Appendix B - Hydrologic Modeling

Two hydrologic models were used in the EA to evaluate hydrologic changes: The Fry-Ark Project RiverWare Model and the Willow Creek Ranch—Daily Surface Water Hydrology Model. Each is discussed in greater detail below.

Fryingpan-Arkansas Project RiverWare Model

The scope of direct and indirect effects analysis includes the Arkansas River Basin from the Arkansas River near Twin Lakes Reservoir to Coolidge, Kansas (EA Figure 1). To analyze hydrologic changes associated with Proposed Actions, Reclamation contracted Precision Water Resources Engineering to develop a Fry-Ark Project RiverWare Model. (Model documentation is also included in Appendix B.) The Fry-Ark Project RiverWare Model evaluated direct and cumulative effects associated with the Temporary Program. This model was also used to evaluate potential cumulative effects associated with the proposed Donala and BLM 40-year contracts.

The Fry-Ark RiverWare Model predicts future hydrology for No Action and Proposed Actions based on the Arkansas River Basin's complex policy, administration, and operational procedures. The model runs on a daily timestep with a full mode run period of October 1, 1990, through December 31, 2015. This period contains 25 full water and calendar years. Initial conditions for modeling runs were based on the Arkansas River Basin's conditions as existing on September 30, 2016, (See Appendix B, Section 6-Model Scenarios for Temporary Excess Capacity Account NEPA Analysis for additional detail). Current exchange potential is up to 10,000 ac-ft of Fry-Ark Project Water in Twin Lakes Reservoir or Turquoise Reservoir under Aurora and CSU long-term contracts. This remained unchanged through the modeling runs.

Water demands were developed by Reclamation for the Arkansas River Basin for 2017 (October 1, 2016 to September 30, 2017) to represent existing conditions. Water demand scenarios were created to represent potential future water demands in 2032, 2047 and 2058. The future water demands used projections from the AVC/Master Contract EIS (Reclamation 2014) supplemented by current and future water infrastructure and operations and demands provided by major water users in the Arkansas River Basin.

The main parameter modified during scenario development was the maximum storage content for each excess capacity storage account in Pueblo Reservoir along with the future demands. Table B-1 shows the maximum storage account by excess capacity type used.

Temporary Program Accounting

Reclamation used excess capacity storage requested from historic temporary contractors to define current Temporary Program storage demand and to estimate future demand. These entities are listed in Table B-2. These entities were not included in Master Contract. Additional detail on each application was included Table 4 in Chapter 2. The maximum contract amounts included in these contract applications were used to estimate future excess capacity needs.

Table B-1-Modeled Pueblo Excess Capacity Storage

Excess Capacity Account Type	Total Simulated Excess Capacity Storage by Model Scenario (ac-ft)						
	2017	2032		2047		2058*	
	Existing Condition	No Action	Proposed Action	No Action	Proposed Action	No Action	Proposed Action
Overall Total	72,705	82,571	107,705	92,009	122,009	97,437	126,938
Long-Term Contracts (w/o Master Contract)	55,475	66,500	66,500	67,000	67,000	67,000	67,999
Master Contract	7,401	16,071	16,071	25,009	25,009	29,938	29,938
Temporary contracts	9,829	0	25,000	0	30,000	0	29,001

*Donala and BLM 40-year contracts are included in the Proposed Action

Table B-2 - Modeled Temporary Excess Capacity Accounts

Temporary Excess Capacity Account	Total Simulated Excess Capacity Storage (ac-ft)			
	2017	2032	2047	2058
Arkansas Groundwater Users Association (AGUA)	2,600	3,600	3,600	3,600
Arkansas River Farmers Group	50	1,000	1,000	1,000
BLM	400	500	500	500
Catlin Canal Company	100	1,000	1,000	1,000
Colorado Department of Corrections	80	150	150	150
Colorado Water Protective District Association (CWPDA)	5,000	7,000	7,000	7,000
CPW	1,000	1,500	1,500	1,500
Donala (Out-of-District)	499	499	499	0
Upper Arkansas Water Conservancy District (Out-of-District)	50	100	100	100
City of Victor (Out-of-District)	50	50	50	50
Total Flex Accounts	0	9,601	14,601	3,212
Total Annual Accounts	**9,829**	**25,000**	**30,000**	**29,938**
Temporary Excess Capacity Account	**Total Simulated Excess Capacity Storage (ac-ft)**			
	2017		**2017**	
Flex Accounts				
Upper Arkansas (M&I)	0	1,440	2,190	2,190
Lower Arkansas (M&I)	0	6,049	9,199	9,199

Lower Arkansas (Agricultural)	0	2,112	3,212	3,212
Flex Accounts Total	**0**	**9,601**	**14,601**	**14,601**

Flex accounts were developed to simulate other potential temporary excess capacity storage and exchange contract requests using historic contract requests (see Appendix A, Section 5.8). For modeling purposes, flex accounts use a maximum storage amounts to simulate other potential temporary contracts in service areas upstream and downstream of Pueblo Reservoir that utilized a mixture of water rights included in historic temporary contract applications.

Water demands for 2032, 2047, and 2058 Scenarios were based on information included in historic temporary contract applications for each temporary contract entity. Please see Section 5.8 of Appendix B for additional discussion on development of the modeling Scenarios.

Flow Management Programs and Minimum Flow Requirements

The Fry-Ark RiverWare Model also incorporates existing flow management programs and minimum flow requirements constraining water operations in the Arkansas River Basin. Table B-3 lists each program and/or requirement included. Additional descriptions of these programs and requirements can be found in Appendix B and the AVC/Master Contract EIS (Reclamation 2013).

Table B-3-Flow Management and Minimum Flow Requirements

Program	Type	Location	Description
Lake Fork Instream Flow Right (ISFR)	A	Lake Fork	15 cfs minimum instream flow from Sugarloaf outlet to Willow Creek, 20 cfs from Willow Creek to Arkansas River.
Lake Creek ISFR	B	Lake Creek	15 cfs minimum instream flow in Lake Creek downstream from Twin Lakes.
Salida 7Q10[1] Flow	B	Salida Wastewater Treatment Plant (WWTP) Effluent Discharge	Nov-Jan, 189 cfs; Feb-Apr, 180 cfs; May-Jul, 239 cfs; Aug-Oct, 229 cfs.
Salida Q710	B	Salida WWTP	Sep-Jun, 240 cfs; Jul-Aug, 260 cfs
Chaffee County Recreational In-Channel Diversion	B	Arkansas River near Wellsville gage	Mar 15-late May, 250 cfs; late May-Jul, 700-1,800 cfs; Jul1-Aug 31, 700 cfs; Aug 16-Nov 15, 250 cfs
Upper Arkansas Voluntary Flow Management Program	C	Arkansas River near Wellsville gage	Aug 16-Jun 30, 250 cfs; Jul 1-Aug 15, 700 cfs.
Arkansas River Outfitters Association Stipulation[2]	B	Arkansas River near Wellsville gage	0 cfs/249, 250-499 cfs/50, 500-999 cfs/75; 1,000-1499 cfs/175; 2000-2999 cfs/250; 3000+ cfs/500.

[1] 7Q10 is defined by the Environmental Protection Agency as the lowest 7-day average flow that occurs (on average) once every 10 years (EPA 2018).
[2] Measured as gaged flow/maximum exchange.

Fremont County 7Q10	B	Fremont County WWTP Effluent Discharge	190 cfs minimum flow.
Pueblo Reservoir Inflows	B	Arkansas River at Portland gage	190 cfs minimum flow.
Pueblo Flow Management Program and ICD	B	Arkansas River at Moffat St. gage	100-500 cfs target based on hydrology. Exchanges curtailed when flow is less than target.
Aurora Stipulation	B	Arkansas River at Moffat St. gage	Exchanges curtailed at flows below 57 cfs.
Arkansas River Low Flow Program	D	Arkansas River downstream of Pueblo Fish Hatchery	3,000 ac-ft of CSU and Pueblo Water storage in Pueblo Reservoir available to be released during when flows is less than 50 cfs.
St Charles Mesa Pumping Plant Minimum Flows	B	Arkansas River at Moffat St. gage	CSU and Aurora exchanges curtailed if SCMWD is pumping and river flow is less than 50 cfs and specific conductance is greater than 850 µS/cm.
Pueblo Flow Management Program	B	Arkansas River downstream of Runyon Lake and Black Hills Power Plant.	City of Fountain, CSU, Aurora, Pueblo Water, Southeastern, and City of Pueblo exchange curtailment when flows are below the 85 cfs target flow.
Avondale Flow Requirements	B	Arkansas River near Avondale gage	Aurora exchange curtailment when flows are below 500 cfs
La Junta Flow Requirements	B	Arkansas River at La Junta gage	35 cfs minimum flow
Dry-Streambed	B	Pueblo Reservoir to Rocky Ford Ditch	10 cfs (exclusion Pueblo Reservoir releases and transmountain diversion)
Trans-mountain Project Bypass Flows	A	West Slope, Roaring Fork, Fryingpan and Homestake drainages	Multiple bypass flow requirements.

Type
A Mandatory Storage Bypass/Release
B Mandatory Exchange/Alternate Point of Diversion Curtailment
C Voluntary Exchange/Alternate Point of Diversion Curtailment
D Voluntary Storage Releases

Winter Water Storage Program

The Winter Water Storage Program allows agricultural water users to store native Arkansas River flow during the winter in Pueblo Reservoir, John Martin Reservoir, and other offline channel reservoirs below Pueblo Reservoir. Beginning in 1975, a program was developed giving all entities the option to divert water into storage for use during the subsequent irrigation season. The Winter Water Storage Program is effective from November 15 through March 15 annually

and is administered by the State of Colorado with a priority date of March 1, 1910. It typically stores between 30,000 and 50,000 ac-ft in Pueblo Reservoir (Reclamation 2013) and was included in hydrologic modeling. See Section 2.4 of Appendix B for additional detail.

Modeling Scenarios

Water operation Scenarios were developed using estimated water demands for years 2032, 2047, and 2058 from demands included in the SDS and AVC/Master Contract EIS hydrologic modeling. Reclamation and Precision Water Resources Engineering also held numerous conferences with water users in the Arkansas River Basin to understand their operations and projected future demands. See Chapter 4 of Appendix B for additional detail. Water operations to meet 2017 demands were used to represent the existing conditions.

Years 2032 and 2047 water demand and operations were used to evaluate predicted hydrologic changes associated with the continuation of the Temporary Program. Year 2058 water demand and operations were used to evaluate cumulative effects associated with the proposed Donala and BLM long-term contracts. Temporary Program modeling assumed a 2032 Scenario temporary excess capacity storage demand of 25,000 ac-ft, and 2047 and 2058 Scenarios assumed a 5,000 ac-ft demand increase in flex accounts for a total of 30,000 ac-ft.

Willow Creek Ranch Daily Surface Water Hydrology Model

Donala contracted with LRE to assist Reclamation in preparing this EA for Donala's proposed 40-Year Contract. Apart from the RiverWare modeling efforts, LRE developed a separate daily hydrologic spreadsheet model to simulate possible effects associated with Donala's project operational changes including use of Pueblo Dam's NOW, SDS pipeline and associated agreements. The simulation of each operation included accounting for changes in routing of Willow Creek Ranch consumptive use and return flows and Pueblo Water return flows and excess lease water. LRE's (2016) *Willow Creek Ranch—Daily Surface Water Hydrology Model and Documentation and Results Summary* is included as Appendix C.

Four accounts were modeled to reflect the Willow Creek Ranch and Pueblo Water sources discussed in Chapter 2 and in Appendix C. The accounts are as follows:

Willow Creek Ranch Consumptive Use

This account tracks the consumptive use (CU) portion of the Willow Creek Ranch water rights historically diverted and used for irrigation. The historic mean annual CU was calculated at 374 ac-ft using the Willow Creek Ranch Water Rights and Regional Contract Operation Model created in 2011.

Willow Creek Historical Return Flow

Willow Creek historical return flow obligations were quantified in Water Rights Decree No. 09CW73. The mean annual historic return flow is 94.42 ac-ft per year for the period of September through April.

Pueblo Water Return Flow Lease

As discussed in Chapter 2, Donala leases 250 ac-ft from Pueblo Water to retime and meet non-irrigation season return flow obligations from September through April. After Pueblo Water receives historic return flow from Willow Creek Ranch during the irrigation season, Pueblo Water releases an equivalent amount of leased water from Turquoise Reservoir to meet Donala's return flow obligations from September through April.

Pueblo Water Excess Lease

Donala's return flow obligations never exceed the 250 ac-ft leased from Pueblo Water and any excess leased water above the return flow obligation is available for use by Donala and is released at Turquoise Reservoir by Pueblo Water in September through April. The quantity of available water depends on that year's return flow obligation, which varies depending on hydrologic conditions.

From the four accounts, the mean annual available CU depletion is 280.00 ac-ft per year as decreed in Case No. 0-CW73 entered on November 15, 2011, and is only available in May through August. Table 11 show the dry, mean and wet year monthly and annual CU for the Willow Creek Ranch water rights. Annual available CU is only available during the historic irrigation season from May through August.

Table B-4-Willow Creek Ranch Flows

Willow Creek Ranch Monthly Flows [AF]										
		Dry			Average			Wet		
Month	Month #	WCR Total CU [AF]	WCR Historical RF [AF]	WCR Available CU [AF]	WCR Total CU [AF]	WCR Historical RF [AF]	WCR Available CU [AF]	WCR Total CU [AF]	WCR Historical RF [AF]	WCR Available CU [AF]
October	10	0	0	0	0	0	0	0	0	0
November	11	0	0	0	0	0	0	0	0	0
December	12	0	0	0	0	0	0	0	0	0
January	1	0	0	0	0	0	0	0	0	0
February	2	0	0	0	0	0	0	0	0	0
March	3	0	0	0	0	0	0	0	0	0
April	4	0	0	0	0	0	0	0	0	0
May	5	0	0	0	39	23.61	15.39	170	47.5	122.5
June	6	122.4	24	98.4	147	23.61	123.39	207	47.5	159.5
July	7	68.8	24	44.8	118	23.61	94.39	172	47.5	124.5
August	8	0	0	0	70	23.61	46.39	143	47.5	95.5
September	9	0	0	0	0	0	0	0	0	0
Annual		191.2	48	143.2	374	94.42	279.58	692	190	502

Taken from LRE 2016, see Appendix C.

Pueblo Water Lease Water is delivered by Pueblo Water over the eight-month period following the return flow pattern in Table B-5 and previously supplied to Reclamation to support Donala's temporary contract applications. Any Pueblo Water excess leased water is delivered to Donala alongside the available CU water and split evenly over the eight-month period.

Table B-5-Pueblo Water Lease Deliveries

PBWW Lease Delivery Monthly Flows [AF]										
		Dry			Average			Wet		
Month	Month #	PBWW Lease Pattern	PBWW RF Lease [AF]	PBWW Excess Lease [AF]	PBWW Lease Pattern	PBWW RF Lease [AF]	PBWW Excess Lease [AF]	PBWW Lease Pattern	PBWW RF Lease [AF]	PBWW Excess Lease [AF]
October	10	0.11	5.40	25.25	0.11	10.26	19.45	0.11	20.65	7.50
November	11	0.27	12.82	25.25	0.26	24.30	19.45	0.26	48.90	7.50
December	12	0.19	8.88	25.25	0.18	16.95	19.45	0.18	34.11	7.50
January	1	0.14	6.72	25.25	0.13	12.65	19.45	0.13	25.46	7.50
February	2	0.11	5.40	25.25	0.11	10.34	19.45	0.11	20.80	7.50
March	3	0.10	4.61	25.25	0.10	8.99	19.45	0.10	18.09	7.50
April	4	0.05	2.16	25.25	0.05	4.49	19.45	0.05	9.03	7.50
May	5	0	0	0	0	0	0	0	0	0
June	6	0	0	0	0	0	0	0	0	0
July	7	0	0	0	0	0	0	0	0	0
August	8	0	0	0	0	0	0	0	0	0
September	9	0.04	2.02	25.25	0.07	6.45	19.45	0.07	12.97	7.50
Annual		1	48	202.00	1	94.42	155.58	1	190	60.00

Taken from LRE 2016, see Appendix C.

LRE's modeling for Donala's 40-Year Contract includes the Arkansas River from Leadville to Pueblo, as well as Lake Fork Creek below Turquoise Reservoir, Lake Creek below Twin Lakes, Pueblo Reservoir and neighboring conveyance infrastructure. It does not consider any operations below Pueblo Reservoir. Below Pueblo Reservoir operations were included in the Fry-Ark Project RiverWare Model.

Waste water return flows in Fountain Creek were not modeled because Donala's proposed 40-year contract is an alternate source of water for existing uses. See the EA Water Quality Section for additional discussion regarding Donala's return flows.

LRE used a 28-year study period from water year 1982 to 2009 to represent existing hydrology. This is period is representative of when the Willow Creek Ranch was actively irrigated. Beginning in 2009, irrigation of the Ranch ceased. This time-period is also consistent with AVC/Master Contract EIS modeling. See Appendix C for more information LRE's Donala 40-Year Contract Model documentation.

BLM 40-Year Contract Modeling

The proposed BLM 40-Year contract does not include any operational changes to those operations included in the Fry-Ark RiverWare Model. Therefore, no additional modeling was completed. A qualitative assessment of the direct effects associated with BLM's 40-year contracting No Action and Proposed Action alternative is included later in this Section. Cumulative effects are included in the Temporary Program analysis.

Surface Water Resources

Surface water resources discussed in this EA include the Arkansas River and rivers and streams tributary to the Arkansas River from the East Slope headwaters of Colorado along the Continental Divide to the Arkansas River just downstream of the Colorado-Kansas state line near Coolidge, Kansas. Surface water resources also includes all natural and impounded water and

for this analysis is limited to Arkansas River Basin reservoirs in Colorado. See EA Figure 1 in Chapter 1 for a map showing geographic scope.

Reclamation relied on previous hydrologic and NEPA analyses completed in the Arkansas River Basin for the SDS and AVC/Master Contract EISs, to identified appropriate streamflow gage locations and reservoirs for evaluation. Reclamation applied significance criteria in Table B-6 similar to the AVC/Master Contract EIS to characterize effects to overall annual and monthly streamflow and storage. Effects of surface water hydrology changes on other resources are described in all other appropriate sections of this chapter.

Table B-6-Surface Water Hydrology Effect and Intensity Description

Effect Intensity	Intensity Description*
Negligible	Change in streamflow or reservoir contents would be unmeasurable or of imperceptible consequences. The change would be considered unmeasurable or imperceptible is less than 2.5 percent.
Minor	Measurable change to streamflow or reservoir contents, but the change is within the accuracy of USGS streamflow measurements. USGS streamflow accuracy is generally within 10 percent and for consistency, the same percent is used for reservoir effects.
Moderate	Measurable change to streamflow or reservoir content greater than 10 percent but would not likely cause an adverse effect with regional consequences, such as affecting Colorado's ability to meet Arkansas River Compact terms or affect the ability of senior water right holders to divert water (based either on quantity of water or state at diversion structure).
Major	Measurable change to streamflow or reservoir content greater than 10 percent and would likely cause an adverse effect with regional consequences.

*Except for "major effects, surface water hydrology does not use "beneficial" or "adverse" to describe changes in streamflow or storage contents. Rather, the terms "increase" and "decrease" are used. Descriptions of how changes in hydrology affect specific resources are presented in those sections.

Temporary Program Modeling Results

The thirteen streamflow gages listed in Table 14 were used to compare predicted hydrologic changes associated with 2017, 2032, 2047, and 2058 water operations under the Proposed Actions with the No Action Alternative. Table B-7 shows predicted annual mean daily streamflow at each gage under each modeling Scenario for the Temporary Program. All Proposed Action Scenarios include both Donala and BLM's prior annual temporary contract requests. The 2032 Proposed Action Scenario uses estimated Arkansas River Basin 2032 demands with a Temporary Program of 25,000 ac-ft for temporary excess capacity storage and exchange contracts.

The 2047 Proposed Action Scenario increases all operations to meet projected 2047 demands and increases the Temporary Program's temporary contract storage to 30,000 ac-ft. The 2057 Scenario uses 2057 estimated demands but keeps the Temporary Program's temporary contract

storage at 30,000 ac-ft. The 2057 Scenario also includes Donala's proposed 40-year contract operations including the use of Pueblo Dam's NOW, SDS pipeline, and associated agreements.

Modeling results show only minor differences in annual mean daily streamflow under the Proposed Action. Largest predicted increase in annual stream flow (0.9 percent) occurs at the Arkansas River at the Catlin Dam, near Fowler, Colorado under the 2032 Proposed Action Scenario. The greatest predicted decrease of 0.3 percent occurs in the 2032 Proposed Action Scenario at the Lake Creek below Twin Lakes, Arkansas River at Avondale, and Arkansas River at Coolidge, Kansas stream gages. A 0.3 percent decrease at the Arkansas River at Avondale also occurs in the 2047 Proposed Action Scenario and all predicted changes in annual mean daily streamflow were less than 1 percent and are considered negligible.

Predicted monthly mean daily streamflow with changes greater than two percent are summarized in Table B-8. Year 2032 Scenarios are used to predict surface water effects associated with continuation of the Temporary Program. Below is a discussion of changes in monthly mean daily streamflow for each stream gage locations under the 2032, 2047, and 2058 Temporary Program Scenarios.

Lake Creek below Twin Lakes

Lake Creek flows below Twin Lakes are predicted to increase during the winter months under the Temporary Program in 2032 (using 25,000 ac-ft of temporary excess capacity storage). Minor increase in monthly mean 2032 streamflow would occur in December and January with moderate increases in February. A minor decrease in April flows is also predicted.

Increasing the Temporary Program's storage to 30,000 ac-ft, as reflected in the 2047 and 2058 Scenarios, results in a moderate decrease in Lake Creek below Twin Lakes' January mean daily streamflow. Minor decreases in 2047's October and 2058's January and October mean daily streamflow. Minor increases are predicted in 2047's February, March, and August mean daily streamflow and 2058's March and December mean daily streamflow. All other changes in 2032, 2047, and 2058 monthly mean daily streamflow would be negligible.

Arkansas River at Granite

In the 2032 Scenario, the Arkansas River at Granite would see a minor increase in January's mean daily streamflow under for the Temporary Program. The 2047 Scenario results in a minor decrease in mean October daily streamflow and a minor increase in August and December. These predicted changes are slightly above the 2.5 percent negligible criteria. The 2058 December mean daily streamflow would have a minor increase. All other changes in 2032, 2047 and 2058 monthly mean daily streamflow would be negligible.

Table B-7-Modeled Results of Annual Mean Daily Streamflow Comparisons for Temporary Program

Stream Gage Location	Mean Daily Streamflow (cfs)									
	2017	2032 Scenarios			2047 Scenarios			2058 Scenarios		
	Existing Condition	No Action Alternative	Proposed Action	Percent Change	No Action Alternative	Proposed Action	Percent Change	No Action	Proposed Action	Percent Change
Lake Creek Below Twin Lakes	154.2	161.0	160.5	-0.3%	157.0	157.3	0.2%	156.7	156.7	0.0%
Arkansas River at Granite	375.2	383.1	383.1	0.0%	381.1	382.0	0.2%	381.1	382.0	0.2%
Arkansas River at Wellsville	674.9	682.4	682.3	0.0%	680.6	681.3	0.1%	680.5	681.3	0.1%
Arkansas River at Portland	719.9	722.6	722.0	-0.1%	718.4	718.5	0.0%	716.6	716.7	0.0%
Arkansas River above Pueblo Combined Flows[3]	*567.3*	521.2	520.4	-0.8%	471.7	470.7	-0.2%	467.0	466.7	-0.1%
Arkansas River at Moffat Street	576.7	531.2	530.4	-0.2%	482.3	481.2	-0.2%	477.8	477.5	-0.1%
Fountain Creek at Pueblo	199.2	242.8	242.9	0.0%	279.9	280.1	0.1%	279.8	280.1	0.1%
Arkansas River at Avondale	862.5	863.7	861.3	-0.3%	853.6	850.8	-0.3%	850.3	848.3	-0.2%
Arkansas River at Catlin Dam near Fowler	510.3	511.0	515.6	0.9%	501.7	503.6	0.4%	499.6	502.2	0.5%
Arkansas River at La Junta	221.6	227.9	229.2	0.6%	218.6	218.8	0.1%	217.9	218.3	0.2%
Arkansas River at Las Animas	222.3	228.5	229.6	0.5%	219.8	219.8	0.0%	219.4	219.4	0.2%
Arkansas River below John Martin Reservoir	275.7	281.0	281.8	0.3%	274.1	274.7	0.2%	273.6	274.4	0.3%
Arkansas River at Coolidge, Kansas	182.5	184.9	184.3	-0.3%	182.2	182.3	0.1%	181.5	181.9	0.2%

[3] These are combined flows below Pueblo Reservoir are computed as Arkansas River Above Pueblo gage combined with Pueblo Fish Hatchery Return Flows.

Table B-8-Mean Monthly Flow by Modeled Scenario

MODELING SCENARIOS CHANGES IN STREAMFLOW									
	2032			2047			2058		
Month	No Action (cfs)	Proposed Action (cfs)	Change (%)	No Action	Proposed Action (cfs)	Change (%)	No Action (cfs)	Proposed Action (cfs)	Change (%)
LAKE CREEK BELOW TWIN LAKES GAGE									
Mean Flow Changes >2.5 Percent									
Jan	13.6	14.6	7.2%	24.6	21.8	-11.4%	24.2	22.3	-7.9%
Feb	15.0	17.1	14.0%	25.0	25.7	2.8%	**	**	**
Mar	**	**	**	41.0	43.9	7.1%	40.9	44.8	9.5%
Apr	47.6	45.6	-4.1%	**	**	**	**	**	**
Jun	**	**	**	**	**	**	**	**	**
Jul	**	**	**	**	**	**	**	**	**
Aug	**	**	**	151.8	155.7	2.6%	**	**	**
Sept	**	**	**	**	**	**	**	**	**
Oct	**	**	**	63.3	60.9	-3.8%	63.7	61.6	-3.3%
Nov	**	**	**	**	**	**	**	**	**
Dec	21.7	22.3	2.8%	**	**	**	22.7	24.2	6.6%
GRANITE GAGE									
Mean Flow Changes >2.5 Percent									
Feb	94.2	96.6	2.5%	**	**	**	**	**	**
Aug	**	**	**	345.3	354.1	2.5%	**	**	**
Oct	**	**	**	206.3	200.9	-2.6%	**	**	**
Dec	**	**	**	122.5	125.8	2.7%	120.8	126.1	4.4%
ABOVE PUEBLO (COMBINED FLOW)									
Mar	**	**	**	170.7	179.0	4.9%	169.6	177.8	4.8%
Apr	471.4	494.4	4.9%	**	**	**	**	**	**
Oct	190.1	195.5	2.8%	174.9	181.8	3.9%	172.5	179.7	4.2%
Nov	185.2	177.9	-4.0%	**	**	**	**	**	**
MOFFAT GAGE									
Mean Monthly Flow Changes >2.5 Percent									
Mar	**	**	**	171.5	179.8	4.8%	*170.4*	*178.7*	*4.9%*
Apr	471.4	494.4	4.9%	**	**	**	**	**	**
Oct	190.1	195.5	2.8%	175.0	181.8	3.9%	172.5	179.7	4.2%
Nov	186.0	178.7	-3.9%	**	**	**	**	**	**
AVONDALE GAGE									
Mean Monthly Flow Changes >2.5 Percent									
Mar	**	**	**	413.7	424.2	2.5%	**	**	**
Oct	**	**	**	440.8	454.0	3.0%	437.9	450.3	2.8%

MODELING SCENARIO CHANGES IN STREAMFLOW									
	2032			2047			2058		
Month	No Action (cfs)	Proposed Action (cfs)	Change (%)	No Action	Proposed Action (cfs)	Change (%)	No Action (cfs)	Proposed Action (cfs)	Change (%)
CATLIN GAGE									
Mean Monthly Flow Changes >2.5 Percent									
Mar	**	**	**	195.5	203.0	3.8%	**	**	**
Apr	431.1	443.5	2.9%	**	**	**	**	**	**
Sept	**	**	**	270.7	280.2	3.5%	270.4	278.3	2.9%
Oct	**	**	**	173.8	182.4	4.9%	171.8	180.8	5.2%
LA JUNTA GAGE									
Mean Monthly Flow Changes >2.5 Percent									
Jan	**	**	**	53.3	51.3	-3.8%	**	**	**
Mar	**	**	**	89.1	92.9	4.3%	90.1	92.6	2.8%
Apr	**	**	**	**	**	**	174.2	168.9	-3.0%
Aug	232.7	240.5	3.4%	**	**	**	**	**	**
Sept	**	**	**	147.6	153.1	3.7%	**	**	**
Oct	**	**	**	130.6	134.6	3.1%	129.6	133.9	3.3%
LAS ANIMAS GAGE									
Mean Monthly Flow Changes >2.5 Percent									
Jan	**	**	**	**	**	**	96.5	93.8	-2.8%
Apr	**	**	**	**	**	**	131.7	126.8	-3.7%
Jul	413.1	426.5	3.2%	**	**	**	**	**	**
Aug	**	**	**	**	**	**	242.2	249.1	2.8%
Sept	**	**	**	**	**	**	140.8	144.7	2.8%
Oct	**	**	**	**	**	**	129.1	133.3	3.3%
BELOW JOHN MARTIN GAGE									
Mean Monthly Flow Changes >2.5 Percent									
Mar	5.3	5.9	11.3%	3.7	5.9	59.5%	2.8	4.6	64.3%
COOLIDGE, KANSAS									
No Monthly Flow Changes >2.5%									
FOUNTAIN CREEK AT PUEBLO GAGE									
Annual	***242.8***	***242.9***	*0.0%*	***279.9***	***280.1***	***0.1%***	***279.8***	***280.1***	***0.1%***
Mean Monthly Flow Changes >2.5 Percent									
Mar	**	**	**	169.4	176.5	4.2%	**	**	**
Jun	**	**	**	471.0	452.8	-3.9%	474.5	455.3	-4.0%
Oct	**	**	**	**	**	**	189.2	200.5	6.0%

Arkansas River at Portland

All changes in monthly mean daily streamflow in the Arkansas River at Portland are predicted to be negligible.

Arkansas River above Pueblo

For this location, Arkansas River above Pueblo flows and Pueblo Fish Hatchery return flows are combined. This allows for an easier comparison of flow management programs and minimum flow requirements previously listed in Table B-3 in this appendix.

The Temporary Program would result in minor increases in April and October's mean flows under the 2032 program with 25,000 ac-ft of temporary excess capacity storage. Minor decreases in the November 2032 mean flows would also occur. 2047 October mean flows would experience a minor decrease, while August and December mean flows have minor increases. 2058 December mean flows would also have minor increases. All other changes in 2032, 2047, and 2058 mean monthly flows would be negligible.

Fountain Creek at Pueblo

All flow changes in Fountain Creek under the 2032 Temporary Program would be negligible. Modeling predicts minor increases in March's mean monthly flows and minor decreases in June's monthly flows under the 2047 increased Temporary Program. Minor June mean flow decreases, and minor October mean flow increases would also occur in the 2058 when compared to the No Action Alternative. All other changes in mean monthly flows would be negligible.

Arkansas River at Moffat

The Arkansas River at Moffat had only minor increases in mean monthly flows in 2032's April, October and November flows, 2047 and 2058's March and October flows. All other changes in 2032, 2047, and 2058 mean monthly flows would be negligible.

Arkansas River near Avondale

All changes in mean monthly flows under the 2032 Temporary Program would be negligible for the Arkansas River near Avondale. Year 2047 March and October mean flows and 2058 mean October flow would have minor increases. All other changes in 2032, 2047, and 2058 mean monthly flows would be negligible.

Arkansas River at Catlin Dam, near Fowler

Minor increases in April mean flow in the Arkansas River at Catlin Dam are predicted under the Temporary Program's 2032 Scenario. Minor increases would also occur in 2047's March, September and October and minor increases in the 2057's September and October mean flows. All other changes in 2032, 2047 and 2058 mean monthly flows would be negligible.

Arkansas River at La Junta

Only minor increases in August mean flows at the Arkansas River at La Junta are predicted for the Temporary Program's 2032 Scenario. Minor decreases in 2047's January and 2058's April mean flows are predicted. Minor increases also occur in 2047 March, September, and October mean flows and 2058's March and October flows. All other changes in 2032, 2047 and 2058 mean monthly flows would be negligible.

Arkansas River at Las Animas

Only minor increases in the July mean flow at the Arkansas River at Las Animas are predicted for the Temporary Program's 2032 Scenario. Minor decreases in 2058 January and April's mean flows and minor increases in 2058's fall mean flows (August through September) are also predicted. All other changes in 2032, 2047 and 2058 mean monthly flows would be negligible.

Arkansas River below John Martin Reservoir

Minor changes in March mean flows under Temporary Program's 2032 Scenario and major changes under the 2058 Scenario are predicted using the effect intensity criteria. The 2032 modeled change is a 0.6 cfs increase from 5.3 cfs to 5.9 under the Proposed Action. The 2058 modeled change is a 1.8 cfs increase from 2.8 cfs to 4.6 cfs under the Proposed Action. All other changes in 2032, 2047 and 2058 mean monthly flows would be negligible.

Arkansas River near Coolidge, Kansas

All changes in monthly mean flows at the Arkansas River near Coolidge, Kansas would be negligible.

Donala's 40-year Contract Modeling Results

Flows at thirteen stream gages were modeled in this EA's hydrologic study. One additional synthetic gage was developed using data from five gages to estimate flows at Rock Creek at the confluence with Lake Fork Creek. For this EA hydrologic analysis, Reclamation primarily focused on changes in four flows at four stream gage locations which are discussed below. These stream gages are Lake Creek below Twin Lakes, Arkansas River below Granite, Arkansas River at Parkdale, Arkansas River above Pueblo and are included in Chapter 2-Figure 3. Additional information on the Willow Creek Ranch Surface Water Hydrology Model and modeling results are presented in Appendix C.

Maximum daily changes by month for representative year-type (Dry, Mean, and Wet) are summarized in Tables B-9 to B-13 for the 28-year study period. Discussion from each stream gage is as follows:

Lake Creek below Twin Lakes

Maximum daily changes in streamflow per year-type in Lake Creek below Twin Lakes gage are shown in Table B-9. Predicted streamflow changes range from negligible to minor under all year-types. Minor changes occur in Dry and Mean years with changing ranging from a 2.8% decrease in February 1998 to 6.8% decrease in September 2003.

Table B-9-Maximum Lake Creek below Twin Lakes change in daily flow for Representative Year-Types

	Maximum Day of a Representative Dry Year (2003, 11th Percentile)					Maximum Day of a Representative Average Year (1998, 50th Percentile)					Maximum Day of a Representative Wet Year (1985, 89th Percentile)				
	Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference	
	cfs	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*
Jan	14.4	14.4	13.6	-0.8	**-5.7%**	65.3	65.3	64.7	-0.6	**-0.9%**	78.1	78.1	77.9	-0.2	**-0.3%**
Feb	14.4	14.4	13.6	-0.9	**-6.0%**	23.3	23.3	22.7	-0.7	**-2.8%**	347.9	347.9	347.6	-0.3	**-0.1%**
Mar	14.4	14.4	13.6	-0.8	**-5.7%**	17.3	17.3	16.7	-0.6	**-3.6%**	120.2	120.2	120.0	-0.2	**-0.2%**
Apr	43.4	43.4	42.6	-0.8	**-1.9%**	14.3	14.3	13.7	-0.6	**-4.5%**	163.0	163.0	162.8	-0.3	**-0.2%**
May	66.0	66.0	66.0	0.0	**0.0%**	20.0	20.0	19.4	-0.6	**-3.2%**	288.4	288.4	285.7	-2.8	**-1.0%**
Jun	173.0	173.0	170.9	-2.1	**-1.2%**	279.0	279.0	276.5	-2.5	**-0.9%**	542.9	542.9	539.4	-3.5	**-0.6%**
Jul	237.0	237.0	235.9	-1.1	**-0.5%**	200.0	200.0	198.1	-1.9	**-1.0%**	308.6	308.6	305.8	-2.8	**-0.9%**
Aug	46.0	46.0	46.0	0.0	**0.0%**	36.0	36.0	34.9	-1.1	**-3.2%**	157.4	157.4	155.1	-2.3	**-1.5%**
Sep	12.4	12.4	11.6	-0.8	**-6.8%**	12.3	12.3	11.7	-0.6	**-5.2%**	57.4	57.4	57.2	-0.3	**-0.4%**
Oct	13.4	13.4	12.6	-0.8	**-6.1%**	13.3	13.3	12.7	-0.6	**-4.7%**	86.7	86.7	86.4	-0.2	**-0.3%**
Nov	14.4	14.4	13.6	-0.8	**-5.8%**	14.3	14.3	13.7	-0.6	**-4.5%**	68.5	68.5	68.2	-0.3	**-0.4%**
Dec	14.4	14.4	13.6	-0.8	**-5.7%**	15.3	15.3	14.7	-0.6	**-4.0%**	65.9	65.9	65.7	-0.2	**-0.4%**

Table B-10 shows the maximum daily change by month for the complete 28-year study period. A 41.1% or 0.6 cfs decrease in streamflow occurs on December 13, 1985, under the Proposed Action. The model also predicts a moderate decrease in Lake Creek flow below Twin Lakes in May of a wet year (-13.2%).

Table B-101-Maximum Lake Creek below Twin Lakes change in daily flow for 28-Year Study Period

	Maximum Day of Dry Years (2002, 2003, 2004, 2005)					Maximum Day of Average Years (1982, 1986, 1987, 1988, 1989, 1990, 1991, 1993, 1994, 1996, 1997, 1998, 1999, 2001, 2006, 2007, 2009)					Maximum Day of Wet Years (1983, 1984, 1985, 1995,2008)				
	Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference	
	cfs	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*
Jan	14.4	14.4	13.6	-0.8	**-5.7%**	10.1	10.1	9.5	-0.6	**-6.1%**	14.1	14.1	13.9	-0.2	**-1.7%**
Feb	12.4	12.4	11.6	-0.9	**-7.0%**	10.3	10.3	9.7	-0.7	**-6.4%**	11.1	11.1	10.9	-0.3	**-2.3%**
Mar	14.4	14.4	13.6	-0.8	**-5.7%**	10.3	10.3	9.7	-0.6	**-6.0%**	11.1	11.1	10.9	-0.2	**-2.2%**
Apr	14.4	14.4	13.6	-0.8	**-5.8%**	7.6	7.6	7.0	-0.6	**-8.4%**	16.1	16.1	15.9	-0.3	**-1.6%**
May	15.0	15.0	15.0	0.0	**0.0%**	20.0	20.0	19.4	-0.6	**-3.2%**	21.0	21.0	18.2	-2.8	**-13.2%**
Jun	83.0	83.0	80.9	-2.1	**-2.5%**	94.0	94.0	91.5	-2.5	**-2.6%**	72.0	72.0	68.5	-3.5	**-4.8%**
Jul	35.0	35.0	33.9	-1.1	**-3.2%**	27.0	27.0	25.1	-1.9	**-7.1%**	173.0	173.0	170.2	-2.8	**-1.6%**
Aug	13.0	13.0	13.0	0.0	**0.0%**	16.0	16.0	14.9	-1.1	**-7.1%**	33.0	33.0	30.7	-2.3	**-7.0%**
Sep	12.4	12.4	11.6	-0.8	**-6.8%**	11.3	11.3	10.7	-0.6	**-5.7%**	15.1	15.1	14.9	-0.3	**-1.7%**
Oct	12.4	12.4	11.6	-0.8	**-6.6%**	11.3	11.3	10.7	-0.6	**-5.5%**	6.1	6.1	5.9	-0.2	**-4.0%**
Nov	13.4	13.4	12.6	-0.8	**-6.3%**	8.2	8.2	7.6	-0.6	**-7.8%**	18.1	18.1	17.9	-0.3	**-1.4%**
Dec	14.4	14.4	13.6	-0.8	**-5.7%**	1.5	1.5	0.9	-0.6	**-41.1%**	18.1	18.1	17.9	-0.2	**-1.3%**

Arkansas River below Granite

All predicted changes in Arkansas River below Granite streamflow are negligible. The maximum decrease of 2.5% occurs only May of wet years as shown in Table B-11.

Arkansas River at Parkdale

The Arkansas River at Parkdale also experiences negligible changes in streamflow under this Proposed Action. Table B-12 shows the maximum daily change by month for each representative year-type. The maximum predicted decrease of 1.9% occurs in May of a wet year.

Table B-11- Maximum Daily Change model at Arkansas River below Granite for the 28-Year Study Period

	Maximum Day of Dry Years (2002, 2003, 2004, 2005)					Maximum Day of Average Years (1982, 1986, 1987, 1988, 1989, 1990, 1991, 1993, 1994, 1996, 1997, 1998, 1999, 2001, 2006, 2007, 2009)					Maximum Day of Wet Years (1983, 1984, 1985, 1995,2008)				
	Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference	
	cfs	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*
Jan	66.2	66.2	65.4	-0.8	-1.2%	92.5	92.5	91.9	-0.6	-0.7%	99.1	99.1	98.9	-0.2	-0.2%
Feb	53.1	53.1	52.2	-0.9	-1.6%	92.5	92.5	91.9	-0.7	-0.7%	105.6	105.6	105.4	-0.3	-0.2%
Mar	55.7	55.7	54.9	-0.8	-1.5%	92.5	92.5	91.9	-0.6	-0.7%	112.1	112.1	111.9	-0.2	-0.2%
Apr	125.5	125.5	124.6	-0.8	-0.7%	84.5	84.5	83.8	-0.6	-0.8%	111.6	111.6	111.4	-0.3	-0.2%
May	171.0	171.0	171.0	0.0	0.0%	145.6	145.6	144.4	-1.2	-0.9%	215.9	215.9	210.4	-5.4	-2.5%
Jun	224.0	224.0	220.0	-4.0	-1.8%	650.3	650.3	645.5	-4.9	-0.7%	612.3	612.3	605.5	-6.8	-1.1%
Jul	144.1	144.1	141.9	-2.2	-1.5%	241.5	241.5	237.7	-3.8	-1.6%	676.8	676.8	671.2	-5.5	-0.8%
Aug	146.0	146.0	146.0	0.0	0.0%	136.1	136.1	133.9	-2.2	-1.6%	244.3	244.3	239.7	-4.6	-1.9%
Sep	101.5	101.5	100.6	-0.8	-0.8%	122.5	122.5	121.9	-0.6	-0.5%	164.3	164.3	164.1	-0.3	-0.2%
Oct	108.3	108.3	107.5	-0.8	-0.7%	118.8	118.8	118.2	-0.6	-0.5%	142.4	142.4	142.2	-0.2	-0.2%
Nov	79.5	79.5	78.7	-0.8	-1.1%	117.7	117.7	117.1	-0.6	-0.5%	125.8	125.8	125.6	-0.3	-0.2%
Dec	66.3	66.3	65.5	-0.8	-1.2%	97.9	97.9	97.2	-0.6	-0.6%	119.0	119.0	118.7	-0.2	-0.2%

Arkansas River above Pueblo

Table B-13 shows the predicted Arkansas River changes in streamflow by month for representative dry, mean and wet years. The spreadsheet model predicts a 39.9% decrease in October daily flows using the 2003 hydrology. The predicted decrease in flow was 0.4 cfs under extreme low-flow conditions. These low flows do not reflect the Pueblo Fish Hatchery return flows reported in the modeling for the Temporary Program.

Table B-14 shows the predicted Arkansas River changes in streamflow by month for 28-year study period. Major decreases (15.1% to 39.5%) where predicted to occur in February, September and October of dry years. These decreases occurred during one day in September, two days in October using 2002 hydrology and one day in February using 2005 hydrology. Predicted flows do not include the Pueblo Fish Hatchery return flows.

Table B-12- Maximum Daily Change model at Arkansas River at Parkdale for the 28-Year Study Period

	Maximum Day of a Representative Dry Year (2003, 11th Percentile)					Maximum Day of a Representative Average Year (1998, 50th Percentile)					Maximum Day of a Representative Wet Year (1985, 89th Percentile)				
	Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference	
	cfs	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*
Jan	8.7	8.7	8.3	-0.4	**-4.2%**	51.3	51.3	51.0	-0.3	**-0.5%**	117.1	117.1	117.0	-0.1	**-0.1%**
Feb	20.4	20.4	20.0	-0.4	**-1.9%**	62.3	62.3	62.0	-0.3	**-0.5%**	655.1	655.1	655.0	-0.1	**0.0%**
Mar	27.4	27.4	27.0	-0.4	**-1.3%**	98.3	98.3	98.0	-0.3	**-0.3%**	535.1	535.1	535.0	-0.1	**0.0%**
Apr	91.4	91.4	91.0	-0.4	**-0.4%**	332.3	332.3	332.0	-0.3	**-0.1%**	770.1	770.1	770.0	-0.1	**0.0%**
May	37.0	37.0	37.0	0.0	**0.0%**	697.4	697.4	697.0	-0.4	**-0.1%**	905.8	905.8	904.0	-1.8	**-0.2%**
Jun	860.4	860.4	859.0	-1.4	**-0.2%**	683.6	683.6	682.0	-1.6	**-0.2%**	2022.2	2022.2	2020.0	-2.2	**-0.1%**
Jul	176.7	176.7	176.0	-0.7	**-0.4%**	788.3	788.3	787.0	-1.3	**-0.2%**	1521.8	1521.8	1520.0	-1.8	**-0.1%**
Aug	135.0	135.0	135.0	0.0	**0.0%**	398.7	398.7	398.0	-0.7	**-0.2%**	347.5	347.5	346.0	-1.5	**-0.4%**
Sep	40.4	40.4	40.0	-0.4	**-0.9%**	190.3	190.3	190.0	-0.3	**-0.2%**	296.1	296.1	296.0	-0.1	**0.0%**
Oct	0.9	0.9	0.6	-0.4	**-39.9%**	310.3	310.3	310.0	-0.3	**-0.1%**	570.1	570.1	570.0	-0.1	**0.0%**
Nov	82.4	82.4	82.0	-0.4	**-0.5%**	328.3	328.3	328.0	-0.3	**-0.1%**	93.1	93.1	93.0	-0.1	**-0.1%**
Dec	0.5	0.5	0.5	0.0	**0.0%**	50.3	50.3	50.0	-0.3	**-0.6%**	105.1	105.1	105.0	-0.1	**-0.1%**

Table B-13-Maximum Daily Change model at Arkansas River above Pueblo for Representative Year-Types

	Maximum Day of Dry Years (2002, 2003, 2004, 2005)					Maximum Day of Average Years (1982, 1986, 1987, 1988, 1989, 1990, 1991, 1993, 1994, 1996, 1997, 1998, 1999, 2001, 2006, 2007, 2009)					Maximum Day of Wet Years (1983, 1984, 1985, 1995,2008)				
	Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference	
	cfs	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*
Jan	221.9	221.9	221.2	-0.8	**-0.3%**	299.5	299.5	298.9	-0.6	**-0.2%**	319.5	319.5	319.3	-0.2	**-0.1%**
Feb	218.5	218.5	217.7	-0.8	**-0.4%**	273.5	273.5	272.9	-0.6	**-0.2%**	324.5	324.5	324.2	-0.2	**-0.1%**
Mar	191.1	191.1	190.3	-0.8	**-0.4%**	263.6	263.6	263.0	-0.6	**-0.2%**	316.4	316.4	316.2	-0.2	**-0.1%**
Apr	235.4	235.4	234.6	-0.8	**-0.3%**	222.4	222.4	221.8	-0.6	**-0.3%**	303.3	303.3	303.0	-0.2	**-0.1%**
May	238.0	238.0	238.0	0.0	**0.0%**	284.6	284.6	283.4	-1.2	**-0.4%**	274.5	274.5	269.5	-5.1	**-1.9%**
Jun	358.9	358.9	355.1	-3.8	**-1.1%**	843.3	843.3	838.7	-4.5	**-0.5%**	1283.2	1283.2	1276.8	-6.4	**-0.5%**
Jul	229.0	229.0	227.0	-2.1	**-0.9%**	441.8	441.8	438.2	-3.5	**-0.8%**	1012.6	1012.6	1007.4	-5.2	**-0.5%**
Aug	236.0	236.0	236.0	0.0	**0.0%**	308.0	308.0	306.0	-2.1	**-0.7%**	467.1	467.1	462.9	-4.3	**-0.9%**
Sep	187.4	187.4	186.6	-0.8	**-0.4%**	288.4	288.4	287.8	-0.6	**-0.2%**	354.3	354.3	354.1	-0.2	**-0.1%**
Oct	118.9	118.9	118.1	-0.8	**-0.6%**	242.1	242.1	241.5	-0.6	**-0.2%**	336.3	336.3	336.1	-0.2	**-0.1%**
Nov	188.4	188.4	187.7	-0.8	**-0.4%**	334.7	334.7	334.1	-0.6	**-0.2%**	358.9	358.9	358.6	-0.2	**-0.1%**
Dec	226.0	226.0	225.2	-0.8	**-0.3%**	234.6	234.6	234.0	-0.6	**-0.2%**	340.6	340.6	340.4	-0.2	**-0.1%**

Table B-14-Maximum Daily Change Model at Arkansas River above Pueblo for the 28-Year Study Period

	Maximum Day of Dry Years (2002, 2003, 2004, 2005)					Maximum Day of Average Years (1982, 1986, 1987, 1988, 1989, 1990, 1991, 1993, 1994, 1996, 1997, 1998, 1999, 2001, 2006, 2007, 2009)					Maximum Day of Wet Years (1983, 1984, 1985, 1995,2008)				
	Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference		Baseline Condition	No Action	Proposed Action	Difference	
	cfs	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*	*cfs*	*cfs*	*cfs*	*cfs*	*%*
Jan	8.7	8.7	8.3	-0.4	**-4.2%**	51	51	51	-0.3	**-0.5%**	71	71	71	-0.1	**-0.2%**
Feb	2.6	2.6	2.2	-0.4	**-15.1%**	21	21	21	-0.3	**-1.4%**	77	77	77	-0.1	**-0.2%**
Mar	16.4	16.4	16.0	-0.4	**-2.2%**	67	67	67	-0.3	**-0.4%**	82	82	82	-0.1	**-0.1%**
Apr	91.4	91.4	91.0	-0.4	**-0.4%**	34	34	34	-0.3	**-0.8%**	205	205	205	-0.1	**-0.1%**
May	37.0	37.0	37.0	0.0	**0.0%**	103	103	103	-0.4	**-0.4%**	318	318	316	-1.8	**-0.6%**
Jun	174.4	174.4	173.0	-1.4	**-0.8%**	583	583	581	-1.6	**-0.3%**	306	306	304	-2.2	**-0.7%**
Jul	47.7	47.7	47.0	-0.7	**-1.5%**	195	195	194	-1.3	**-0.6%**	1222	1222	1220	-1.8	**-0.1%**
Aug	0.6	0.6	0.6	0.0	**0.0%**	231	231	230	-0.7	**-0.3%**	292	292	291	-1.5	**-0.5%**
Sep	1.0	1.0	0.6	-0.4	**-39.5%**	57	57	57	-0.3	**-0.5%**	139	139	139	-0.1	**-0.1%**
Oct	0.9	0.9	0.6	-0.4	**-39.9%**	62	62	62	-0.3	**-0.4%**	169	169	169	-0.1	**-0.1%**
Nov	52.4	52.4	52.0	-0.4	**-0.7%**	54	54	54	-0.3	**-0.5%**	63	63	63	-0.1	**-0.2%**
Dec	72.4	72.4	72.0	-0.4	**-0.5%**	50	50	50	-0.3	**-0.6%**	54	54	54	-0.1	**-0.2%**

Reclamation utilized the Fry-Ark RiverWare Model to identify cumulative changes in streamflow contributed to the Donala 40-Year Contract. The 2058 Proposed Action model run was compared to another run that excluded Donala's Willow Creek Ranch operations and excess capacity storage in Pueblo Reservoir but included all other 2058 temporary contracts. This model run assumed that no temporary or long-term excess capacity storage contract with Donala is executed and the Willow Creek Ranch water rights revert to native Arkansas River flows. The model run also assumes water leased from Twin Lakes to meet historic return flow requirements would no longer be needed.

Results showed no changes in annual streamflow at the Arkansas River at Wellsville, Portland, and at Coolidge, Kansas. The modeling also predicted no changes of flows at the Fountain Creek at Pueblo location. Annual streamflow changes are shown in Table 22 but are all less than 1 percent and are considered negligible.

Except for flows downstream of John Martin Reservoir, all predicted mean monthly streamflow changes would be less than 1 percent. The mean March monthly flow would increase by about 0.4 cfs under this Proposed Action from 4.2 cfs to about 4.6 cfs. This represents about a 10 percent increase in mean stream flows for the month of March. Modeling also predicts that March monthly mean flows at the Coolidge, Kansas gage would increase by about 0.3 cfs under the Proposed Action. This is a 0.2 percent increase in the March Monthly mean flow at Coolidge, Kansas with an increase from 152.4 cfs to 152.7 cfs.

Table B-15-Donala 2058 40-Year Contract Annual Flow Comparison

Stream Gage Location	**No Action w/ Temporary Program Annual Flow** (cfs)	**Proposed Action Annual Flows** (cfs)	**Flow Change** (cfs)	**Percent Change** (cfs)
Lake Creek Below Twin Lakes	157.3	157.2	-0.1	-0.09%
Arkansas River above Pueblo Combined Flows[4]	467.2.	466.7	-0.5	-0.11%
Arkansas River at Moffat Street	477.5	478.0	0.5	0.10%
Arkansas River at Avondale	848.8	848.3	-0.5	-0.06%
Arkansas River at Catlin Dam near Fowler	502.5	502.2	-0.3	0.06%
Arkansas River at La Junta	218.4	218.3	-0.1	-0.05%
Arkansas River at Las Animas	219.5	219.4	-0.1	-0.04%
Arkansas River below John Martin Reservoir	274.5	274.4	-0.1	-0.03%

*The No Action Alternative for this analysis assumes continuation of the Temporary Program using 30,000 ac-ft of excess capacity storage in Pueblo Reservoir.

Reservoirs

In addition to Reclamation's East Slope Fry-Ark Project facilities (Turquoise, Twin Lakes and Pueblo reservoirs), John Martin, Clear Creek and Trinidad Lake reservoirs were selected for this hydrologic analysis. Reservoir analyses focus primarily on Pueblo Reservoir and a brief description of each reservoir follows.

The Fry-Ark RiverWare Model was used to evaluate predicted changes in reservoir elevations and storage content for the Temporary Program and Donala and BLM 40-year excess capacity contracts. Additional information on Colorado reservoirs in the Arkansas River Basin can be found in the Surface Water Hydrology Affected Environment Supplement, Appendix D.1 of the AVC/Master Contract Final EIS. The document can be accessed at: https://www.usbr.gov/avceis/.

[4] These are combined flows below Pueblo Reservoir are computed as Arkansas River Above Pueblo gage combined Homestake and Busk-Ivanhoe water projects. Turquoise Reservoir regulates the surface flow of Lake with Pueblo Fish Hatchery Return Flows.

Effects on Surface Water Resources-Reservoirs

Fryingpan-Arkansas Project RiverWare Reservoir Modeling Results

Table B-16 shows the predicted mean end of month (EOM) water surface elevation for the major reservoirs within the Arkansas River Basin. Mean monthly reservoir elevation for Pueblo Reservoir is predicted to increase between 1.66 feet in the 2032 Scenario to 1.40 feet in the 2058 Scenario under the Proposed Action. All other reservoir evaluation changes are predicted to decrease less than 3.74 inches and to increase by up to 1.68 inches under all modeled Scenarios.

There would be negligible changes in excess capacity storage at John Martin Reservoir and negligible to minor changes at Turquoise, Twin, Clear Creek, and Trinidad reservoirs under the various demand and storage scenarios. As expected, largest changes in reservoir elevations occur at Pueblo Reservoir when comparing the No Action and Action alternatives. Changes in Pueblo Reservoir's total content are graphically depicted in Figures B-1, B-2, and B-3. The additional storage that would occur under the Temporary Program is shown in red for each modeled scenario.

Contract excess capacity accounts. These changes are primarily the result of water leases from the long-term excess capacity storage accounts to the temporary excess capacity accounts. These changes only occur if the long-term contract entity makes operational decisions to lease water to the temporary excess capacity entity. See Appendix B-Section 5.5 through 5.7 for additional details on simulated long-term and temporary excess capacity accounts.

Storage demands on an excess capacity account are the operations, transactions, or other processes that represents a lease, transfer, exchange, or other outflow of storage from the excess capacity account. Storage demands vary by entity and are independent decision made based on the current excess capacity storage volume and other controlled sources, hydrologic projections, and anticipated future demands.

The most common types of demands simulated in the model are:

- Direct diversion from Pueblo Reservoir
- Deliveries via releases to the river and subsequent diversion upstream
- Delivery exchanges via out-of-priority upstream diversions with concurrent release of stored water from Pueblo Reservoir to native flow
- Exchanges from Pueblo Reservoir to upstream storage locations
- Augmentation or delayed return flow required releases to native flow
- Contract exchanges or trades to various locations
- Leases/sales to other entities with excess capacity storage accounts

As mentioned previously and discussed in Appendix B, a majority of the temporary excess capacity accounts rely on the leases of long-term excess capacity storage and exchange contracts or other mechanism as their water supply.

Table B-16-Modeled Mean EOM Reservoir Elevation

Reservoir	No Action	Proposed Action	No Action	Proposed Action	No Action	Proposed Action	ft.	In.
2032	**Mean**		**Min.**		**Max.**		**Difference**	
Turquoise Reservoir	9,844.95	9,844.90	9,829.1	9,828.50	9,870.60	9,870.60	-0.05	-0.60
Twin Lakes	9,179.34	9,179.40	9,162.00	9,164.40	9,194.30	9,194.20	0.06	0.72
Clear Creek	8,873.55	8,873.48	8,865.60	8,865.60	8,876.50	8,876.50	-0.07	-0.84
Pueblo	4,872.21	4,873.87	4,852.90	4,855.20	4,893.90	4,893.90	1.66	19.92
John Martin	3,815.88	3,815.91	3,795.10	3,795.20	3,852.60	3,852.60	0.03	0.41
Trinidad Lake	6,185.54	6,185.68	6,166.90	6,166.90	6,215.20	6,215.20	0.14	1.68
2047	**Mean**		**Min.**		**Max.**		**Difference**	
Turquoise Reservoir	9,845.08	9,844.99	9,827.50	9,827.50	9,870.80	9,870.70	-0.09	-1.08
Twin Lakes	9,179.96	9,179.64	9,164.40	1,964.00	9,197.10	9,197.40	-0.32	-3.84
Clear Creek	8,873.78	8,873.68	8,865.60	8,865.60	8,876.50	8,876.50	-0.10	-1.20
Pueblo	4,866.05	4,867.69	4,841.60	4,843.00	4,893.90	4,893.90	1.64	19.68
John Martin	3,815.24	3,815.29	3,794.50	3,794.40	3,852.50	3,852.50	0.05	0.6
Trinidad Lake	6,185.34	6,185.38	3166.90	6166.90	6215.10	6215.10	0.04	0.48
2058	**Mean**		**Min.**		**Max.**		**Difference**	
Turquoise Reservoir	9,845.07	9,845.01	9,827.50	9,827.50	9,870.80	9,870.70	-0.06	-0.72
Twin Lakes	9,179.82	9,179.57	9,164.20	9,164.00	9,196.80	9,197.60	-0.25	-3.00
Clear Creek	8,873.56	8,873.38	8,865.60	8,865.60	8,876.50	8,876.50	-0.18	-2.16
Pueblo	4,865.94	4,867.34	4,841.90	4,843.00	4,893.90	4,893.90	1.40	16.80
John Martin	3,815.25	3,815.23	3,794.50	3,794.40	3,852.30	3,852.30	-0.02	-0.24
Trinidad Lake	6,185.37	6,185.39	6,166.90	6,166.90	6,215.10	6,215.10	0.02	0.24

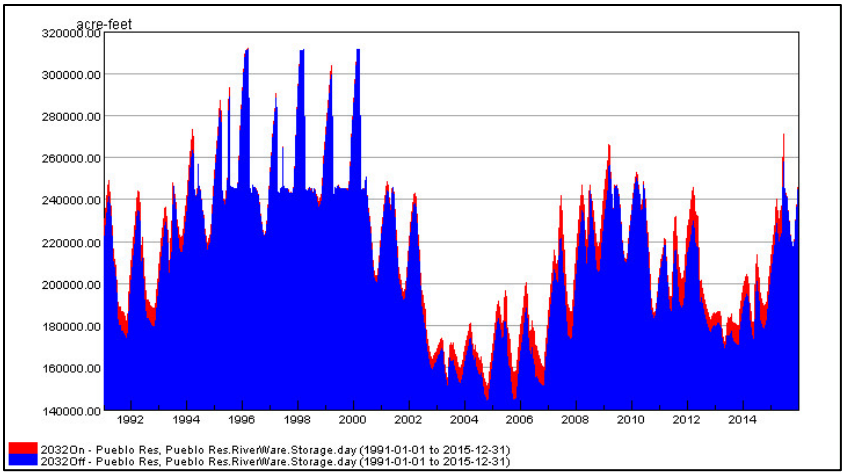

Figure B-1-2032 Modeled Pueblo Reservoir EOM Storage Content

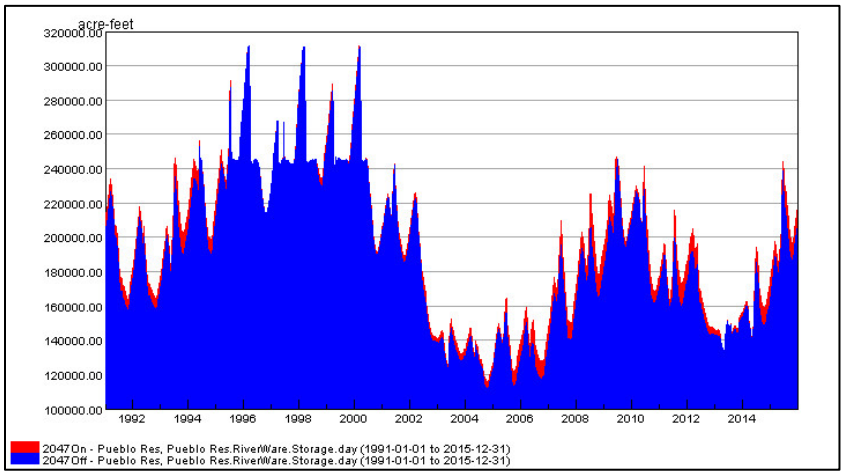

Figure B-2-2047 Modeled Pueblo Reservoir EOM Storage Content

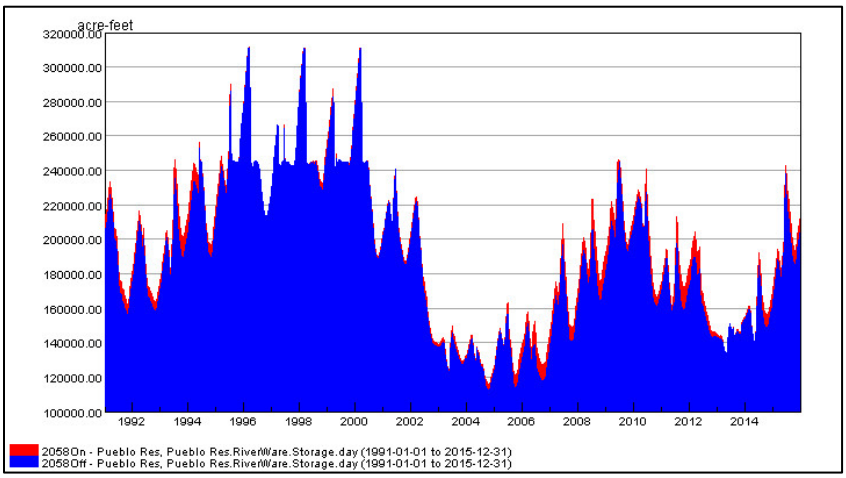

Figure B-3-2057 Modeled Pueblo Reservoir EOM Storage Content

Table B-17-Modeled Existing Long-Term Contract Storage Demand Storage Volumes

Excess Capacity Account	Max Contract Amount	2032 Demand				2047 Demand				2058 Demand			
		Annual Daily Avg.		Difference		Annual Daily Avg. (ac-ft)		Difference		Annual Daily Avg.		Difference	
		No Action	Proposed Action	(ac-ft)	Percent	No Action	Proposed Action	(ac-ft)	Percent	No Action	Proposed Action	(ac-ft)	Percent
Pueblo Water	15,000	12,261.7	12,011.1	-250.6	-2.0%	12,629.7	12,423.3	-206.4	-1.6%	12,392.6	12,101.5	-291.1	-2.3%
City of Aurora	10,000	1,066.0	1,023.9	-42.1	-3.9%	1,192.0	1,116.3	-15.2	-1.3%	1,183.9	1,119.7	-64.1	-5.4%
Colorado Springs Utilities	28,000	1,455.1	1,478.9	23.7	1.6%	2,412.0	2,118.7	-92.6	-3.8%	2,428.9	2,093.9	-335.1	-13.8%
Fountain	2,500	6.2	6.2	0.0	0.0%	5.5	5.3	0.1	1.1%	5.5	5.3	-0.2	-3.5%
Pueblo West	10,000	1,791.8	1,234.1	-557.7	-31.1%	2,325.4	1,594.2	-402.7	-17.3%	2,080.4	1,466.6	-613.7	-29.5%
Security	1,500	13.1	13.7	0.6	4.6%	10.3	10.1	-0.1	-1.0%	10.0	10.0	0.0	-0.2%
Master Contract	29,938	6,278.8	5,628.7	-650.1	-10.4%	8,134.8	7,524.3	-507.6	-6.2%	8,800.9	8,190.6	-610.3	-6.9%
LT Total	**96,938**	**22,872.8**	**21,396.5**	**-1,476.2**	**-6.5%**	**26,709.7**	**24,792.2**	**-1,224.5**	**-4.6%**	**26,902.1**	**24,987.6**	**-1,914.5**	**-7.1%**