12,201
1955	196	147	171	153	152	187	224	9,497	16,347	5,661	952	147	33,835
1956	163	147	171	153	152	187	353	22,282	23,594	1,621	152	147	49,122
1957	163	147	171	153	152	187	256	13,150	50,215	45,255	9,870	817	120,536
1958	163	147	171	153	152	187	147	24,331	30,376	1,784	152	147	57,911
1959	163	147	171	153	152	187	147	7,581	33,470	4,052	223	147	46,594
1960	169	147	171	153	152	187	1,348	10,331	29,890	5,198	208	147	48,102
1961	163	147	171	153	152	187	147	11,492	17,411	1,265	152	2,177	33,618
1962	1,394	147	171	153	152	187	8,192	22,206	37,307	21,368	1,780	147	93,205
1963	163	147	171	153	152	187	147	11,394	4,978	322	198	153	18,165
1964	163	147	171	153	152	187	147	16,242	20,457	8,345	888	147	47,200
1965	163	147	171	153	152	187	1,381	14,259	38,947	33,724	6,115	2,948	98,349
1966	1,526	147	171	153	152	187	183	14,511	9,860	2,351	204	147	29,593
1967	163	147	171	153	152	187	147	11,427	23,435	10,805	376	147	47,311
1968	163	147	171	153	152	187	147	6,981	35,863	7,338	4,344	147	55,793
1969	163	147	171	153	152	187	1,793	20,067	18,087	12,728	621	144	54,414
1970	1,333	147	171	153	152	187	326	25,518	31,359	13,651	625	3,580	77,203
1971	471	147	171	153	152	237	3,953	8,774	31,624	14,185	445	470	60,782
1972	283	147	171	153	152	187	143	9,568	29,833	4,380	152	207	45,376
1973	475	147	171	153	152	187	147	14,987	32,919	23,765	2,699	152	75,956
1974	163	147	171	153	152	257	965	24,704	26,408	5,837	551	147	59,657
1975	163	147	171	153	152	187	189	8,907	27,978	21,326	1,590	196	61,160
1976	163	147	171	153	152	187	147	12,372	15,668	4,240	426	147	33,974
1977	163	147	171	153	152	187	147	3,828	5,720	516	152	147	11,484
1978	163	147	171	153	152	196	211	10,365	43,788	16,956	1,160	147	73,609
1979	163	147	171	153	152	187	147	12,850	40,693	17,017	1,398	147	73,226
1980	163	147	171	153	152	187	232	10,461	37,263	8,802	152	147	58,032
1981	154	147	171	153	152	187	890	11,428	26,537	5,163	2,383	1,841	49,205
1982	1,588	147	171	153	152	187	147	9,457	37,371	18,742	3,316	807	72,239
1983	212	147	171	153	152	187	147	6,665	44,027	33,869	10,901	497	97,128
1984	154	147	171	153	152	187	147	31,157	52,523	33,201	10,553	1,664	130,209
1985	911	149	171	153	152	187	1,131	20,617	39,166	12,381	1,137	144	76,301
1986	342	147	171	153	152	425	459	15,199	41,393	13,894	1,588	1,103	75,026
1987	287	147	171	153	152	187	1,871	17,644	21,713	3,244	435	147	46,151
1988	163	147	171	153	152	187	147	12,536	26,263	2,796	204	147	43,067
1989	163	147	171	153	152	187	1,569	5,539	4,990	1,691	275	147	15,184
1990	299	147	171	153	152	187	147	6,481	28,340	5,063	152	147	41,439
1991	190	131	136	136	158	187	131	16,913	36,070	8,227	537	146	62,963
1992	157	153	153	153	161	211	983	19,659	20,055	8,283	1,058	200	51,225
1993	137	131	136	136	144	194	426	23,538	47,189	23,476	2,195	631	98,333
1994	182	148	143	143	166	195	1,302	19,442	26,168	1,645	145	140	49,818
1995	145	166	450	207	139	153	165	6,058	45,815	45,354	12,424	934	112,011
1996	134	148	146	136	131	180	845	30,344	44,119	11,060	471	240	87,955
1997	198	132	153	153	145	444	966	29,195	51,306	14,683	3,795	297	101,468
1998	293	183	189	189	191	194	194	16,979	28,658	17,947	2,749	230	67,996
1999	171	153	144	161	167	165	231	13,060	39,333	11,489	3,856	952	69,882
2000	253	142	135	146	159	199	1,239	30,582	24,964	4,625	168	238	62,850
2001	168	149	135	135	137	161	691	21,042	20,179	3,213	1,311	144	47,465
2002	152	131	137	145	126	155	231	6,817	4,390	154	154	150	12,742
2003	163	147	171	153	152	187	278	20,629	32,682	5,022	168	580	60,333
2004	71	51	53	52	53	124	50	12,203	9,876	2,591	52	50	25,228
2005	41	36	41	50	63	82	145	16,760	26,015	6,578	709	86	50,606
2006	345	39	34	31	48	66	3,101	26,829	28,331	6,155	197	42	65,217
2007	520	39	34	31	48	78	862	22,417	25,291	5,882	852	196	56,250
2008	64	115	105	104	95	116	472	17,684	51,763	23,958	3,031	101	97,609
2009	86	95	116	119	114	127	1,131	32,089	37,169	9,496	378	115	81,033
Average	289	139	161	145	144	187	781	15,678	29,706	11,366	1,832	438	60,865

ATTACHMENT 3 - B
Estimated Fry-Ark Project Diversions (AF)
70th %ile Climate Scenario

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1950	163	147	171	153	152	187	353	35,501	3,302	375	152	147	40,804
1951	163	147	171	153	152	187	393	37,691	821	5,317	204	147	45,546
1952	163	147	171	153	152	187	885	48,307	40,440	11,438	1,849	147	104,040
1953	163	147	171	153	152	187	498	24,613	4,018	321	152	147	30,722
1954	163	147	171	153	152	187	147	4,497	332	150	152	147	6,398
1955	163	147	171	153	152	187	318	19,414	3,889	1,237	166	147	26,145
1956	163	147	171	153	152	187	1,782	16,258	11,685	6,776	171	147	37,792
1957	163	147	171	153	152	187	147	54,068	48,639	13,880	5,153	363	123,223
1958	163	147	171	153	152	187	304	35,360	2,124	5,566	152	147	44,626
1959	163	147	171	153	152	187	147	21,213	14,255	2,816	152	147	39,704
1960	163	147	171	153	152	187	1,571	16,865	11,449	6,833	219	147	38,057
1961	163	147	171	153	152	187	190	18,352	3,729	1,763	179	147	25,333
1962	165	147	171	153	152	187	9,490	42,478	21,314	10,091	977	147	85,472
1963	163	147	171	153	152	187	260	9,471	1,927	447	152	147	13,378
1964	163	147	171	153	152	187	147	22,246	14,051	2,176	152	147	39,892
1965	163	147	171	153	152	187	8,615	42,753	21,691	10,332	953	147	85,465
1966	165	147	171	153	152	187	147	17,091	7,320	2,036	268	147	27,985
1967	163	147	171	153	152	187	842	16,994	10,396	6,383	152	147	35,886
1968	163	147	171	153	152	187	147	33,496	2,073	729	152	147	37,717
1969	163	147	171	153	152	187	502	36,895	421	5,030	152	147	44,120
1970	163	147	171	153	152	187	184	42,254	9,189	4,793	152	235	57,781
1971	163	147	171	153	152	187	3,806	37,063	8,016	5,944	216	147	56,166
1972	163	147	171	153	152	187	147	31,386	2,416	867	152	147	36,089
1973	163	147	171	153	152	187	180	43,996	8,713	4,528	183	147	58,720
1974	163	147	171	153	152	187	679	46,157	3,238	1,194	152	147	52,540
1975	163	147	171	153	152	187	613	30,798	8,547	3,037	288	147	44,403
1976	163	147	171	153	152	187	194	16,903	7,306	2,029	152	147	27,704
1977	163	147	171	153	152	187	147	4,126	2,087	336	152	147	7,968
1978	163	147	171	153	152	229	2,960	34,468	7,505	5,617	305	147	52,019
1979	163	147	171	153	152	187	147	34,181	7,009	4,070	152	147	46,679
1980	163	147	171	153	152	187	588	30,389	7,852	3,193	153	147	43,296
1981	154	147	171	153	152	187	1,198	40,200	3,455	156	152	147	46,272
1982	163	147	171	153	152	187	146	30,916	21,367	9,899	776	142	64,220
1983	163	147	171	153	152	187	1,167	34,805	29,881	9,091	1,987	147	78,051
1984	154	147	171	153	152	187	147	37,892	53,216	15,413	5,930	373	113,935
1985	163	149	171	153	152	187	278	47,357	21,284	3,970	349	147	74,362
1986	163	147	171	153	152	187	144	43,905	20,627	3,876	152	147	69,825
1987	163	147	171	153	152	187	1,976	29,036	9,894	958	147	147	43,133
1988	163	147	171	153	152	187	147	20,941	13,942	2,140	154	147	38,444
1989	163	147	171	153	152	187	1,154	8,617	825	148	152	147	12,016
1990	299	147	171	153	152	187	195	18,450	8,437	2,545	152	147	31,036
1991	190	131	136	136	158	187	131	39,585	3,349	1,405	136	131	45,676
1992	157	153	153	153	161	211	662	33,355	7,866	2,666	221	148	45,907
1993	137	131	136	136	144	194	1,376	40,019	29,384	8,723	1,657	131	82,170
1994	182	148	143	143	166	195	1,766	29,205	10,194	1,115	145	140	43,542
1995	145	166	450	207	139	153	190	43,201	41,856	12,538	2,428	165	101,639
1996	101	148	146	136	131	180	8,159	42,742	21,047	9,967	752	131	83,641
1997	183	132	153	153	145	245	601	47,527	41,442	11,563	2,064	148	104,357
1998	170	183	189	189	191	194	203	31,310	20,756	9,570	1,052	175	64,182
1999	171	153	144	161	167	164	3,355	29,642	8,057	5,824	305	155	48,296
2000	200	142	135	146	159	199	145	42,231	8,055	4,221	154	149	55,935
2001	168	149	135	135	137	161	776	38,529	2,422	705	135	131	43,583
2002	152	131	137	145	126	155	153	4,361	1,577	157	154	149	7,397
2003	163	147	171	153	152	187	198	32,405	3,657	1,663	152	147	39,196
2004	71	51	53	52	53	58	50	17,198	2,987	633	52	50	21,310
2005	41	36	41	50	63	82	976	25,885	9,809	1,020	107	66	38,176
2006	51	39	34	31	48	66	30	31,862	20,755	9,570	818	30	63,333
2007	64	39	34	31	48	66	31	41,186	7,560	3,559	31	30	52,679
2008	64	115	105	104	95	116	1,613	39,706	31,667	9,427	2,100	101	85,213
2009	86	95	116	119	114	127	324	45,508	8,584	4,463	174	115	59,824
Average	155	139	161	145	144	177	1,064	31,214	12,662	4,605	605	147	51,217

ATTACHMENT 3 - C
Estimated Fry-Ark Project Diversions (AF)
50th %ile Climate Scenario

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1950	163	147	171	153	152	187	1,708	29,055	4,182	460	152	147	36,676
1951	163	147	171	153	152	187	243	35,373	3,235	4,076	226	147	44,274
1952	163	147	171	153	152	187	816	48,211	33,393	12,680	2,596	150	98,819
1953	163	147	171	153	152	187	1,617	21,322	4,883	384	152	147	29,480
1954	163	147	171	153	152	187	250	4,698	148	152	152	147	6,520
1955	163	147	171	153	152	187	204	11,859	3,606	867	152	147	17,809
1956	163	147	171	153	152	187	1,237	18,715	6,744	4,554	152	147	32,522
1957	163	147	171	153	152	187	316	55,300	31,903	16,966	3,595	200	109,253
1958	163	147	171	153	152	187	164	33,654	4,509	4,269	152	147	43,867
1959	163	147	171	153	152	187	147	16,854	11,509	2,869	152	147	32,651
1960	163	147	171	153	152	187	1,073	20,035	6,029	4,698	159	147	33,115
1961	163	147	171	153	152	187	150	11,825	3,593	1,434	152	147	18,275
1962	165	147	171	153	152	187	6,983	41,718	19,742	13,614	1,526	152	84,710
1963	163	147	171	153	152	187	147	7,320	629	197	152	147	9,566
1964	163	147	171	153	152	187	147	18,223	11,208	2,205	152	147	33,056
1965	163	147	171	153	152	187	6,391	42,524	20,615	14,137	1,571	156	86,368
1966	165	147	171	153	152	187	147	13,280	4,299	1,180	160	147	20,188
1967	163	147	171	153	152	187	357	18,462	4,626	3,873	152	147	28,590
1968	163	147	171	153	152	187	155	28,039	1,717	542	152	147	31,725
1969	163	147	171	153	152	187	343	35,421	2,334	3,894	152	147	43,264
1970	163	147	171	153	152	187	303	42,638	5,623	3,790	152	147	53,626
1971	163	147	171	153	152	197	3,236	27,102	14,678	6,555	277	150	52,981
1972	163	147	171	153	152	187	253	26,810	2,127	644	152	147	31,107
1973	163	147	171	153	152	187	311	44,574	5,838	3,603	152	147	55,598
1974	163	147	171	153	152	187	1,208	38,116	6,651	2,101	152	147	49,349
1975	163	147	171	153	152	187	948	27,746	8,941	3,642	345	147	42,742
1976	163	147	171	153	152	187	205	13,214	4,747	1,048	152	147	20,487
1977	163	147	171	153	152	187	916	4,512	1,283	263	152	147	8,247
1978	174	147	171	153	152	251	2,507	27,000	14,510	6,413	394	147	52,020
1979	163	147	171	153	152	187	155	32,553	5,625	4,064	152	147	43,670
1980	163	147	171	153	152	187	1,101	27,169	8,144	3,687	164	147	41,387
1981	154	147	171	153	152	187	2,598	29,843	4,079	159	152	147	37,942
1982	163	147	171	153	152	187	271	33,538	10,838	11,240	954	153	57,968
1983	163	147	171	153	152	187	1,404	34,556	26,832	9,352	2,540	147	75,805
1984	154	147	171	153	152	187	366	38,497	38,780	19,901	4,608	241	103,358
1985	163	149	171	153	152	187	1,742	45,670	15,387	5,901	361	147	70,184
1986	163	147	171	153	152	187	806	41,873	14,166	5,390	152	147	63,508
1987	163	147	171	153	152	187	4,310	31,488	1,980	357	152	147	39,407
1988	163	147	171	153	152	187	147	16,399	10,784	2,094	168	147	30,713
1989	163	147	171	153	152	187	538	6,900	147	152	152	147	9,010
1990	299	147	171	153	152	187	246	15,338	5,811	1,734	152	147	24,537
1991	190	131	136	136	158	187	131	34,973	6,717	2,114	136	131	45,140
1992	157	153	153	153	161	211	884	27,651	7,938	3,152	239	148	41,000
1993	137	131	136	136	144	194	1,692	40,076	26,783	9,176	2,299	132	81,038
1994	182	148	143	143	166	195	3,860	30,730	1,908	337	145	140	38,096
1995	145	166	450	207	139	153	179	43,218	36,058	13,949	3,188	165	98,017
1996	101	148	146	136	131	180	5,055	41,575	18,762	13,024	1,199	196	80,653
1997	183	132	153	153	145	245	599	47,959	35,024	13,240	2,872	148	100,853
1998	170	183	189	189	191	194	365	33,423	10,035	10,624	1,131	191	56,885
1999	171	153	144	161	167	164	2,897	25,187	14,981	6,598	391	155	51,168
2000	200	142	135	146	159	199	404	39,429	6,960	4,323	154	149	52,401
2001	168	149	135	135	137	161	1,535	30,498	2,135	525	135	131	35,844
2002	152	131	137	145	126	155	149	4,827	1,202	164	154	149	7,492
2003	163	147	171	153	152	187	572	28,714	7,119	2,459	152	147	40,136
2004	71	51	53	52	53	58	50	11,061	3,139	509	52	50	15,201
2005	41	36	41	50	63	82	3,198	27,026	1,327	278	55	53	32,251
2006	51	39	34	31	48	66	129	34,647	11,045	11,008	998	46	58,141
2007	64	39	34	31	48	66	198	38,596	6,304	3,517	31	30	48,957
2008	64	115	105	104	95	116	1,821	38,861	27,032	9,207	2,493	101	80,115
2009	86	95	116	119	114	127	723	46,366	5,521	3,725	119	115	57,226
Average	155	139	161	145	144	178	1,177	29,037	10,264	4,885	656	143	47,083

ATTACHMENT 3 - D
Estimated Fry-Ark Project Diversions (AF)
30th %ile Climate Scenario

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1950	163	147	171	153	152	187	1,809	31,007	1,049	203	152	147	35,341
1951	163	147	171	153	152	187	1,014	29,509	3,233	6,640	273	165	41,808
1952	163	147	171	153	152	187	1,051	39,199	38,494	9,414	2,577	155	91,864
1953	163	147	171	153	152	187	1,631	22,035	1,762	206	152	147	26,906
1954	163	147	171	153	152	187	157	1,011	147	152	152	147	2,739
1955	163	147	171	153	152	187	867	11,611	1,484	418	152	147	15,652
1956	163	147	171	153	152	187	1,202	16,793	7,097	4,553	152	147	30,918
1957	163	147	171	153	152	187	555	55,594	44,695	8,209	2,507	151	112,684
1958	163	147	171	153	152	187	781	29,852	4,580	6,881	152	147	43,366
1959	163	147	171	153	152	187	187	21,469	2,076	1,079	152	147	26,084
1960	163	147	171	153	152	187	907	17,401	6,033	4,484	153	147	30,099
1961	163	147	171	153	152	187	293	11,047	1,393	751	152	147	14,756
1962	165	147	171	153	152	187	7,048	44,144	4,849	9,675	436	147	67,274
1963	163	147	171	153	152	187	243	5,934	147	152	152	147	7,748
1964	163	147	171	153	152	187	181	23,047	1,718	610	152	147	26,828
1965	163	147	171	153	152	187	6,334	44,685	5,367	9,984	494	147	67,986
1966	165	147	171	153	152	187	364	13,142	1,185	540	152	147	16,505
1967	163	147	171	153	152	187	238	16,424	4,370	3,528	152	147	25,833
1968	163	147	171	153	152	187	147	30,291	771	357	152	147	32,838
1969	163	147	171	153	152	187	970	30,627	2,337	6,329	156	147	41,540
1970	163	147	171	153	152	187	504	37,635	3,564	4,892	150	227	47,945
1971	163	147	171	153	152	212	3,795	25,188	10,810	5,906	157	147	47,002
1972	163	147	171	153	152	187	156	28,801	1,287	434	152	147	31,952
1973	167	147	171	153	152	187	583	39,177	4,230	4,891	205	147	50,210
1974	163	147	171	153	152	187	956	38,043	5,770	1,486	152	147	47,527
1975	163	147	171	153	152	187	906	28,364	4,369	2,947	304	147	38,011
1976	163	147	171	153	152	187	820	13,479	1,794	360	152	147	17,727
1977	163	147	171	153	152	187	313	453	147	152	152	147	2,338
1978	168	147	171	153	152	282	3,116	24,885	10,587	5,744	243	147	45,797
1979	163	147	171	153	152	187	147	30,096	8,934	4,000	156	147	44,453
1980	163	147	171	153	152	187	1,007	27,646	3,475	3,048	151	147	36,448
1981	154	147	171	153	152	187	2,755	32,639	545	152	152	147	37,354
1982	163	147	171	153	152	187	337	29,035	7,603	8,889	371	147	47,356
1983	163	147	171	153	152	187	968	32,033	24,539	7,880	2,017	147	68,558
1984	154	147	171	153	152	187	273	37,504	46,038	7,275	1,876	147	94,078
1985	163	149	171	153	152	187	1,576	49,070	1,507	617	152	147	54,045
1986	163	147	171	153	152	187	716	45,334	703	952	152	147	48,976
1987	163	147	171	153	152	187	1,476	21,492	10,832	1,102	152	147	36,175
1988	163	147	171	153	152	187	147	20,989	2,018	570	152	147	24,996
1989	163	147	171	153	152	187	1,275	5,880	147	152	152	147	8,725
1990	299	147	171	153	152	187	1,199	14,987	2,035	756	152	147	20,386
1991	190	131	136	136	158	187	131	34,749	5,646	1,565	136	131	43,297
1992	157	153	153	153	161	211	857	28,738	3,591	2,510	225	148	37,057
1993	137	131	136	136	144	194	1,122	38,267	23,246	7,372	1,609	131	72,626
1994	182	148	143	143	166	195	1,258	21,837	10,870	1,258	145	140	36,486
1995	145	166	450	207	139	153	277	39,993	41,811	11,158	3,488	166	98,153
1996	101	148	146	136	131	180	5,223	43,539	4,479	9,342	320	131	63,875
1997	183	132	153	153	145	245	754	40,098	40,266	9,838	2,836	148	94,952
1998	170	183	189	189	191	194	522	29,854	7,644	8,857	689	183	48,865
1999	171	153	144	161	167	164	3,325	23,927	10,825	5,759	221	155	45,172
2000	200	142	135	146	159	199	321	34,109	9,882	4,121	151	149	49,714
2001	168	149	135	135	137	161	1,174	34,568	1,420	384	135	131	38,697
2002	152	131	137	145	126	155	237	4,150	369	154	154	149	6,059
2003	163	147	171	153	152	187	355	28,468	6,105	1,913	152	147	38,113
2004	71	51	53	52	53	58	50	9,704	1,263	194	52	50	11,654
2005	41	36	41	50	63	82	514	21,490	10,652	1,182	83	53	34,288
2006	81	39	34	31	48	66	208	30,250	8,300	8,760	402	30	48,248
2007	64	39	34	31	48	66	147	34,219	9,287	3,504	63	30	47,530
2008	64	115	105	104	95	116	1,192	36,877	24,767	7,819	1,990	101	73,345
2009	86	95	116	119	114	127	1,213	40,326	3,315	4,735	199	115	50,559
Average	156	139	161	145	144	179	1,131	27,545	8,458	3,780	482	140	42,459

Appendix D.1 - Surface Water Hydrology Affected Environment Supplement

Introduction

Appendix D.1 supplements the Surface Water Hydrology portion of Chapter 3 - Affected Environment. This appendix contains more information about the environment that could be affected by implementation of the alternatives.

Methods

In order to analyze the effects of the alternatives, a study period was chosen to represent the hydrology in the study area. Chapter 4 and associated appendices evaluate the effects of the alternatives on streamflow during a 28-year study period from 1982 - 2009. This study period was chosen because it characterizes typical years, contains extreme low and high flow years, and includes operations of important actions that affect hydrology in the study area. A statistical summary of the study period, as compared to the long-range statistics for the Arkansas River at Cañon City gage, is presented in Table 1. The annual flows, as compared with the mean long-term flows, are shown in Figure 1.

The mean for the study period is 4.6 percent higher than the overall long-term period of record; however, the median is less than 0.1 percent lower than the overall period of record. The primary reason for the higher mean flow is the increase in transmountain imports to the basin during the study period, as compared to the overall period of record. The long-term minimum and maximum years are included in the study period. As described in previous sections, several significant events affect the annual flows shown in the Arkansas River at Cañon City gage hydrograph, such as West Slope diversions into the basin, storage in Pueblo Reservoir and Turquoise Lake, operation of Twin Lakes Dam, and Colorado Canal transfers from agriculture to municipal uses.

Table 1. Statistical Comparison of Annual Flow at Arkansas River at Cañon City Gage for Full Period of Record and EIS Study Period

Statistic	Value (ac-ft)		Percent Difference Study Period to Overall (%)
	Overall 1900-2009	Study Period 1982-2009	
Absolute Minimum	202,440	202,440	0
Median	511,476	511,102	-0.1
Mean	520,345	544,175	4.6
Absolute Maximum	940,328	940,328	0

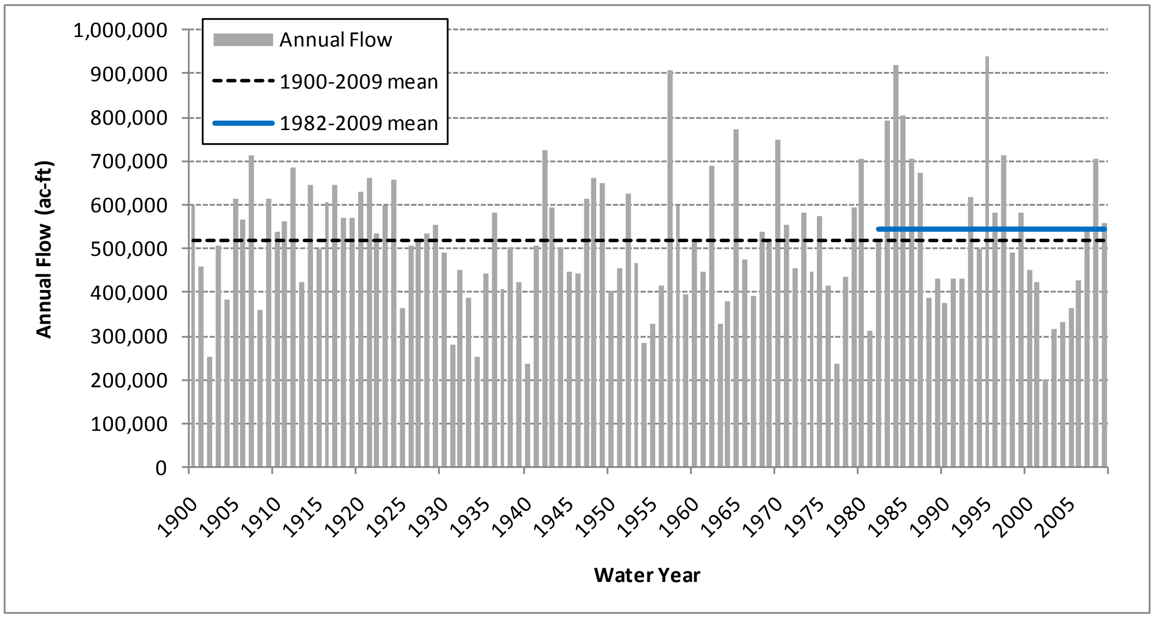


Figure 1. Arkansas River at Cañon City Gage Annual Flow

Affected Environment

The following sections supplement the surface water hydrology affected environment information in Chapter 3.

Native Water Rights

Water users own rights to surface water according to water rights seniority and availability. When there is not enough water in the river to meet all water rights, a call is placed on the river, and diversions are satisfied based on the date of appropriation of the water right. Figure 2 shows major water rights, date of appropriation, and how frequently the major water rights get their full share of water. Historically, water rights with priority dates earlier than 1874 are nearly always in priority. There are a large number of water rights with appropriation dates between 1874 and 1890, consequently, water rights later than 1890 have historically only been in priority less than 20 percent of the time.

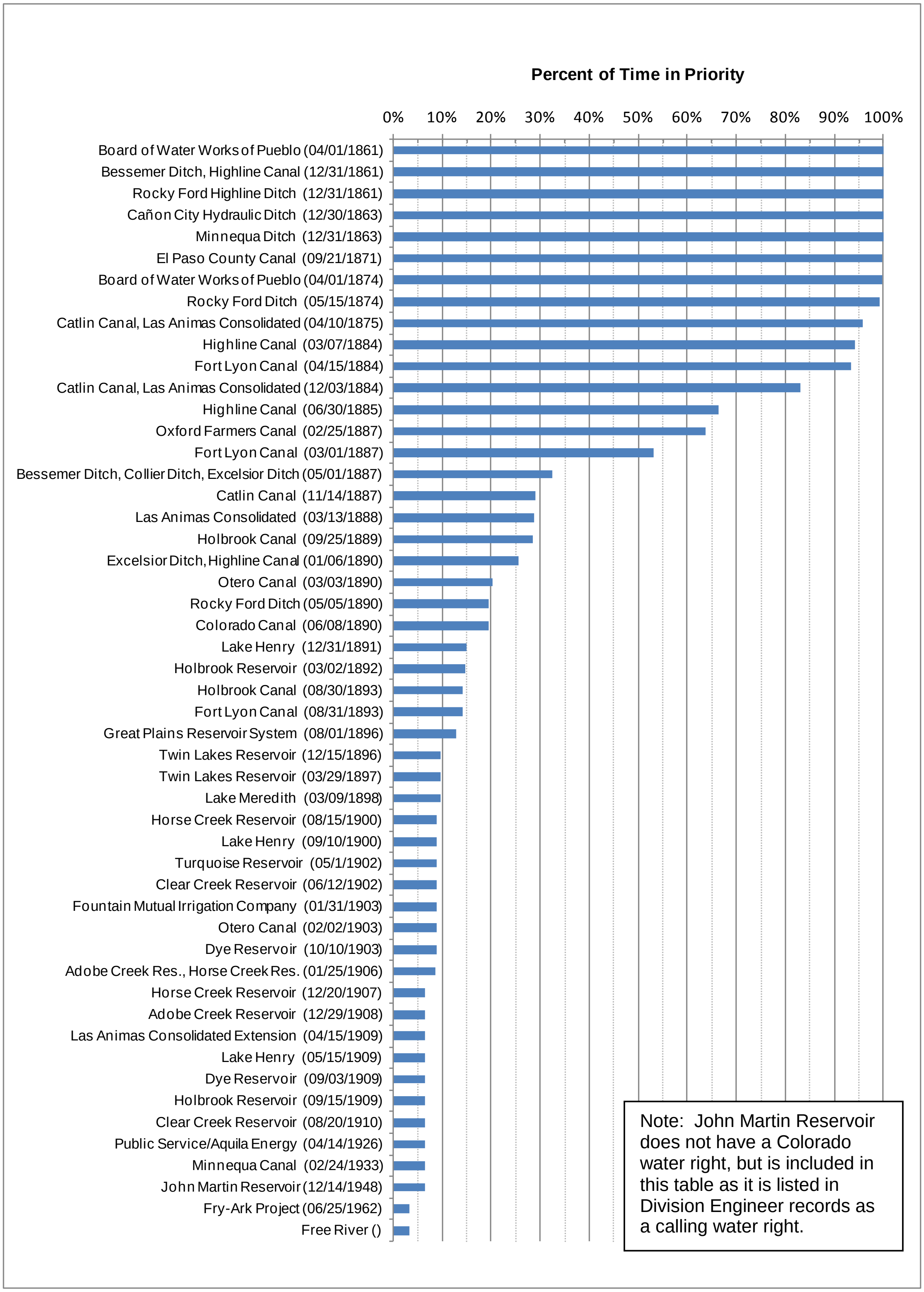


Figure 2. Major Direct Flow and Storage Water Rights on Arkansas River in Study Area

Exchanges and Alternate Points-of-Diversion

Exchanges and alternate points-of-diversion are the primary means for moving consumptive use water to upstream storage and conveyance facilities. There are several decreed exchanges on the Arkansas River as well as numerous others that currently have applications in water court or are being considered by municipal entities within the basin. Many of the exchanges into Pueblo Reservoir are governed by the water right stipulation of June 5, 1985, that allows entities exchanging into Pueblo Reservoir storage to share exchange opportunities. A summary of the decreed, pending, and potential future exchanges into Pueblo Reservoir is presented in Table 2.

Because alluvial groundwater is hydraulically connected to streams, pumping alluvial wells can cause decreases in streamflow at times when water rights for the wells are not in-priority (sometimes referred to as out-of-priority diversions). To protect senior water rights from injury, streamflow depletions are “replaced” in time and volume through augmentation plans using various sources of water. Sources of water can include but are not limited to reservoir releases, purchase of reusable return flows, or other surface water rights.

Flow Management Programs and Minimum Flow Requirements

The high demand and limited supply of water in the Arkansas River require various operational rules and legal requirements to be enforced. There are several legally binding flow programs and minimum flow requirements within the study area along the Arkansas River. Table 3 presents a summary of these programs, including those agencies that are a party to the program, the location of flow measurement, a brief description, whether the program is mandatory or voluntary, and whether it applies to exchanges or to reservoir release. Many of the minimum flows are tied to decreed change cases and exchanges.

Table 2. Major Arkansas River Exchange Priorities into Pueblo Reservoir

Priority	Beneficiary	Amount	Case	Priority Date
1	Southeastern	[1]	B42135, 88CW143, 84CW56	2/10/1939
2	Board of Water Works of Pueblo	27 cfs	83CW18, 84CW62, 84CW63, 84CW64, 84CW35, 84CW202, 84CW203, 84CW177, 84CW178	6/05/1985
3	Colorado Canal Company Agricultural Entities	100 cfs		
4	Board of Water Works of Pueblo	50 cfs		
	Colorado Canal Companies	50 cfs		
5	Colorado Canal Companies	50 cfs		
6	Colorado Springs	77 cfs minus Board of Water Works of Pueblo Exchange under #2 and #4		
7	City of Aurora	Applicable Maximum Rate of Flow Allowed by Decree in 83CW18		
8	Colorado Springs	100 cfs minus Colorado Springs Exchange under #6		
9	Colorado Canal Companies	1/2 of remaining exchange potential up to 756 cfs		
	Colorado Springs	1/2 of remaining exchange potential minus Rocky Ford I under #9		
	City of Aurora	Up to 40 cfs of 1/2, but not to exceed 500 ac-ft annually; thereafter 25% of 1/2 up to an additional 500 ac-ft annually.		
10	Colorado Springs	William Creek Reservoir		
11	Pueblo West	6.0 cfs (measured return flows)	85CW134A	12/31/1985
12	City of Aurora (Rocky Ford II)	Applicable Maximum Rate of Flow Allowed by Decree in 99CW169	99CW169	12/28/1999
13	City of Pueblo	[2]	01CW160	5/15/2000
	City of Fountain	60 cfs	01CW108, 01CW146	[4]
	Southeastern	50 cfs [3]	01CW151	[4]
	Pueblo West	100 cfs	01CW152	[4]
14	Aurora – Rocky Ford Highline	500 cfs	05CW105	[4]
15	Southeastern	Varies	06CW8	[4]
	Restoration of Yield Storage – Holbrook Reservoir	2,000 cfs	06CW120	[4]
16	Super Ditch	Varies	10CW4	[4]
17	Other currently undecreed exchanges, including return flows originating from non-tributary groundwater	[5]	[5]	[5]

Notes
[1] Measured Municipal Fry-Ark Project Return Flows generated and re-purchased by the same entity.
[2] See discussion on Pueblo Flow Management Program in below sections.
[3] Non-measured Municipal and Agricultural Fry-Ark Project Return Flows.
[4] Priority yet to be determined.
[5] No water rights application or decree.

Table 3. Flow Management Programs and Minimum Flow Requirements

Program	Binding Parties	Type [1]	Location	Description
Lake Fork CWCB Instream Flow Right	Reclamation	Mandatory Storage Bypass/Release	Lake Fork downstream from Turquoise Lake	Decreed minimum flow of 15 cfs from Sugarloaf Dam outlet to Willow Creek, 20 cfs from Willow Creek to Arkansas.
Lake Creek CWCB Instream Flow Right	Aurora	Mandatory Exchange/APOD Curtailments	Lake Creek downstream from Twin Lakes	Decreed instream flow right of 15 cfs.
Salida Q710	Exchangers	Mandatory Exchange/APOD Curtailments	Salida WWTP Effluent Discharge	Nov-Jan, 189 cfs; Feb-Apr, 180 cfs; May-Jul, 239 cfs; Aug-Oct, 229 cfs.
Salida Q710	Aurora	Mandatory Exchange/APOD Curtailments	Salida WWTP Effluent Discharge	Sep-Jun, 240 cfs; Jul-Aug, 260 cfs
Chaffee County Recreational In-Channel Diversion	Water Right	Mandatory Exchange/APOD Curtailments	Arkansas River near Wellsville gage	Mar 15-Thurs. before last Mon. in May, target 250 cfs; Fri. before last Mon. in May-June 30, target 700-1,800 cfs (adjustable); Jul 1-Aug 31, target 700 cfs; Aug 16-Nov 15, target 250 cfs.
Upper Arkansas Voluntary Flow Management Program	Southeastern, Colorado Department of Natural Resources, Colorado Division of Parks and Wildlife, Chaffee County, Arkansas River Outfitters Association, & Trout Unlimited Volunteers: Reclamation, Colorado Springs, Aurora & Board of Water Works of Pueblo	Voluntary Exchange/ APOD Curtailments and Storage Releases	Arkansas River near Wellsville gage	Aug 16-Jun 30, target 250 cfs; Jul 1-Aug 15, target 700 cfs
Arkansas River Outfitters Association Stipulation	Aurora (Rocky Ford I and II and leased agricultural water)	Mandatory Exchange/APOD Curtailments	Arkansas River near Wellsville gage	Gage / Maximum exchange 0-249 / 0, 250-499 / 50, 500-999 / 75, 1000-1499 / 125, 1500-1999 / 175, 2000-2999 / 250, 3000+ / 500
Fremont County Q710	Exchangers	Mandatory Exchange/APOD Curtailments	Fremont County WWTP Effluent Discharge	190 cfs minimum flow
Pueblo Reservoir Inflows	Aurora	Mandatory Exchange/APOD Curtailments	Arkansas River at Portland gage	155 cfs native flow when all senior water rights diverting.
Pueblo Flow Management Program and Recreational In-Channel Diversion [2]	Exchangers, water right	Mandatory Exchange/APOD Curtailments	Arkansas River Legacy Whitewater Park	100-500 cfs target flow. Exchanges curtailed when flow is less than target flow. Target flow varies based on hydrologic state.
Stipulation	Aurora (Rocky Ford I and II and leased agricultural)	Mandatory Exchange/APOD Curtailments	Arkansas River at Moffat St. gage	57 cfs minimum flow

Table 3. Flow Management Programs and Minimum Flow Requirements (continued)

Program	Binding Parties	Type [1]	Location	Description
Arkansas River Low Flow Program	Board of Water Works of Pueblo, Colorado Springs Utilities	Voluntary Storage Releases	Arkansas River at Downstream of Fish Hatchery Return Flows	3,000 ac-ft of water stored in Pueblo Reservoir available to be released during times when is flow is less than 50cfs.
St. Charles Mesa Pumping Plant Minimum Flows	Colorado Springs and Aurora	Mandatory Exchange/APOD Curtailments	Arkansas River at Moffat St. gage	Exchanges curtailed if SCMWD is pumping, flow is < 50 cfs and specific conductance is >850 µS/cm.
Pueblo Flow Management Program [2]	Fountain, Colorado Springs Utilities, Aurora, Board of Water Works of Pueblo, Southeastern and City of Pueblo	Mandatory Exchange/APOD Curtailments	Arkansas River at Combined Flow location [3]	85 cfs target flow
Avondale Flow Requirements [2]	Aurora (Rocky Ford II from Lake Meredith)	Mandatory Exchange/APOD Curtailments	Arkansas River near Avondale gage	500 cfs minimum flow
La Junta Flow Requirements	Aurora (Rocky Ford I and II during recoup.)	Mandatory Exchange/APOD Curtailments	Arkansas River at La Junta gage	35 cfs minimum flow
Dry-Streambed	Aurora	Mandatory Exchange/APOD Curtailments	Any river location within exchange reach (generally Rocky Ford ditch to Pueblo Reservoir)	10 cfs (excluding reservoir releases and transmountain)
Transmountain Project Bypass Flows	Reclamation, Southeaster, Twin Lakes Reservoir and Canal Company, Colorado Springs Utilities, Aurora	Mandatory Storage Bypass	Multiple locations in the Roaring Fork drainage, Fryingpan drainage, and Homestake drainage	Multiple bypass flow requirements.

Notes:
(1) APOD is an alternate-point-of-diversion. WWTP is wastewater treatment plant.
(2) For Colorado Canal exchanges, Arkansas Valley Ditch Assoc. must be notified when flow reaches 500 cfs.
(3) Combined flow location is downstream of Runyon Lake and Black Hills Powerplant return flows.

Upper Arkansas Voluntary Flow Management Program

The Upper Arkansas Voluntary Flow Management Program is designed to provide water for fisheries and recreation in the Upper Arkansas River. The program is primarily aimed at target flows for release of Fry-Ark Project water from Twin Lakes and Turquoise Lake to Pueblo Reservoir. Several entities are party to the program (see Table 3), and other entities, such as Colorado Springs, the Board of Water Works of Pueblo and the city of Aurora, coordinate storage releases with the program. The flow recommendations are “intended to provide an annual flow regime that helps the state maintain the brown trout fishery, meet the demand for boating recreation, support the region’s tourism industry, and allow managers of the Arkansas Headwaters Recreation Area to meet their obligation to manage recreation and natural resources within the area’s boundaries” (King 2012).

Recommended flows for the program are defined at the Arkansas River near Wellsville gage. Components of the recommended flows include the following (King 2012):

1. The highest priority is the maintenance of a minimum year-round flow of at least 250 cfs to protect the fishery.

2. Spawning flows (October 15 to November 15) should remain as stable as possible to enhance spawning success. Winter incubation flows (mid-November through April) should be maintained at a level of not more than 5 inches below river height during the spawning period. The optimum incubation flow range is from 250 to 400 cfs, depending on spawning flows:

If the Spawning Flow (October 15 – November 15) is between:	Then the Minimum Incubation Flow (November 16 – (April 30) is:
300-500 cfs	250 cfs
500-600 cfs	325 cfs
600-700 cfs	400 cfs

3. To the extent possible, between April 1 and May 15, Reclamation should maintain flows within the range of 250 cfs to 400 cfs in order to provide conditions favorable to egg hatching and fry emergence.

4. Subject to water and storage availability, Reclamation should augment flows during the July 1 to August 15 period to maintain flows at 700 cfs through releases from the Fry-Ark Project. The 700 cfs is a target; when augmentation occurs, every effort should be made to ensure that flows are as near 700 cfs as possible. Colorado Parks and Wildlife, using funds collected from commercial outfitters, shall be responsible for replacing evaporative losses caused by summer augmentation.

5. Deliveries in excess of 10,000 acre-feet (July 1 – August 15) should be subject to review and consideration, prior to such deliveries, by Reclamation, Southeastern and the Colorado Department of Natural Resources.

6. Reclamation should avoid dramatic fluctuations on the river as much as possible throughout the year. When it is necessary to alter flow rates, Reclamation should limit the daily change to 10 to 15 percent. In addition, to the extent that water and storage conditions allow flow augmentation through August 15, the ramp down shall begin at approximately 8:00 am on August 15. Reclamation should reduce flows as close to the 10 percent level as possible on August 15 and thereafter ramp down flows each day as close to the 15 percent level as possible until the river reaches native flow.

7. It may be possible to improve feeding conditions for brown trout by reducing flows between Labor Day and October 15 in years when flows would otherwise be higher than those recommended by Colorado Parks and Wildlife. If potential benefits warrant the effort, Arkansas Headwater Recreation Area managers, Colorado Parks and Wildlife,

> Reclamation and the Division 2 Engineer should work with water users to seek opportunities for reducing flows after Labor Day.

In addition, based on further discussions with program participants, if possible within Reclamation constraints, the Department of Natural Resources suggests the following: if there is a need to increase flows above 400 cfs during the winter incubation flow period, the Department of Natural Resources recommends that these increased flows occur prior to March 1. Further, if possible, flows should not exceed 600 cfs from November 16 to February 28. If additional water must be moved, it is preferred these releases occur prior to March 15 or during runoff when native flows exceed 1,000 cfs provided that flows do not exceed Arkansas Headwaters Recreation Area High Water Advisory thresholds of 1,200 cfs at the Arkansas River below Granite gage (USGS 0708050) or 3,200 cfs at the Arkansas River at Parkdale gage (USGS 07094500) (King 2012).

City of Pueblo Flow Management Program and Recreational In-Channel Diversion

In 2001, the City of Pueblo filed a Recreational In-Channel Diversion water right application in Division 2 Water Court (01CW160), which was decreed April 5, 2006 with a priority date of May 15, 2000 (Colorado Water Court 2006). Shortly after the Recreational In-Channel Diversion application, Colorado Springs, Board of Water Works of Pueblo, City of Aurora, Southeastern, and other entities signed two intergovernmental agreements for a target flow program on the Arkansas River through the City of Pueblo. Releases from storage are not made to meet intergovernmental agreement target flows. The target flows only curtail exchanges by entities that are party to the intergovernmental agreement.

A schematic of this reach is shown in Figure 3. The dashed red line in Figure 3 shows AVC's three possible intake points: 1) Pueblo Dam (Comanche South, Pueblo Dam South, and Pueblo Dam North alternatives), 2) Joint Use Pipeline (Joint Use Pipeline North Alternative), and 3) below the City of Pueblo boat course (River South Alternative). The components of the program (City of Pueblo et al. 2004a, 2004b) are shown in Figure 3 and discussed below

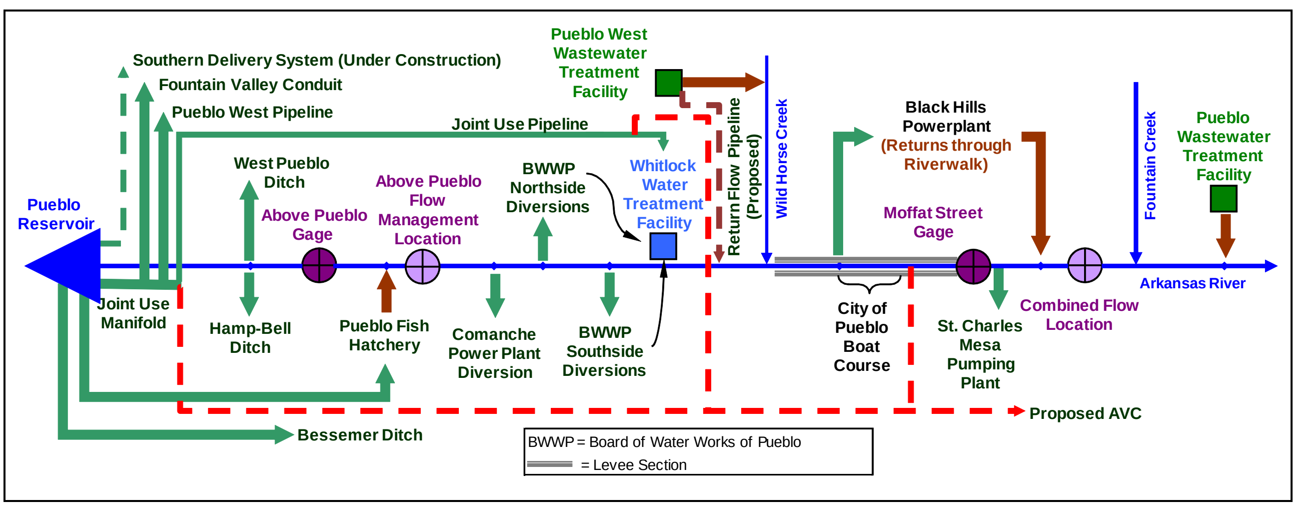


Figure 3. Schematic of Arkansas River Through the City of Pueblo

- Year-round Flows – Exchanges (or changes of water rights) will be reduced or curtailed as necessary to attain an average daily flow of 100 cfs at the Arkansas River above Pueblo gage (including Pueblo Fish Hatchery return flows and an amount equal to any below dam diversions by or for the benefit of the parties to the agreement). Likewise, exchanges will be reduced or curtailed to attain an average daily flow of 85 cfs at the combined flow location (downstream from the inflow from Runyon Lake, and above the confluence with Fountain Creek).
- Recreational Flows – From March 16 through November 14 of each year, exchanges (or changes of water rights) will be reduced or curtailed as necessary to maintain the average flows specified in Figure 4. The "Above Average" flows shown on the graph shall apply when the National Resources Conservation Service "most probable" forecast for the Arkansas River at Salida is 100 percent or more, and the "Below Average" flow shall apply when the forecast is less than 100 percent.
- Equitable Allocation of Operational Hours – The original intergovernmental agreement contained a clause "to generally achieve on a monthly basis a 50/50 balance of time between periods of reduction of the Subject Exchanges and periods of no reduction of the Subject Exchanges." The exchanges are curtailed to the extent necessary to meet flow targets on Thursdays at 3:00 p.m. to accommodate recreational uses over the weekend period. The exchanges would cease to be curtailed at 12:00 p.m. on Mondays to allow entities party to the intergovernmental agreement to realize their exchange potential.
- Dry-Year Exception - No obligation to reduce or curtail exchanges when the "Most Probable Flow" forecast by the Natural Resources Conservation Service is below 70 percent.

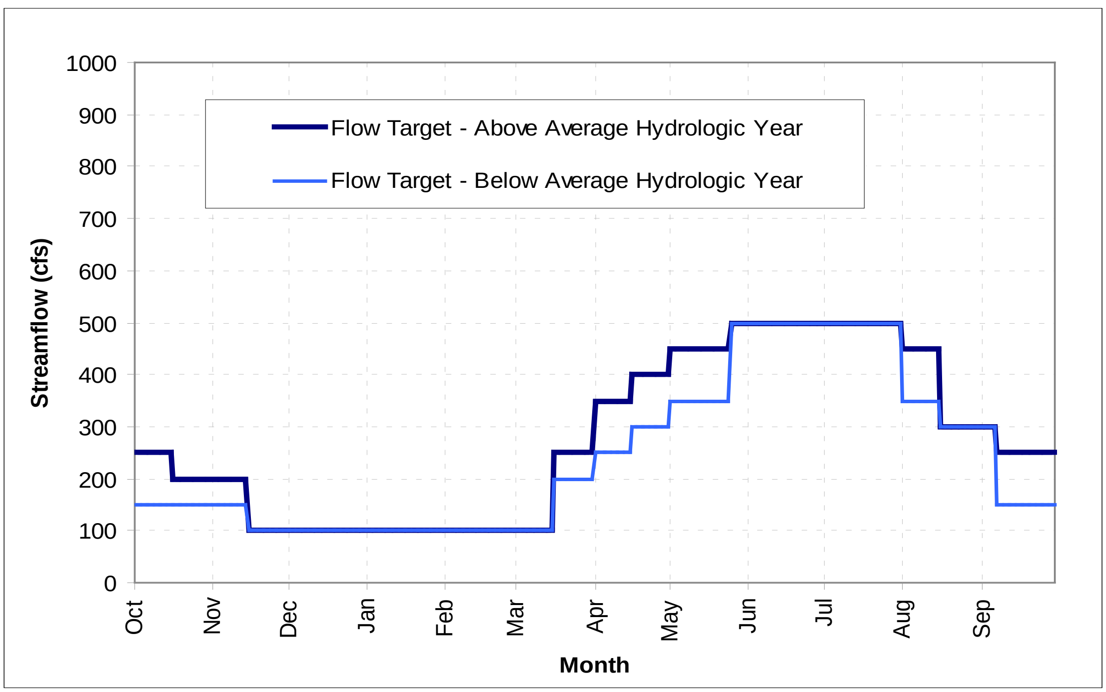


Figure 4. Recreational Flow Targets at the Arkansas River Above Pueblo Gage for Pueblo Flow Management Program

Restoration of Yield was developed in principle as part of the Pueblo Flow Management Program Intergovernmental Agreements (City of Pueblo et al. 2004a, 2004b). The intent of the program is to develop operations and facilities that would allow the signatory parties to recover a portion of the reusable return flows not stored in Pueblo Reservoir by exchange because of parties' participation in the Pueblo Flow Management Program or due to hydrologic conditions. The city of Aurora has signed a temporary agreement with the Holbrook Irrigating Company to use excess capacity in the Holbrook system as part of the Restoration of Yield program (Holbrook and Aurora 2005). The city of Aurora then signed agreements with other Restoration of Yield participants to divide the available excess capacity between the participants (Aurora et al. 2005).

The agreement between Aurora and Holbrook allows use of the entire Holbrook system by Aurora, including both Holbrook Reservoir and Dye Reservoir. The Temporary Substitute Water Supply Plan that was obtained by Aurora to administer the program includes the ability to divert unexchanged reusable return flows in the Colorado Canal system as well (Wolfe 2005).

The active storage capacity for Holbrook Reservoir is approximately 6,200 acre-feet (Simpson 2005). The agreements state the Restoration of Yield participants may use "Excess Capacity" in the reservoirs. Thus, the Restoration of Yield participants can only store water in Holbrook Reservoir when space is available beyond Holbrook's normal operations.

Water used to fill Holbrook Reservoir under normal operations can be diverted by several means: the Holbrook Reservoir native flow storage rights (priority dates of 3/2/1892 and 9/15/1909), by exchange from lower portions of the Arkansas River, release from Colorado Canal system reservoirs, and through the Winter Water Storage Program (Division 2 diversion and water rights records). Because the native water rights' priority dates are relatively junior, the reservoirs are only able to divert water during times of high flow on the river and do not always fill under their native flow right. The reservoirs often fill during the Winter Water season. However, as part of the agreements, Holbrook will operate so that Winter Water does not spill Restoration of Yield participant water from the Holbrook system if Winter Water storage space is available in Pueblo Reservoir (Holbrook and Aurora 2005).

Arkansas River Low Flow Program

The Arkansas River Low Flow Program's goal is to promote the biological health of the Arkansas River and the success of the Corridor Legacy Project (Board of Water Works Pueblo and Colorado Springs Utilities 2009). The program is an agreement in which the Board of Water Works of Pueblo and Colorado Springs Utilities each make 1,500 ac-ft of water stored in Pueblo Reservoir available to be released during times when the flow in the river at the Arkansas River above Pueblo location (defined as Arkansas River above Pueblo gage plus hatchery return flows) is less than 50cfs. The Board of Water Works of Pueblo and Colorado Springs Utilities can use their existing contract space in Pueblo Reservoir or pursue additional excess capacity storage contracts to provide water for the program. Colorado Springs Utilities' participation in this program will begin when the Southern Delivery System Project begins water deliveries, which is scheduled for 2016.

Transmountain Project Bypass Flows

Individual diversion structures on the Fry-Ark collection system are limited based upon a 1978 agreement (Table 4; Southeastern et al. 1978) that establishes bypass flow requirements, while diversions of the Fryingpan River near Thomasville gage are further limited by the original Fry-Ark Operating Principals (Table 5; U.S House of Representatives 1960).

Table 4. Bypass Flows below Fry-Ark Collection System Diversion Structures

Location	Bypass Flow (cfs)
Roaring Fork Drainage	
Hunter Creek below diversion	12.0
Midway Creek below diversion	5.0
No Name Creek below diversion	4.0
Hunter Creek at confluence with Roaring Fork	21.0
Fryingpan Drainage	
Fryingpan River below diversion	10.4
South Fork below diversion	5.6
Chapman Gulch below diversion	3.0
Sawyer Lake Creek below diversion	1.0
Lily Pad Creek below diversion	0.6
Ivanhoe Creek below diversion	1.4
Middle Cunningham Creek below diversion	0.9
North Cunningham Creek below diversion	0.9
South Cunningham Creek below diversion	0.5
Mormon Creek below diversion	1.6
Carter Creek below diversion	1.6
North Fork Creek below diversion	0.9
Granite Creek below diversion	1.6
Total Fryingpan drainage	30.0

Source: Southeastern et al. 1978

Table 5. Bypass Flows for Fryingpan River near Thomasville Gage

Start Date	End Date	Bypass Flow (cfs)
1-Oct	31-Mar	30
1-Apr	30-Apr	100
1-May	31-May	150
1-Jun	30-Jun	200
1-Jul	31-Jul	100
1-Aug	31-Aug	75
1-Sep	30-Sep	65

Source: Fry-Ark Operating Principals (U.S. House of Representatives 1960)

The Operating Principles provide for the Fry-Ark Project, by agreement with the Twin Lakes Reservoir and Canal Company, to operate an exchange to maintain specified target streamflows in the Roaring Fork River. The Twin Lakes Reservoir and Canal Company agrees to bypass water on Lincoln Creek and the Roaring Fork, up to 3,000 acre-feet per year to maintain minimum flows between October 1 and September 30 (Table 6). The Fry-Ark then delivers a like amount (adjusted for transit losses) to the Twin Lakes Reservoir and Canal Company in Twin Lakes (Reclamation 2010).

Table 6. Bypass Flows for Independence Pass Transmountain Collection System

Month	Grizzly Diversion (cfs)	Roaring Fork Diversion (cfs)
October	3.0	0.0
November	3.0	0.0
December	3.0	0.0
January	3.0	0.0
February	3.0	0.0
March	3.0	0.0
April	3.0	0.0
May	3.0	0.0
June	4.0	4.0
July	4.0	4.0
August	4.0	3.0
September	4.0	3.0

Source: Reclamation 2010
Notes:
(1) The water exchange will be implemented October 1 through September 30.
(2) The releases to the Roaring Fork River at the Roaring Fork Diversion Dam and Lincoln Creek at the Grizzly Diversion Dam shall be accounted as shown in the table.
(3) At any time the Twin Lakes Reservoir and Canal Company is bypassing water, in addition to that designated above, it will be assumed that the Company could not have diverted that water and will not receive any credit for exchange in excess of the above amounts.
(4) In the event less water than the above amounts is bypassed, only the amount actually bypassed will be credited.
(5) The total volume of the release at both gages combined shall not exceed 3,000 acre-feet in any one water year.
(6) No credit for exchange will be made on days when there is no documentation of such bypasses.
(7) No credit will be given for water bypassed when diversions are called out by the State Engineer.

The Homestake Project collection system is restricted by minimum bypass flow requirements stipulated to as part of the environmental permitting process (Table 7). The Homestake Project will occasionally divert water from the various tributary streams and release water from Homestake Reservoir to meet the bypass flow requirement at the Homestake Creek at Gold Park gage (Colorado Water Conservation Board 2007).

Table 7. Homestake Project Bypass Flows

Location of Bypass Measurement	Amount (cfs)
French Creek Diversion Dam	1.67
Fancy Creek Diversion Dam	1.00
Missouri Creek Diversion Dam	3.00
Sopris Creek Diversion Dam	2.00
East Fork Homestake Creek Diversion Dam	2.67
Middle Fork Homestake Creek Diversion Dam	6.00
USGS Gage Homestake Creek at Gold Park	24.00

Streamflow

This section presents supplemental information on streamflow gages within the study area, including a description of each gage and historical average monthly streamflow. Historical monthly streamflow values were developed from daily data by averaging the daily streamflow for each day during the month. The monthly streamflow was then averaged for each year throughout the study period (unless otherwise noted) to calculate the historical monthly streamflow provided in this section (e.g., one average streamflow for each month of the year). Average daily historical streamflow graphs are also presented for certain gages to supplement information in Chapter 3.

Arkansas River – Headwaters to Salida

The Arkansas River from its headwaters to Salida generally corresponds to Water District 11. The Arkansas River at Leadville gage is the most upstream gage in this reach and documents streamflow immediately above the affected reach. The Arkansas River near Wellsville gage is located about 3 miles downstream of Salida, and is included in this reach as the most downstream gage. This reach also includes gages on Lake Fork Creek and Lake Creek immediately downstream from Turquoise Lake and Twin Lakes, respectively. Several streamflow gages in this reach are used to administer flow management and other flow programs, and data are often accessed by recreational water users within the reach (Table 8 and Table 9).

- Arkansas River at Leadville, CO (07081200): The Arkansas River at Leadville gage essentially measures native Arkansas River flows upstream from the Lake Fork confluence and will be used as the headwaters gage in the simulation model. A small volume of transbasin water from the Columbine, Ewing and Wurtz ditches and a small volume of water diversion and use in the Leadville area must be adjusted to estimate true native flows. The period-of-record for this gage is 1967 through present. The Colorado Decision Support System dataset is missing data for the gage for water years 1984-1989 and part of 1990.

- Lake Fork Creek below Sugar Loaf Dam (07082500): The Lake Fork Creek below Sugar Loaf Dam gage essentially measures releases from Turquoise Lake through its river outlet to Lake Fork (Figure 5). The gage is located upstream from tributary inflows, including Halfmoon Creek. The period-of-record for this gage is 1970 through present. The Colorado Decision Support System dataset is missing data for the gage in 1991.

- Lake Creek below Twin Lakes (LAKBTLCO): The Lake Creek below Twin Lakes gage essentially measures releases from Twin Lakes through its river outlet to Lake Creek (Figure 6). The gage is located upstream from tributary inflows. The period-of-record for this gage is 1954 through present. The Colorado Decision Support System dataset is missing data for the gage in 1985, 1991, and 1992.

- Arkansas River at Granite (07086000): The Arkansas River at Granite gage is located downstream from the confluence of Lake Creek and the Arkansas River, but upstream from the confluence with Clear Creek. Therefore, the Granite gage is influenced by any transmountain water released from Twin Lakes and Turquoise Lake downstream, as well as the storage and releases of native Arkansas River flows (Figure 7). The period-of-record for this gage is 1910 through present, with missing data only in the first year of record.

- Arkansas River near Nathrop (07091200): The Arkansas River near Nathrop gage is located on the Arkansas River near the town of Nathrop, immediately upstream from

Brown's Canyon. Readings at the Arkansas River near Nathrop gage are currently only made during the summer months. There are two periods of continuous measurements at the Arkansas River near Nathrop gage: 1965 through 1982 and 1989 through 1993. Therefore, streamflow data are incomplete from 1983 to 1989 and 1994 to present at the Arkansas River near Nathrop gage.

- Arkansas River at Salida (07091500): The Arkansas River at Salida gage is adjacent to the town of Salida, upstream from the town's wastewater treatment facilities. The Arkansas River at Salida gage has a long, continuous period-of-record (1910 through present) and its projected streamflow by the National Resources Conservation Service (NRCS) is used as a basis for determining target flows for the Pueblo Flow Management program.

- Arkansas River near Wellsville (07093700): The Arkansas River near Wellsville gage is downstream from Salida, and includes discharges from the Salida wastewater treatment facility. The Arkansas River near Wellsville gage is important in the Arkansas River Basin because it is used to administer the Upper Arkansas Voluntary Flow Management Program. The period-of-record for this gage is 1961 through present, with missing data for a short period in September 1989.

Table 8. Historical Mean Monthly Flow – Arkansas River from Headwaters to Granite

Month	Historical Mean Monthly Streamflow (cfs)		
	Arkansas River at Leadville gage [(1)]	Lake Fork Creek below Sugar Loaf Dam gage [(2)]	Lake Creek below Twin Lakes gage [(3)]
Jan	17	4	123
Feb	16	4	144
Mar	20	4	143
Apr	38	8	122
May	173	23	412
Jun	309	66	675
Jul	138	76	470
Aug	67	25	253
Sep	37	7	86
Oct	30	5	68
Nov	24	4	67
Dec	19	4	90
Average	74	19	222

Notes:
(1) Data missing for water years 1984 to1989 and a portion of 1990. Data filled using regression equation with (Arkansas River at Granite gage – Lake Fork Creek below Sugar Loaf Dam gage – Lake Creek below Twin Lakes gage).
(2) Data missing for water year 1991. Data filled using Lake Fork Creek above Sugar Loaf Dam gage.
(3) Data missing for water years 1985 and 1991 to1992. Data filled using mass balance of Twin Lakes storage, gage data for Lake Creek above Twin Lakes and Mt. Elbert Conduit inflows.

Table 9. Historical Mean Monthly Flow - Arkansas River from Granite to Wellsville

Month	Historical Mean Monthly Streamflow (cfs)			
	Arkansas River at Granite	Arkansas River near Nathrop [(1)]	Arkansas River at Salida	Arkansas River near Wellsville
Jan	186	329	324	400
Feb	206	365	328	402
Mar	216	349	333	398
Apr	241	342	332	387
May	744	1,004	980	1,098
Jun	1,303	1,846	1,923	2,082
Jul	862	1,161	1,260	1,332
Aug	456	719	733	804
Sep	195	379	384	445
Oct	163	319	345	408
Nov	151	310	337	423
Dec	167	280	321	408
Average	408	781	634	717

Note:
(1) Data missing water years 1983 through 1989, and only operated seasonally 1994 to present. Values are average of available data.

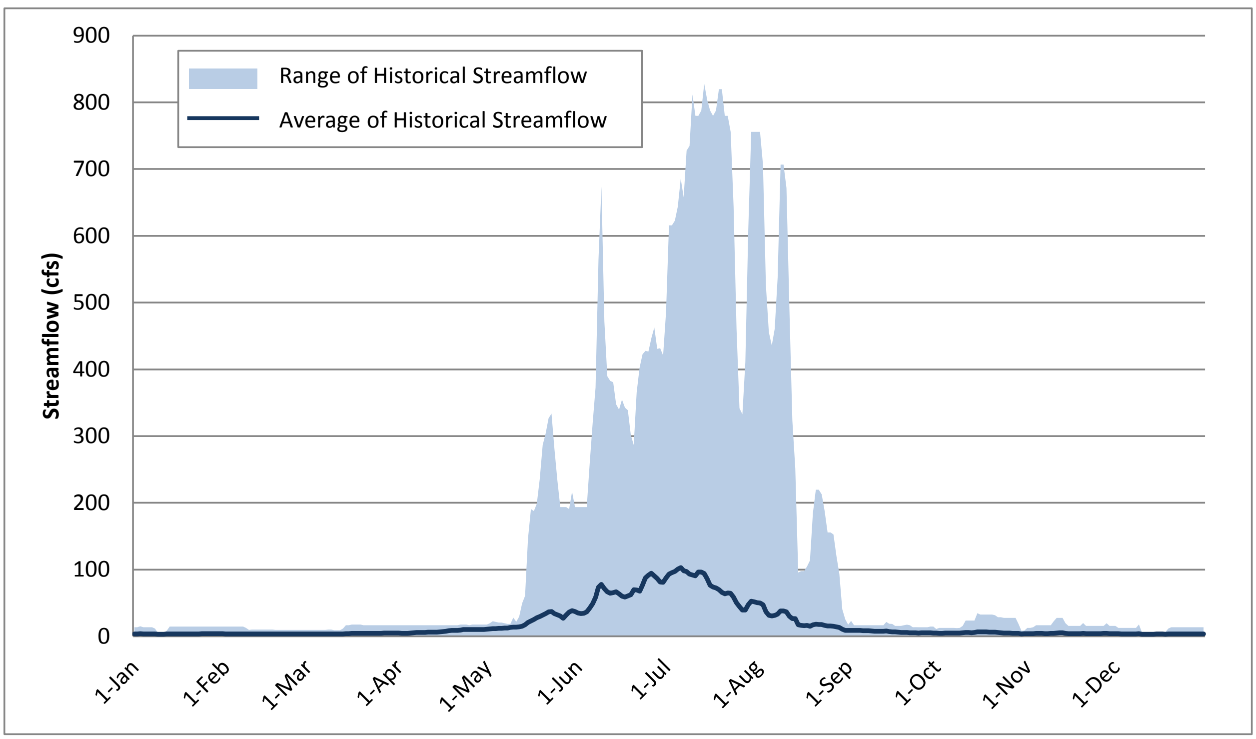


Figure 5. Average Daily Historical Streamflow – Lake Fork below Sugar Loaf Dam

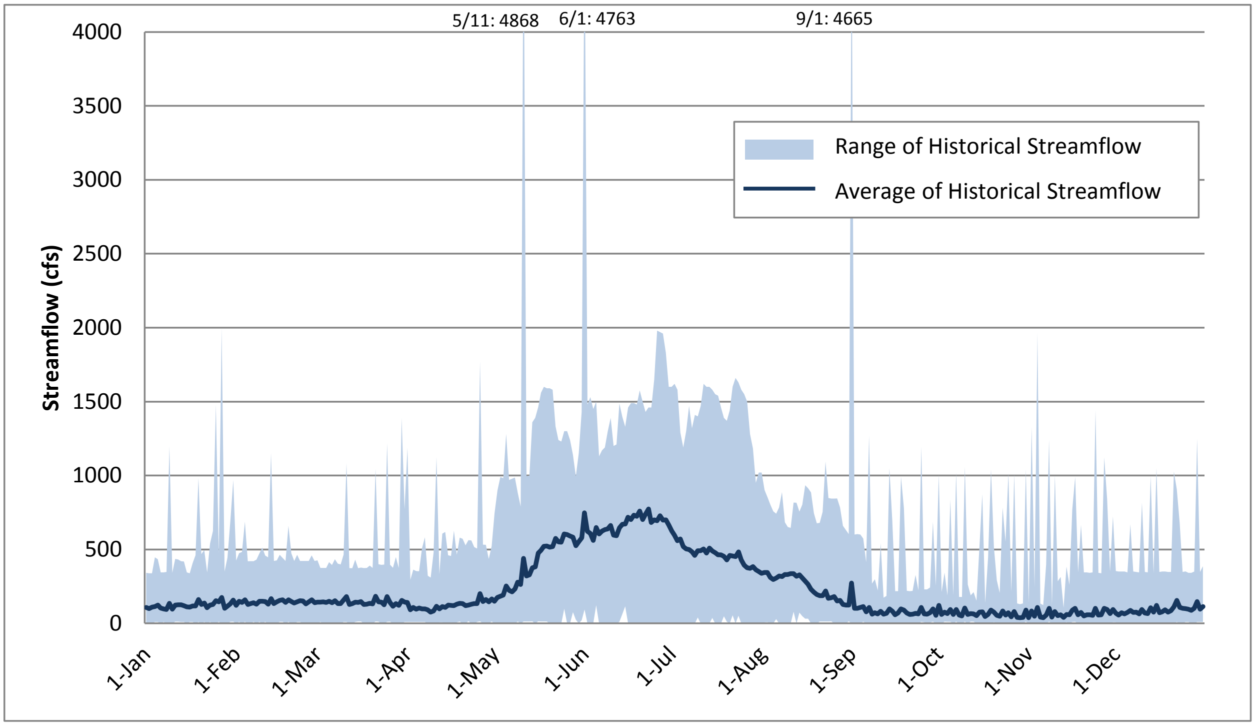


Figure 6. Average Daily Historical Streamflow – Lake Creek below Twin Lakes

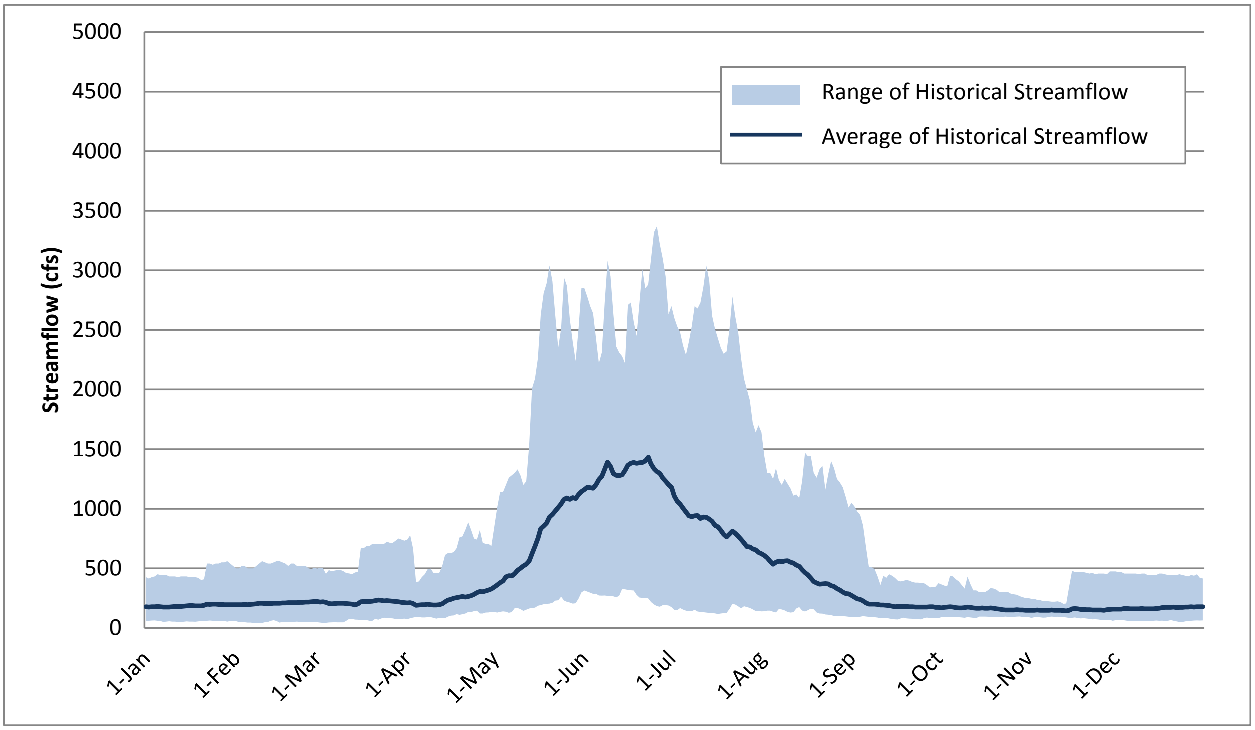


Figure 7. Average Daily Historical Streamflow - Arkansas River at Granite

Arkansas River – Salida to Pueblo Reservoir

The reach of river from Salida to Pueblo Reservoir corresponds to Water District 12. Agricultural diversions begin to affect streamflow within this reach. Gages include those on the Arkansas River and one on Grape Creek, a tributary to the Arkansas River within this reach (Table 10).

- Arkansas River at Parkdale (07094500): The Arkansas River at Parkdale gage is located west of Cañon City upstream from the Royal Gorge. The gage is upstream from most major diversions and inflows that begin in the Cañon City area, including Grape Creek. The period-of-record for the gage is 1945 to present, with missing data from 1956-1964. The gage has been operated seasonally (i.e. from spring through fall) since 1995.

- Grape Creek near Westcliffe (07095000): The Grape Creek near Westcliffe gage is the only gaging station on Grape Creek and is located approximately 0.5 miles upstream from DeWeese Reservoir. DeWeese Reservoir is located approximately 24 miles upstream from the Grape Creek confluence with the Arkansas River. The confluence is less than one mile upstream from the Arkansas River at Cañon City gage. The gage is influenced by irrigation diversions and return flows in the Wet Mountain Valley upstream from the gage (Figure 8). The Grape Creek near Westcliffe gage has been in continuous operation since 1930.

- Arkansas River at Cañon City (07096000): The Arkansas River at Cañon City gage has the longest period-of-record on the Arkansas River, dating back to 1889, with some missing data between 1890 and 1896. Although flows at the gage are influenced by transmountain diversions and storage, there are relatively few consumptive use diversions upstream from the gage (Figure 9). Therefore, as shown previously shown, it can be used to investigate long-term streamflow trends in the basin.

- Arkansas River at Portland (07097000): The Arkansas River at Portland gage is about four miles upstream from Pueblo Reservoir, and is the closest gage to the upstream end of the reservoir. Essentially, the gage measures streamflow into the reservoir, as there is nearly no tributary inflow between the gage and the reservoir. The overall period-of-record for this gage is from 1939 to 1952 and 1975 to present. There are no missing data for the EIS study period.

Table 10. Historical Mean Monthly Flow - Arkansas River from Salida to Pueblo Reservoir

Month	Historical Mean Monthly Streamflow (cfs)			
	Arkansas River at Parkdale gage [(1)]	Grape Creek near Westcliffe gage	Arkansas River at Cañon City gage	Arkansas River at Portland gage
Jan	469	14	426	417
Feb	484	17	437	420
Mar	487	33	456	438
Apr	454	50	421	465
May	1,223	57	1,141	1,258
Jun	2,328	84	2,242	2,368
Jul	1,522	47	1,379	1,476
Aug	927	36	804	912
Sep	511	19	396	456
Oct	511	17	367	433
Nov	517	19	407	458
Dec	474	15	426	431
Average	936	34	743	796

Note:
(1) Gage operated seasonally since 1995. Values are an average of available data.

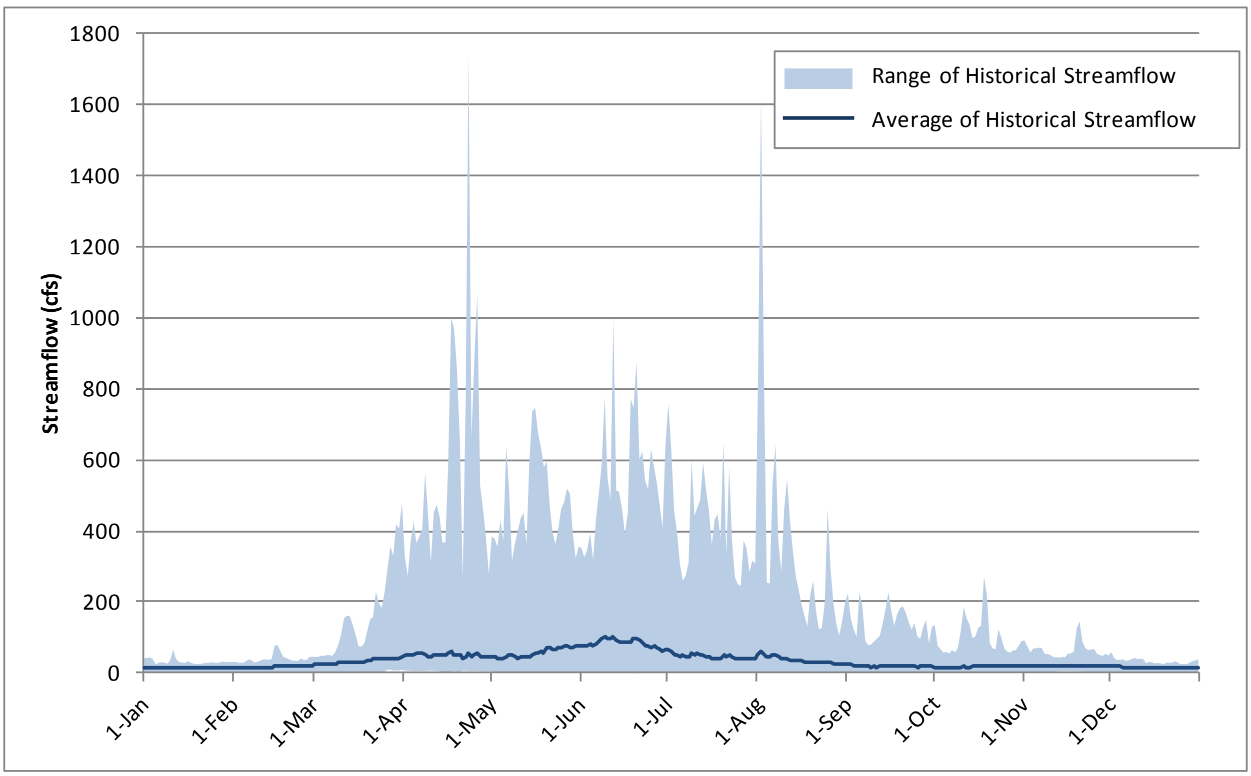


Figure 8. Average Daily Historical Streamflow - Grape Creek near Westcliffe Gage

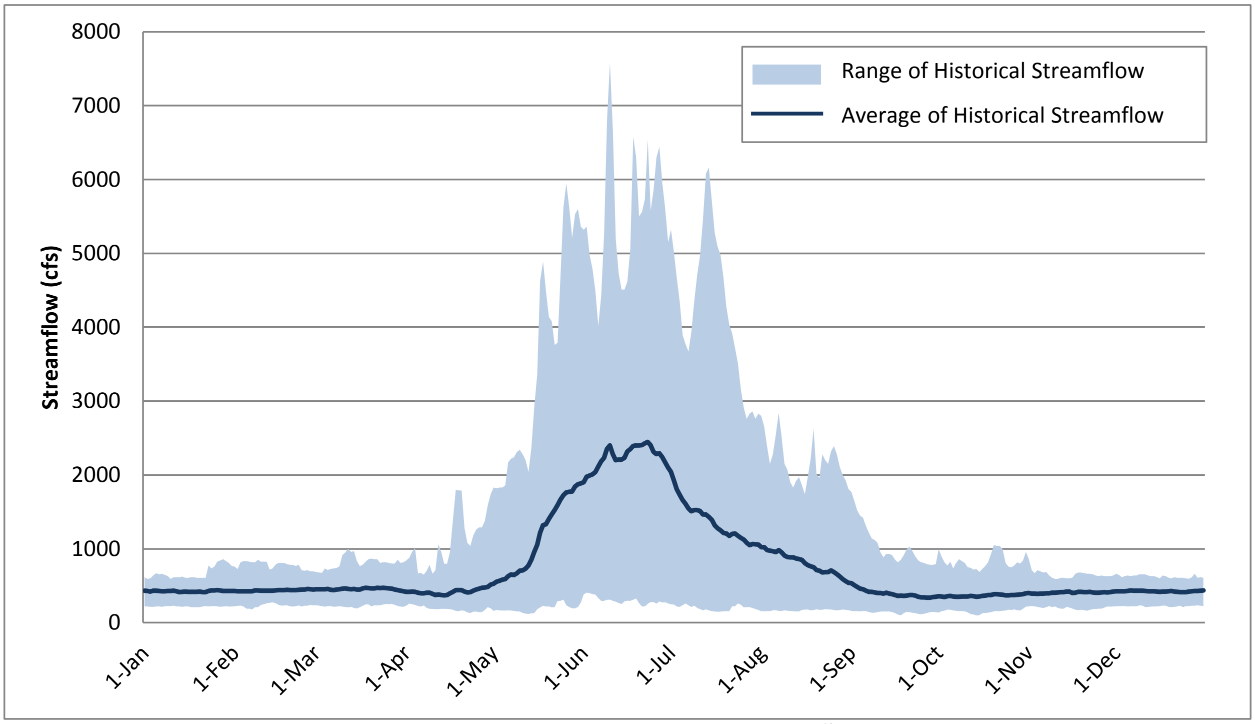


Figure 9. Average Daily Historical Streamflow - Arkansas River at Cañon City Gage

Arkansas River - Pueblo Reservoir to Fowler

The Arkansas River from Pueblo Reservoir to Fowler primarily encompasses Water District 14. Streamflow within this reach is influenced by releases from Pueblo Reservoir, tributary inflows from Fountain Creek, and agricultural diversions (except for the Bessemer Ditch which diverts directly from Pueblo Dam). The streamflow gages represent flow through and east of the City of Pueblo (Table 11).

- Arkansas River above Pueblo (07099400): The Arkansas River above Pueblo gage is immediately downstream from Pueblo Reservoir. This gage generally represents river releases from Pueblo Reservoir. However, there are return flows from the Pueblo Fish Hatchery that enter the river downstream from the gage. When a target flow at the Arkansas River above Pueblo gage is mentioned, it is assumed to include the Fish Hatchery return flows. The gage is the basis for both year-round flows and the recreational flows in the Pueblo Flow Management Program. The period-of-record for this gage is 1966 to present. In 2002, the Board of Water Works of Pueblo began diversions through its pipeline from Pueblo Dam. Thus, streamflow after this period does not include flows that were previously released from Pueblo Reservoir to its Northside intake structure downstream from the gage.

- Arkansas River at Moffat St. (07099970): The Arkansas River at Moffat St. gage is located immediately upstream from the St. Charles Mesa pumping plant, just downstream from the Interstate 25 crossing of the Arkansas River in Pueblo. Because the gage measures flow over the diversion dam immediately downstream of both the gage and pumping plant, the gage essentially measures flow downstream of the pumping plant. The pumping plant typically operates only during the winter, and only pumps less than 2 cfs, so its effect on gage flow is minimal. This gage generally represents the amount of flow through the city of Pueblo's kayak course (Figure 10). Aquila Energy diverts water upstream from this gage and returns downstream from the gage. The period-of-record for the gage is 1989 to present.

- Arkansas River near Avondale (07109500): The Arkansas River near Avondale gage is located downstream from the confluence with Fountain Creek, and upstream from the major agricultural diversions. Because the gage includes flows from Fountain Creek and most of the major agricultural deliveries, this gage has the highest average annual flow of any gage on the Arkansas River in Colorado (Figure 11). The period-of-record for this gage is 1939 to present, with data missing from 1952 to 1965.

- Arkansas River near Nepesta (07117000): The Arkansas River near Nepesta gage is located approximately nine miles west of Fowler, and is downstream from Colorado Canal and Rocky Ford Highline Canal diversions. The period-of-record for this gage is 1921 to present.

Table 11. Historical Mean Monthly Flow - Arkansas River from Pueblo Reservoir to Fowler

	Historical Mean Monthly Streamflow (cfs)			
Month	Arkansas River above Pueblo gage	Arkansas River at Moffat Street gage [1]	Arkansas River near Avondale gage	Arkansas River near Nepesta gage
Jan	166	90	385	345
Feb	198	112	420	311
Mar	327	270	565	432
Apr	585	471	893	661
May	1,235	1,124	1,699	1,383
Jun	2,189	1,957	2,550	2,023
Jul	1,490	1,258	1,749	1,355
Aug	958	766	1,276	940
Sep	424	295	627	433
Oct	346	225	544	421
Nov	240	190	480	424
Dec	149	96	360	342
Average	694	573	965	758

Note:
(1) Period-of-Record: 1989 to present. Values are average of available data.

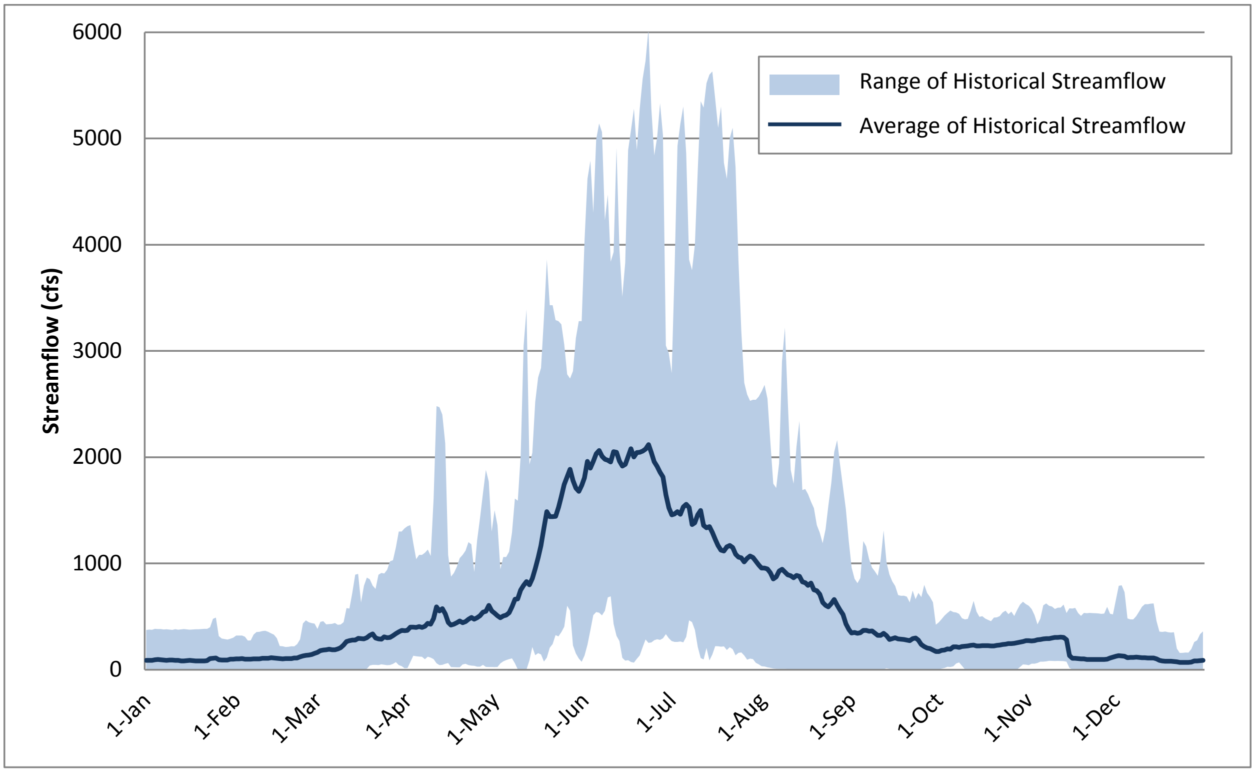


Figure 10. Average Daily Historical Streamflow - Arkansas River at Moffat St. Gage

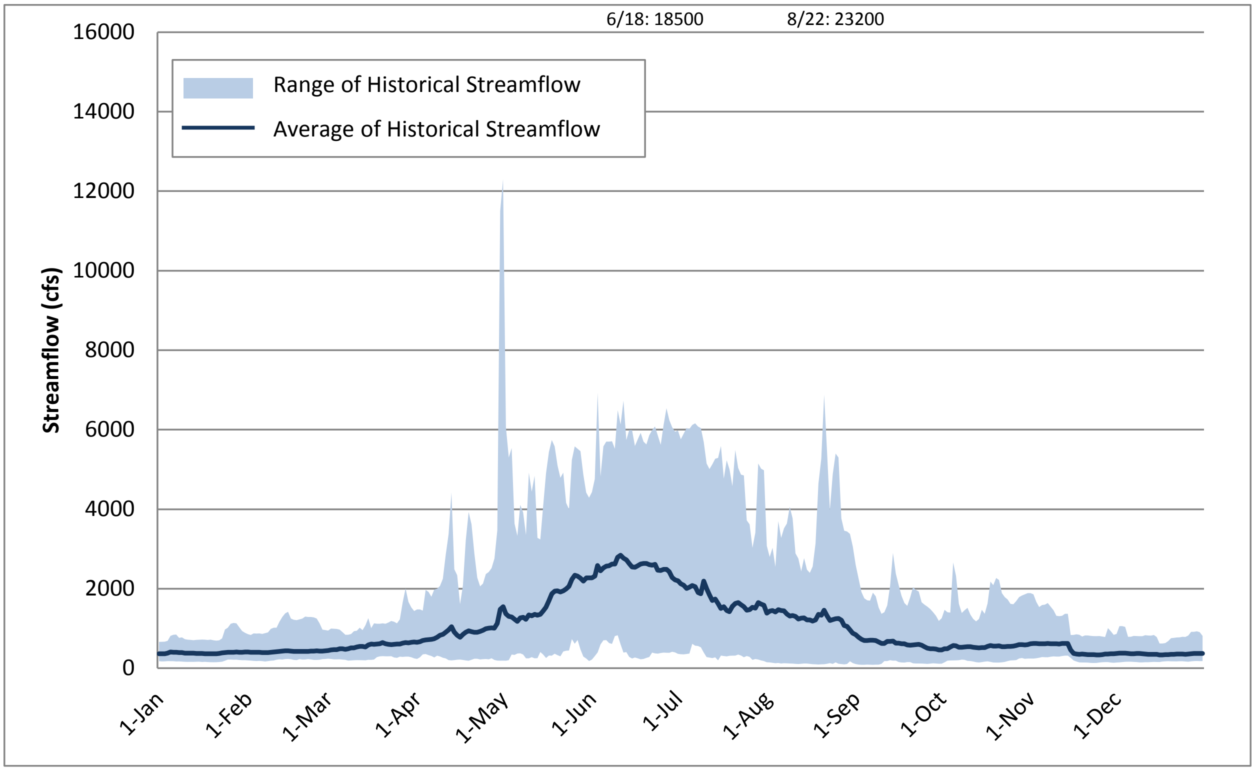


Figure 11. Average Daily Historical Streamflow - Arkansas River near Avondale Gage

Arkansas River – Fowler to John Martin Reservoir

The Arkansas River from Fowler to Las Animas encompasses Water District 17. This reach shows the effects of agricultural diversions and return flows in the Arkansas River within various parts of the river (Table 12).

- Arkansas River at Catlin Dam (07119700): The Arkansas River at Catlin Dam gage is on the Arkansas River below the Catlin Canal diversion dam. There are three Colorado Division of Water Resources reporting statins at this location:

  ARKCATCO – Gaged flow below the Catlin Canal Diversion.
  CATCANCO – Gaged flow in the Catlin Canal
  ARKCACCO – Mathematically combined flow (flow above the diversion).

  The USGS reports data for ARKCACCO, which is the mathematical sum of Arkansas River streamflow below the Catlin Canal diversion and Catlin Canal diversions (CDWR 2000). Therefore, the reported gage flows, and thus the flows shown herein, are flows immediately above the Catlin Canal diversion. Although the period-of-record for gages at this location 1965 to present, data is only presented since 1991 since prior to this date, reporting at this gage was performed differently.

- Arkansas River near Rocky Ford (07120500): The Arkansas River near Rocky Ford gage is a recently installed gage located just upstream from the confluence with Timpas Creek. The station was installed in 1999, and has been operational since that time. The gage is downstream from Fort Lyon Storage Canal diversions and Lake Meredith releases, but upstream from Fort Lyon Canal diversions.

- Arkansas River at La Junta (07123000): The Arkansas River at La Junta gage is downstream from Fort Lyon Canal and downstream from Crooked Arroyo. The Arkansas River at La Junta gage is downstream from most major diversions, including the Fort Lyon Canal, but upstream from the Las Animas Consolidated Ditch. Arkansas River at La Junta gage flows are often the lowest flows on the river upstream of John Martin Reservoir. The period-of-record for the Arkansas River at La Junta gage is 1912 to present.

- Arkansas River at Las Animas (07124000): The Arkansas River at Las Animas gage is located immediately upstream from John Martin Reservoir and downstream from all diversions on the Arkansas upstream from John Martin Reservoir. Arkansas River at Las Animas gage flows are often slightly higher than La Junta gage flows because of agricultural return flows that accrue to the river (Figure 12). The period-of-record for the Arkansas River at Las Animas gage is 1939 to present.

Table 12. Historical Mean Monthly Flow – Fowler to Las Animas

Month	Historical Mean Monthly Streamflow (cfs)			
	Arkansas River at Catlin Dam gage (1)	Arkansas River near Rocky Ford gage (2)	Arkansas River at La Junta gage	Arkansas River at Las Animas gage
Jan	316	91	161	193
Feb	243	73	160	206
Mar	388	160	123	138
Apr	633	346	139	127
May	1,343	745	572	588
Jun	1,854	951	887	877
Jul	1,166	573	521	488
Aug	885	421	339	322
Sep	417	165	131	129
Oct	382	191	177	172
Nov	433	199	137	172
Dec	335	83	128	162
Average	702	334	290	298

Note:
(1) Period-of-Record: 1991-present.
(2) Period-of-Record: 2000-present. Values are average of available data.

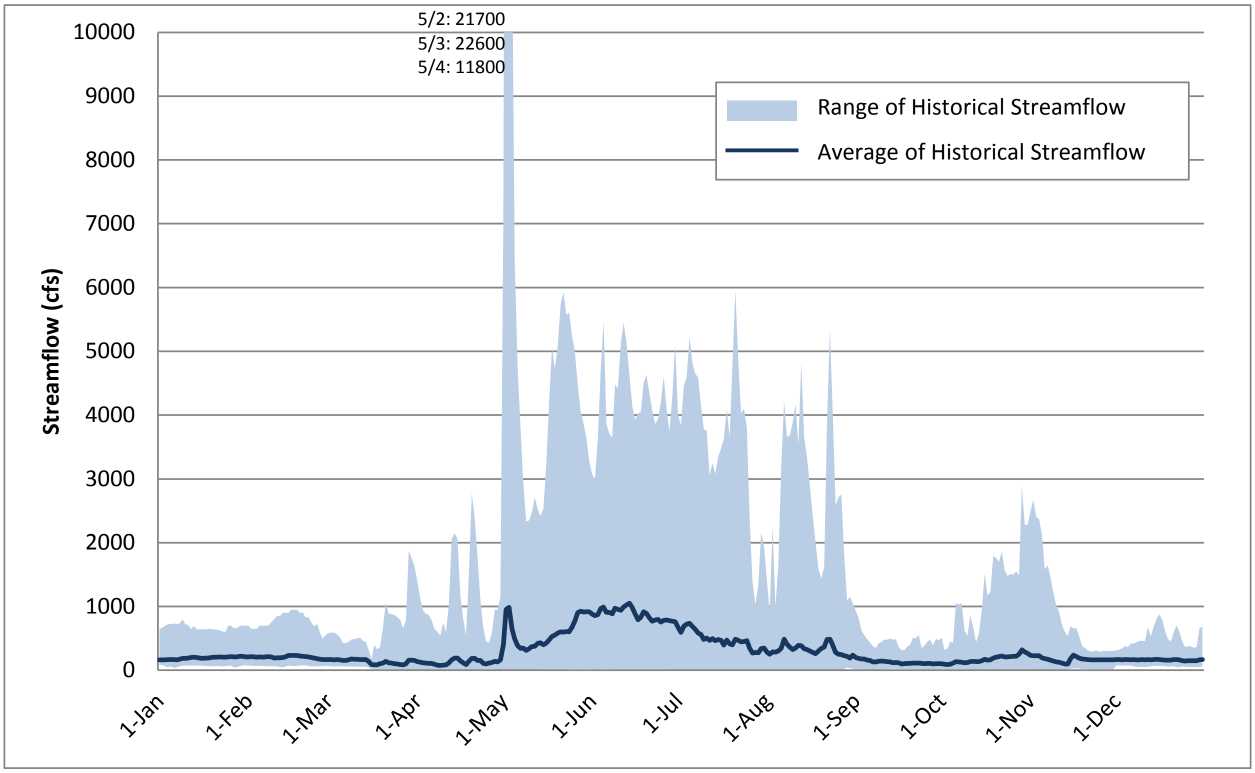


Figure 12. Average Daily Historical Streamflow - Arkansas River at Las Animas Gage

Arkansas River –John Martin Reservoir to Granada

The Arkansas River from John Martin Reservoir primarily encompasses Water District 67, and includes three streamflow gages (Table 12). This reach shows the effects of operations downstream from John Martin Reservoir, and includes the terminus point of the AVC study area at the Arkansas River near Granada gage.

- Arkansas River below John Martin Reservoir (07130500): The Arkansas River below John Martin Reservoir gage is located immediately downstream from John Martin Reservoir, and measures total releases from the reservoir. The gage is upstream from major canal diversions downstream from the reservoir. The period-of-record for the gage is 1938 to present, although gage data was published as the "at Caddoa" gage prior to October 1947 when John Martin Reservoir was completed.

- Arkansas River at Lamar (07133000): The Arkansas River at Lamar gage is located on the Arkansas River immediately north of Lamar. The gage is approximately eight miles downstream from the Amity Canal diversion, but upstream from Lamar wastewater treatment facility discharges. The period-of-record for the Arkansas River at Lamar gage is 1913 through 1955 and 1959 to present.

- Arkansas River near Granada (07134180): The Arkansas River near Granada gage is the most downstream gage in the study area. The gage is located approximately 17 miles east of Lamar, approximately midway between Lamar and the Colorado-Kansas state line. The gage is located downstream from most major diversions in Colorado (Figure 13). The period-of-record for the Arkansas River near Granada gage is 1980 through present, with some occasional data between 1899 and 1903.

Table 13. Historical Mean Monthly Flow – Las Animas to Granada

Month	Historical Mean Monthly Streamflow (cfs)		
	Arkansas River below John Martin Reservoir gage	Arkansas River at Lamar gage	Arkansas River near Granada gage
Jan	29	52	124
Feb	24	43	117
Mar	93	61	112
Apr	427	151	171
May	662	244	268
Jun	810	359	360
Jul	891	453	446
Aug	541	189	222
Sep	349	72	95
Oct	211	40	74
Nov	18	30	87
Dec	14	39	111
Average	341	145	183

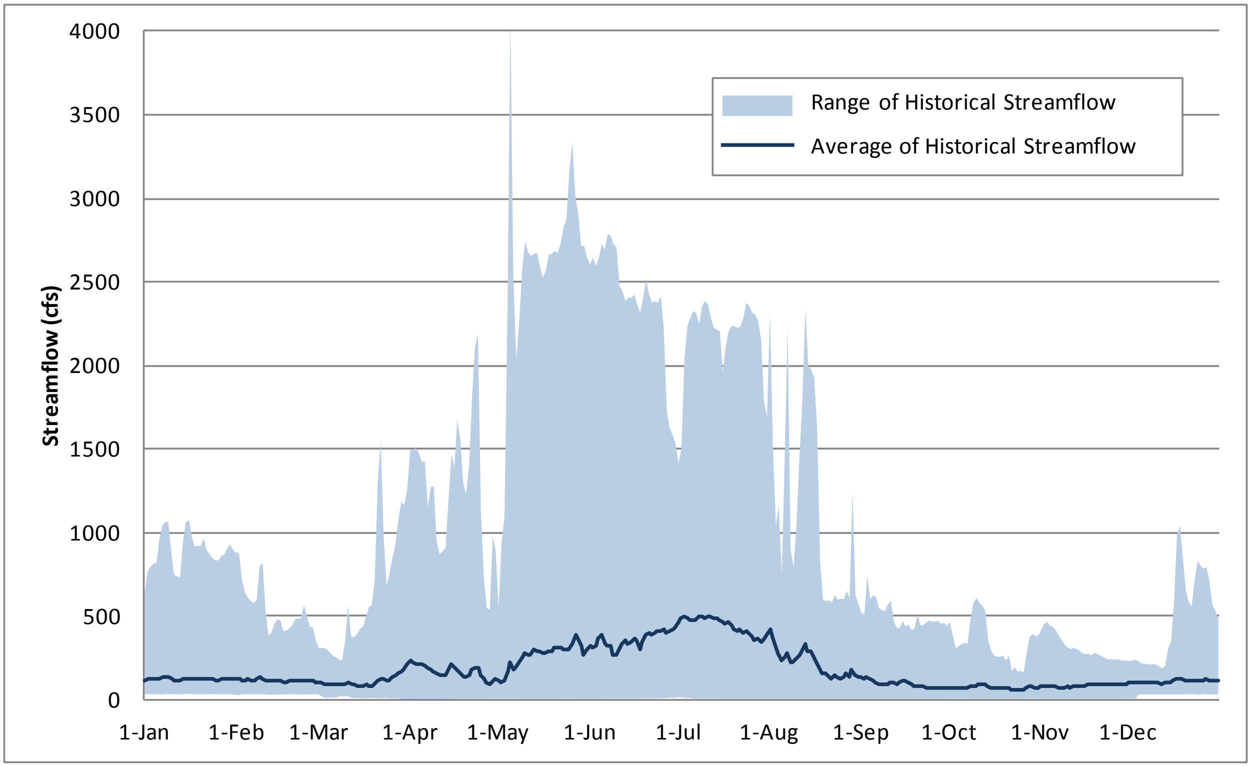


Figure 13. Average Daily Historical Streamflow - Arkansas River near Granada Gage

Fountain Creek

The Fountain Creek basin corresponds to portions of Water District 10. The study area includes Fountain Creek downstream from the Fountain Creek below Janitell Road gage, located at the southern end of Colorado Springs (Table 14). This reach shows effects of operations by Master Contract participants in the Fountain Creek basin.

- Fountain Creek below Janitell Road (07105530): The Fountain Creek below Janitell Road gage is the most upstream gage in the study area on Fountain Creek. The gage is located below the Colorado Springs Utilities’ Las Vegas Street Wastewater Treatment Facility. Although a portion of the non-sewered return flows from Colorado Springs return to Fountain Creek upstream from this gage, it represents the flow of Fountain Creek upstream from the study area. All Fountain Creek Master Contract participants’ sewered and non-sewered return flows accrue to the Arkansas River downstream from this gage. The period-of-record for the gage is 1989 to present.

- Fountain Creek at Security (07105800): The Fountain Creek at Security gage is on Fountain Creek at the town of Security, downstream from the Security wastewater treatment facility outfall and upstream from both the Widefield and Fountain wastewater treatment facility outfalls. The gage contains Colorado Springs’ sewered return flows and nearly all non-sewered return flows. The period-of-record for this gage is 1965 to present.

- Fountain Creek near Fountain (07106000): The Fountain Creek near Fountain gage is downstream from the city of Fountain and the Fountain Sanitation District’s wastewater treatment facility outfall. The gage is also downstream from potential diversions to the proposed Williams Creek Reservoir from Fountain Creek, but upstream from expected releases from the proposed Williams Creek Reservoir via Williams Creek or a pipeline along Williams Creek. The Fountain Creek near Fountain gage has a split period-of-record. The gage contains early data from 1939-1954 and a later period from 1986 to present.

- Fountain Creek near Piñon (07106300): The Fountain Creek near Piñon gage is on Fountain Creek near the El Paso/Pueblo County line. The streamflow at the gage includes nearly all return flows from existing development in El Paso County. The cross section at the Fountain Creek near Piñon gage is unstable due to eroding channel banks and lateral channel migration (Reclamation 2008). Therefore, there could be some reliability issues with the data. The period-of-record for the gage is 1973 to present.

- Fountain Creek at Pueblo (07106500): The Fountain Creek at Pueblo gage is on Fountain Creek in the City of Pueblo approximately 1.5 miles upstream from its confluence with the Arkansas River. The gage likely contains some non-sewered municipal return flows from the City of Pueblo (Figure 14). The period-of-record for the gage is 1922 to present, with no data from 1926-1940 and 1966-1970.

Table 14. Historical Mean Monthly Flow – Fountain Creek Basin

Month	Historical Mean Monthly Streamflow (cfs)				
	Fountain Creek below Janitell Road gage [(1)]	Fountain Creek at Security gage	Fountain Creek near Fountain gage [(2)]	Fountain Creek near Piñon gage	Fountain Creek at Pueblo gage
Jan	80	94	115	114	117
Feb	93	104	123	122	128
Mar	104	118	139	136	140
Apr	155	166	178	165	169
May	235	253	275	258	266
Jun	193	218	241	219	222
Jul	144	167	181	147	151
Aug	169	192	209	189	199
Sep	112	125	120	103	100
Oct	94	114	111	104	110
Nov	92	105	129	127	134
Dec	71	88	109	106	113
Average	129	145	161	149	154

Note:
(1) Period-of-Record: 1989-present. Values are an average of available data.
(2) Period-of-Record: 1986-present. Values are an average of available data.

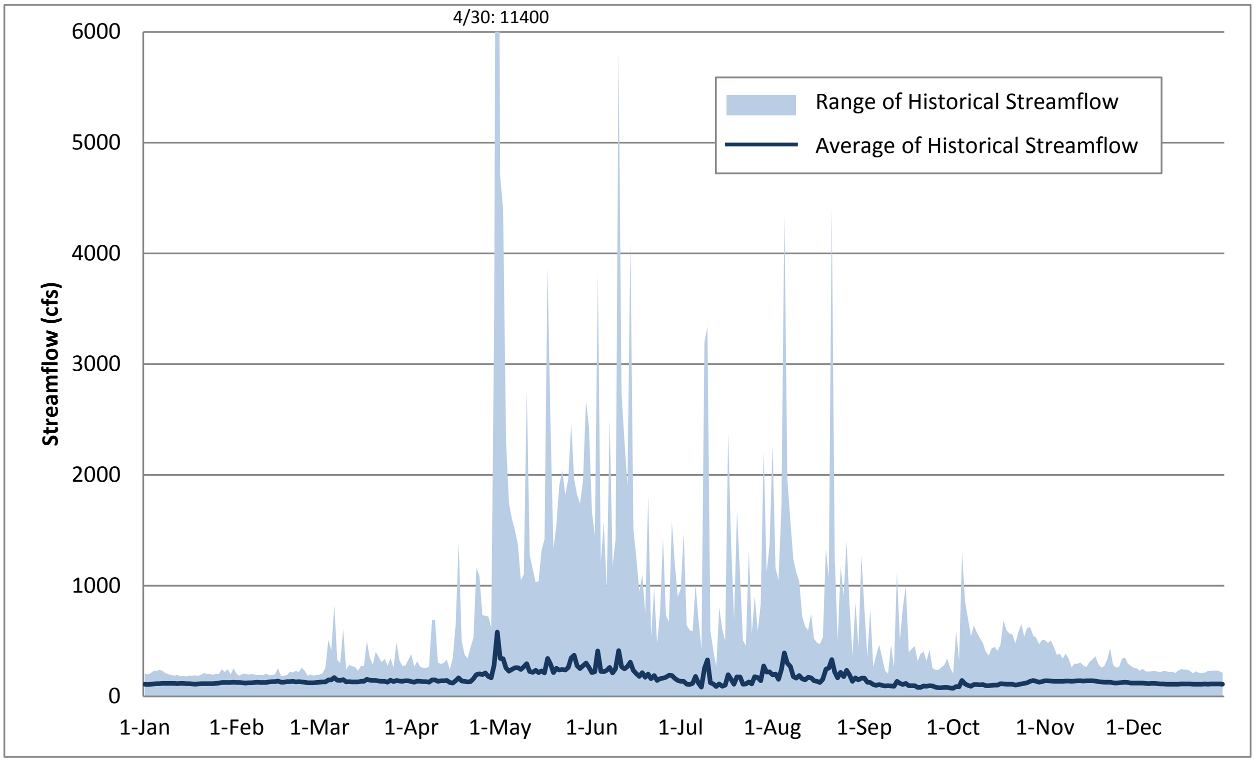


Figure 14. Average Daily Historical Streamflow - Fountain Creek at Pueblo Gage

West Slope

The West Slope study area for surface water hydrology was defined using results of the hydrologic model results, which summarize expected diversions through each of the transmountain diversion projects simulated in the model. A summary of simulated transmountain diversions from the hydrologic model is presented in Appendix D.5. The hydrologic model results show that diversions in the Fry-Ark Project, the Busk-Ivanhoe System, Twin Lakes Project, and Homestake Project would differ from existing conditions. Therefore, these system and the water bodies that the systems divert from are included in the study area.

Transmountain collection system diversion locations on tributaries upstream from each gage are described along with each gage. Most of these smaller streams are not currently gaged and/or the effects analyses were not performed on individual tributaries. Therefore, only mainstem gages on rivers and creeks immediately downstream from all diversions for each transmountain project are included.

- Fryingpan River near Thomasville (USGS Station No. 09078600): The Fryingpan River could be affected by changes in diversions from the Fry-Ark Project and the Busk-Ivanhoe system. The Fryingpan River near Thomasville gage is the most upstream gage that fully captures effects of these systems, and is also used for administration of instream flows. The Fry-Ark Northside Collection system diverts water from Carter Creek, North Fork Fryingpan River, Mormon Creek, North Cunningham Creek, Middle Cunningham Creek, Ivanhoe Creek, Lily Pad Creek, Granite Creek and the Fryingpan River. Additionally, portions of the Fry-Ark Southside collection system divert water from Sawyer Creek, Chapman Creek and the South Fork Fryingpan River. A series of diversion structures and tunnels and pipelines convey this water to the Boustead Tunnel, which then conveys water to Turquoise Lake on the East Slope. Average annual diversions from the Fryingpan River Basin are approximately 43,700 acre-feet per year, or approximately 81 percent of the total Boustead Tunnel collection system diversions. Average annual streamflow for this gage is shown in Figure 15.

- Hunter Creek near Aspen (09074000): Changes in diversions by the Fry-Ark Project could affect streamflow in Hunter Creek. The Hunter Creek near Aspen gage is located downstream from all Fry-Ark diversions. Portions of the Fry-Ark Southside collection system divert water from Hunter Creek (a tributary to the Roaring Fork River at Aspen) and its tributaries, including Midway Creek and No Name Creek. Diversion structures on these creeks divert water into the Hunter Tunnel, which conveys water to the Boustead Tunnel. Average annual diversions from the Hunter Creek basin are approximately 9,900 acre-feet per year, or approximately 19 percent of the total Boustead Tunnel collection system diversions. Average annual streamflow for this gage is shown in Figure 16.

- Roaring Fork above Difficult Creek (09073300): Changes in diversions by the Twin Lakes Project could affect streamflow in the Roaring Fork River. The Roaring Fork above Difficult Creek gage is located downstream from all Twin Lakes Project diversions but upstream from the Hunter Creek confluence. The Independence Pass Transmountain Diversion System (collection system for the Twin Lakes Project), collects water from several tributaries within the upper Roaring Fork Basin and transports this water through the Twin Lakes Tunnel to Twin Lakes in the Arkansas River Basin, where it is stored and delivered to Twin Lakes Projects shareholders. Existing diversion structures for this system include those on the Roaring Fork River and its tributaries, Lost Man Creek, Lincoln Creek, Brooklyn Creek, Tabor Creek, New York Creek, and Grizzly Creek. Both Colorado Springs and the City of Aurora (major share-holders in the project) convey their yield from the Twin Lakes Project to the Otero Pump Station and Homestake Pipeline via the Twin Lakes Pipeline.

- Roaring Fork below Maroon Creek (Colorado Division of Water Resources Station No. ROABMCCO): The Roaring Fork below Maroon Creek gage is the first active streamflow gage located downstream from the confluence with Hunter Creek, and reflects changes in streamflow from both Fry-Ark Project Hunter Creek diversions and Twin Lakes Project diversions. The Roaring Fork below Maroon Creek gage only includes data from November 1988 through present.

- Homestake Creek at Gold Park (09064000): Changes in diversions through the Homestake Project could affect streamflow in the Homestake Creek Basin. The Homestake Project diversion system diverts water from the Homestake Creek watershed, a tributary of the Eagle River, into Homestake Reservoir. From Homestake Reservoir, this water is diverted to Turquoise Lake through the Homestake Tunnel. Tributaries to Homestake Creek upstream from this gage that have diversions to the Homestake Collection System include French Creek, Fancy Creek, Sopris Creek, and Missouri Creeks). Streamflow in these tributaries is not gaged.

Table 15. Historical Mean Monthly Flow – West Slope

Month	Historical Mean Monthly Streamflow (cfs)				
	Fryingpan River near Thomasville gage	Hunter Creek near Aspen gage	Roaring Fork above Difficult Creek gage	Roaring Fork below Maroon Creek gage [(1)]	Homestake Creek at Gold Park gage
Jan	24	6	14	82	6
Feb	23	6	14	73	6
Mar	31	7	16	75	7
Apr	96	23	32	120	18
May	320	123	141	435	70
Jun	383	182	316	870	97
Jul	164	71	143	479	64
Aug	80	31	53	207	32
Sep	58	18	36	143	17
Oct	50	16	27	124	14
Nov	37	10	20	104	10
Dec	29	7	16	88	7
Average	108	42	69	234	29

Note:
(1) Period-of-Record: 1988 to 2009.

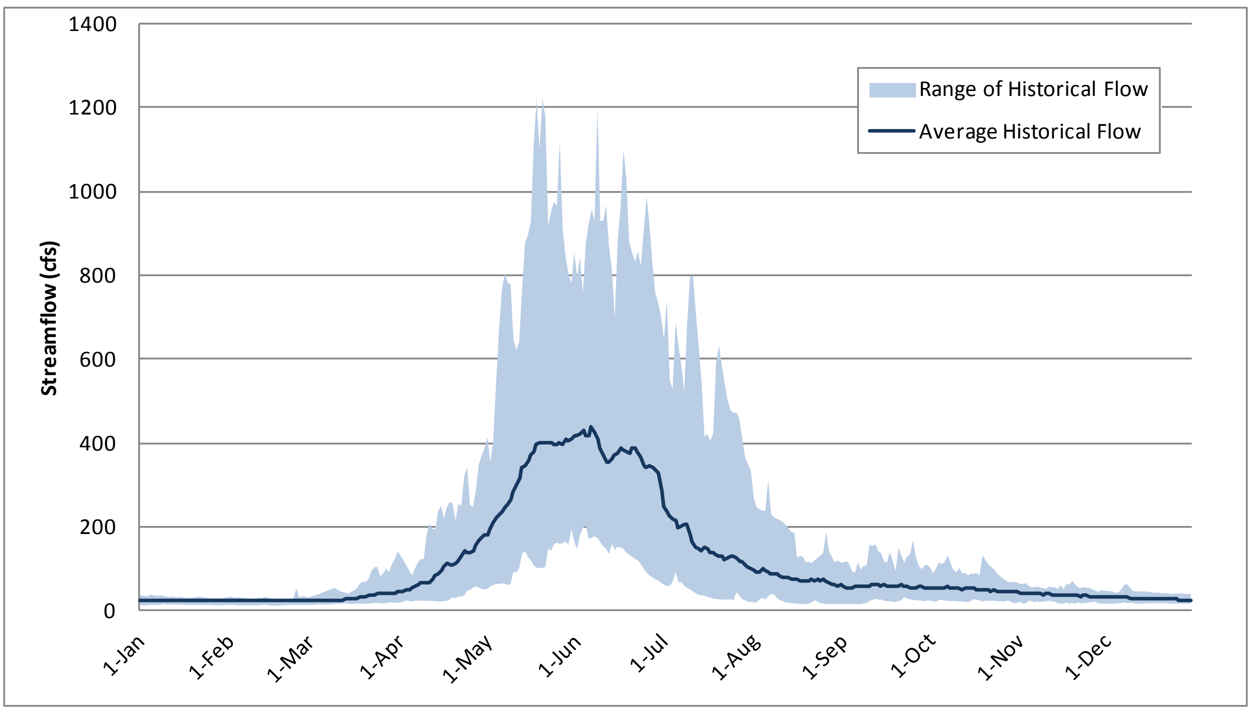


Figure 15. Average Daily Historical Streamflow - Fryingpan River near Thomasville Gage

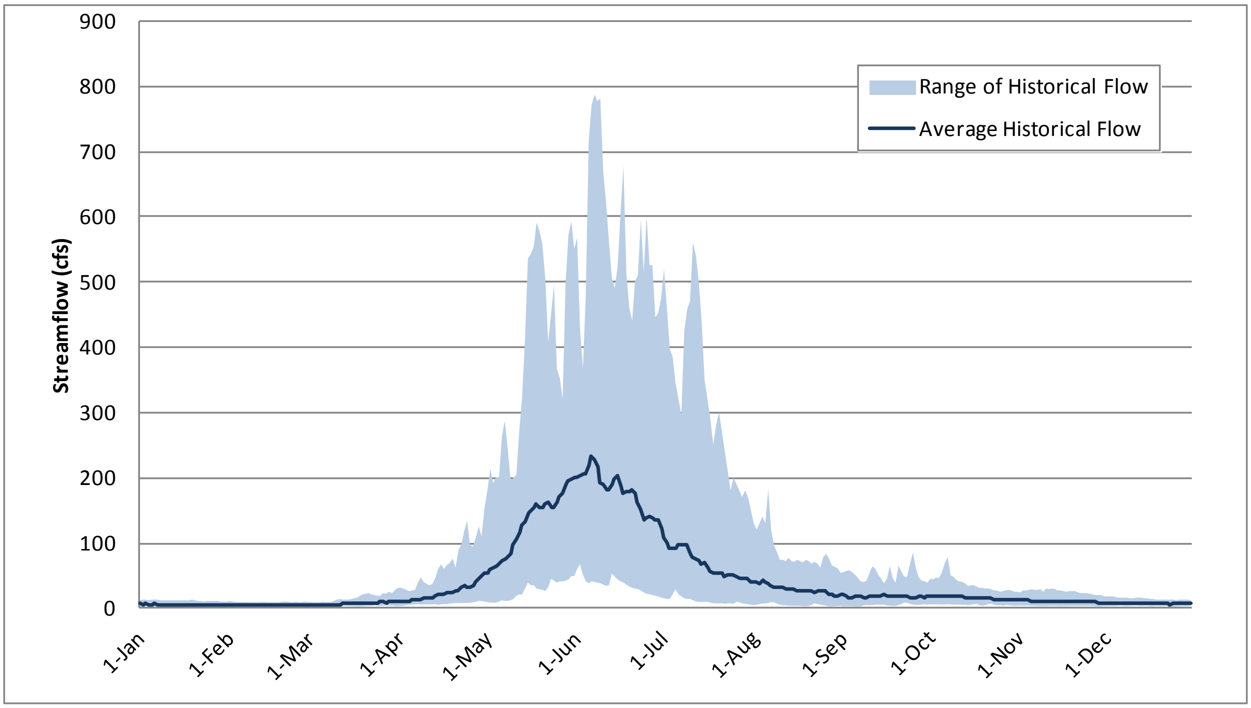


Figure 16. Average Daily Historical Streamflow - Hunter Creek near Aspen Gage.

Reservoirs

This section presents supplemental information on major reservoirs within the study area, including accounts and elevation-area-capacity curves.

Turquoise Lake

Through the Fry-Ark Project, Reclamation increased the capacity of Turquoise Lake from its original capacity of 17,416 acre-feet to its current capacity of 129,398 acre-feet (Figure 17). The original reservoir only contained accounts for the original Colorado Fuel and Iron storage system. During enlargement, additional storage space was added for the Fry-Ark Project and the Homestake Project. Table 16 presents the storage accounts in Turquoise Lake. Aurora and the Board of Water Works of Pueblo each own 5,000 acre-feet of Colorado Fuel and Iron storage space and 5,000 acre-feet of Busk-Ivanhoe storage space. However, the Colorado Fuel and Iron storage space can only be used on an "if-and-when" basis while the Busk-Ivanhoe storage space can only be used for agricultural storage. Because the Busk-Ivanhoe space can only be used to store agricultural water, which is seldom done by the municipal entities, this space is usually empty and the Colorado Fuel and Iron if-and-when accounts are able to use this space. Therefore, for all practical purposes, Aurora and the Board of Water Works of Pueblo each own one 5,000 acre-feet account. The elevation-area-capacity curve for Turquoise Lake is presented in Figure 18.

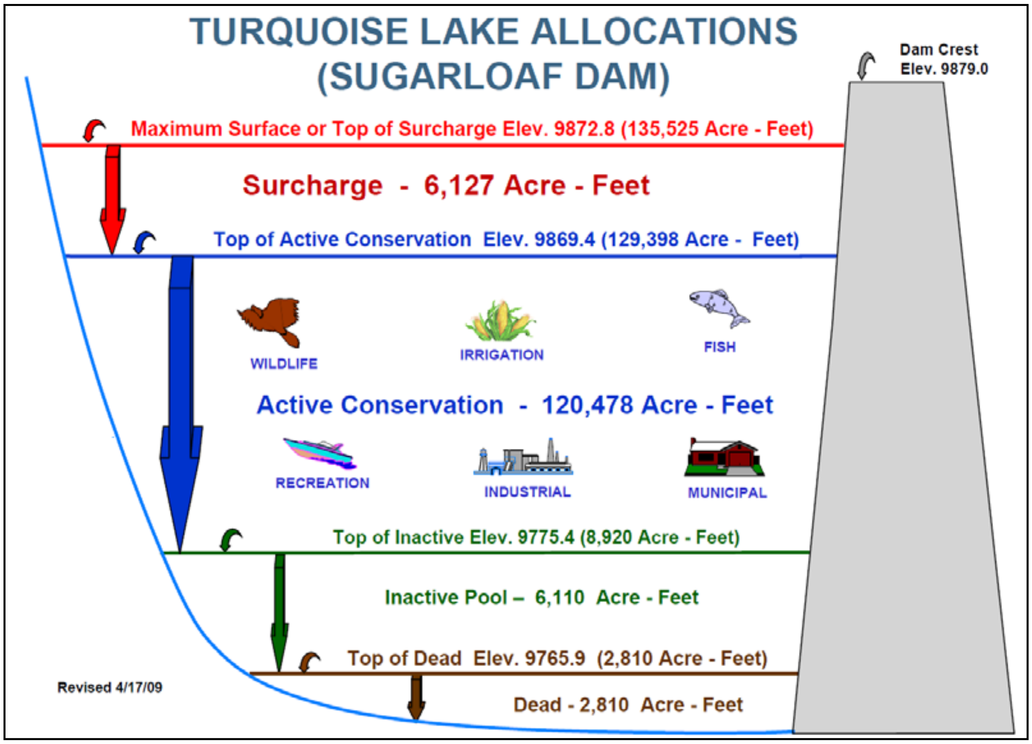


Figure 17. Turquoise Lake Allocations

Table 16. Turquoise Lake Accounts

Account			**Storage (ac-ft)**
Dead/Inactive			8,920
Active	CF&I		
		Colorado Springs	17,416
		Aurora	5,000
		Board of Water Works of Pueblo	5,000
		Sub-Total	27,416
	Homestake		
		Aurora	15,000
		Colorado Springs	15,000
		Sub-Total	30,000
	Fry-Ark Project		63,062
	Sub-Total		120,478
Total			129,398

Source: Fry-Ark AOP (Reclamation 2009)

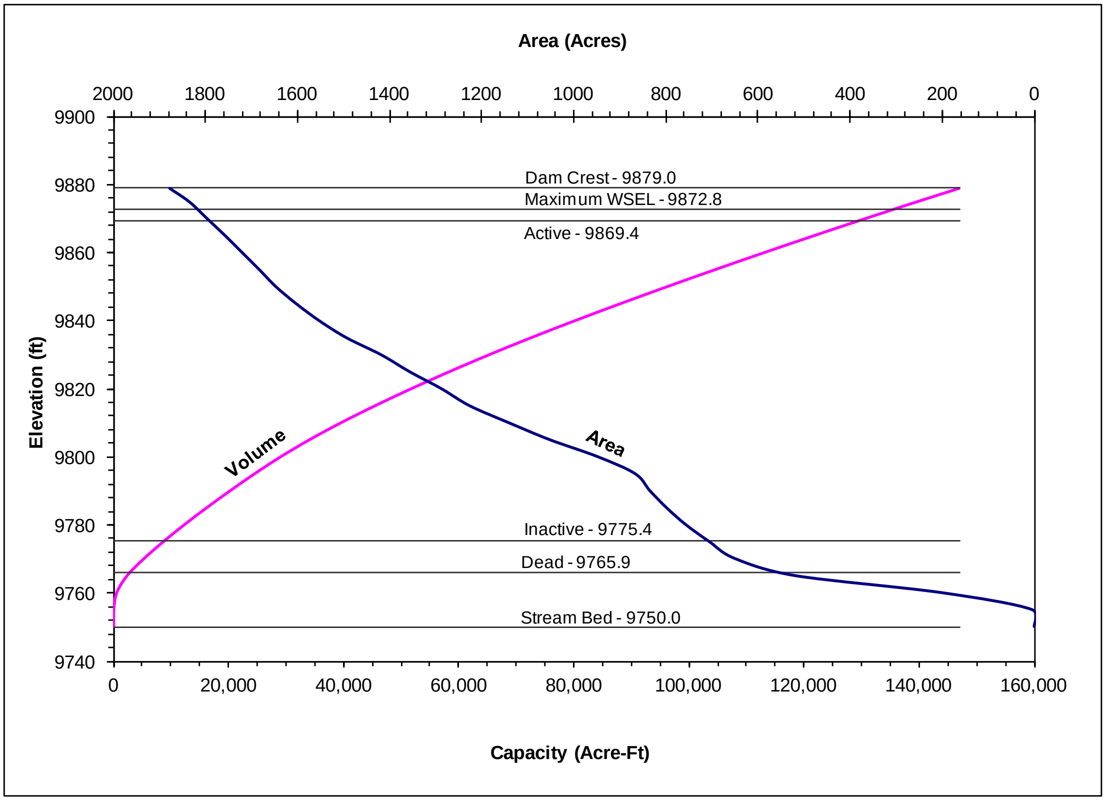


Figure 18. Elevation-Area-Capacity Curve for Turquoise Lake

Twin Lakes

As with Turquoise Lake, Twin Lakes was enlarged by Reclamation during construction of the Fry-Ark project. The original owner of the reservoir was the Twin Lakes Reservoir and Canal Company, during which time the reservoir had approximately 54,452 acre-feet of active storage. Reclamation added 13,465 acre-feet of active storage to bring the total active storage to 67,917 acre-feet and the total storage to 140,855 acre-feet (Figure 19). The accounts in Twin Lakes are presented in Table 17, while overall reservoir allocations are shown in Figure 19. An elevation-area-capacity curve for Twin Lakes is presented in Figure 20.

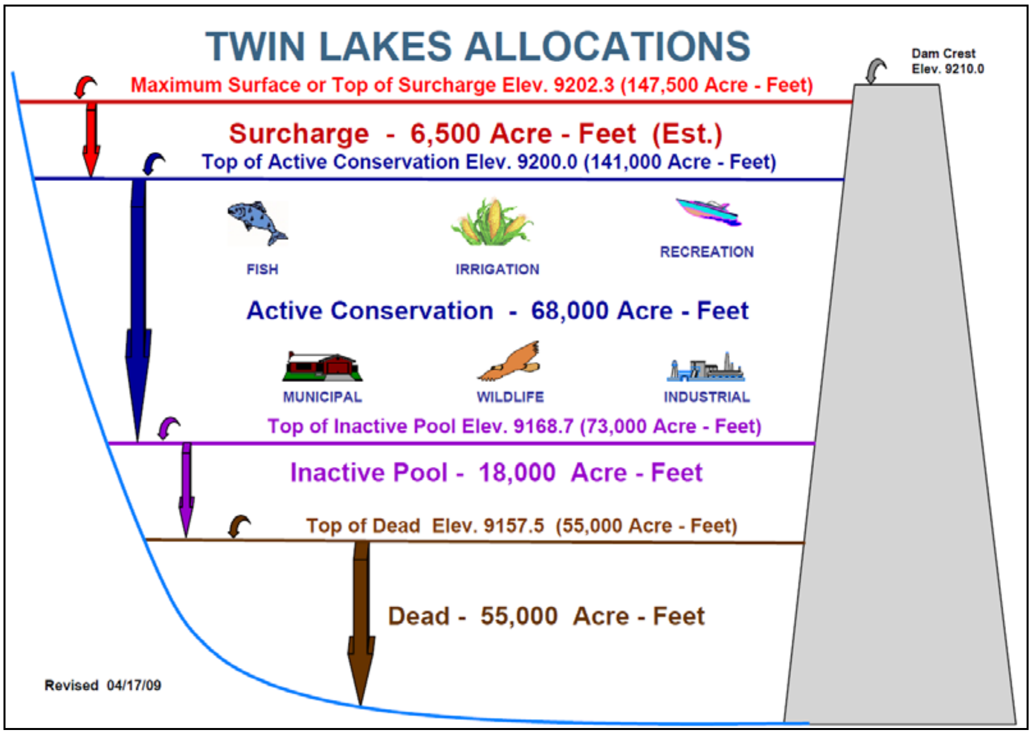


Figure 19. Twin Lakes Allocations

Table 17. Twin Lakes Accounts

Account			Storage (ac-ft)
Dead/Inactive			72,938
Active	Twin Lakes Project		
		Colorado Springs	29,762
		Aurora	2,733
		Board of Water Works of Pueblo	12,602
		Pueblo West	6,476
		Augmentation	495
		Other M&I	2052
		Colorado Canal Agriculture	308
		Sub-Total	54,452
	Fry-Ark Project		13,465
	Sub-Total		67,917
Total			140,855

Source: Fry-Ark AOP (Reclamation 2009); Twin Lakes Project storage accounts based on share information provided by Scott Campbell (2010).

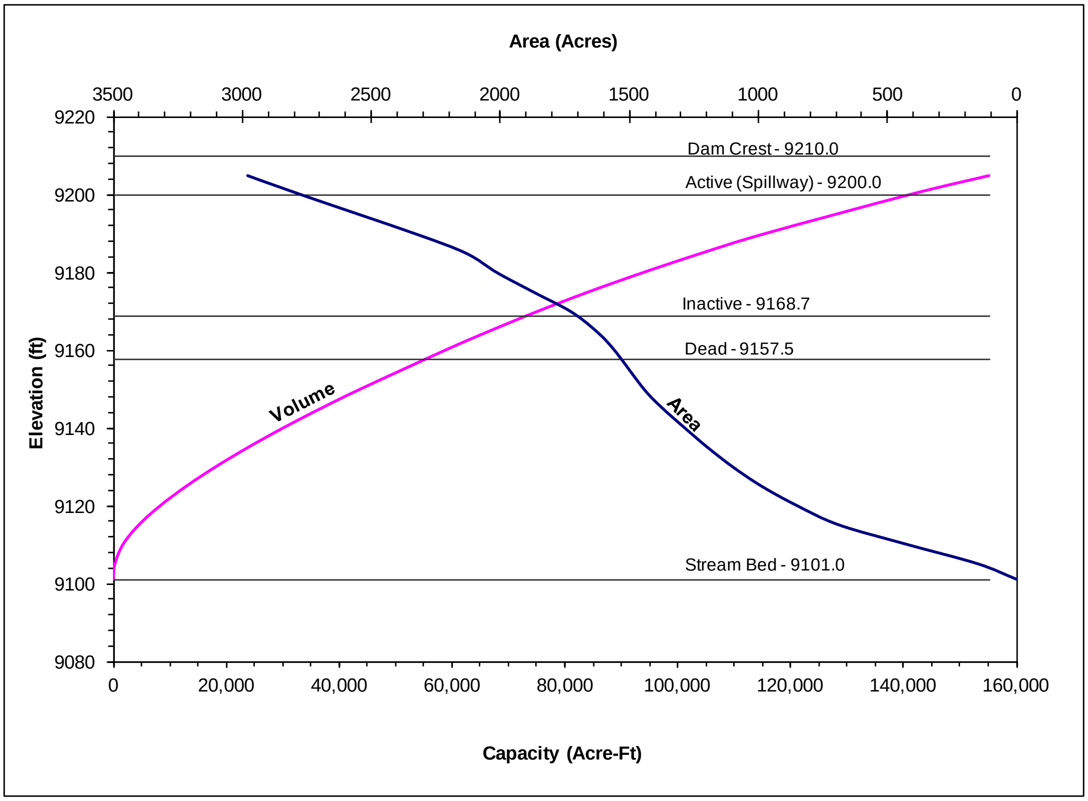


Figure 20. Elevation-Area-Capacity Curve for Twin Lakes

Pueblo Reservoir

Pueblo Reservoir was constructed as part of the Fry-Ark Project and had no additional non-Project space added to the Fry-Ark Project volume requirements. Therefore, Fry-Ark Project space is the only account in the reservoir. Total active capacity of Pueblo Reservoir is 256,949 acre-feet. In addition to the active capacity, Pueblo Reservoir has dedicated flood control space of 26,991 acre-feet and a joint use pool of 66,000 acre-feet (Figure 21). The joint use pool must be evacuated between April 15 and November 1 for flood control use. Outside of this period, the joint use pool can be used for conservation storage. The accounts in Pueblo Reservoir are presented in Table 18. An elevation-area-capacity curve for Pueblo Reservoir is in Figure 22.

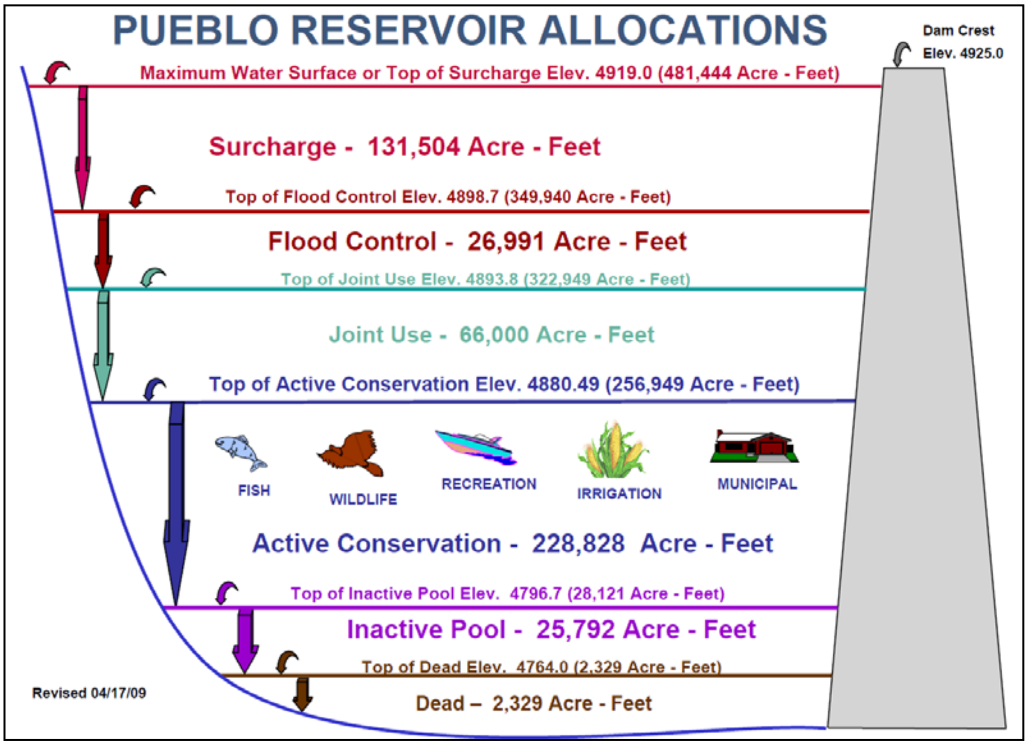


Figure 21. Pueblo Reservoir Allocations

Table 18. Pueblo Reservoir Accounts

Account		Storage (ac-ft)
Dead/Inactive		28,121
Active	Fry-Ark Project	228,828
Joint Use		66,000
Flood Control		26,991
Total Capacity		349,940

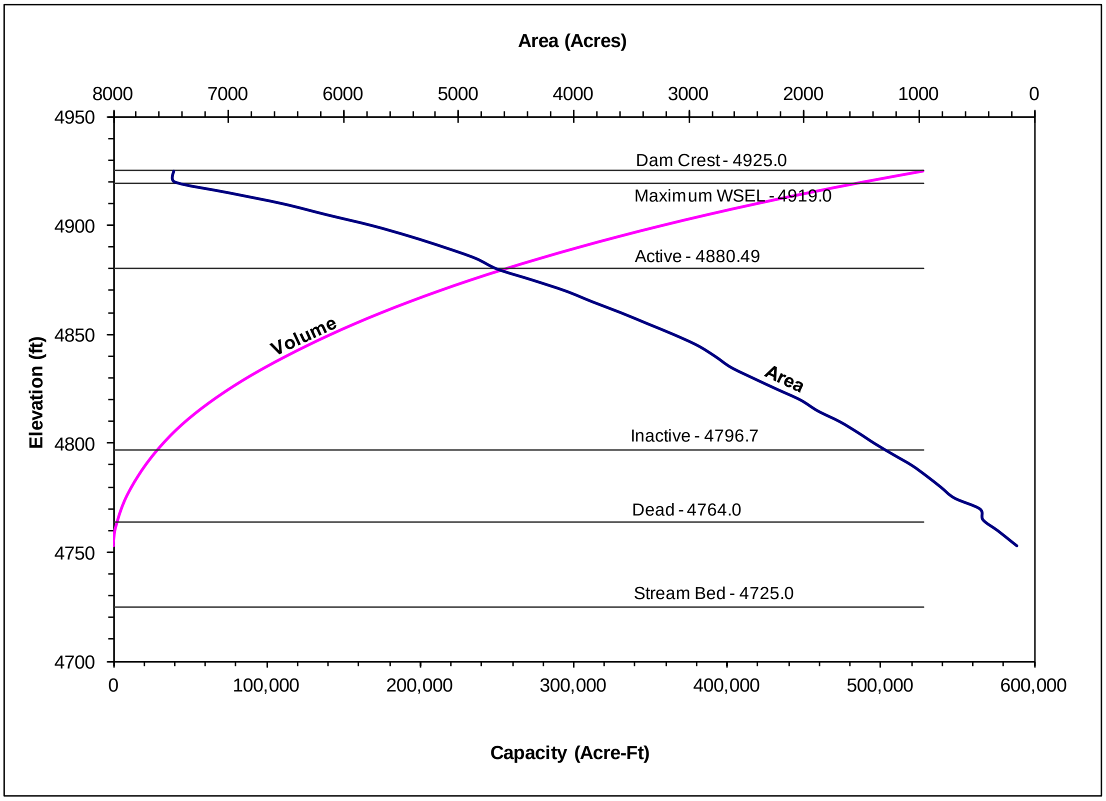


Figure 22. Elevation-Area-Capacity Curve for Pueblo Reservoir

Reclamation has historically contracted with entities to store non-Project water in Fry-Ark Project storage space. These contracts were historically referred to as “If-and-When” contracts and were approved on an annual basis. The largest users of these contracts have historically been Colorado Springs and the City of Aurora. These contracts are now referred to as “short-term excess capacity contracts” (short-term contracts). Historical contract amounts are shown in Table 19, Table 20, and Table 21.

“Long-term excess capacity contracts” (long-term contracts) in Project facilities are held by Aurora, the Board of Water Works Pueblo and Southern Delivery System participants, including Colorado Springs Utilities, City of Fountain, Security Water District and Pueblo West Metropolitan District. A variety of water supplies are used to fill this space, including exchange of reusable return flows.

Table 19. Historical Pueblo Reservoir Excess Capacity Contracts (1986-1993)

Entity	1986	1987	1988	1989	1990	1991	1992	1993
Aurora	1,000	1,000	1,000	10,000	10,000	10,000	1,000	
AGUA								
Beaver Park								
Bessemer Ditch								1,250
Brewer, Robert							283	
Bureau of Land Management								
Carter, Alvin							281	220
Catlin Canal Co			250	250	250	300	300	300
Cesar Dairy								
Colorado Springs	500		1,000		2,500	6,000	6,000	10,000
Colorado Department of Corrections								
CWPDA								
Dept. of Parks and Outdoor Rec.								
City of Fountain								
Holbrook Mutual Company								
Jordan, Gerald								
LAWMA								
LAVWCD								
Orville Tomky							58	
Public Service Company								
Board of Water Works of Pueblo		250	2,000	2,000	2,000	3,000	3,000	3,000
Pueblo West Metropolitan District								
Round Mountain								
Salida								
Security Water District								
SEWAE								
Southwest Ready Mix								
Stratmoor Hills								
St. Charles Mesa Water District								
United Feeders								
Upper Arkansas Water Conservancy District								
Victor								
Widefield Water and Sanitation District								
TOTALS	**1,500**	**1,250**	**4,250**	**12,250**	**14,750**	**19,300**	**10,922**	**14,770**

Source: 1999-2003 (Moberg 2004); 2004-2009 (Hopkins 2010).

Table 20. Historical Pueblo Reservoir Excess Capacity Contracts (1994-2001)

Entity	1994	1995	1996	1997	1998	1999	2000	2001
Aurora	1,700	3,500	3,000	3,000	1,000	3,000	3,000	3,000
AGUA								
Beaver Park	1,000	1,000						
Bessemer Ditch		10,000						
Brewer, Robert	400	400						
Bureau of Land Management								
Carter, Alvin	335							
Catlin Canal Co	1,000	1,000	1,000	1,000				
Cesar Dairy	150	250						
Colorado Springs	10,000	10,000	10,000	10,000	10,000	10,000	2,500	5,000
Colorado Department of Corrections	75	220						
CWPDA	1,000	2,100						
Dept. of Parks and Outdoor Rec.	7,200	3,500						
City of Fountain								
Holbrook Mutual Company		3,403						
Jordan, Gerald	500	500						
LAWMA		165						
LAVWCD								
Orville Tomky	250							
Public Service Company			1,000					
Board of Water Works of Pueblo	3,000	3,000	3,000	3,000	3,000	3,000	5,000	5,000
Pueblo West Metropolitan District						1,000	1,000	1,000
Round Mountain								
Salida								
Security Water District								
SEWAE								
Southwest Ready Mix	50							
Stratmoor Hills								
St. Charles Mesa Water District								
United Feeders								
Upper Arkansas Water Conservancy District	120	150			50	50		
Victor								
Widefield Water and Sanitation District								
TOTALS	**26,780**	**39,188**	**18,000**	**17,000**	**14,050**	**17,050**	**11,500**	**14,000**

Source: 1999-2003 (Moberg 2004); 2004-2009 (Hopkins 2010).

Table 21. Historical Pueblo Reservoir Excess Capacity Contracts (2002-2009)

Entity	2002	2003	2004	2005	2006	2007	2008	2009
Aurora	5,000	5,000	10,000	10,000	10,000	10,000	10,000	10,000
AGUA								500
Beaver Park								
Bessemer Ditch						1,000	1,000	1,000
Brewer, Robert								
Bureau of Land Management				500	400	400	400	400
Carter, Alvin								
Catlin Canal Co		200	100	100				
Cesar Dairy								
Colorado Springs	5,000	10,000	10,000	15,000	15,000	17,000	17,000	17,000
Colorado Department of Corrections					100	120	200	300
CWPDA		1,000	750	3,750	5,000	6,500	6,500	6,500
Dept. of Parks and Outdoor Rec.			2,000	600	590	600	650	1,000
City of Fountain		1,300	1,300	1,300	600	600	600	600
Holbrook Mutual Company								
Jordan, Gerald								
LAWMA								
LAVWCD			500	500	500	1,000	2,000	2,500
Orville Tomky								
Public Service Company								
Board of Water Works of Pueblo	5,000	5,000	5,000	3,000	6,000	6,000	6,000	6,000
Pueblo West Metropolitan District	2,000	2,000	3,000	6,000	9,000	9,000	9,000	9,000
Round Mountain						50	50	50
Salida		350	350	350	350	625	625	625
Security Water District		400	400	400	200	400	400	200
SEWAE		100						
Southwest Ready Mix								
Stratmoor Hills			100	100	100	100	100	100
St. Charles Mesa Water District		150	260	375			500	500
United Feeders							216	216
Upper Arkansas Water Conservancy District					50	1,000	1,000	1,000
Victor							100	100
Widefield Water and Sanitation District		400	400	400	400	400	400	400
TOTALS	**17,000**	**25,900**	**34,160**	**42,375**	**48,290**	**54,795**	**56,741**	**57,991**

Source: 1999-2003 (Moberg 2004); 2004-2009 (Hopkins 2010).

Colorado Canal Reservoirs

Lake Henry and Lake Meredith are off-channel reservoirs within the Colorado Canal system. Crowley County leases Lake Henry and Lake Meredith for recreational purposes. Water is diverted to the reservoirs from the Arkansas River through Colorado Canal. However, Lake Henry is upstream from Lake Meredith, thus water from Lake Henry can be delivered to Lake Meredith, but not vice-versa. Lake Henry is able to serve a portion of the irrigated lands under the system by gravity, but Lake Meredith cannot. Releases are made from the reservoirs to the Arkansas River and either exchanged to the Colorado Canal headgate for use by the agricultural shareholders, or exchanged to Pueblo Reservoir for use by municipal shareholders. The active capacity of Lake Henry is 8,691 acre-feet, while the active capacity of Lake Meredith is 39,804 acre-feet. Elevation-area-capacity curves for Lake Meredith and Lake Henry are in Figure 23 and Figure 24, respectively.

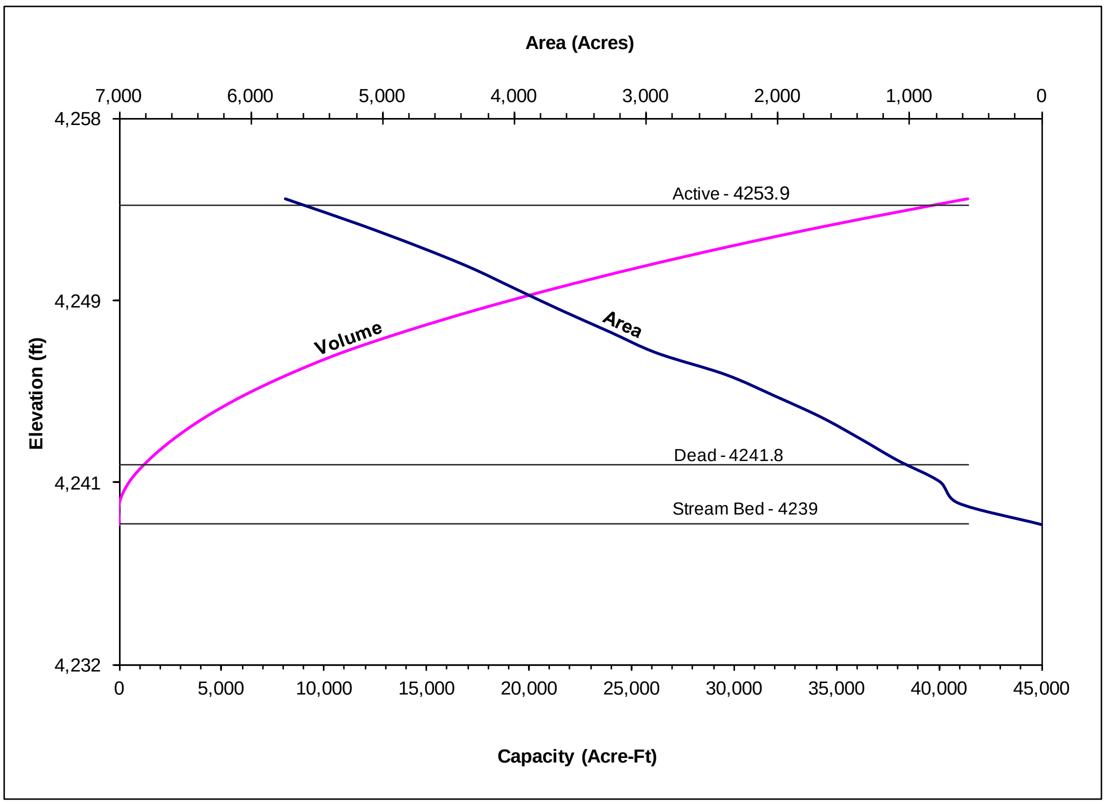


Figure 23. Elevation-Area-Capacity Curve for Lake Meredith

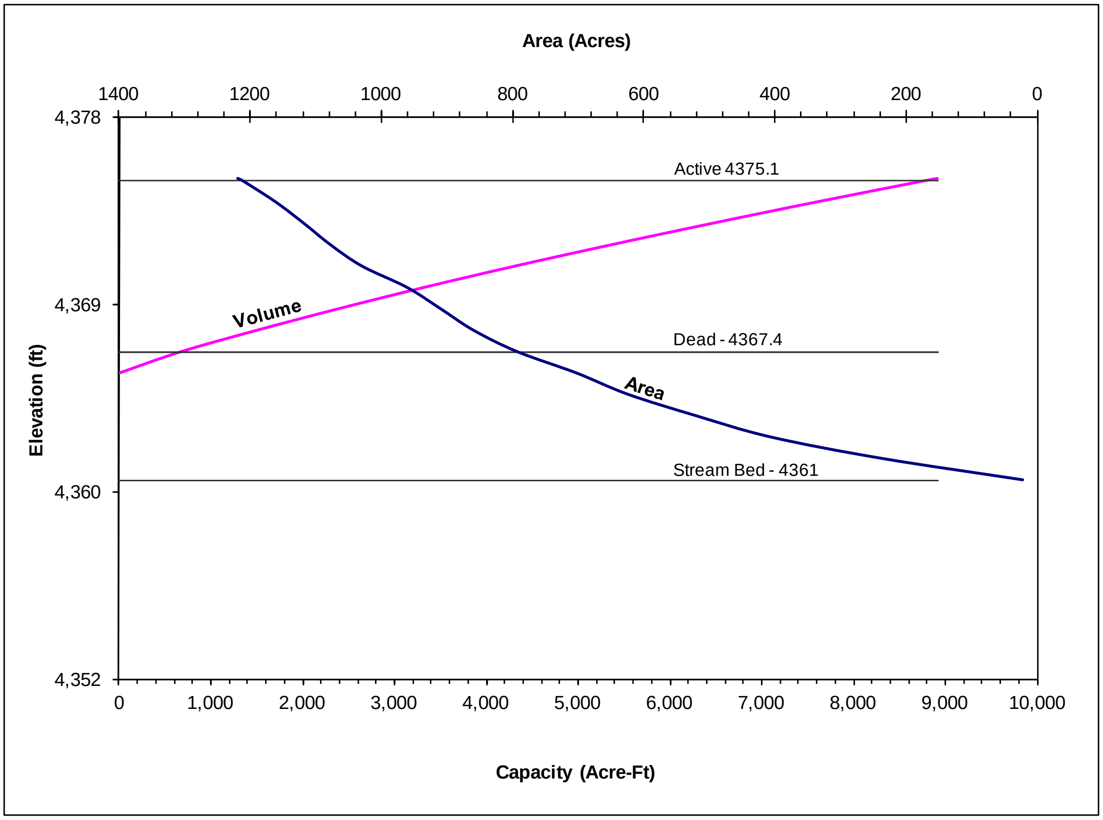


Figure 24. Elevation-Area-Capacity Curve for Lake Henry

Holbrook Reservoir

Holbrook Reservoir is part of the Holbrook System, which is used for Restoration of Yield storage previously discussed. Holbrook Reservoir is filled via the Holbrook Canal, which has a capacity of about 700 cfs. Holbrook Reservoir is leased by the Colorado Division of Wildlife as a State Wildlife Area. The active storage capacity of Holbrook Reservoir is about 6,200 acre-feet, and the surface area of the reservoir is slightly more than 600 acres. An elevation-area-capacity curve for the reservoir is shown in Figure 25.

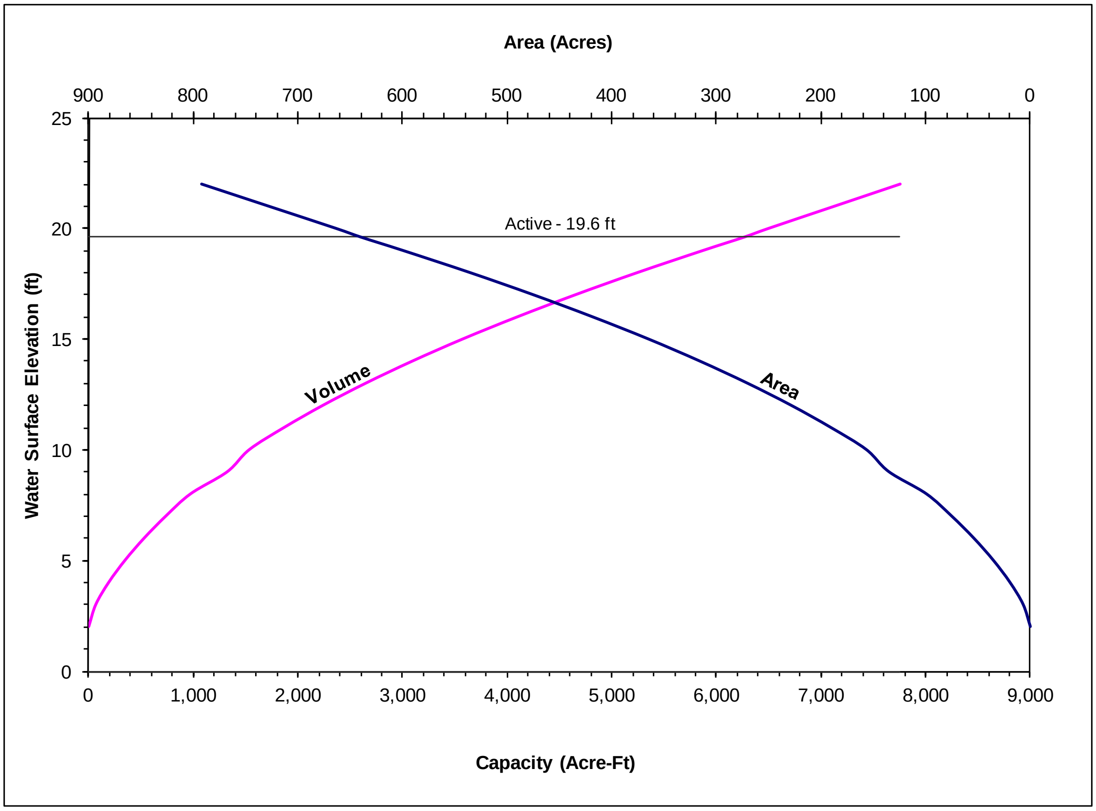


Figure 25. Elevation-Area-Capacity Curve for Holbrook Reservoir

John Martin Reservoir

John Martin Reservoir is an on-channel reservoir primarily used for flood control, irrigation, recreation and administration of the Arkansas River Compact between the states of Colorado and Kansas. The reservoir is located on the Arkansas River downstream from the town of Las Animas. John Martin Reservoir is owned and operated by the U.S. Army Corps of Engineers. The total capacity at top of dam is 793,400 ac-ft, maximum recreation and conservation storage is 344,000 ac-ft, and there is no dead storage. Elevation-area-capacity curves for John Martin Reservoir accounts are presented in Figure 26.

The Arkansas River and the Purgatoire River are the largest sources of inflow into John Martin Reservoir. As measured near Las Animas above John Martin Reservoir, the Arkansas River contributes about 83 percent of measured inflows to John Martin Reservoir, while the Purgatoire River contributes about 17 percent. Spring and early summer snowmelt contribute to Purgatoire River streamflow, and late summer thunderstorms can create large inflows into John Martin Reservoir. The Arkansas River Compact Administration's "Resolution Concerning An Operating Plan for John Martin Reservoir (as amended)" (also known as the 1980 Operating Plan) governs specific operations of John Martin Reservoir.

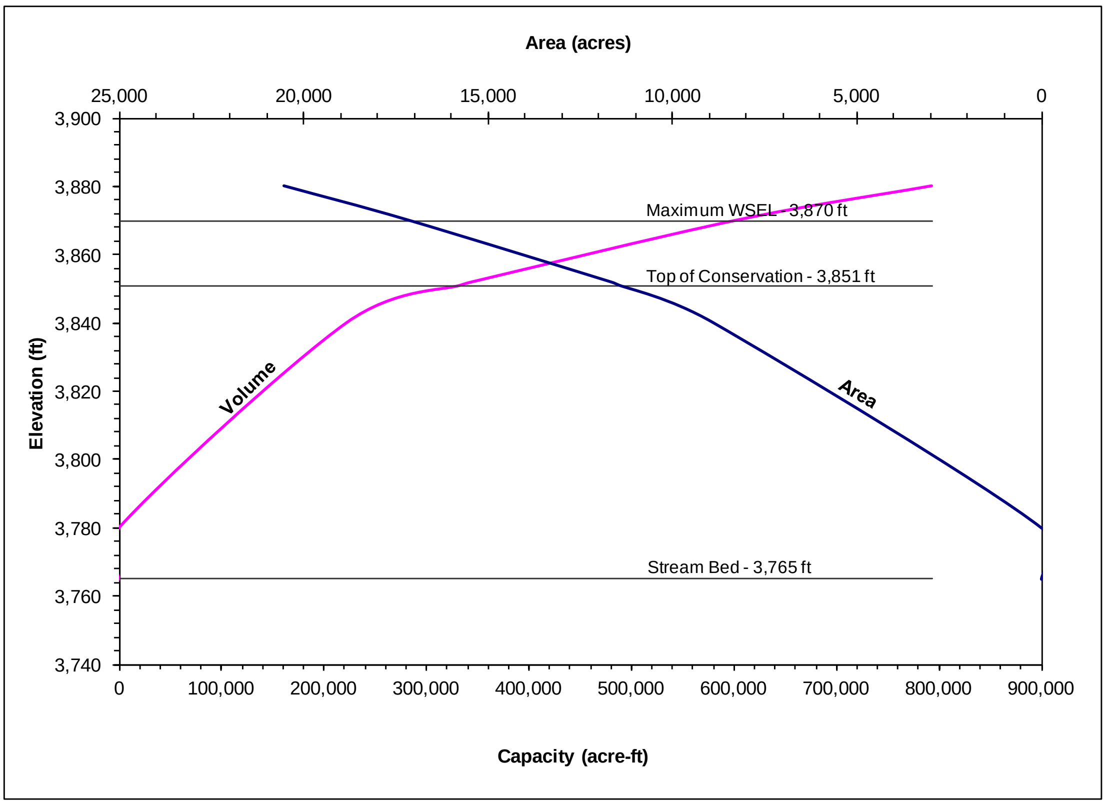


Figure 26. Elevation-Area-Capacity Curve for John Martin Reservoir

Homestake Reservoir

Homestake Reservoir is located on Homestake Creek above the Homestake Creek at Gold Park gage and has a capacity of about 43,000 acre-feet. Homestake Reservoir stores water captured in the collection system prior to its diversion to Turquoise Reservoir through the Homestake Tunnel. The reservoir was constructed during construction of the Homestake project, and was completed in 1967. Homestake reservoir typically fills in wet years and some average years, but does not fill in drier years (Figure 27).

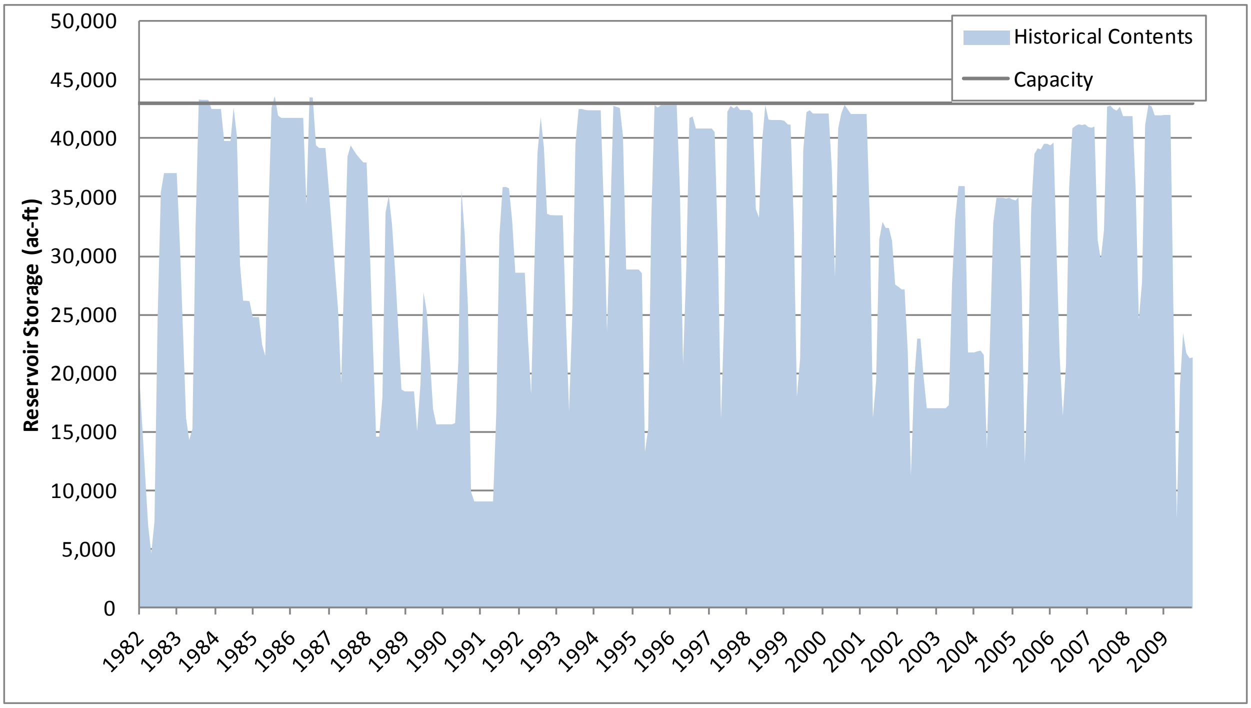


Figure 27. Daily Historical Storage - Homestake Reservoir

Grizzly Reservoir, which is a small equalizing reservoir at the inlet to the Twin Lakes Tunnel, is not included in the study area because it fluctuates daily based on diurnal runoff patterns, and is expected to continue to fluctuate similarly to existing conditions regardless of the alternative being analyzed in this EIS.

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Appendix D.2 - AVC Yield Analysis

Introduction

AVC participants have proposed to use several water supply sources for delivery through the AVC to help meet projected demand. These supplies include Fry-Ark allocations, Fry-Ark return flows, and non Fry-Ark Project (referred to in this appendix as non-Project) water. This appendix determines long-term Fry-Ark yields for AVC participants, assesses their potential Fry-Ark return flow yields, and quantifies non-Project water supplies needed under various supply scenarios. This appendix also discusses the adequacy of requested Master Contract storage space in context of the results of this yield analysis. This analysis does not consider the potential effects of climate change on water supply yields. These effects are examined in Appendix C. This yield analysis is a basic broad-level investigation and intended only for use by and to support the AVC EIS.

This yield analysis was conducted to determine the suitability of identified water supplies to meet AVC demand projected at the time of the analysis. During subsequent hydrologic and water supply operations modeling, additional information became available regarding assumptions and datasets that could affect the results of this yield analysis. Additionally, this analysis resulted in an increase in the projected annual delivery through AVC. This new information does not substantially affect the overall conclusions of the analysis.

Methods

A spreadsheet model was developed to analyze long-term AVC operations and yield specifically for AVC entities. The spreadsheet model only considers Fry-Ark supplies and non-Project supplies for AVC entities. The spreadsheet model does not simulate full Fry-Ark Project operations, nor does it simulate any other water users or uses in the basin. The methods and results were deemed appropriate for the intentions of this yield analysis. A more comprehensive investigation of Arkansas River Basin operations for the alternatives analyzed in detail in the EIS is performed by the Daily Model, as documented in the EIS.

The simulation period of this yield analysis is for water years 1950-2009. This period was selected because it contains several extended drought, average, and wet periods that affect Fry-Ark yield. The yield analysis uses a monthly time step for all demands, deliveries, storage, and exchanges. Monthly time-steps are appropriate for overall Fry-Ark project operations and AVC operations. All AVC supplies, demands and storage accounts are lumped into single nodes. This lumping was performed to simplify the analysis and was determined to be an adequate simplification to estimate overall yields of proposed AVC supplies.

This yield analysis considers potential Fry-Ark supplies, Fry-Ark return flows and non-Project supplies. Simulation of Fry-Ark operations for AVC entities includes these entities' allocation of

West Slope and East Slope Fry-Ark supplies, and simulation of AVC entities' allocated Fry-Ark carryover storage in Pueblo Reservoir. Simplifying assumptions are used regarding transit losses and evaporation to estimate net Fry-Ark yields available to AVC participants. Fry-Ark return flows are calculated based upon a participant's simulated use of reusable Fry-Ark water (both allocations and return flows), and the ability to exchange them to Pueblo Reservoir. Non-Project supplies are those identified and quantified by the participants. Yields of both Fry-Ark return flows and non-Project supplies depend on the ability to exchange those supplies to Pueblo Reservoir. Exchange potential was taken from other yields studies performed in the basin. The model operates the requested Master Contract storage space for AVC entities using both Fry-Ark return flows and non-Project supplies as sources of water for that account.

The spreadsheet model uses a simple sequential mass balance to simulate AVC operations. This operation can be represented by the following equation:

$$S_{t+1} = S_t + I_t - O_t - L_t$$

Where:

t = month
S = storage (both Fry-Ark carryover and Master Contract)
I = inflows (AVC Fry-Ark supplies, Fry-Ark return flows and non-Project supplies)
O = outflows (deliveries to AVC entities)
L = losses (evaporation and transit)

During any individual time-step, water supply available for delivery by AVC entities is the carryover storage from the previous time-step (both Fry-Ark carryover and Excess Capacity accounts) plus inflows (Fry-Ark yields, Fry-Ark return flows and non-Project supplies) minus evaporative and transit losses. Water delivered to AVC is then either full demand (if adequate supply is available) or reduced demand (based on how much supply is available). Any excess inflows are then added to carryover storage, and the process is repeated in the following month. Accounts for both the Fry-Ark carryover storage and Master Contract storage are separate to ensure that only Fry-Ark supplies are stored in Fry-Ark carryover storage space and non-Project supplies are stored in Master Contract storage space. Because Fry-Ark allocations are considered a supplemental supply, non-Project water and Fry-Ark return flows stored in Master Contract space are used to satisfy AVC demands before Fry-Ark supplies are used.

The yield model is somewhat limited based on methods and assumptions. A monthly time step may not fully capture daily variances in exchange potential, water supply availability and associated effects on storage contents and streamflow conditions. Additionally, lumping of supplies, demands and storage could potentially overestimate the use of individual non-Project water supplies, especially if participants are unable or unwilling to lease excess non-Project supplies to other AVC entities. These limitations are not expected to affect the overall results of the analysis. The Daily Model (Appendices D.3 and D.4) is a more comprehensive effects analysis of full AVC operations on a daily time step.

Data sets and methods of this yield analysis are discussed in the following sections. Additionally, a sensitivity analysis was performed to investigate how certain changes in the assumptions may affect results of the analysis, and is contained in the results section of this appendix.

Fry-Ark Project

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. The Fry-Ark Project consists of five reservoirs and one transmountain diversion tunnel, and supplements municipal and agricultural demands within the Arkansas Valley of Colorado. A simplified schematic of the East Slope features of the Fry-Ark Project appears in Figure 1.

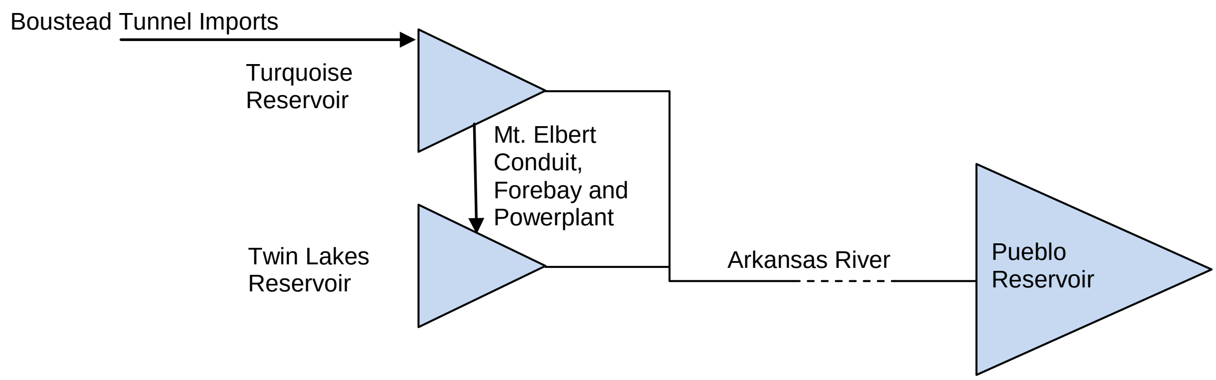

Figure 1. Schematic of Fry-Ark East Slope Facilities

The original estimated yield of the Fry-Ark Project from both West Slope imports and East Slope water rights was 80,400 ac-ft (Southeastern 1979). Several studies have confirmed that estimate (Reclamation 1990; Montgomery Watson 2000). Historical data (see following sections), however, show that historical yields of the Fry-Ark Project (since substantial completion in 1982) have averaged about 72,000 ac-ft per year (53,995 ac-ft West Slope yield; 17,757 East Slope yield). The difference between actual yields and yield estimates are partially due to uncompleted portions of the West Slope collection system, less than planned demand on the East Slope for supplemental lower municipal deliveries during initial years of the project, and inherent differences between actual conditions and assumed conditions in hydrologic analyses. For these reasons, a combination of historical and "potential" data is used in the yield analysis for Fry-Ark supplies and operations. The following sections briefly describe data and assumptions used in the yield model for Fry-Ark supplies, demands, operations and accounting.

Fry-Ark Supplies

The Southeastern Colorado Water Conservancy District (Southeastern) owns water rights on both the East and West Slopes of the Continental Divide in Southern Colorado. West Slope water rights are imported through the Boustead Tunnel, and are subsequently referred to as Boustead Tunnel imports. East Slope water rights are native Arkansas River water rights decreed in 1962 and 1969 with a 1939 priority date (thus they are occasionally referred to as "native yield"). However, operations of these rights are based on the Arkansas River Compact and depend upon various conditions, one being the conservation pool at John Martin Reservoir being full or spilling. Therefore, the East Slope water rights are rarely in priority (see Appendix D.1 for information regarding the percent of time East Slope water rights have historically been in priority). Fry-Ark return flows could also be available for use in the AVC. Fry-Ark return flows accrue to the Arkansas River through municipal and agricultural use of Fry-Ark allocations, and can be exchanged to Pueblo Reservoir. Exchanges to Pueblo Reservoir require an excess capacity account (Reclamation 2011a).

Because existing and future conditions model runs contemplate full use of Fry-Ark facilities for a study period (1950 to 2009) longer than the historical existence of the project (generally 1970s to present), the model uses a composite data set of potential yields and historical yields to simulate these supplies. This section describes the calculation methods used to determine potential volume of Fry-Ark water available on a monthly basis for both East and West Slope water rights, as well as return flows.

Boustead Tunnel Imports

The Boustead Tunnel diverts water from the Roaring Fork and Fryingpan River basins on the West Slope of the Continental Divide in the Sawatch Range. Water rights for the Boustead Tunnel and West Slope Fry-Ark collection systems were decreed in a District 38 general adjudication (Civil Action No. 4613, Garfield County). The priority date of the Boustead Tunnel/collection system diversions is July 29, 1957. Through the Fry-Ark Operating Principles (House Document No. 130, 87th Congress, 1st Session; House of Representatives 1961), Boustead Tunnel diversions are limited to 120,000 ac-ft in any one year, and 2,352,800 ac-ft in any 34 years. The Boustead Tunnel diversion rate is limited to 945 cfs (Stipulation of Division 5 Case No. 02CW324 and 02CW365, Garfield County).

The Operating Principles provide for the Fry-Ark Project, by agreement with the Twin Lakes Reservoir and Canal Company (Twin Lakes Company), to operate an exchange to maintain specified target streamflows in the Roaring Fork River. The Twin Lakes Company agrees to bypass water on Lincoln Creek and the Roaring Fork, up to 3,000 ac-ft per year to maintain minimum flows between October 1 and September 30. The Fry-Ark then delivers a like amount (adjusted for transit losses) to The Twin Lakes Company in Twin Lakes Reservoir (Reclamation 2010). This adjustment has been made to all datasets used in this analysis.

During some years, historical diversions through Boustead Tunnel were limited for various reasons, including the extent of West Slope diversion system features, amount of East Slope Fry-Ark storage space available, and limited historical Fry-Ark demands. Furthermore, the Boustead Tunnel did not begin diversions to the East Slope until 1972. As a result, reliance upon historical imports for the Boustead Tunnel may not accurately represent the amount of water that was potentially available for diversion during any given year. A composite set of potential Boustead import data was developed for the model. Using potential imports allows the model to determine how much of the imports would be curtailed, and not simply assume it would be the same as historical. The model, however, does operate similarly to historical conditions by not importing Boustead water when space is unavailable.

Data used for developing a composite data set of potential Boustead Tunnel imports are available from various sources of information. Reclamation maintains records of historical imports in its annual operating plans and related in-house data sets (Reclamation 2010), while the State of

Colorado maintains records of physical imports as measured at the discharge of the Boustead Tunnel into Turquoise Reservoir (Station ID 09077160, DWR 2011). Southeastern has an informal data set that accounts for historical foregone diversions on the West Slope (Southeastern 2011). An independent model developed and maintained by Grand River Consulting Corporation contains hydrology and water rights data in the Colorado River Basin that simulates maximum potentially and legally available imports through the Boustead tunnel (Grand River Consulting 2004, 2009). Potential Boustead Tunnel imports used in this yield analysis are a composite of available data sets, as seen in Figure 2 and Table 1.

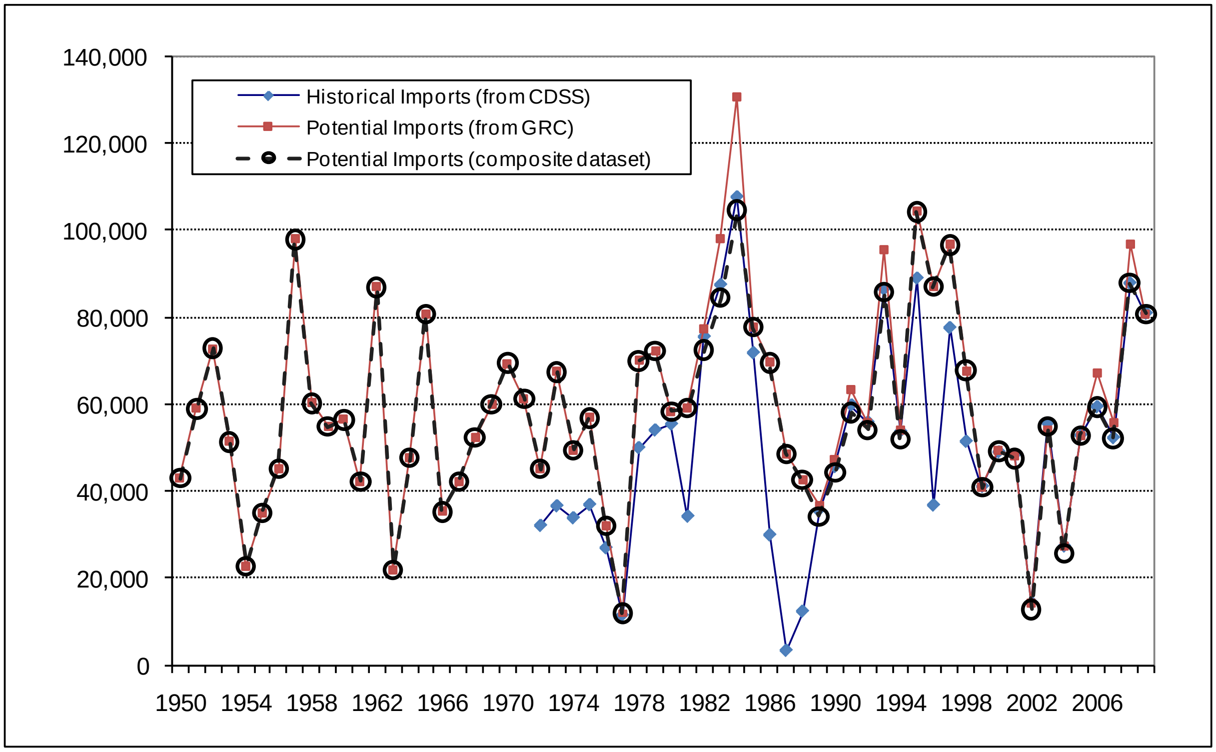

Figure 2. Comparison of Net Boustead Tunnel Import Data Sets

The composite data were developed as follows:

- Water years 1982-2009:
  - In years where Fry-Ark East Slope water rights are in priority for more than five days, or when foregone Boustead diversions were recorded by Southeastern, the GRC model output is used for potential imports in the simulation. It is assumed Fry-Ark storage or demand conditions curtailed imports during those years. Since the GRC model is a more comprehensive development of available flows, the data represent potential imports more accurately than using a dataset comprised of historical inflows plus the foregone diversions recorded by Southeastern.
  - In years where Fry-Ark East Slope water rights were not in priority for more than five days and foregone Boustead diversions were not recorded by Southeastern, composite potential imports are assumed to equal historical diversions.
- Water years prior to 1982: Composite potential imports in the simulation equal GRC model output. Prior to 1982, the historical diversions do not represent the full potential import as West Slope diversion facilities were not complete and operational.

Table 1. Potential Boustead Yield Data Sets

WY	Net Boustead Imports (ac-ft) [1]			WY	Net Boustead Imports (ac-ft) [1]		
	Historical [2,3]	Potential[4]	Composite Potential [5]		Historical [2,3]	Potential [4]	Composite Potential [5]
1950	[3]	43,045	43,045	1980	52,391	58,419	58,419
1951	[3]	58,966	58,966	1981	31,188	59,040	59,040
1952	[3]	72,842	72,842	1982	72,488	77,174	72,488
1953	[3]	51,371	51,371	1983	84,438	97,883	84,438
1954	[3]	22,854	22,854	1984	104,639	130,664	104,639
1955	[3]	34,908	34,908	1985	68,797	77,713	77,713
1956	[3]	45,227	45,227	1986	28,452	69,564	69,564
1957	[3]	97,944	97,944	1987	340	48,567	48,567
1958	[3]	60,212	60,212	1988	11,325	42,567	42,567
1959	[3]	54,876	54,876	1989	34,236	36,498	34,236
1960	[3]	56,454	56,454	1990	44,270	47,389	44,270
1961	[3]	42,319	42,319	1991	58,136	63,405	58,136
1962	[3]	86,925	86,925	1992	54,064	55,731	54,064
1963	[3]	21,891	21,891	1993	85,737	95,567	85,737
1964	[3]	47,660	47,660	1994	52,042	54,107	52,042
1965	[3]	80,843	80,843	1995	88,264	104,276	104,276
1966	[3]	35,279	35,279	1996	35,537	86,941	86,941
1967	[3]	42,117	42,117	1997	76,379	96,620	96,620
1968	[3]	52,501	52,501	1998	50,997	67,756	67,756
1969	[3]	60,072	60,072	1999	40,141	40,821	40,821
1970	[3]	69,494	69,494	2000	47,695	49,223	49,223
1971	[3]	61,283	61,283	2001	47,529	48,303	47,529
1972	29,067	45,168	45,168	2002	12,782	14,474	12,782
1973	33,579	67,418	67,418	2003	54,989	54,268	54,989
1974	30,826	49,444	49,444	2004	25,588	25,588	25,588
1975	33,870	56,852	56,852	2005	52,811	52,811	52,811
1976	23,937	32,177	32,177	2006	59,336	66,982	59,336
1977	8,413	11,942	11,942	2007	52,223	55,807	52,223
1978	46,959	70,000	70,000	2008	87,790	96,967	87,790
1979	51,022	72,208	72,208	2009	80,842	80,851	80,842
				Average	48,766	59,338	57,829
				Average (82-09)	53,995	65,661	62,428

Notes:
[1] Data sets have been adjusted for full Twin Lakes Reservoir and Canal Company exchange.
[2] DWR, 2011
[3] Fry-Ark diversions from the West Slope did not begin until May 16, 1972. Full diversions did not commence until after 1981. Historical diversions are curtailed if Project storage is full.
[4] GRC, 2004, 2009
[5] Years where Fry-Ark East Slope water rights are in priority for more than five days, or when foregone Boustead diversions were recorded by Southeastern include: 1985-1988, 1995-2000

East Slope Water Rights

East slope Fry-Ark water rights were decreed in a District 11 General Adjudication (Civil Action No. 5141, Chaffee County) and District 14 General Adjudication (Civil Action No. B-42135, Pueblo County), which established an appropriation date for Fry-Ark East Slope facilities of February 10, 1939. The Fry-Ark water right for Pueblo Reservoir was decreed on June 24, 1962, while Fry-Ark water rights for Twin Lakes and Turquoise Reservoir were decreed on July 9, 1969, all with a 1939 priority date subject to previously decreed rights. Essentially, East Slope water rights allow Fry-Ark to store native water during periods when the conservation pool at John Martin Reservoir is full and/or spilling, and East Slope decrees are in priority. In this yield analysis, East Slope water rights were estimated as those periods when Pueblo Reservoir was the calling water right or in-priority, or when a "Free River" existed on the Arkansas River based on historical river call records maintained by the Colorado Division of Water Resources. This information was taken from previous studies (CSU 2005). Table 2 compares historical East Slope yields with calculated East Slope yields used in this analysis.

Table 2. Potential Fry-Ark East Slope Yields

WY	Historical East Slope Yield (ac-ft)	Calculated Potential East Slope Yield [2] (ac-ft)	WY	Historical East Slope Yield [3] (ac-ft)	Calculated Potential East Slope Yield [2] (ac-ft)
1950	[1]	0	1980	0	0
1951	[1]	0	1981	0	0
1952	[1]	0	1982	0	0
1953	[1]	0	1983	0	0
1954	[1]	0	1984	0	0
1955	[1]	0	1985	100,657	89,285
1956	[1]	0	1986	1,833	0
1957	[1]	286,713	1987	20,231	264,494
1958	[1]	81,583	1988	0	0
1959	[1]	0	1989	0	0
1960	[1]	0	1990	0	0
1961	[1]	1,876	1991	0	0
1962	[1]	0	1992	0	0
1963	[1]	0	1993	0	0
1964	[1]	0	1994	0	0
1965	[1]	132,470	1995	147,375	144,651
1966	[1]	0	1996	0	0
1967	[1]	0	1997	0	0
1968	[1]	0	1998	55,213	52,259
1969	[1]	0	1999	130,290	175,726
1970	[1]	0	2000	41,603	1,811
1971	[1]	0	2001	0	0
1972	[1]	0	2002	0	0
1973	[1]	0	2003	0	0
1974	[1]	0	2004	0	[4]
1975	0	0	2005	0	[4]
1976	0	0	2006	0	[4]
1977	0	0	2007	0	[4]
1978	0	0	2008	0	[4]
1979	0	0	2009	0	[4]
			Average	14,206	20,514
			Average (1982-2009)	17,757	26,008

Notes:
[1] Pueblo Reservoir was not completed until 1975.
[2] Colorado Springs Raw Water Yield Study (CSU 2005).
[3] Project reservoirs were full from 1985-1988 and 1995-2000. Physical space was unavailable to store East Slope yield.
[4] Values for year 2004-2009 were not calculated in Raw Water Yield Study (CSU 2005). Assumed 0 for calculations based on historical call records.

In recent years, municipalities have been storing more water in carryover and excess capacity accounts. In 2010 and 2011, without U.S. Army Corps of Engineers' waivers, an estimated 8,000 to 11,000 ac-ft of municipal water would have spilled to make room for Project water. When East Slope water comes into priority, current trends indicate that Fry-Ark Project reservoirs would be full, West Slope imports would be curtailed, and non-Project water accounts would be spilled.

Return Flows

Return flows generated from uses of Fry-Ark water can be used and reused to extinction. Most entities make use of their return flows either using exchanges into Pueblo Reservoir or for augmentation (i.e. replacing depletions created by out of priority diversions). Exchanges of return flows into Pueblo Reservoir require an excess capacity account (Reclamation 2011a). Any direct or return flow deliveries used for augmentation are considered fully consumed, and produce no additional reusable water. For municipal water use, any direct or return flow deliveries that are in excess of the amount of water consumed (also referred to as consumptive use) by water users produce return flows. The timing, quantity, and location of municipal return flows vary depending on whether deliveries are made for indoor or outdoor use. The yield analysis divides municipal demands into indoor deliveries and outdoor deliveries, and assumes indoor deliveries remain constant throughout the year and are equal to December's delivery rate (assuming all deliveries during this month are for indoor uses). Annual delivery distributions were taken from the Arkansas Basin Future Water and Storage Needs Assessment (GEI 1998).

For all municipal deliveries, a portion of water delivered is consumed while a portion returns to surface water, either through sewered return flows that flow to a wastewater treatment facility, or through non-sewered return flow that accrue to the system as surface water or ground water runoff. Sewered return flows are assumed to equal 85 percent of indoor water use, and this return flow ratio does not vary by entity. Measured sewered return flows that are purchased by the same entity that generates the return flows can be exchanged under the 1939 priority decreed in Civil Action No. 5141, Chaffee County; and Civil Action No. B-42135, Pueblo County. Although non-sewered return flows can be purchased and exchanged under a junior exchange decree (01CW151, Div. 2, pending), the preferred use of non-sewered return flows is for well augmentation and the junior priority of exchanges for remaining non-sewered return flows (i.e. those not used for augmentation) result in these being an unreliable source of supply, especially during dry years.

This analysis assumes that entities interested in using return flows in AVC would purchase their own return flows and exchange them under the Southeastern's 1939 decree. For purposes of this analysis, it was assumed that these return flows are all sewered return flows, thus making them eligible for exchange under the 1939 decree (which requires the return flows to be measured). Some of the smaller entities may be on septic system, which would then require return flows to be exchanged under the 01CW151 decree. These exchanges and net availability of Fry-Ark return flows to each entity are discussed in later sections of this document.

Fry-Ark Accounting

This section describes assumptions used in the yield analysis for allocation of Fry-Ark water supplies to municipal and agricultural participants, carryover storage allocations, and evaporation and transit losses.

Allocations

Annual Fry-Ark water supplies are allocated and made available for purchase by irrigation entities, municipal water providers and domestic water providers within Southeastern's district boundaries. Through their allocation principles, Southeastern has categorized municipal users into four groupings: municipal entities west of Pueblo, the Board of Water Works of Pueblo, municipal entities east of Pueblo, and Fountain Valley Authority. Each entity is allocated a certain percentage of Fry-Ark yield and storage. According to Southeastern's allocation principles, at least 51 percent of the Fry-Ark yield is allocated to municipal use (Southeastern 1979). The remaining 49 percent of Fry-Ark yield is allocated to agricultural water users. Of the 51 percent municipal allocation, 4 percent is allocated to municipal entities west of Pueblo, 10 percent is allocated to Board of Water Works of Pueblo, 25 percent is allocated to Fountain Valley Authority entities, and 12 percent is allocated to east of Pueblo municipal entities.

Historically, Fry-Ark water use by municipal entities other than Fountain Valley Authority entities has been low, because full population planning horizons have not yet been reached. Since the drought years in the early 2000s, many municipal entities have requested their full allocation. Since then, use of municipal Fry-Ark water allocations have been on the rise, and will continue to meet rising demand projections (Reclamation 2011b).

All AVC participants are included in the Fry-Ark east of Pueblo municipal group. Table 3 lists the Fry-Ark allocations to east of Pueblo entities (Southeastern 2007, 1979). Note that the AVC allocation, according to the allocation principles, is not the full 12 percent, as some east of Pueblo entities are not AVC participants (i.e., Joseph Water Co., O'Neal Water Works, Parkdale Water Association, and Riverside Water Association). In 2007 Southeastern began permanently allocating to municipal use a portion of the 49 percent unallocated yield that was no longer being used for irrigation, known as "Not Previously Allocated Non Irrigation Water" (NPANIW). NPANIW supplies are reallocated under Allocation Principle H, which provides for reallocation of Fry-Ark irrigation water that was used on land where the primary water right has been converted to non-irrigation uses (Southeastern 2007). Based on discussions with Southeastern, this yield analysis assumes 100 percent of NPANIW supplies (2.18 percent of total Fry-Ark allocations) designated for the east of Pueblo municipal group is allocated to AVC participants only, as seen in Table 3. Allocation of NPANIW supply is based on a participant's pro rata share of Fry-Ark yield.

Storage

Fry-Ark allocation groups are also allocated storage space within Fry-Ark reservoirs. A total of 159,000 ac-ft of Fry-Ark storage is set aside for municipal carryover storage (Reclamation 1990). East of Pueblo municipal entities are annually allocated "not less than 37,400 ac-ft" of carryover storage space (Southeastern 1979). This yield analysis does not sub-divide the 37,400 ac-ft of storage for East of Pueblo entities into "sub-accounts" for individual entities. Reductions were made in this yield analysis to account for those East of Pueblo entities that are not participating in AVC.

The model only considers the Fry-Ark Project carryover storage for AVC participants, and Excess Capacity storage for AVC participants. It is assumed that no other entities affect the ability of AVC entities to store Fry-Ark Project water in Fry-Ark carryover storage accounts. For any individual month, if the sum of AVC demand and carryover storage availability is greater than the AVC portion of Fry-Ark potential yields (potential yield * 14.178 percent), then physical yield equals potential yield. If the sum is less than potential AVC yield, than the actual physical yield equals the sum of deliveries and carryover storage availability. Excess capacity storage space and non-Fry-Ark allocation supplies are described in the AVC sections below.

Table 3. Fry-Ark East of Pueblo Allocations

Fry-Ark East of Pueblo Municipal Entity	Fry-Ark Allocation Percentage		Fry-Ark Firm Yield (ac-ft)(1)	
	From Allocation Principles (%)	With NPANIW supplies (%)	Allocation with NPANIW	Return Flows
AVC Participants	**11.473**	**13.585**	**7,120**	**1,931**
96 Pipeline Co.	0.043	0.051	27	10
Avondale Water and Sanitation Dist.	0.264	0.313	164	58
Beehive Water Assoc.	0.035	0.041	22	8
Bents Fort Water Company	0.203	0.241	126	45
Boone, Town of	0.079	0.093	49	17
Cheraw, Town of	0.048	0.056	30	11
Crowley County Water Assoc.	0.802	0.949	497	177
Crowley, Town of	0.042	0.050	26	9
Eads, Town of	0.168	0.199	105	0
East End Water Assn. (La Junta)	0.016	0.019	10	3
Eureka Water Company	0.091	0.108	56	20
Fayette Water Assoc.	0.014	0.017	9	3
Fowler, Town of	0.272	0.322	169	60
Hancock Inc.	0.030	0.036	19	7
Hasty Water Company	0.062	0.073	38	0
Hilltop Water Company	0.065	0.077	40	14
Holbrook Center Soft Water	0.010	0.012	6	2
Homestead Improvement Assoc.	0.015	0.017	9	3
La Junta, City of	1.706	2.020	1,059	377
Lamar, City of	1.999	2.367	1,241	0
Las Animas, City of	0.804	0.952	499	178
Manzanola, Town of	0.118	0.140	73	26
May Valley Water Assoc.	0.308	0.365	191	0
McClave Water Assoc.	0.095	0.112	59	0
Newdale-Grand Valley Water Co.	0.104	0.124	65	23
North Holbrook Water	0.014	0.016	8	3
Olney Springs, Town of	0.088	0.104	54	19
Ordway, Town of	0.281	0.333	175	62
Patterson Valley	0.022	0.026	13	5
Rocky Ford, Town of	0.966	1.144	600	214
South Side Water Assoc. (La Junta)	0.009	0.010	5	2
South Swink Water Company	0.132	0.156	82	29
St. Charles Mesa Water Assoc.	2.096	2.482	1,301	464
Sugar City, Town of	0.091	0.108	57	20
Swink, Town of	0.157	0.186	97	35
Valley Water Assoc.	0.060	0.070	37	13
Vroman Water Assoc.	0.033	0.039	20	7
West Grand Valley Water Inc.	0.019	0.022	12	4
West Holbrook Water	0.004	0.004	2	1
Wiley, Town of	0.109	0.129	68	0
Non-AVC Participants	**0.167**	**0.167**	(2)	(2)
Reserved	**0.360**	**0.427**	(2)	(2)
Total Allocation	**12.000**	**14.178**	**7,120**	**1,931**

Notes:
(1) See subsequent report sections for description of firm yield calculations.
(2) Firm yield values were not calculated for these entities.

It is assumed for most scenarios in this yield analysis that AVC participants make decisions to purchase Fry-Ark allocations when available and store excess allocations (i.e. allocations above AVC delivery requirements) in carryover storage. East of Pueblo entities have historically not utilized their carryover storage space to store their full annual allocations. Carryover space has typically been used to maintain a supply of not more than two or three years of annual demand

(Reynolds 2011). A scenario in this yield analysis will simulate such Fry-Ark carryover storage use.

The period of simulation for this yield analysis predates Fry-Ark facilities, so a monthly average account content value is used for the starting reservoir contents. It is assumed that participants do not maintain a minimum level of Fry-Ark carryover storage.

Evaporation and Transit Losses

Evaporation and transit losses decrease the available yield of Fry-Ark supplies. Volumetric transit loss typically varies with flow, while evaporative losses from reservoirs vary with surface area and atmospheric conditions. For this yield analysis, evaporation losses are simplified to monthly Pueblo Reservoir evaporation rates listed in Table 4, and are applied to the sum of the previous month's account storage and the current month's account inflow. These evaporation rates were developed using average evaporation rates by month as calculated by the Daily Model. A 10 percent transit loss was also applied to Fry-Ark yield in this analysis.

Table 4. Pueblo Reservoir Evaporation Rates

Month	Water Month	Account Evaporation (% of stored water)
Oct	1	0.1
Nov	2	0.2
Dec	3	0.3
Jan	4	0.5
Feb	5	0.8
Mar	6	1.0
Apr	7	0.9
May	8	0.7
Jun	9	0.6
Jul	10	0.5
Aug	11	0.2
Sep	12	0.1
Total		**6.0**

AVC

The following sections discuss the demands and operations of the AVC. Demands are consistent with the purpose and need for the project as described in Chapter 1 of the EIS. Proposed operations of AVC are consistent with the AVC alternatives that would divert water directly from Pueblo Reservoir as described in Chapter 2. Slight variations in water supplies and operations could occur for other alternatives.

AVC Demands

As shown in Table 3, AVC participants include a variety of water providers such as cities, towns, and rural water providers (including districts, companies and associations) throughout the lower Arkansas River Basin. Water users served by these providers include residential, commercial, and industrial customers. The AVC demand has initially been determined to be approximately 9,200 ac-ft per year. Annual releases from Pueblo Dam into the AVC will be approximately

9,700 ac-ft to account for a five percent maximum water treatment plant loss (actual losses may be lower)[1]. It should be noted that the AVC demand is less than the total 2070 participant demand, as use of some existing supplies and infrastructure will continue. The determination of future water demands for AVC participants, useable water supplies, and AVC deliveries are described in Chapter 1 of the EIS.

AVC Operations

Operational components of the AVC include proposed supplies, exchanges, storage, deliveries and other actions necessary to construct and operate the project.

AVC Supplies

Several supply options are available to AVC participants to meet their AVC demand, including Fry-Ark allocations, Fry-Ark return flows, and identified non-Project supplies. Both Fry-Ark allocations and return flows were discussed in a previous section. To be eligible for analysis in the EIS and subsequent contracting processes that are covered by this EIS, non-Project supplies identified by participants had to be quantifiable shares of a specified ditch that were either purchased, or soon to be purchased, by the participant[2]. Identified ditch shares also had to be eligible for exchange to and storage in Pueblo Reservoir. Although they need not be currently decreed as such (e.g. supplies diverted downstream from John Martin Reservoir are ineligible for exchange to Pueblo Reservoir), they will need to be decreed before Reclamation will include them in the Master Contract contracting process. A full listing of these supplies is presented in Appendix A.

At the time of this appendix, nine AVC participants identified Fry-Ark return flows as an AVC supply (Table 5), representing 34.5 percent of AVC Fry-Ark allocations. Approximately 4,200 ac-ft of annual non-Project supply have been identified by various AVC participants (Table 6). It is assumed that Fry-Ark return flows and non-project supplies must be stored in or flow through an excess capacity account before delivery in the AVC.

Table 5. Participants with Fry-Ark Return Flows Delivered in AVC

County	Participant	Annual Return Flow Supply (ac-ft)[(1)]
Otero	Fayette Water Co.	3
	Fowler	65
	Holbrook Center Soft Water	2
	Homestead Improvement Assn.	4
	La Junta, City of	411
	Rocky Ford, City of	233
	South Swink Water Co.	32
Bent	Las Animas, City of	194

Notes:
(1) Potential Fry-Ark return flows under a full AVC demand scenario.

[1] Note that as a result of this analysis, some AVC participant demands were adjusted due to the higher Fry-Ark allocation availability calculated in this yield analysis as compared with the slightly lower value used in the STAG analysis (i.e. many participant demands were based on the amount of Fry-Ark water available). These adjustments would have minimal change in the results of the analysis, thus the original demands were used in category B and C runs described below.

[2] Ultimately, any non-Project water supplies used in AVC or stored in the Master Contract would need to be fully purchased and decreed before a contract for their use can be signed with Reclamation.

Figure 3 presents potential supplies available to AVC participants. Several wet periods (e.g. mid-1980s, late 1990s) and dry periods (e.g. 1977, 2002) are evident in the annual record. The frequency and timing of these periods, in conjunction with storage, define the yield available to AVC participants, as discussed in the Results section of this appendix.

Table 6. Reported AVC Non-project Supplies

County	Participant	Supply	Reported Supply [1] (ac-ft)
Pueblo	St. Charles Mesa Water District	Zoeller Ditch	620
	St. Charles Mesa Water District	Cottonwood Irrigating Ditch	1,040
	St. Charles Mesa Water District	Velasquez Non-exempt Tributary Wells	238
Crowley	96 Pipeline Co.	Colorado Canal/Lake Meredith	3
	Crowley County Water Association	Twin Lakes Reservoir and Canal Company	8
	Crowley County Water Association	Colorado Canal/Lake Meredith	176
	Olney Springs, Town of	Twin Lakes Reservoir and Canal Company	100
	Olney Springs, Town of	Colorado Canal/Lake Meredith Company	56
	Ordway, Town of	Twin Lakes Reservoir and Canal Company	450
	Ordway, Town of	Colorado Canal/Lake Meredith Company	135
	Sugar City	Twin Lakes Reservoir and Canal Company	62
Otero	Bents Fort Water Co.	Twin Lakes Reservoir and Canal Company	34
	La Junta, City of	Holbrook Mutual Canal	800
	Manzanola, Town of	Catlin Canal	26
	Manzanola, Town of	Highline Canal	74
	Rocky Ford, City of	Catlin Canal	215
	Rocky Ford, City of	Rocky Ford Ditch	151
Bent	Las Animas, City of	Las Animas Consolidated Shares	50
Various	Various	Leased Water [2]	N/A
Total	-	-	**4,237**

Notes:
[1] Reclamation, 2011c.
[2] Water available for lease to AVC Participants could include excess Crowley County Twin Lakes and Colorado Canal shares, and Lower Arkansas Valley Water Conservancy District supplies.

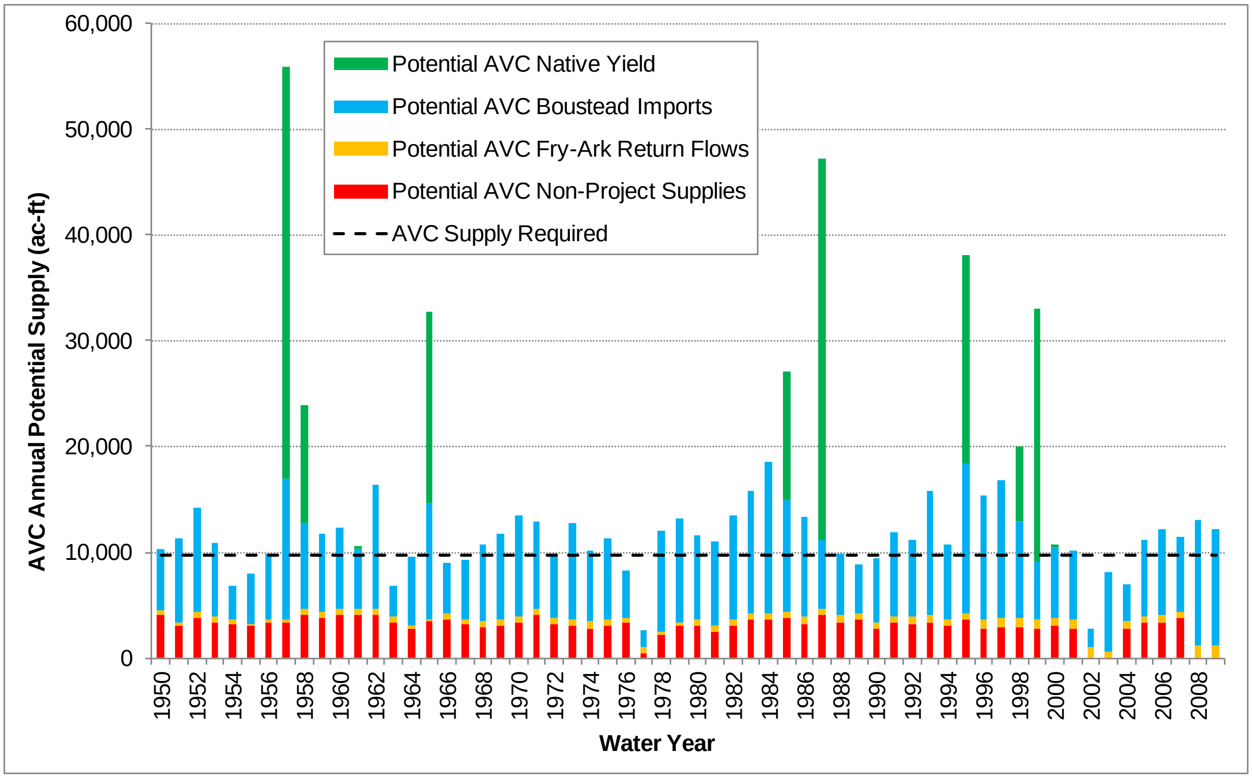

Figure 3. Potential Annual AVC Supplies

Exchanges

Exchanges have been operated in Colorado and managed by the State Engineer's Office since the 1890s as a means to fully use water supplies within the state. The basic concept of an exchange is that a water user may make 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 as long as no senior water rights within the exchange reach or at any other point on the river are injured. Exchanges are typically employed when an entity owns water that is physically downstream from the location where they want to use the water.

Figure 4 presents three hypothetical exchange situations: river conditions before an exchange, river conditions with a Colorado Springs reusable return flow exchange (as an example), and river conditions with a Colorado Canal exchange. It is assumed in these examples that the reduction in flow within the exchange reach does not injure a senior water right in this reach. If there is injury, then the exchange cannot be executed.

- No Exchange: The first box in Figure 4 represents river conditions before exchange. Under this hypothetical example, there is no flow down Fountain Creek, and the flow in the Arkansas River is 500 cfs throughout its length.

- Reusable Return Flow Exchange: The second box presents an example of a reusable return flow exchange. Reusable return flows are generated by the non-consumptive portion of reusable deliveries, such as transmountain water. By Colorado water law, an entity has a right to reuse its reusable return flows to extinction. As shown in the example, 100 cfs of reusable return flows are generated at Colorado Springs wastewater treatment plant. This water flows down Fountain Creek, allowing a like amount of water to be taken by Colorado Springs into Pueblo Reservoir. Flow decreases in the reach from Pueblo Reservoir to Fountain Creek, but remains whole upstream and downstream from this reach.

- Colorado Canal Exchange: The third box presents an example of Colorado Canal exchanges from Lake Meredith. A 150 cfs release of water is made from Lake Meredith to the Arkansas River, while the same amount of water is diverted by Colorado Springs into Pueblo Reservoir. Again, flows within the exchange reach from Lake Meredith to Pueblo Reservoir are reduced by the amount of the exchange, but remain whole upstream and downstream from this reach.

There are several decreed exchanges on the Arkansas River as well as numerous others that currently have applications in water court, or are being contemplated by municipal entities within the basin. Several exchanges depend upon using Fry-Ark storage space to facilitate exchanges. Many exchanges into Pueblo Reservoir are governed by the water right stipulation of June 5, 1985, that requires certain entities exchanging into Pueblo Reservoir storage to share exchange opportunities. The decreed exchanges are administered in a rather complex priority system and often have monthly and annual limitations. For example, as a result of the Winter Water Storage Program decree and priority date (March 1, 1910), most exchanges are not made into Pueblo Reservoir during the Winter Water season. A listing of current decreed exchanges is presented in Appendix D.1.

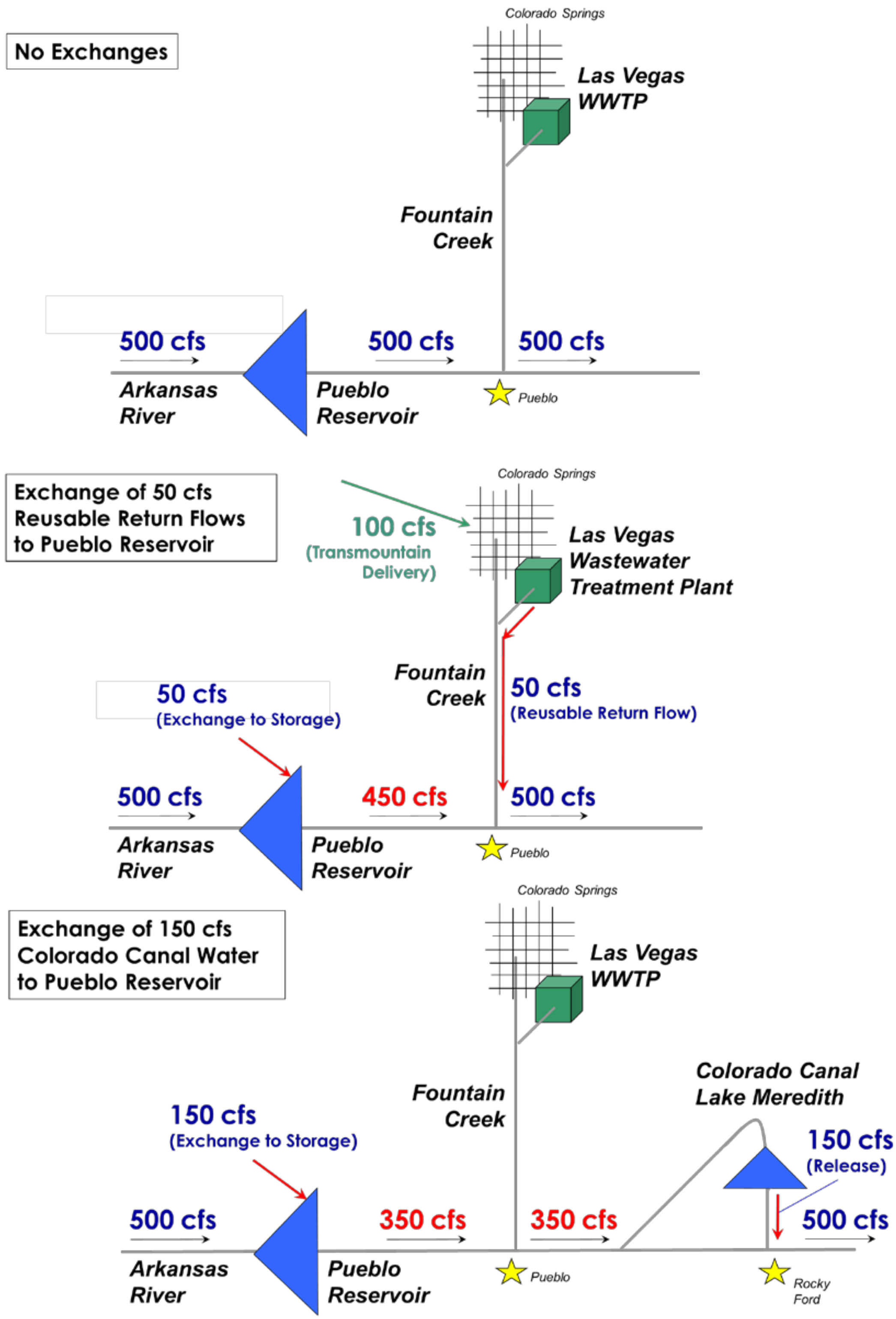

Figure 4. Exchange Examples

To determine the amount of exchange that could occur in a river reach, exchange potential is calculated. Exchange potential is the minimum flow in the river between the exchange points, after considering senior demands, flow management programs, and instream flow rights. Because calculating existing and future exchange potential is very complex in the Arkansas Basin, existing estimates of exchange potential were used in this analysis. The first data set comes from the Full Exchange Impact Model, which was developed to determine Colorado Springs' exchange potential in response to the City of Pueblo's recreational in-channel diversion filing (Colorado Springs Utilities 2005). The second data set is the exchange potential calculated as part of Southeastern's 01CW151 decree application. This yield analysis uses the minimum of the two data sets on a monthly basis to conservatively approximate exchange potential available to AVC participants.

Storage

AVC participants have two options regarding AVC supply storage. Fry-Ark allocations may be stored in Fry-Ark carryover storage. Fry-Ark return flows and non-Project water must be stored in an excess capacity account in Pueblo Reservoir. AVC participants have requested 8,238 ac-ft of long-term excess capacity as part of the Master Contract (Table 7). Evaporation losses are calculated similar to Fry-Ark evaporation losses, and Master Contract starting content is zero.

AVC Deliveries

As discussed in the "AVC Demands" section of this appendix, the initial AVC demand is approximately 9,200 ac-ft per year. Deliveries in the Yield Analysis meet demand distributed on a monthly basis (Table 8). To meet demand, the Yield Analysis assumes AVC participants would first deliver their Fry-Ark return flows and non-Project supplies stored in their Master Contract, in preference to their Fry-Ark allocation. Fry-Ark allocations are assumed to be a supplemental water supply.

AVC releases in the Yield Analysis do not experience channel transit loss, but do have a five percent loss in the proposed water treatment facility. About 9,700 ac-ft of total AVC release would be required to account for this proposed water treatment plant loss.

Table 7. Master Contract Amounts of AVC Participants

County	Participant	Master Contract Storage (ac-ft)
Pueblo	St. Charles Mesa Water District	2,000
Crowley	96 Pipeline Co.	25
	Crowley County Water Association	1,000
	Olney Springs, Town of	125
	Ordway, Town of	750
Otero	Beehive Water Assn.	18
	Bents Fort Water Co.	10
	Fayette Water Co.	16
	Fowler, Town of	50
	Hilltop Water Co.	35
	Holbrook Center Soft Water	12
	Homestead Improvement Assn.	6
	La Junta, City of	2,000
	Manzanola, Town of	60
	Newdale-Grand Valley Water Co.	50
	Patterson Valley	40
	Rocky Ford, City of	1,200
	South Side Water Assoc. (La Junta)	8
	South Swink Water Co.	80
	Valley Water Co.	47
	Vroman	41
	West Grand Valley Water Inc.	15
Bent	Las Animas, City of	300
Prowers	May Valley Water Assoc.	300
Kiowa	Eads, Town of	50

Table 8. AVC Monthly Delivery Schedule

Month	Water Month	AVC Delivery Schedule (%)
Oct	1	7.5
Nov	2	5.0
Dec	3	5.0
Jan	4	5.1
Feb	5	4.5
Mar	6	5.6
Apr	7	8.1
May	8	10.9
Jun	9	12.3
Jul	10	14.2
Aug	11	11.9
Sep	12	10.0

Results

The purpose of this yield analysis is to investigate water supplies that could be used by AVC, which required calculating firm yield of existing supplies, as well as different combinations of non-Fry-Ark supplies, to meet AVC demands. Estimating the firm yield of the various identified supplies is important to finding an optimal balance of use between them. Reclamation defines firm yield as follows:

> *Firm yield is the maximum quantity of water that can be guaranteed with some specified degree of confidence during a specific critical period. The critical period is that period in a sequential record that requires the largest volume from storage to provide a specified yield (Reclamation 2011d).*

Firm yield in this analysis is the maximum annual demand that can be met 100 percent of the time during the analysis period (water years 1950-2009). An example time series of deliveries and storage contents are shown in Figure 5 and Figure 6. Shortages in AVC deliveries would occur during periods when supplies and storage could not meet demand. The critical period is the period of time where shortages first occur as demand rises, and defines the firm yield under a given set of supplies. In other words, the critical period is the point where any additional demand cannot be fully met with the analyzed supplies. Critical points in the yield analysis are found by modifying demand up and down until it is just fully met with no shortages. Critical periods are indicated in Figure 5 by red bars occurring during critical years and/or Figure 6 when storage contents approach zero. Two critical periods occur in years 1958 and 1978 (Figure 6). These critical periods determine the firm yields and shortages of this analysis.

Figure 5 shows that the annual water supplies previously shown in Figure 3 are augmented by reservoir storage to meet full AVC demand during years when supplies are less than demand. For instance, Figure 3 shows that supplies during 1954 and 1955 were less than the total AVC demand. During these years, reservoir storage is released to meet the full AVC demand.

Figure 6 shows simulated storage contents in both the AVC portion of Fry-Ark carryover storage and the AVC Participants' Master Contract. Master Contract storage contents typically are not visible in Figure 6 because monthly exchanged Fry-Ark return flows and non-Project supplies are typically less than AVC demand, thus Master Contract storage is not substantially utilized. It should be noted that on a daily time-step when actual demands and supplies show more variance, use of Master Contract storage space would be greater. Figure 6 also illustrates abrupt storage increases followed by steady storage declines. The large increases in storage occur when the Fry-Ark East Slope water rights come into priority and fill the reservoirs. During years where Fry-Ark storage is not in priority, Boustead imports, in conjunction with storage, only maintains deliveries, rather than fills reservoirs.

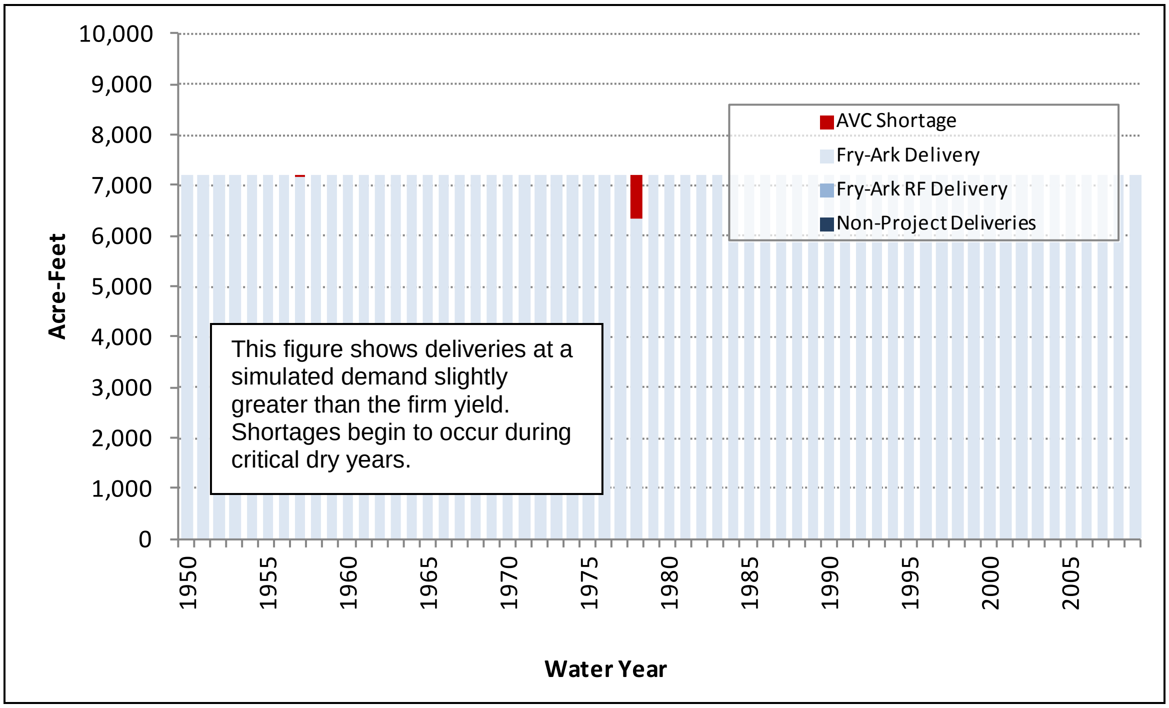

Figure 5. Example of Yield Analysis Output: Simulated Deliveries to AVC Participants

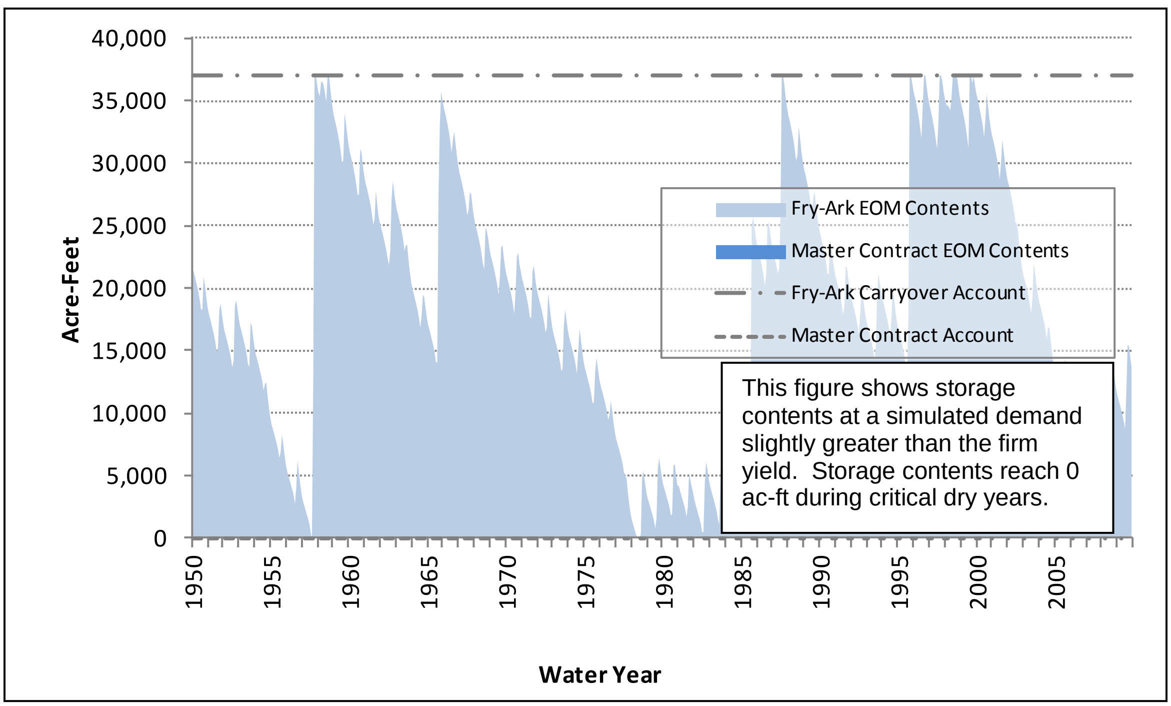

Figure 6. Example of Yield Analysis Output: Simulated Reservoir Account Storage and Critical Period

Several scenarios were considered in this yield analysis to determine the yield of supplies identified for AVC use. These scenarios were grouped into the following categories.

- Category A: Firm Yield of Existing Supplies
- Category B: Full AVC Demand
- Category C: Alternate Supply Combinations

Category A examines the firm yield of existing AVC supplies identified by participants (the annual AVC demand varies between all runs to determine firm yield). Category B and C scenarios are not firm yield analyses. Category B scenarios examine the ability of requested AVC supplies to meet the projected annual AVC demand of 9,253 ac-ft (i.e. the annual AVC demand is the same in all runs). Category C examines alternate combinations of Fry-Ark return flow and non-Project supply use to meet AVC demand (the annual AVC demand is the same in all runs, and the same as Category B scenarios).

Category A – Firm Yield of Existing Supplies

The firm yield analysis results are shown in Table 9. The firm yield of the AVC Fry-Ark allocation (Scenario A1) is 7,120 ac-ft; shortages would occur if demand exceeded this value. This yield includes the use of AVC Fry-Ark carryover storage to store allocated supplies from one year to the next. If the AVC Fry-Ark allocation exceeds the AVC demand, the remaining supply can be stored in available carryover space for subsequent use. Firm yield increases to 7,840 ac-ft as Fry-Ark return flows are used by AVC participants that explicitly requested to use them (Scenario A2).

If all eligible Fry-Ark return flows upstream from John Martin Reservoir (i.e. 72.9 percent) were used by AVC participants, the firm yield would be 8,690 (Scenario A3). Firm yield of all identified supplies, including 34.5 percent return flow use and about 4,200 ac-ft of non-Project supply (Scenario A4), is 10,610 ac-ft, which exceeds the initial AVC demand of 9,253 ac-ft. Firm yield of all identified supplies when Fry Ark carryover space is limited to a two-year supply (Scenario A5), is 9,950 ac-ft. Scenario A6 is similar to Scenario A5, except that additional non-Project water is provided to match the yield of Scenario A4. Attachment A contains additional details regarding these scenario simulations, including a time series of expected supplies and shortages.

Table 9. Yield Analysis Results for Category A: Firm Yield of Existing Supplies

Results	Scenario					
	A1 Fry-Ark Allocation Only	**A2** A1 + 34.5% Fry-Ark Return Flows	**A3** A1 + Full Fry-Ark Return Flows	**A4** A2 + Existing Non-Project Supplies	**A5** A4 + Limited Fry-Ark Carryover Use – Firm Yield	**A6** A4 + Limited Fry-Ark Carryover Use – Increased Non-Project Supplies(1)
Run Settings						
Annual Non-Project Supply (ac-ft)	0	0	0	4,237	4,237	5,550
Percent of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	0.0	34.5	72.9	34.5	34.5	34.5%
Master Contract Storage (ac-ft)	0	8,238	8,238	8,238	8,238	8,238
East of Pueblo Carryover Space Used (ac-ft)	37,400	37,400	37,400	37,400	25,138	25,138
Results – Demand						
Annual AVC Demand (ac-ft) (Firm Yield) (2)	**7,120**	**7,840**	**8,690**	**10,610**	**9,950**	**10,610**
Annual AVC Demand Shortage (ac-ft)	0	0	0	0	0	0
Maximum Monthly Shortage (ac-ft)	0	0	0	0	0	0
Results – Deliveries						
Non-Project (ac-ft)	0	0	0	3,022	3,022	3,953
Fry-Ark Return Flows (ac-ft)	0	827	1,931	741	671	624
Fry-Ark Allocation (ac-ft)	7,120	7,013	6,759	6,847	6,257	6,033
Total Deliveries (ac-ft)	7,120	7,840	8,690	10,610	9,950	10,610

Notes:
(1) Additional non-Project supplies are assumed to be from the Lower Arkansas Valley Water Conservancy District Super Ditch Program.
(2) For Category A runs, the annual AVC demand for the run indicates firm yield for the scenario.

Category B – Full AVC Demand

Results of Category B are in Table 10. With an initial annual AVC demand of 9,253 ac-ft, supply shortages of about 1,000 ac-ft would occur if only Fry-Ark allocations were utilized for AVC supply (Scenario B1). Shortages would continue to occur if Fry-Ark return flows were only utilized by AVC participants that explicitly requested to use them (Scenario B2). Scenarios B1 and B2 are not recommended operational scenarios for the AVC, rather they are shown to represent the amount of shortage that would occur if only Fry-Ark Allocations or return flows were used. Shortages would not occur once identified non-Project supplies are used[3] (Scenario B3). Use of Fry-Ark allocations decrease in these scenarios as Fry-Ark return flows and non-Project supplies are added, because water stored in Master Contract accounts is used before Fry-Ark allocations. Attachment A contains additional details regarding these scenario simulations, including a time series of expected supplies and shortages.

Table 10. Yield Analysis Results for Category B: AVC Demand

Results	Scenario		
	B1 Fry-Ark Allocation Only	B2 B1 + 34.5% Fry-Ark Return Flows	B3 B2 + Existing Non-Project Supplies
Run Settings			
Annual Non-Project Supply (ac-ft)	0	0	4,237
Percent of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	0.0	34.5	34.5
Master Contract Storage (ac-ft)	0	8,238	8,238
East of Pueblo Carryover Space Used (ac-ft)	37,400	37,400	37,400
Results – Demand			
Annual AVC Demand (ac-ft)	9,253	9,253	9,253
Annual AVC Demand Shortage (ac-ft)	1,000	508	0
Maximum Monthly Shortage (ac-ft) (1)	**1,304**	**1,213**	**0**
Results – Deliveries			
Non-Project (ac-ft)	0	0	3,023
Fry-Ark Return Flows (ac-ft)	0	943	598
Fry-Ark Allocation (ac-ft)	8,253	7,802	5,633
Total Deliveries (ac-ft)	8,253	8,745	9,253

Notes:
(1) For Category B runs, full annual AVC demand is used for the runs. A shortage greater than 0 indicates that during critical years in the model run, full demands cannot be met for the give scenario.

[3] This analysis lumps all non-Project supplies together. Information on non-Project supplies available to each participant is contained in Appendix A. If required, additional supply for individual participants could be available by lease from other participants or the Lower Arkansas Valley Water Conservancy District Super Ditch program.

Category C – Alternate Supply Combinations

Results of Category C are shown in Table 11. Scenario C1 illustrates that under the requested Fry-Ark return flow use (i.e. 34.5 percent), the quantity of non-Project water required to fully meet AVC demands (2,090 ac-ft per year) is about half of the non-Project water identified to date by AVC participants (4,237 ac-ft per year). If all eligible Fry-Ark return flows upstream from John Martin Reservoir (i.e. 72.9 percent use) were used by AVC participants, 790 ac-ft per year would be needed to fully meet the AVC demand (Scenario C2). Attachment A contains additional details regarding these scenario simulations, including a time series of expected supplies and shortages.

Table 11. Yield Analysis Results for Category C: Alternative Supply Combinations

Results	Scenario	
	C1 Fry-Ark Allocation + 34.5% Fry-Ark Return Flows + Needed Non-Project Supplies to Meet AVC Demand	**C2** Fry-Ark Allocation + Full Fry-Ark Return Flows + Needed Non-Project Supplies to Meet AVC Demand
Run Settings		
Annual Non-Project Supply (ac-ft)	2,090	790
Percent of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5	72.9
Master Contract Storage (ac-ft)	8,238	8,238
East of Pueblo Carryover Space Used (ac-ft)	37,400	37,400
Results – Demand		
Annual AVC Demand (ac-ft)	9,253	9,253
Annual AVC Demand Shortage (ac-ft)	0	0
Maximum Monthly Shortage (ac-ft) [(1)]	**0**	**0**
Results – Deliveries		
Non-Project (ac-ft)	1,496	562
Fry-Ark Return Flows (ac-ft)	790	1,911
Fry-Ark Allocation (ac-ft)	6,967	6,780
Total Deliveries (ac-ft)	9,253	9,253

Notes:
[(1)] For Category C runs, full annual AVC demand is used for the runs. Both scenarios result in 0 shortages, indicating that the scenario meets full AVC demands for all years in the model run.

Sensitivity Analysis

As discussed in the Methods sections, several assumptions were made in this analysis, to which results may be sensitive. In order to investigate how results of the analysis may change if underlying assumptions in the data and model operations were modified, a sensitivity analysis was performed for key assumptions in the analysis. The results of these analyses are described below.

Historical Fry-Ark Yields

All of the analyses described above use the composite Boustead Tunnel import data set and potential East Slope yields as described in previous sections. In order to determine whether use of only historical data rather than potential data would affect the results of the yield analysis, the spreadsheet model was used to simulate firm yield for the historical Boustead import dataset and historical East Slope yields. The simulation period for these scenarios was water year 1982-2009. The start of this simulation period generally corresponds to the time that both West Slope diversion facilities and East Slope storage facilities were complete and operational. The starting storage content was taken from the 1950-2009 simulations and is approximately 4,000 ac-ft.

The percent difference in firm yield calculated using the two Boustead Tunnel import data sets is less than 0.2 percent (10 ac-ft). The firm yield is not sensitive to the historical or composite Boustead imports. As discussed in the Methods section, the composite dataset equals historical imports, except during years of high East Slope yield and/or high project storage amounts, where the potential dataset is used. Additionally, the East Slope yields tend to have much more water than necessary to fill up the east of Pueblo carryover storage account. The critical period for these simulations occurs in 2008. The composite dataset equals the historical imports during water year 2001-2009, so either dataset results in the same critical period and firm yield.

The percent difference in firm yield calculated using the two East Slope yield data sets is 1.6 percent (130 ac-ft). The sensitivity to the East Slope yields is caused by the substantial difference between the two datasets in 1987 yields. The sensitivity is greater when both historical Boustead imports and East Slope yield are used (17.5 percent or 1,300 ac-ft), as lower historical yields of both data sets during 1987 compound to a 1993 critical point. Historically, 1985-1987 was a wet period with abundant supplies and storage levels and low municipal Fry-Ark demands. Full reservoirs and less need for supply in 1987 resulted in much of the potential East Slope yield bypassing the Fry-Ark system. The 1985-1987 demands in the yield analysis, however, draw down Fry-Ark carry-over storage between 1985 and 1987, which enables storage of more East Slope yields than stored historically. The historical 1987 East Slope and Boustead yields are unable to refill the reservoirs in the yield analysis, resulting in the 1993 critical period. Based on the amount of East Slope yield available in 1987, it is reasonable to expect that the AVC Fry-Ark carryover account would have completely filled in 1987, thus use of the potential data set is justified.

Starting Reservoir Contents

A dry period in the 1950-2009 study period occurred in early 1957, and the East Slope water rights (which typically fill Fry-Ark storage accounts) historically did not come into priority between 1950 and 1957. The starting storage contents for the Fry-Ark carryover storage account is important in determining whether 1957 (and early 1958) represents a critical period in the model. As previously described, the Fry-Ark carryover account was assumed to be half full at the start of the simulation. The spreadsheet model was used to simulate firm yield scenarios using various starting storage contents (Figure 7). The simulation period for these scenarios was water year 1950-2009. The Fry-Ark firm yield is sensitive to low starting reservoir contents as the 1958 critical period occurs early in the simulation. An empty starting storage volume would substantially decrease the firm yield to 250 ac-ft. Little data is available prior to 1950 to justify a change in starting storage contents for the simulation.

The Fry-Ark firm yield is not sensitive to a full starting storage volume, as the 1978 critical period is many years along the simulation period and is not affected by initial conditions. As discussed in the Methods section, an average monthly storage volume was used as the starting contents, as the start of the analysis period predates Fry-Ark facilities. Modeling was not completed to determine what the starting reservoir contents would be in 1950, as potential Boustead imports have not been calculated for periods prior to 1950. Call records are also sparse prior to 1950.

The starting reservoir contents assumption of this analysis are consistent with previous yield studies in the basin (CSU 2005).

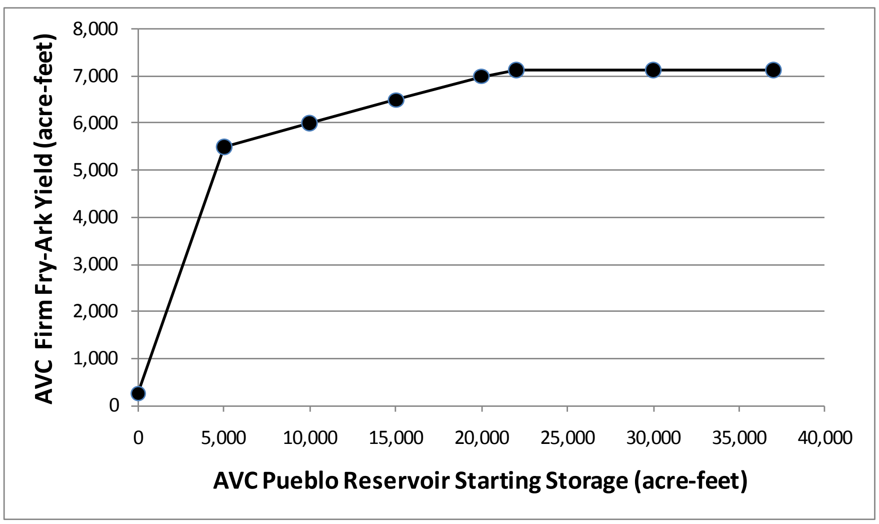

Figure 7. Sensitivity of AVC Firm Yield to Starting Pueblo Reservoir Contents

Preference of Fry-Ark Supplies

The analyses described above all assume that non-Project supplies, including those stored in Master Contract storage space, are used in preference to Fry-Ark supplies. This assumption was made based on the thought that entities would chose to use non-Project supplies first to reduce the chances that these supplies could be spilled form Master Contract storage space, and because Fry-Ark supplies are considered supplemental supplies. This assumption does not maximize deliveries of Fry-Ark supplies to AVC. In order to further examine the implications of this assumption, model runs were performed that used Fry-Ark supplies in preference to non-Project supplies.

Results of runs that always supply AVC with Fry-Ark storage first are shown in Table 12. The effects include more Fry-Ark annual supplies used to meet demand, and subsequently less Fry-Ark allocations are stored in Fry-Ark carryover storage; and less non-project annual supply is used to meet demand, resulting in more Master Contract carryover storage. Similar to Category B, supply shortages of about 1,000 ac-ft would occur if only Fry-Ark allocations were utilized for AVC supply (Scenario D1). Shortages would continue to occur if Fry-Ark return flows were only utilized by AVC participants that explicitly requested to use them (Scenario D2). Shortages would also occur once identified non-Project supplies are used (Scenario D3). This differs from Scenario B3, as these shortages occur during two two-year periods where Fry-Ark allocations and carryover storage are low, and exchange potential limits the use of non-project supplies. The only available supply is Master Contract carryover storage, which is depleted quickly to supply demand. This shortage could be eliminated by increasing the excess capacity space in the Master Contract, or by leasing water from other entities (e.g. Lower Arkansas Valley Water Conservancy District). Non-project supplies in Scenario D3 could be decreased to 3,300 ac-ft without increasing the frequency of shortages.

Table 12. Yield Analysis Results for Category D: Maximum Use of Fry-Ark System

Results	Scenario		
	D1 Fry-Ark Allocation Only	D2 D1 + 34.5% Fry-Ark Return Flows	D3 D2 + Existing Non-Project Supplies
Run Settings			
Annual Non-Project Supply (ac-ft)	0	0	4,237
Percent of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	0.0	34.5	34.5
Master Contract Storage (ac-ft)	0	8,238	8,238
East of Pueblo Carryover Space Used (ac-ft)	37,400	37,400	37,400
Results – Demand			
Annual AVC Demand (ac-ft)	9,253	9,253	9,253
Annual AVC Demand Shortage (ac-ft)	1,000	521	76
Maximum Monthly Shortage (ac-ft)	1,304	1,213	910
Results – Deliveries			
Fry-Ark Allocation (ac-ft)	8,253	8,253	8,253
Fry-Ark Return Flows (ac-ft)	0	39	39
Non-Project (ac-ft)	0	440	885
Total Deliveries (ac-ft)	8,253	8,732	9,177

Conclusions

This analysis concluded that a mixture of Fry-Ark allocations, Fry-Ark return flows and non-Project supplies are required to meet the full AVC demand. The firm yield estimate for Fry-Ark allocations was 7,120 ac-ft. This value slightly decreases when carryover use is limited to a two year supply, but is still greater than the STAG report yield. With Fry-Ark return flows and non-Project supplies identified by the AVC participants, the firm yield is 10,600 acre-feet, which is greater than the initial full AVC demand analyzed by this analysis (9,253 acre-feet as determined by the STAG report; Black & Veatch 2010) and the final full AVC demand as determined and analyzed in this EIS (10,256 acre-feet; see Chapter 1, Appendix A and Appendix D.3). Adjustments in demand were made based on higher Fry-Ark allocation availability calculated in this yield analysis as compared with the slightly lower value used in the STAG analysis (i.e. many participant demands were based on the amount of Fry-Ark water available).

The greatest level of sensitivity found in the analysis is the assumption regarding use of non-Project supplies first and Fry-Ark allocations as a supplemental supply. If the participants were to use Fry-Ark allocations first, the smaller storage levels in the Master Contract space and difficulties in exchanging non-Project supplies to Pueblo Reservoir during drought years limit yield. In actual operations, it is likely that water supply use will be mixed, based on many factors such as individual participant water supply portfolios, risk tolerance, cost, etc.

It should be noted that the findings of this analysis are based on a monthly time step with all participant demands lumped together. A more comprehensive investigation of daily operations was performed by the Daily Model (see Appendix D.3 and D.4). Lumping of supplies, demands and storage could potentially overestimate the use of individual non-Project water supplies, for which temporary or permanent leases from other sources (e.g. other participants or the Lower Arkansas Valley Super Ditch Company) may be required to meet full demands.

Furthermore, the yield analysis considers a study period (1950-2009) that is consistent with (or longer) than that used for many other Colorado municipal utilities for planning purposes (i.e. Colorado Springs Utilities, Northern Water, etc.). The underlying assumption in this analysis is that the 1950-2009 historical hydrology accurately reflects the range of expected future hydrology. If future hydrology is drier, then AVC participants would have several options, including additional permanent agricultural to municipal transfers, leases from other AVC or non-AVC participants (i.e. Crowley County or Lower Arkansas Valley Water Conservancy District), implementation of more stringent conservation measures (e.g. eliminating outdoor watering), or pumping existing wells. A quantitative climate change analysis investigating the sensitivity of AVC water supplies to potential future climate change is in Appendix C.

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Attachment A

Additional details regarding scenario simulations, including time series of expected supplies and shortages.

Scenario: A1: Fry-Ark Allocation Only

Table A1-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	0	Annual AVC Demand Met	7,120	Annual Fry-Ark Allocation	7,120
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	0.0%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	0
Master Contract Storage (ac-ft)	0	Maximum Monthly Shortage	0	Annual Non-Project	0
				Annual Deliveries	7,120

Table A1-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	536	354	354	362	322	401	576	773	876	1,011	845	710	7,120
Fry-Ark Allocation	536	354	354	362	322	401	576	773	876	1,011	845	710	7,120
Fry-Ark Return Flows	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Project Deliveries	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

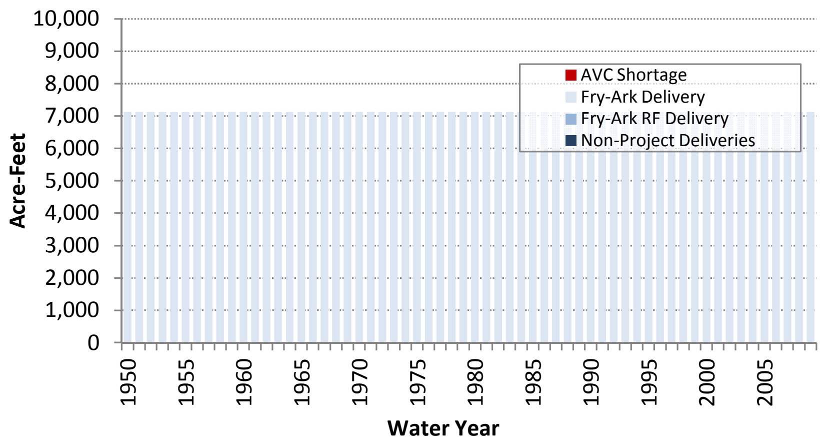

Figure A1-1: Annual AVC Participant Deliveries and Shortages

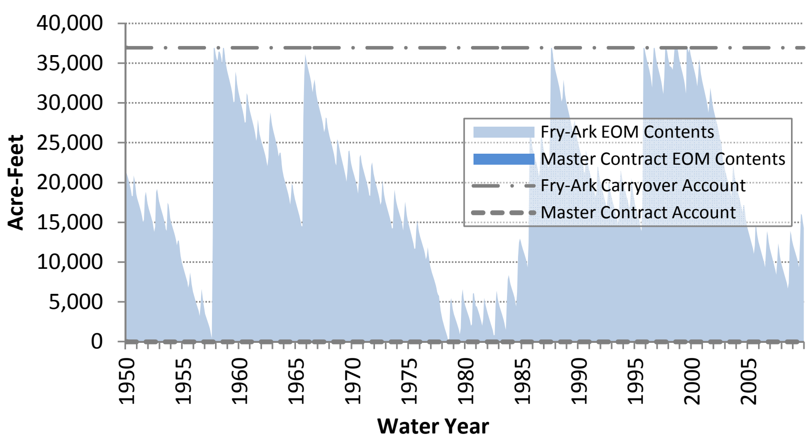

Figure A1-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: A2: Fry-Ark Allocation + Fry-Ark Return Flows

Table A2-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	0	Annual AVC Demand Met	7,840	Annual Fry-Ark Allocation	7,013
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	827
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	0
				Annual Deliveries	7,840

Table A2-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	590	390	390	399	355	442	634	852	965	1,113	930	782	7,840
Fry-Ark Allocation	499	312	308	399	355	442	560	773	857	1,008	822	677	7,013
Fry-Ark Return Flows	91	78	82	0	0	0	74	78	107	104	108	105	827
Non-Project Deliveries	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

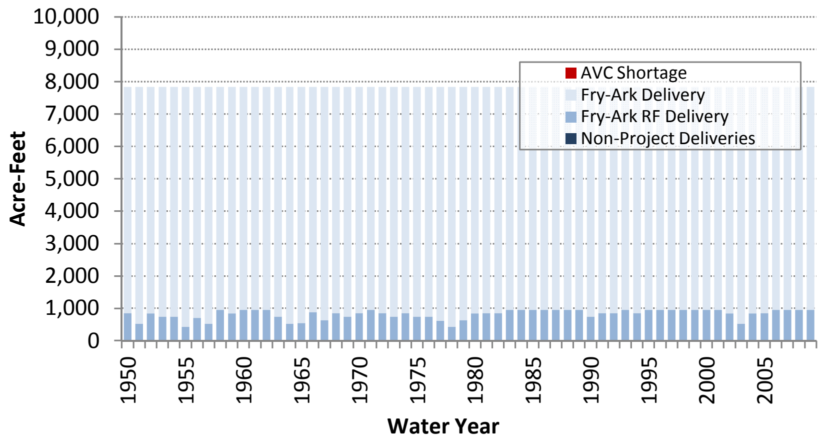

Figure A2-1: Annual AVC Participant Deliveries and Shortages

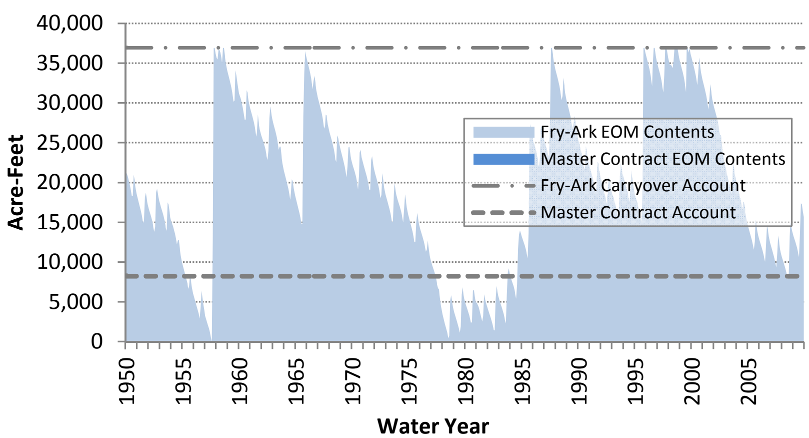

Figure A2-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: A3: Fry-Ark Allocation + Maximum Fry-Ark Return Flows

Table A3-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	0	Annual AVC Demand Met	8,690	Annual Fry-Ark Allocation	6,759
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	72.9%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	1,931
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	0
				Annual Deliveries	8,690

Table A3-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	654	432	432	442	393	490	702	944	1,069	1,233	1,031	867	8,690
Fry-Ark Allocation	441	253	240	442	393	490	534	760	819	988	777	621	6,759
Fry-Ark Return Flows	213	179	192	0	0	0	169	183	250	245	254	246	1,931
Non-Project Deliveries	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

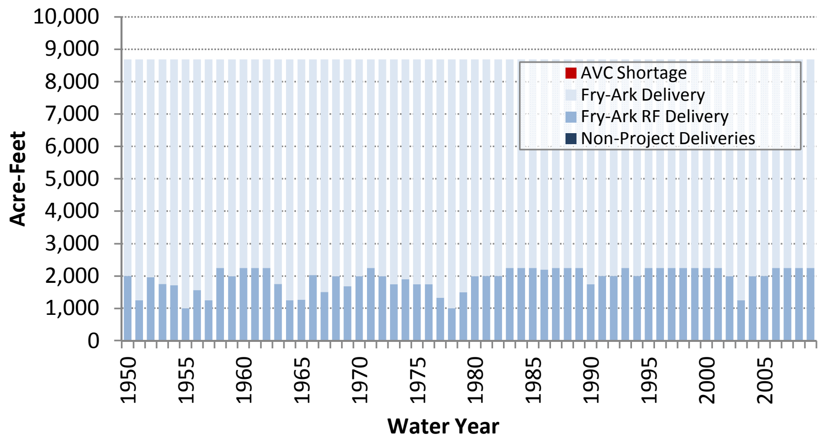

Figure A3-1: Annual AVC Participant Deliveries and Shortages

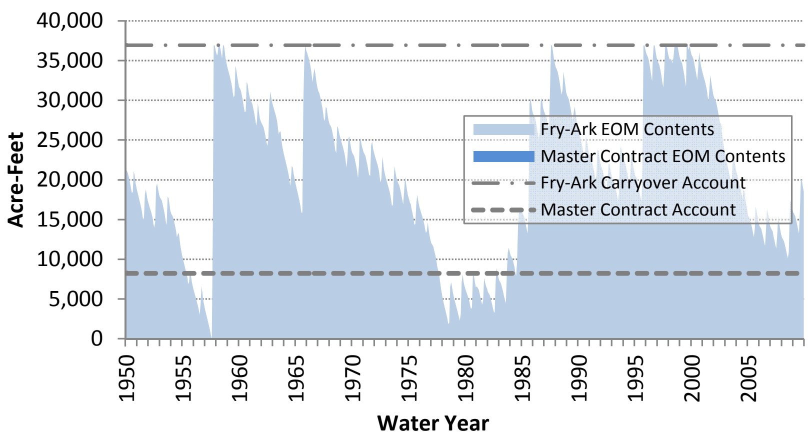

Figure A3-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: A4: Fry-Ark Allocation + Fry-Ark Return Flows + Existing Non-Project Supplies

Table A4-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	4236.69716	Annual AVC Demand Met	10,610	Annual Fry-Ark Allocation	6,847
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	741
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	3,022
				Annual Deliveries	10,610

Table A4-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	799	528	528	539	480	598	858	1,152	1,306	1,506	1,258	1,058	10,610
Fry-Ark Allocation	592	330	446	539	480	497	654	552	309	729	865	852	6,847
Fry-Ark Return Flows	109	87	81	0	0	0	75	85	80	42	75	105	741
Non-Project Deliveries	97	110	0	0	0	101	129	515	916	734	318	101	3,022
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

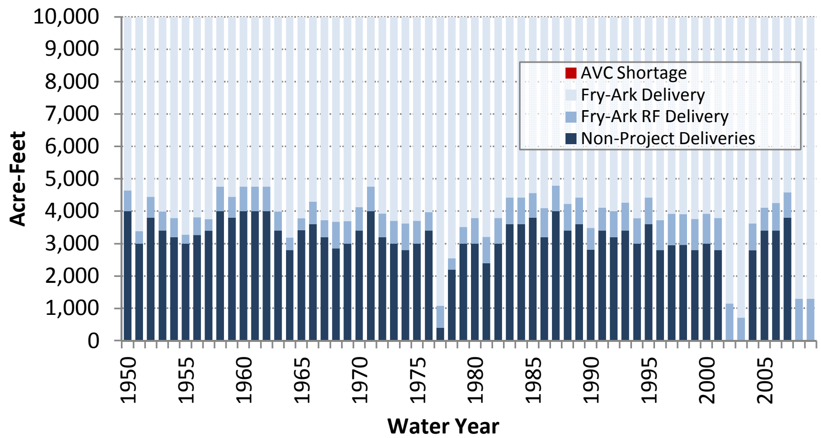

Figure A4-1: Annual AVC Participant Deliveries and Shortages

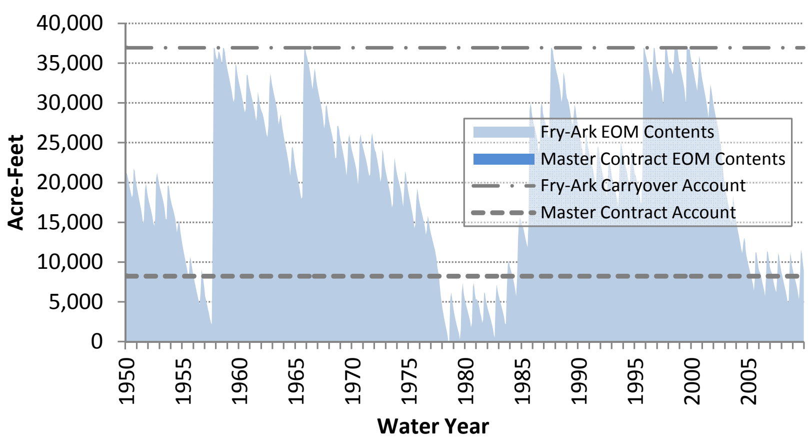

Figure A4-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: A5: Fry-Ark Allocation + Fry-Ark Return Flows + Existing Non-Project Supplies (2 yr limit on carryover storage)

Table A5-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	4236.69716	Annual AVC Demand Met	9,950	Annual Fry-Ark Allocation	6,257
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	671
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	3,022
				Annual Deliveries	9,950

Table A5-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	749	495	495	506	451	561	804	1,081	1,224	1,412	1,180	992	9,950
Fry-Ark Allocation	550	304	420	506	451	460	607	487	237	644	796	795	6,257
Fry-Ark Return Flows	102	81	74	0	0	0	69	79	71	33	66	96	671
Non-Project Deliveries	97	110	0	0	0	101	129	515	916	734	318	101	3,022
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

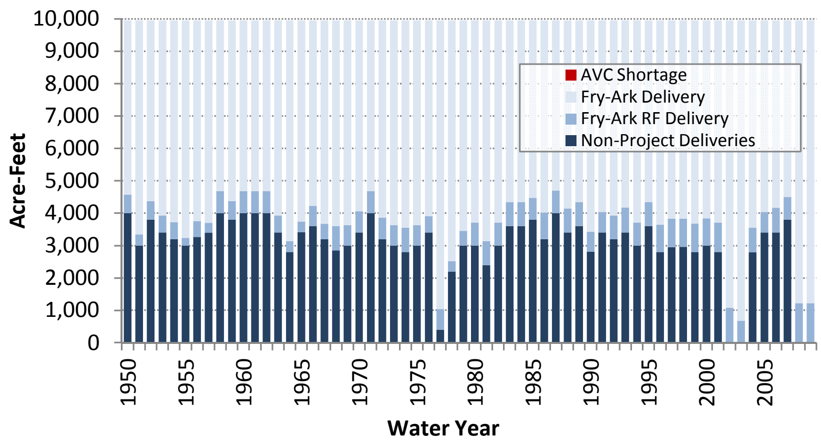

Figure A5-1: Annual AVC Participant Deliveries and Shortages

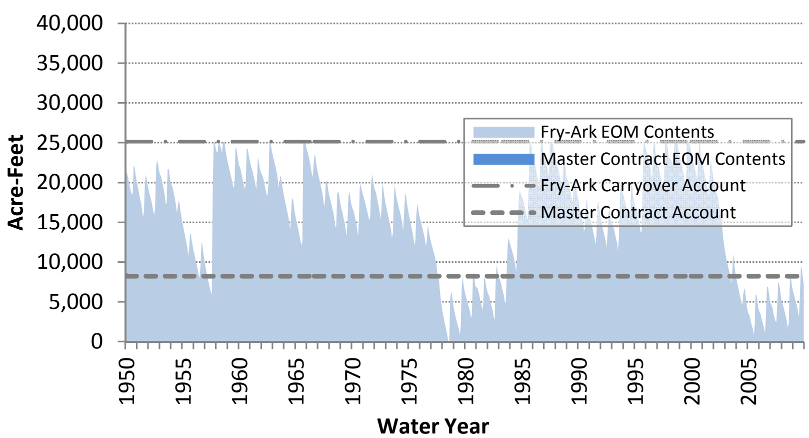

Figure A5-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: A6: Fry-Ark Allocation + Fry-Ark Return Flows + Increased Non-Project Supplies (2 yr limit on carryover storage)

Table A6-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	5550	Annual AVC Demand Met	10,610	Annual Fry-Ark Allocation	6,033
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	624
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	3,953
				Annual Deliveries	10,610

Table A6-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	799	528	528	539	480	598	858	1,152	1,306	1,506	1,258	1,058	10,610
Fry-Ark Allocation	567	301	455	539	480	467	622	401	98	474	795	832	6,033
Fry-Ark Return Flows	105	82	72	0	0	0	68	79	60	17	48	93	624
Non-Project Deliveries	126	145	0	0	0	131	168	672	1,148	1,015	415	133	3,953
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

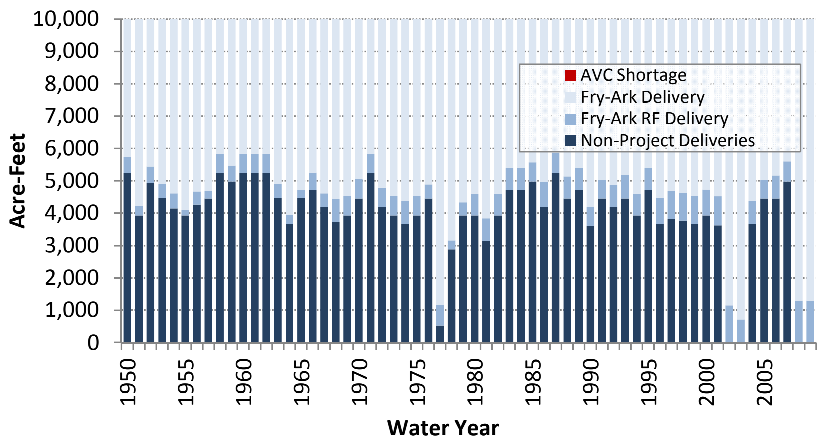

Figure A6-1: Annual AVC Participant Deliveries and Shortages

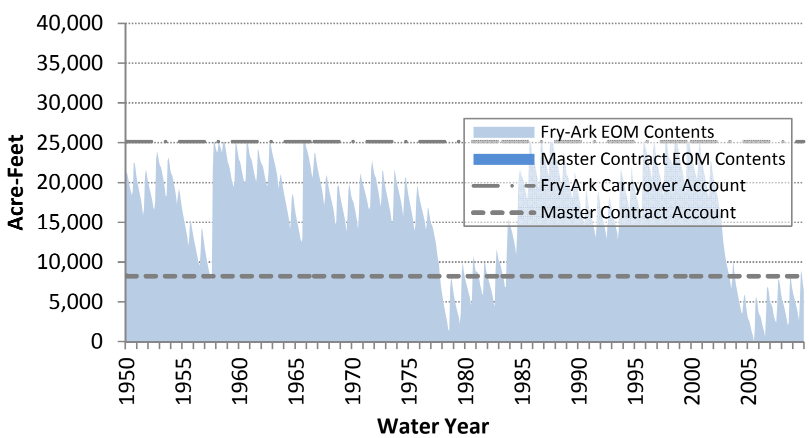

Figure A6-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: B1: Fry-Ark Allocation Only

Table B1-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	0	Annual AVC Demand Met	9,253	Annual Fry-Ark Allocation	8,253
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	0.0%	Annual AVC Demand Shortage	1,000	Annual Fry-Ark Return Flows	0
Master Contract Storage (ac-ft)	0	Maximum Monthly Shortage	1,304	Annual Non-Project	0
				Annual Deliveries	8,253

Table B1-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	697	460	460	470	419	522	748	1,005	1,139	1,313	1,098	923	9,253
Fry-Ark Allocation	617	390	372	367	320	376	511	959	1,133	1,292	1,052	863	8,253
Fry-Ark Return Flows	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Project Deliveries	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC Shortage	79	70	88	103	99	146	237	46	6	22	45	59	1,000

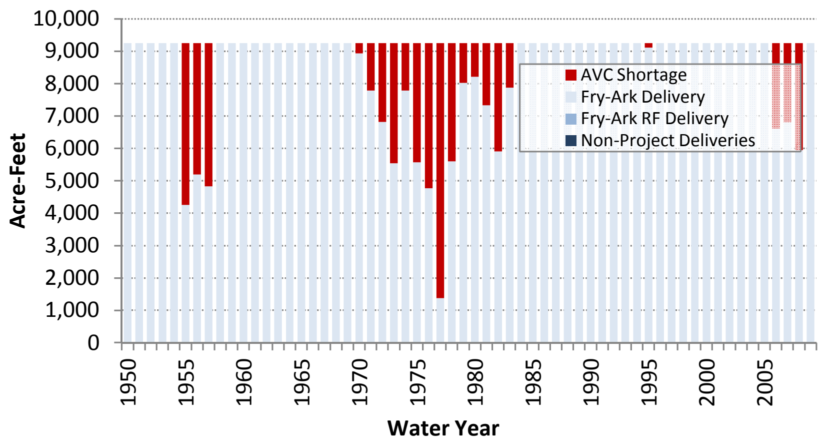

Figure B1-1: Annual AVC Participant Deliveries and Shortages

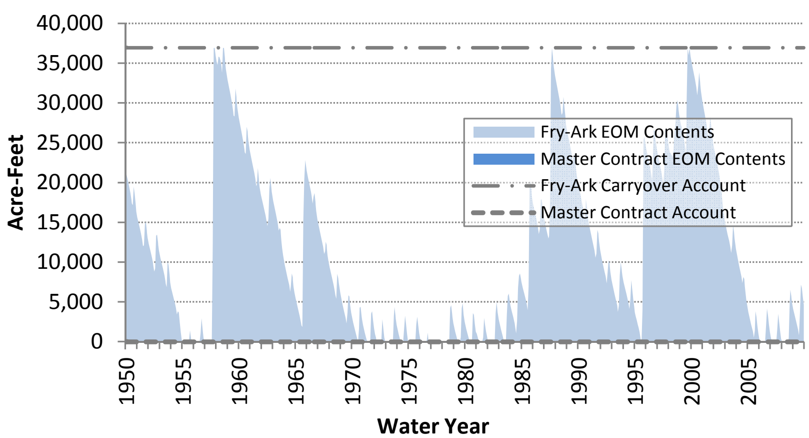

Figure B1-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: B2: Fry-Ark Allocation + Fry-Ark Return Flows

Table B2-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	0	Annual AVC Demand Met	9,253	Annual Fry-Ark Allocation	7,802
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5%	Annual AVC Demand Shortage	508	Annual Fry-Ark Return Flows	943
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	1,213	Annual Non-Project	0
				Annual Deliveries	8,745

Table B2-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	697	460	460	470	419	522	748	1,005	1,139	1,313	1,098	923	9,253
Fry-Ark Allocation	550	341	335	429	373	452	549	890	1,010	1,170	944	758	7,802
Fry-Ark Return Flows	104	90	95	0	0	0	79	82	123	123	126	122	943
Non-Project Deliveries	0	0	0	0	0	0	0	0	0	0	0	0	0
AVC Shortage	43	29	31	42	46	70	121	32	5	20	28	42	508

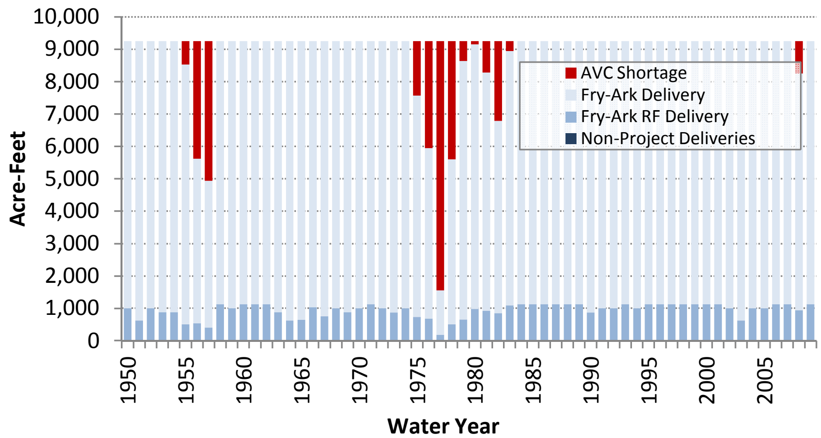

Figure B2-1: Annual AVC Participant Deliveries and Shortages

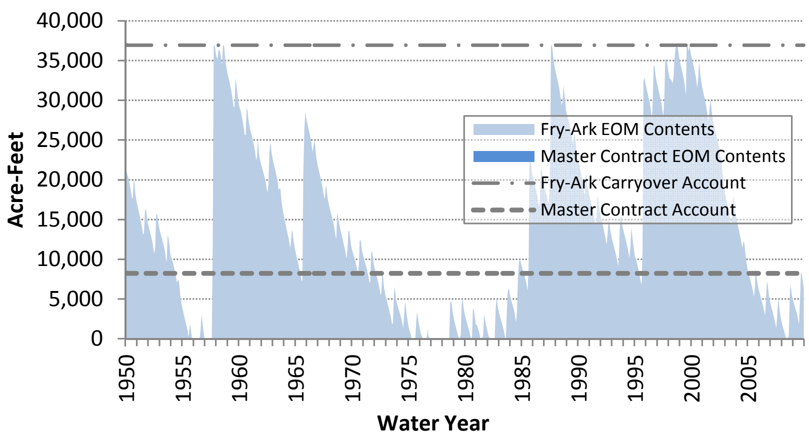

Figure B2-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: B3: Fry-Ark Allocation + Fry-Ark Return Flows + Existing Non-Project Supplies

Table B3-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	4237	Annual AVC Demand Met	9,253	Annual Fry-Ark Allocation	5,633
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	598
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	3,023
				Annual Deliveries	9,253

Table B3-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	697	460	460	470	419	522	748	1,005	1,139	1,313	1,098	923	9,253
Fry-Ark Allocation	506	276	393	470	419	421	557	418	160	555	723	735	5,633
Fry-Ark Return Flows	94	74	67	0	0	0	63	72	62	24	56	87	598
Non-Project Deliveries	97	110	0	0	0	101	129	515	917	734	318	101	3,023
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

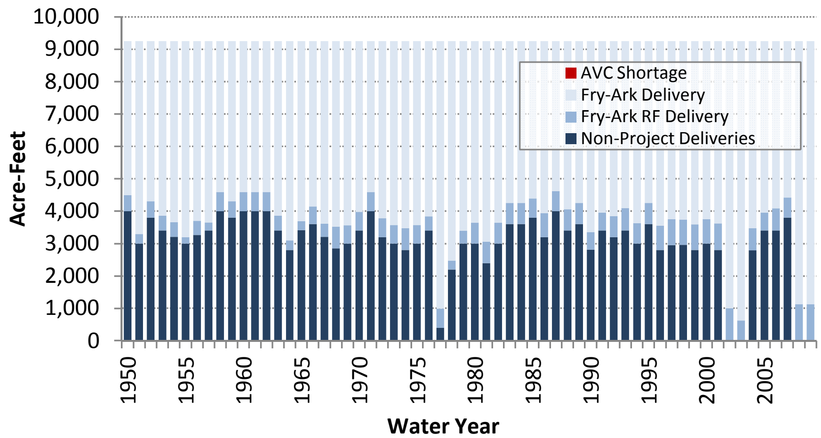

Figure B3-1: Annual AVC Participant Deliveries and Shortages

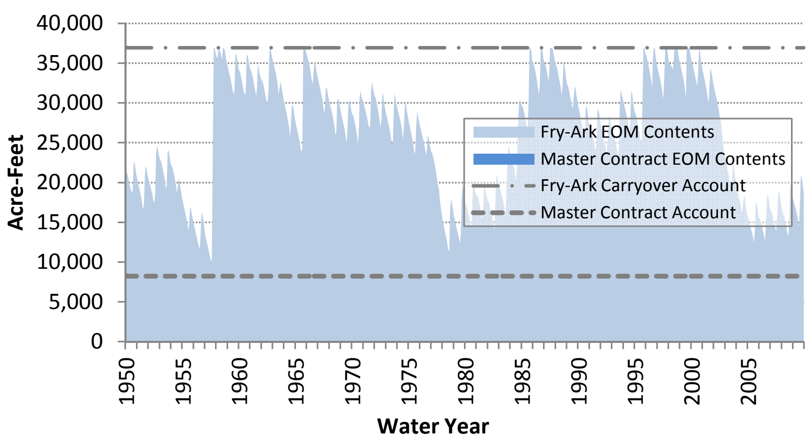

Figure B3-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: C1: Fry-Ark Allocation + Requested Fry-Ark Return Flows + Needed Non-Project Supplies to Meet AVC Demand

Table C1-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	2090	Annual AVC Demand Met	9,253	Annual Fry-Ark Allocation	6,967
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	34.5%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	790
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	1,496
				Annual Deliveries	9,253

Table C1-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	697	460	460	470	419	522	748	1,005	1,139	1,313	1,098	923	9,253
Fry-Ark Allocation	548	323	378	470	419	471	608	667	592	877	847	767	6,967
Fry-Ark Return Flows	101	83	82	0	0	0	75	82	95	75	93	105	790
Non-Project Deliveries	48	54	0	0	0	51	65	256	452	362	158	50	1,496
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

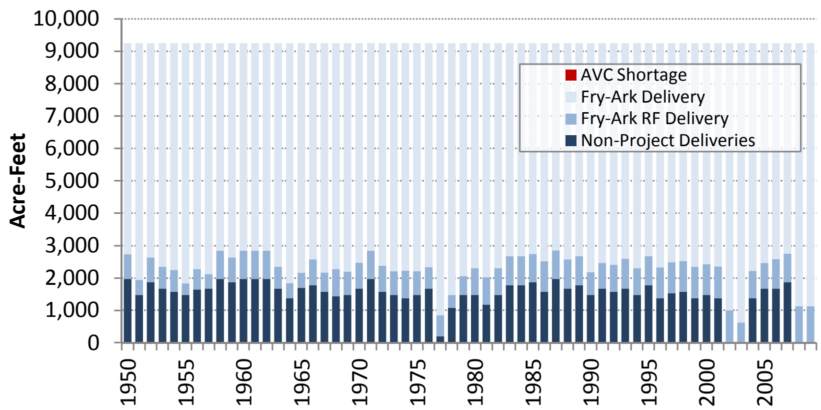

Figure C1-1: Annual AVC Participant Deliveries and Shortages

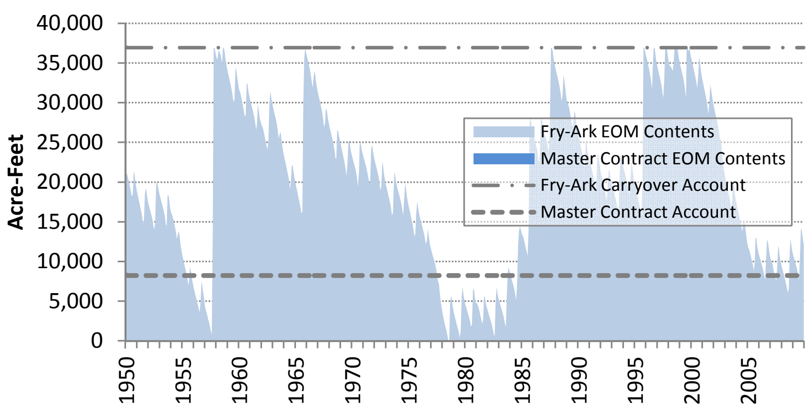

Figure C1-2: Annual AVC Fry-Ark and Master Contract Storage Contents

Scenario: C2: Fry-Ark Allocation + Maximum Fry-Ark Return Flows + Needed Non-Project Supplies to Meet AVC Demand

Table C2-1: Scenario Settings and Results

Run Settings		Results – Demand (ac-ft)		Results – Supplies (ac-ft)	
Annual Non-Project Supply (ac-ft)	790	Annual AVC Demand Met	9,253	Annual Fry-Ark Allocation	6,780
% of AVC Fry-Ark Allocation Whose Return Flows are Used in AVC	72.9%	Annual AVC Demand Shortage	0	Annual Fry-Ark Return Flows	1,911
Master Contract Storage (ac-ft)	8,238	Maximum Monthly Shortage	0	Annual Non-Project	562
				Annual Deliveries	9,253

Table C2-2: Average Monthly AVC Participant Demands and Deliveries

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVC Demand	697	460	460	470	419	522	748	1,005	1,139	1,313	1,098	923	9,253
Fry-Ark Allocation	457	257	267	470	419	502	553	721	727	954	795	656	6,780
Fry-Ark Return Flows	221	183	193	0	0	0	170	188	242	223	243	247	1,911
Non-Project Deliveries	18	20	0	0	0	19	24	96	170	136	59	19	562
AVC Shortage	0	0	0	0	0	0	0	0	0	0	0	0	0

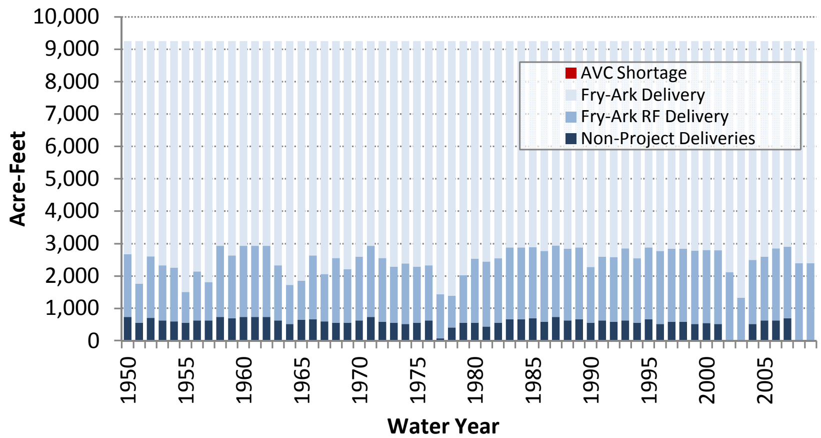

Figure C2-1: Annual AVC Participant Deliveries and Shortages

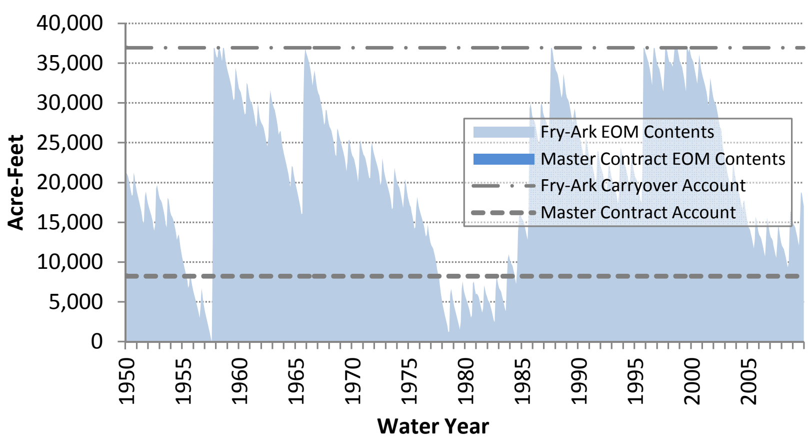

Figure C2-2: Annual AVC Fry-Ark and Master Contract Storage Contents