Appendix D

Investigation and Analysis Report

Appendix D. Investigation and Analysis Report

The purpose of the Investigation and Analysis Report is to present information that supports the formulation, evaluation, and conclusions of the Duchesne County Water Conservancy District Watershed Plan and Environmental Assessment (Plan-EA). The report is required and must be included as an appendix to the Final Plan-EA.

The procedures, techniques, assumptions, and the scope and intensity of the investigations for each subject are described in sufficient detail so that a reader not familiar with the watershed or its problems can form an opinion on the adequacy of the Plan-EA. This report supplements information contained in the Plan-EA and is not intended to replace or duplicate information contained therein.

February 2025

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AECOM

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D.1. Introduction

The planning studies presented in this Investigation and Analysis Report (I&A Report) are based on standard methods, procedures, and computer programs used and approved for use by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). The following information gives a summary of the investigation and analysis for the key planning studies in the preparation of the Plan-EA for the proposed Duchesne County Water Conservancy District Watershed measures. Engineering analysis, concept design information, and resource survey information was summarized from engineering technical memos (TMs) and resource survey reports prepared for this project. Resource surveys are included in Appendix E of the Plan EA, with exception of cultural surveys containing sensitive location information. Engineering TMs are available upon request. Requests for additional information can be submitted to the following address:

USDA-NRCS
Wallace F. Bennett Federal Building
125 S State St., Room 4010
Salt Lake City, UT 84138-1100

Information included in this I&A Report include procedures, techniques, assumptions, scope, and intensity of the investigations and analyses completed for seven areas proposed for improvement within the Duchesne County Water Conservancy District Watershed (Watershed) in Duchesne County, Utah (Table 1-1).

Table 1-1. Proposed Sites for Improvement

Site No.	Site Name	Location		Canal Length	Description
		Latitude	Longitude		
Site 1	Yellowstone Feeder Canal	40.4554	-110.25896	22.3 miles	Open mostly unlined irrigation canal constructed between 1938 and 1940
Site 2	Coyote Canal	40.43118	-110.14458	8,147 feet	Open unlined irrigation canal constructed in 1981
Site 3	South Boneta Canal	40.36209	-110.3258	2.4 miles	Open unlined irrigation canal constructed 100+ years ago
Site 4	Dry Gulch Class B Canal	40.36207	-110.22929	31 miles	Open unlined irrigation canal system constructed 100+ years ago
Site 5	Dry Gulch Class C Canal	40.25377	-110.18744	8.3 miles	Open unlined irrigation canal system constructed 100+ years ago
Site 6	Red Cap Extension Canals/Laterals	40.20762	-110.19746	9 miles	open unlined irrigation canal system constructed in approximately 1967
Site 7	Gray Mountain Canal	40.15008	-110.22125	7.9 miles	open mostly unlined irrigation canal system constructed 100+ years ago

D.2. Water Loss Analysis

A water loss analysis was conducted at each canal to determine the range of water loss experienced in each system. The water loss calculations focused on losses specific to seepage. Water loss calculations for overwatering, operations losses, etc., were not evaluated due to insufficient flow information within the systems. Evaporation losses were not calculated because they were considered insignificant, typically on the order of only 1-2 percent. Methodology used to calculate loss assumed that the water demand of the canal systems are evenly distributed along the canal lengths analyzed.

The seepage rate method was used to estimate water loss and consists of a seepage rate multiplied by an area measurement (where water is subject to seep into the ground), to determine the seepage volume per unit of time. Soil seepage rate information for the analysis was obtained from United States Geological Survey (USGS) soil data (Schwarz and Alexander 1995). Seepage area measurements were calculated by multiplying the wetted perimeter of the canals by the canal length. The wetted perimeters were estimated by using an average flow velocity of 4 fps to calculate the equivalent cross-sectional area of the water in the canals. The area measurement was then used to calculate the wetted perimeter, and the wetted perimeter was multiplied by the length of the canal to determine the seepage area of the canal. The area measurements assumed a constant flow throughout the length of the canal. If there was zero flow at the end of the canal, the seepage area was cut in half to adjust for this condition. The average of the wetted perimeter at the start and end of the canal was used to calculate the seepage area when there is a given flow at the end of the canal.

Percent seepage loss of the total water diverted was calculated by dividing the seepage volume by the amount of water diverted into the canal. Seepage loss per day was estimated and multiplied by the number of days in the typical irrigation season to determine the estimated annual loss due to seepage for each canal. The results of the water loss analysis, using the average daily flow, is included in Table 2-1. Average daily flows were calculated from flow data obtained from the Duchesne River and Tributaries of Utah (Duchesne County Water Conservancy District [DCWCD] et al. 2020), available gage data, or information provided by the irrigation companies. Detailed information on the water loss analysis conducted for each canal system are included in the engineering TMs (Franson Civil Engineers [Franson] 2021a, 2021b 2021c, and 2021d, and Jones & DeMille Engineering [JDE] 2021a, 2021b and 2021c), which are included in Appendix E of the Plan-EA.

Table 2-1. Average Water Loss from Seepage

Site No	Site Name	Average Loss from Seepage	
		%	Annual (ac-ft)
Site 1	Yellowstone Feeder Canal	18.9	2,960
Site 2	Coyote Canal	13.5	591
Site 3	South Boneta Canal	58.7	812
Site 4	Dry Gulch Class B Canal: Class B Main System	4.9	854
	Dry Gulch Class B Canal: Lateral F	84.5	5,021
	Dry Gulch Class B Canal: Lateral I	34.0	3,612
	Dry Gulch Class B Canal: Bluebell Lateral	51.6	10,685
	Dry Gulch Class B Canal Total		20,172
Site 5	Dry Gulch Class C Canal	21.9	4,662
Site 6	Red Cap Extension Canals/Laterals	35.8	4,784
Site 7	Gray Mountain Canal	23.4	12,721

D.3. Sediment and Erosion Analysis

A sediment analysis was conducted for Coyote Canal (JDE 2021b included in Appendix E of the Plan-EA) to determine the amount of erosion that has occurred resulting in sedimentation into Brown's Draw Reservoir. Erosion was estimated by comparing the current conditions to pre-erosion conditions and used a combination of topographic survey, photograph/historical aerial image review, and known feature elevations to perform calculations. Erosion of sediment from the canal was estimated at 15,200 cubic yards (9.42) ac-ft. Calculations for additional sediment erosion potential were also performed and estimated 10,900 cubic yards (6.76 ac-ft) of sediment could continue to erode from the canal and deposit in the reservoir.

D.4. Hydraulic Analysis

Hydraulic analyses were completed for each site and are documented in the Franson and JDE TMs included in Appendix E of the Plan-EA. Open canals proposed for lining (Site 1 Yellowstone Feeder Canal and Site 7 Gray Mountain Canal) were modeled using a Geographical Information System (GIS) alignment and operational model was developed relying on Google Earth Digital Elevation Model (DEM) data. A manning's roughness (n) value of 0.013 for concrete liner was used for the Gray Mountain Canal n value of 0.023 for shotcrete or concrete was used for Yellowstone Feeder Canal to determine the lining dimensions for the required design flow. An NRCS-provided calculation spreadsheet that uses Manning's Open Channel Flow Equation to calculate open channel flow was used for hydraulic analysis calculations.

A summary of the methods used for hydraulic analysis of the canals proposed for piping is provided for each canal below.

- **Site 2 (Coyote Canal):** Elevation data and system information was obtained from irrigation company board members and topographic surveys. This information was used to create an alignment and profile in AutoCAD Civil 3D. An n value of 0.012 for HDPE pipe was chosen. A calculation spreadsheet was created to determine pipeline sizing and water velocities.
- **Site 3 (South Boneta Canal), Site 4 (Dry Gulch Class B Canal System), and Site 5 (Dry Gulch Class C Canal System:** A model was developed using Google Earth DEM data and system information obtained from irrigation company personnel. A Hazen-Williams coefficient of 150 for HDPE pipe was used to determine pipe size and the class required to convey the required flow with no turnouts for Site 3 and with turnouts a specified locations for Sites 4 and 5. The NRCS standard of 72 percent of maximum pressure rating was used for design. A calculation spreadsheet was used to compare existing system lengths, quantities, future alternative material quantities, and quantify operation differences between the existing and future system.
- **Site 6 (Red Cap Extension Canals/Laterals):** A model was created in InfoWater Pro using Google Earth DEM data and system information obtained from irrigation company personnel. The pipeline was modeled assuming all irrigation users were irrigating at the same time to model the lowest dynamic pressure that could be experienced at each junction. A Hazen-Williams coefficient of 130 for HDPE pipe was used to determine pipe size and the class required to convey the required flow with turnouts at specified locations. The NRCS standard of 72 percent of maximum pressure rating was used for design.

Detailed information on the hydraulic analysis conducted for each canal system are included in the engineering TMs (Franson Civil Engineers 2021a, 2021b 2021c, and 2021d, and JDE 2021a, 2021b and 2021c), which are included in Appendix E of the Plan-EA.

D.5. Topographic Surveys

Topographic surveys were not completed at Site 3 (Coyote Canal), Site 4 (Dry Gulch Class B Canal System), or Site 5 (Dry Gulch Class C Canal System). A topographic survey was completed at Site 1 (Yellowstone Feeder Canal) for a previous lining project in 2016 to obtain the existing cross sections along segments of the canal (JDE 2016), but no supplemental topographic survey was performed as part of the Plan-EA. The previous 2016 survey was used to obtain existing canal cross sections to aid in engineering analysis and concept design. Topographic surveys were performed as part of this Plan-EA for Site 2 (Coyote Canal) and Site 6 (Red Cap Extension Canals/Laterals) to obtain the existing cross sections of the canals, find section corners for future ROW work, and to aid in concept design (JDE 2019 and 2021d).

D.6. Engineering

Seven sites for improvements within the Watershed were evaluated to be included in the Watershed Plan and Environmental Assessment (Plan-EA). System deficiencies and water loss issues were identified and alternatives formulated by the engineering team to improve existing irrigation systems. Several alternatives were developed for each site and alternatives were eliminated if they were considered infeasible, had exorbitant costs, did not meet the purpose and need, did not meet the specific goals established for each site, or other critical factors. Refer to the Plan-EA for the description of the alternatives eliminated.

Alternatives formulated by the engineering team to be included in detailed study for each site are listed below. Conceptual designs were developed for alternatives included in detailed study to support the environmental analysis in the Plan-EA. Design criteria used in conceptual design included:

- NRCS Conservation Practice Standards for Irrigation Ditch Lining (NRCS 2019), Pond Sealing or Lining – Concrete (NRCS 2016), and Irrigation Pipeline (2020).
- NRCS Technical Note for Structural Design of Flexible Conduits (NRCS 2015a)
- NRCS National Engineering Manual Utah Supplement Subpart A Design (NRCS 2011)

Refer to the Plan-EA for a detailed description of measures proposed for the alternatives included in detailed study. The No Action Alternative must also be evaluated for comparison. The No Action Alternative considers the actions that would take place if no federal action or federal funding were provided. The sponsors most likely course of action at each site would include operations and maintenance (O&M) activities to maintain the existing systems. Table 6-1 below provides a list of the alternatives included and eliminated from detailed study.

Table 6-1. Alternatives Included and Eliminated From Detailed Study

Alternatives Included	Alternatives Eliminated
Site 1 Yellowstone Feeder Canal	
No Action	Membrane Liner
Line Segments with Concrete	Pipe Segments with HDPE
	HDPE Pipeline
Site 2 Coyote Canal	
No Action	Riprap and Erosion Control
HDPE Pipe	Dual Pipeline
Site 3 South Boneta Canal	
No Action	Canal Lining
HDPE Pipe	Pipe Segments
	Pipe and Realign
Site 4 Dry Gulch Class B Canal System	
No Acton	Canal Lining
HDPE Pipe	Pipe Segments
	Pipe and Realign
Site 5 Dry Gulch Class C Canal System	
No Action	Canal Lining
HDPE Pipe	Pipe Segments
Site 6 Red Cap Extension Canals/Laterals	
No Action	Pipeline with Pump Station
HDPE Pipe	Line with Concrete
Site 7 Gray Mountain Canal	
No Action	Membrane Liner
Concrete Liner	Slip Lined Concrete
Membrane Liner	Membrane Liner with Shotcrete Base
Pipe	HPE and Steel Pipeline or Steel Pipeline

D.7. Cost Estimates

D.7.1. No Action Alternative

No Action Alternative Costs consist of O&M measures to maintain existing canal systems including canal cleaning, vegetation removal, beaver maintenance, washout repairs, vegetation control, spraying, mowing, direct labor costs, fuel, equipment, and non-routine maintenance. O&M costs for each site are listed below.

- Site 1 (Yellowstone Feeder Canal): $17,600 per year
- Site 2 (Coyote Canal): $16,600 per year
- Site 3 (South Boneta Canal): $8,600 per year
- Site 4 (Dry Gulch Class B Canal System): $22,800 per year
- Site 5 (Dry Gulch Class C Canal System): $63,700 per year
- Site 6 (Red Cap Extension Canals/Laterals): $41,800 per year
- Site 7 (Gray Mountain Canal): $51,000 per year

D.7.2. Preferred Alternative

The construction costs for the Preferred Alternative measures are based on 2021 U.S. dollars and include estimated quantities of construction materials and labor. Total installation costs for the project are $41,049,000 and include construction ($33,302,000), design engineering ($3,331,000), construction engineering ($3,331,000), administrative time ($876,000), permitting ($86,000), and real property rights (including acquisition for mitigation) ($123,000). Detailed cost estimate information for each site is included in Section 7.2.1 through 7.2.7 below. All construction cost estimates were rounded to the nearest thousand. Estimated O&M costs for each site are listed below.

- Site 1 (Yellowstone Feeder Canal): $1,700 per year
- Site 2 (Coyote Canal): $600 per year
- Site 3 (South Boneta Canal): $1,600 per year
- Site 4 (Dry Gulch Class B Canal System): $9,600 per year
- Site 5 (Dry Gulch Class C Canal System): $4,000 per year
- Site 6 (Red Cap Extension Canals/Laterals): $12,800 per year
- Site 7 (Gray Mountain Canal): $1,300 per year

7.2.1 Site 1 (Yellowstone Feeder Canal)

Table 7-1. Site 1 Detailed Construction Cost Estimate

Item Description	Unit	Quantity	Unit Price	Price[1]
Clearing and Grubbing	LF	13,200	$3.50	$46,000
Canal Excavation and Preparation	CY	4,950	$30.00	$149,000
Borrow	TON	1,530	$30.00	$46,000
Rock Base Aggregate	TON	5,720	$30.00	$172,000
Geocomposite Liner	SY	41,000	$12.00	$492,000
Concrete	CY	3,315	$370	$1,227,000
Cut Off Wall	EA	20	$1,000	$20,000
			Construction Subtotal	**$2,152,000**
Mobilization	LS	1	$216,000	$216,000
Construction Staking	LS	1	$22,000	$22,000
Contingency (5% of Construction Subtotal)	LS	1	$108,000	$108,000
Resource Mitigation (cultural)	LS	1	$1,000	$1,000
			TOTAL PROBABLE CONSTRUCTION COST	**$2,499,000**

1 – Rounded to the nearest thousand

Table 7-2. Site 1 Installation Cost

Item	Cost
Construction	$2,499,000
Design Engineering (assumed 10% of construction cost)[1]	$250,000
Construction Engineering (assumed 10% of construction cost)[1]	$250,000
Permitting	$8,000
Real Property Rights	$0
Natural Resource Rights	$0
Water Rights	$0
Relocation Payments	$0
Administrative (NRCS – assumed 1.5% of construction)	$37,500
Administrative (Sponsors – assumed 1.5% of construction)	$37,500
Total Installation Cost	**$3,082,000**

1 – Rounded to the nearest thousand

7.2.2 Site 2 (Coyote Canal)

Table 7-3. Site 2 Detailed Construction Cost Estimate

Item Description	Unit	Quantity	Unit Price	Price[1]
Rock Excavation	LF	1,000	$12.00	$12,000
Imported Pipe Bedding	LF	2,250	$10.00	$23,000
HDPE Pipe 54" DR 32.5 (63 psi)	LF	3,528	$115.73	$408,000
HDPE Pipe 63" DR 32.5 (63 psi)	LF	885	$156.99	$139,000
Install HDPE Pipe 54" DR 32.5 (63 psi)	LF	3,528	$40.00	$141,000
Install HDPE Pipe 63" DR 32.5 (63 psi)	LF	885	$45.00	$40,000
Pipe Inlet Screen Structure	LS	1	$275,000	$275,000
Dissipation Structure	LS	1	$30,000	$30,000
Channel Shaping	CY	1,000	$15.00	$15,000
Bank and Flowline Stabilization	SY	2,800	$40.00	$112,000
			Construction Subtotal	**$1,195,000**
Mobilization	LS	1	$120,000	$120,000
Construction Staking	LS	1	$13,000	$13,000
Traffic Control	LS	1	$12,000	$12,000
Contingency (10% of Construction Subtotal)	LS	1	$120,000	$120,000
			TOTAL PROBABLE CONSTRUCTION COST	**$1,460,000**

1 – Rounded to the nearest thousand

Table 7-4. Site 2 Installation Cost

Item	Cost
Construction	$1,460,000
Design Engineering (assumed 10% of construction cost)[1]	$146,000
Construction Engineering (assumed 10% of construction cost)[1]	$146,000
Permitting	$7,000
Real Property Rights	$0
Natural Resource Rights	$0
Water Rights	$0
Relocation Payments	$0
Administrative (NRCS – assumed 1.5% of construction)	$22,000
Administrative (Sponsors – assumed 1.5% of construction)	$22,000
Total Installation Cost	**$1,803,000**

1 – Rounded to the nearest thousand

7.2.3 Site 3 (South Boneta Canal)

Table 7-5. Site 3 Detailed Construction Cost Estimate

Item Description	Unit	Quantity	Unit Price	Price[1]
HDPE Pipe 22" DR 32.5 (63 psi)	LF	12,883	$19.20	$247,000
Install HDPE Pipe 22" DR 32.5 (63 psi)	LF	12,883	$14.00	$180,000
			Construction Subtotal	**$427,000**
Mobilization	LS	1	$25,000	$25,000
Appurtenances (Air Release Valves, Valves, Drains, etc.)	LS	1	$124,000	$124,000
Resource mitigation (ULT)	LS	1	$27,000	$27,000
Contingency (10% of Construction Subtotal)	LS	1	$43,000	$43,000
			TOTAL PROBABLE CONSTRUCTION COST	**$646,000**

1 – Rounded to the nearest thousand

Table 7-6. Site 3 Installation Cost

Item	Cost
Construction	$646,000
Design Engineering (assumed 10% of construction cost)[1]	$65,000
Construction Engineering (assumed 10% of construction cost)[1]	$65,000
Permitting	$8,000
Real Property Rights	$0
Natural Resource Rights	$0
Water Rights	$0
Relocation Payments	$0
Administrative (NRCS – assumed 1.5% of construction)	$9,500
Administrative (Sponsors – assumed 1.5% of construction)	$9,500
Total Installation Cost	**$803,000**

1 – Rounded to the nearest thousand

7.2.4 Site 4 (Dry Gulch Class B Canal System)

Table 7-7. Site 4 Detailed Construction Cost Estimate

Item Description	Unit	Quantity	Unit Price	Price[1]
HDPE Pipe 8" DR 17 (125 psi)	LF	1,130	$5.50	$6,000
HDPE Pipe 8" DR 21 (100 psi)	LF	2,030	$4.50	$9,000
HDPE Pipe 8" DR 26 (80 psi)	LF	474	$3.60	$2,000
HDPE Pipe 10" DR 26 (80 psi)	LF	2,060	$5.70	$12,000
HDPE Pipe 10" DR 32.5 (63 psi)	LF	8,033	$4.60	$37,000
HDPE Pipe 12" DR 32.5 (63 psi)	LF	1,670	$6.30	$11,000
HDPE Pipe 16" DR 26 (80 psi)	LF	1,955	$12.40	$24,000
HDPE Pipe 16" DR 32.5 (63 psi)	LF	8,540	$10.00	$85,000
HDPE Pipe 18" DR 17 (125 psi)	LF	1,214	$23.80	$29,000
HDPE Pipe 18" DR 21 (100 psi)	LF	792	$19.50	$15,000
HDPE Pipe 18" DR 26 (80 psi)	LF	1,426	$15.90	$23,000
HDPE Pipe 18" DR 32.5 (63 psi)	LF	1,646	$12.80	$21,000
HDPE Pipe 20" DR 32.5 (63 psi)	LF	9,625	$15.80	$152,000
HDPE Pipe 22" DR 32.5 (63 psi)	LF	2,697	$19.20	$52,000
HDPE Pipe 24" DR 21 (100 psi)	LF	1,849	$34.10	$63,000
HDPE Pipe 24" DR 26 (80 psi)	LF	1,214	$27.80	$34,000
HDPE Pipe 28" DR 32.5 (63 psi)	LF	3,803	$31.00	$118,000
HDPE Pipe 30" DR 32.5 (63 psi)	LF	6,800	$35.70	$243,000
HDPE Pipe 32" DR 32.5 (63 psi)	LF	2,641	$40.50	$107,000
HDPE Pipe 34" DR 32.5 (63 psi)	LF	6,394	$45.70	$292,000
HDPE Pipe 36" DR 32.5 (63 psi)	LF	3,855	$51.40	$198,000
HDPE Pipe 42" DR 32.5 (63 psi)	LF	9,445	$70.00	$661,000
Install HDPE Pipe 8" DR 17 (125 psi)	LF	1,130	$10.00	$11,000
Install HDPE Pipe 8" DR 21 (100 psi)	LF	2,030	$10.00	$20,000
Install HDPE Pipe 8" DR 26 (80 psi)	LF	474	$10.00	$5,000
Install HDPE Pipe 10" DR 26 (80 psi)	LF	2,060	$10.00	$21,000
Install HDPE Pipe 10" DR 32.5 (63 psi)	LF	8,033	$10.00	$80,000
Install HDPE Pipe 12" DR 32.5 (63 psi)	LF	1,670	$10.00	$17,000
Install HDPE Pipe 16" DR 26 (80 psi)	LF	1,955	$12.00	$23,000
Install HDPE Pipe 16" DR 32.5 (63 psi)	LF	8,540	$12.00	$102,000
Install HDPE Pipe 18" DR 17 (125 psi)	LF	1,214	$13.00	$16,000
Install HDPE Pipe 18" DR 21 (100 psi)	LF	792	$13.00	$10,000
Install HDPE Pipe 18" DR 26 (80 psi)	LF	1,426	$13.00	$19,000
Install HDPE Pipe 18" DR 32.5 (63 psi)	LF	1,646	$13.00	$21,000
Install HDPE Pipe 20" DR 32.5 (63 psi)	LF	9,625	$14.00	$135,000

Item Description	Unit	Quantity	Unit Price	Price[1]
Install HDPE Pipe 22" DR 32.5 (63 psi)	LF	2,697	$14.00	$38,000
Install HDPE Pipe 24" DR 21 (100 psi)	LF	1,849	$15.00	$28,000
Install HDPE Pipe 24" DR 26 (80 psi)	LF	1,214	$15.00	$18,000
Install HDPE Pipe 28" DR 32.5 (63 psi)	LF	3,803	$17.00	$65,000
Install HDPE Pipe 30" DR 32.5 (63 psi)	LF	6,800	$18.00	$122,000
Install HDPE Pipe 32" DR 32.5 (63 psi)	LF	2,641	$19.00	$50,000
Install HDPE Pipe 34" DR 32.5 (63 psi)	LF	6,394	$20.00	$128,000
Install HDPE Pipe 36" DR 32.5 (63 psi)	LF	3,855	$21.00	$81,000
Install HDPE Pipe 42" DR 32.5 (63 psi)	LF	9,445	$22.00	$208,000
I-Canal North PRV Station #1	LS	1	$34,000	$34,000
Bluebell PRV Station #1	LS	1	$104,000	$104,000
Bluebell PRV Station #2	LS	1	$39,000	$39,000
I-Canal South PRV Station #2	LS	1	$78,000	$78,000
			Construction Subtotal	**$3,667,000**
Mobilization	LS	1	$367,000	$367,000
Appurtenances (Air Release Valves, Valves, Drains, etc.)	LS	1	$367,000	$367,000
Construction Staking	LS	1	$7,000	$7,000
Resource mitigation ($36,000 ULT/$15,000 cultural)	LS	1	$51,000	$51,000
Contingency (9.6% of Construction Subtotal)	LS	1	$351,000	$351,000
			TOTAL PROBABLE CONSTRUCTION COST	**$4,810,000**

1 – Rounded to the nearest thousand

Table 7-8. Site 4 Installation Cost

Item	Cost
Construction	$4,810,000
Design Engineering (assumed 10% of construction cost)[1]	$481,000
Construction Engineering (assumed 10% of construction cost)[1]	$481,000
Permitting	$25,000
Real Property Rights (assumed $560/acre for 85.4 acres of land)	$48,000
Natural Resource Rights	$0
Water Rights	$0
Relocation Payments	$0
Administrative (NRCS – assumed approximately 1% of construction)	$48,000
Administrative (Sponsors – assumed approximately 1% of construction)	$48,000
Total Installation Cost	**$5,941,000.00**

1 – Rounded to the nearest thousand

7.2.5 Site 5 (Dry Gulch Class C Canal System)

Table 7-9. Site 5 Detailed Construction Cost Estimate

Item Description	Unit	Quantity	Unit Price	Price[1]
HDPE Pipe 8" DR 21 (100psi)	LF	1,404	$4.50	$6,000
HDPE Pipe 10" DR 32.5 (63) psi	LF	1,200	$4.60	$6,000
HDPE Pipe 12" DR 26 (80) psi	LF	1,971	$7.80	$15,000
HDPE Pipe 16" DR 32.5 (63) psi	LF	200	$10.00	$2,000
HDPE Pipe 72" DR 32.5 (63) psi	LF	28,517	$282.66	$8,061,000
Install HDPE Pipe 8" DR 21 (100) psi	LF	1,404	$10.00	$14,000
Install HDPE Pipe 10" DR 21 (63) psi	LF	1,200	$10.00	$12,000
Install HDPE Pipe 12" DR 21 (80) psi	LF	1,971	$10.00	$20,000
Install HDPE Pipe 16" DR 21 (63) psi	LF	200	$12.00	$2,000
Install HDPE Pipe 72" DR 21 (63) psi	LF	28,517	$55.00	$1,568,000
PRV Station #1 (184+80, Seven 14-in PRV's, mechanical parts, vault/Station Building, installation)	LS	1	$ 494,000	$494,000
PRV Station #2 (285+12, End, seven 14-in PRV's, mechanical parts, vault/Station Building, installation)	LS	1	$ 494,000	$494,000
			Construction Subtotal	**$10,694,000**
Mobilization	LS	1	$535,000	$535,000
Appurtenances (Air Release Valves, Drains, etc.)	LS	1	$962,000	$962,000
Construction Staking	LS	1	$91,000	$91,000
Resource mitigation (cultural)	LS	1	$17,000	$17,000
Contingency (5% of Construction Subtotal)	LS	1	$535,000	$535,000
			TOTAL PROBABLE CONSTRUCTION COST	**$12,834,000**

1 – Rounded to the nearest thousand

Table 7-10. Site 5 Installation Cost

Item	Cost
Construction	$12,834,000
Design Engineering (assumed 10% of construction cost)	$1,283,000
Construction Engineering (assumed 10% of construction cost)	$1,283,000
Permitting	$8,000
Real Property Rights (assumed $560/acre for 6.34 acres of land)	$4,000
Natural Resource Rights	$0
Water Rights	$0
Relocation Payments	$0
Administrative (NRCS – assumed 1.48% of construction)	$190,500
Administrative (Sponsors – assumed 1.48% of construction)	$190,500
Total Installation Cost	**$15,793,000**

1 – Rounded to the nearest thousand

7.2.6 Site 6 (Red Cap Extension Canals/Laterals)

Table 7-11. Site 6 Detailed Construction Cost Estimate

Item Description	Unit	Quantity	Unit Price	Price[1]
Rock Excavation	LF	30,000	$12.00	$360,000
Imported Pipe Bedding	LF	30,000	$10.00	$300,000
HDPE Pipe 8" DR 26 (80 psi)	LF	3,122	$3.60	$11,000
HDPE Pipe 8" DR 32.5 (63 psi)	LF	4,777	$2.90	$14,000
HDPE Pipe 12" DR 26 (80 psi)	LF	3,550	$7.80	$28,000
HDPE Pipe 12" DR 32.5 (63 psi)	LF	1,273	$6.30	$8,000
HDPE Pipe 16" DR 26 (80 psi)	LF	2,452	$12.40	$30,000
HDPE Pipe 16" DR 32.5 (63 psi)	LF	4,382	$10.00	$44,000
HDPE Pipe 18" DR 26 (80 psi)	LF	758	$15.90	$12,000
HDPE Pipe 20" DR 26 (80 psi)	LF	3,924	$19.60	$77,000
HDPE Pipe 20" DR 32.5 (63 psi)	LF	20,796	$15.80	$329,000
HDPE Pipe 24" DR 26 (80 psi)	LF	2,890	$27.80	$80,000
HDPE Pipe 24" DR 32.5 (63 psi)	LF	29,839	$22.40	$668,000
HDPE Pipe 26" DR 32.5 (63 psi)	LF	1,929	$26.70	$52,000
HDPE Pipe 28" DR 32.5 (63 psi)	LF	4,523	$31.00	$140,000
HDPE Pipe 36" DR 32.5 (63 psi)	LF	6,507	$51.40	$334,000
HDPE Pipe 42" DR 32.5 (63 psi)	LF	6,345	$70.00	$444,000
HDPE Pipe 48" DR 32.5 (63 psi)	LF	9,094	$91.20	$829,000
Install HDPE Pipe 8" DR 26 (80 psi)	LF	3,122	$10.00	$31,000
Install HDPE Pipe 8" DR 32.5 (63 psi)	LF	4,777	$10.00	$48,000
Install HDPE Pipe 12" DR 26 (80 psi)	LF	3,550	$10.00	$36,000
Install HDPE Pipe 12" DR 32.5 (63 psi)	LF	1,273	$10.00	$13,000
Install HDPE Pipe 16" DR 26 (80 psi)	LF	2,452	$12.00	$29,000

Item Description	Unit	Quantity	Unit Price	Price[1]
Install HDPE Pipe 16" DR 32.5 (63 psi)	LF	4,382	$12.00	$53,000
Install HDPE Pipe 18" DR 26 (80 psi)	LF	758	$13.00	$10,000
Install HDPE Pipe 20" DR 26 (80 psi)	LF	3,924	$14.00	$55,000
Install HDPE Pipe 20" DR 32.5 (63 psi)	LF	20,796	$14.00	$291,000
Install HDPE Pipe 24" DR 26 (80 psi)	LF	2,890	$15.00	$43,000
Install HDPE Pipe 24" DR 32.5 (63 psi)	LF	29,839	$15.00	$448,000
Install HDPE Pipe 26" DR 32.5 (63 psi)	LF	1,929	$16.00	$31,000
Install HDPE Pipe 28" DR 32.5 (63 psi)	LF	4,523	$17.00	$77,000
Install HDPE Pipe 36" DR 32.5 (63 psi)	LF	6,507	$21.00	$137,000
Install HDPE Pipe 42" DR 32.5 (63 psi)	LF	6,345	$22.00	$140,000
Install HDPE Pipe 48" DR 32.5 (63 psi)	LF	9,094	$25.00	$227,000
Pipe Inlet Screen Structure	LS	1	$275,000	$275,000
Mainline Meters	EACH	2	$20,000	$40,000
Turnouts	EACH	70	$8,000	$560,000
			Construction Subtotal	**$6,304,000**
Mobilization	LS	1	$315,000	$315,000
Appurtenances (Air Release Valves, Drains, etc.)	LS	1	$441,000	$441,000
Construction Staking	LS	1	$36,000	$36,000
Traffic Control	LS	1	$63,000	$63,000
Resource mitigation ($3,000 ULT / $32,000 cultural)	LS	1	$35,000	$35,000
Contingency (5% of Construction Subtotal)	LS	1	$312,000	$312,000
			TOTAL PROBABLE CONSTRUCTION COST	**$7,506,000**

1 – Rounded to the nearest thousand

Table 7-12. Site 6 Installation Cost

Item	Cost
Construction	$7,506,000
Design Engineering (assumed 10% of construction cost)[1]	$751,000
Construction Engineering (assumed 10% of construction cost)[1]	$751,000
Permitting	$25,000
Real Property Rights (assumed $560/acre for 66.47 acres)	$37,000
Natural Resource Rights	$0
Water Rights	$0
Relocation Payments	$0
Administrative (NRCS – assumed 1.25% of construction)	$94,000
Administrative (Sponsors – assumed 1.25% of construction)	$94,000
Total Installation Cost	**$9,258,000**

1 – Rounded to the nearest thousand

7.2.7 Site 7 (Gray Mountain Canal)

Table 7-13. Site 7 Detailed Construction Cost Estimate

Item Description	Unit	Quantity	Unit Price	Price[1]
Clearing and Grubbing	LF	10,620	$3.50	$37,000
Canal Excavation and Preparation	CY	14,868	$30.00	$446,000
Rock Base Aggregate	TON	5,576	$30.00	$167,000
Geocomposite Liner	SY	35,396	$12.00	$425,000
Concrete	CY	3,929	$370	$1,454,000
Turnouts	EA	8	$8,500	$68,000
Bridge/Road Crossing	EA	3	$69,000	$207,000
Access Road	LF	10,620	$12.00	$127,000
Construction Subtotal				**$2,931,000**
Mobilization	LS	1	$293,000.00	$293,000
Construction Staking	LS	1	$26,000.00	$26,000
Resource Mitigation (cultural)	LS	1	$4,000.00	$4,000
Contingency (10% of Construction Subtotal)	LS	1	$293,000.00	$293,000
TOTAL PROBABLE CONSTRUCTION COST				**$3,547,000**

1 – Rounded to the nearest thousand

Table 7-14. Site 7 Installation Cost

Item	Cost
Construction	$3,547,000
Design Engineering (assumed 10% of construction cost)[1]	$355,000
Construction Engineering (assumed 10% of construction cost)[1]	$355,000
Permitting	$5,000
Real Property Rights	$0
Natural Resource Rights	$0
Water Rights	$0
Relocation Payments	$0
Administrative (NRCS – assumed 1.5% of construction)	$53,500
Administrative (Sponsors – assumed 1.5% of construction)	$53,500
Total Installation Cost	**$4,369,000**

1 – Rounded to the nearest thousand

D.8. Biology

Biological surveys for the project include two surveys for Endangered Species Act (ESA) Ute ladies'-tresses (ULT;*Spiranthes diluvialis*), which are listed as threatened. Field surveys were conducted between August 24 through August 30, 2020, and August 2 through August 27, 2021, by Todd Sherman with Wetland Resources, who is a Senior Professional Wetland Scientist. Survey reports were prepared that documented the survey results (Wetland Resources 2020 and 2021). Surveys were conducted in accordance with the U.S. Fish and Wildlife Service (USFWS) protocol (USFWS 1992, 2007, and 2011) and supplemental publication and studies (Arft 1995 and Fertig 2005). Known sites containing ULTs were visited to confirm that ULTs were in bloom during the surveys. The survey area for the seven sites included a 300-foot buffer around each site. Please refer to the *Spiranthes diluvialis* survey reports included in Appendix E of the Plan-EA for further information on survey methods used. Note that the survey report included in Appendix E does not contain maps or photographs to protect the sensitive locations of identified ULT. Results of the survey are incorporated into the Plan-EA.

D.9. Waters and Wetlands

National Wetlands Inventory (NWI) data and the National Hydrography Dataset [NHD] USGS 2022) and the NWI (USFWS 2022) were used to depict and calculate waters and wetlands within the Project area. A base SHP file of NWI data for freshwater wetlands and ponds was included and minor modifications made within the project area to remove NWI wetland areas within areas of known development involving road fill corridors and other filled areas. A base NHD dataset SHP file was used for stream/canal features and corrected where necessary to follow the centerline of the flowing water course observed on aerial imagery.

D.10. Vegetation, Noxious Weeds, and Invasive Plants

Vegetation cover for the Project area was meshed from NWI data (USFWS 2022), land cover data (Multi-Resolution Land Characteristics Consortium [MRLC] 2019), and Gap Analysis Project (GAP) data (USGS 2011). A base SHP file of MRLC data was used and areas of NWI freshwater wetlands and ponds subtracted from the MRLC data set. Because MRLC land cover does not include mapped riparian vegetation, the GAP data was used to determine the extents of mapped riparian vegetation. The GAP riparian vegetated areas were determined then subtracted from the MRLC data. Total area calculations added the remaining land cover for MRLC data, wetland and pond data from NWI, and riparian areas from the GAP to calculate the total vegetative cover types within the Project area.

Dominant vegetation types and noxious/invasive plants were observed at each of the seven Sites by biologist Greg Allington and resource specialist Bobbi Preite to support reporting in the Plan-EA. Site visits were performed on July 19, 2022, and July 20, 2022.

D.11. Geographical Information System Data Calculations

Project maps were produced using QGIS version 3.16. All data sets used a projected coordinate system of NAD 1983 State Plane Central Utah in U.S. feet (FIPS 4302). Measurements were performed using planimetric methods.

D.12. Cultural

Class III cultural surveys were conducted and Culture Resource Survey Reports were prepared by Montgomery Archaeological Consultants, Inc. (MOAC). The first report was completed in 2021 (MOAC 2021) for an area covering 666.3 acres of land. A file search was conducted using the SEGO database on February 26, 2021, to identify inventories within ½-mile of the project area. A literature review and record search were also conducted to identify previously recorded sites within the same search radius. Cadastral plats, historic aerial photographs, historic maps, and other historic resources were also reviewed. The field work was performed between April 19 through 23 and April 28 through May 1, 2021 by Principal Investigator, Jody Patterson and Field Supervisor, Jessica Del Bozque. An intensive Class III pedestrian survey included walking parallel transects spaced no more than 15 meters apart on 450.3 acres of the 666.3-acre inventory area. Approximately 216 acres within the survey area was previously inventoried within the last 10 years.

The second report was completed in 2023 (MOAC 2023) for an area covering 27.9 acres. The additional area covered was to include new land within the Project area that had not been previously included in the original report. A file search was conducted using the SEGO database on October 3, 2022, to identify inventories within ½-mile of the project area. A literature review and record search were also conducted to identify previously recorded sites within the same search radius. Cadastral plats, historic aerial photographs, historic maps, and other historic resources were also reviewed. The field work was performed on October 6 and 7, 2022 by Principal Investigator, Jody Patterson and Field Supervisor, Jessica Del Bozque. An intensive Class III pedestrian survey included walking parallel transects spaced no more than 15 meters apart on 27.9 acres.

A copy of the reports could not be included in Appendix E due to sensitive location information for historical resources. However, results of the survey are incorporated into the Plan-EA.

D.13. Water Budget and Depletion Analysis

A water budget was developed by JDE and is included in Appendix E of the Plan-EA (JDE 2024). It was developed to determine the difference in consumptive water use between the No Action Alternative and the Action Alternative for documenting accretion and depletion. Consumptive use changes considered phreatophyte water consumption savings and additional consumption from an extended irrigation season and additional irrigated lands. Phreatophyte consumption of 60% of seepage losses was used for calculations and was based on other NRCS Projects in the Uintah Basin. Refer to Section D14.2 for calculated canal seepage water losses. The difference in consumptive use was calculated for each Site for improvement. Implementation of the Project was found to result in a net accretion of 5,725 ac-ft of water. The results presented in the JDE Memo were based on JDE spreadsheet calculations as presented in Table 13-1.

Table 13-1. Project Change in Consumptive Use

Item	Accretion / (Depletion) ac-ft
Current Phreatophyte Consumptive Use Eliminated by Project Measures	27,714
Projected Crop Consumptive Use for Extended Sprinkler Irrigation Season	(6,680)
Projected Crop Consumptive Use for Extended Flood Irrigation Season	(6,867)
Projected Crop Consumptive Use for Additional Irrigated Acreage	(5,443)
Total Consumptive Use Change	5,724

D.14. Stream Flow Assessment

D.14.1. Depletion and Accretion

Depletion and accretion amounts determined from the water budget and depletion analysis (see Section D.13), were compared by JDE to current annual stream flow volumes to determine the net percent change in annual stream flow. This was calculated by first determining the annual change in consumptive use at each Site for improvement, as depicted in Table 14-1. These values were added to determine the net annual change in consumptive use per stream reach, as appropriate. Annual stream flow data was collected from water commissioner reports (Carter 2022 and Swasey 2023) and stream gage data (USGS 2024), and compared to the annual change in consumptive use per reach to arrive at a percent annual flow volume change (see Table 14-2).

Table 14-1. Project Change in Consumptive Use Per Site

Site	Sprinkler Irrigation (acres)	Flood Irrigation (acres)	Additional Irrigated Acres	Total Increased Irrigation Consumptive Use (ac-ft)	Total Decrease in Phreatophyte Consumptive Use (ac-ft)	Total Change in Consumptive Use (ac-ft)
Site 1	3,526	4,803	0	8,329	1,115	(7,214)
Site 2	953	1,074	0	2,027	182	(1,845)
Site 3	277	147	0	424	487	63
Site 4	1,924	843	0	2,767	11,591	8,824
Site 5	0	0	0	0	2,797	2,797
Site 6	0	0	5,443	5,443	2,870	(2,573)
Site 7	0	0	0	0	5,672	5,672
Total	**6,680**	**6,867**	**5,443**	**18,990**	**24,714**	**5,724**

Table 14-2. Project Change in Annual Stream Flow Volume

Stream	Stream Reach	Net Change in Consumptive Use	Total Annual Stream Flow Volume	% Change
Lake Fork River	Yellowstone Feeder Canal Intake to Class B Canal Intake	(9,059)	1,015,805	(0.90%)
Lake Fork River	Class B Canal Intake to Class C Canal Intake	(235)	1,015,805	(0.02%)
Lake Fork River	Class C Canal Intake to South Boneta Canal Intake	2,562	1,015,805	0.25%
Lake Fork River	South Boneta Canal Intake to Duchesne River	2,625	1,015,805	0.26%
Duchesne River	Duchesne Feeder Canal Intake to Gray Mountain Canal Intake	(2,573)	1,015,805	0.25%
Duchesne River	Gray Mountain Canal Intake to Lake Fork River Confluence	3,099	1,015,805	0.30%
Duchesne River	Downstream of the Lake Fork Confluence	5,724	1,015,805	0.56%

The analysis shows that the net percent annual change in flow volume is negligible at a fraction of a percent. Therefore, JDE determined that the change in consumptive use would have a negligible change to flows in Lake Fork or Duchesne River. However, stream flow should consider other water savings as described in Section D.14.2.

D.14.2. Water Savings and Conveyance Efficiency

For this Project JDE considered canal metering and canal seepage as contributors to increased stream flow. The JDE Water Budget and Depletion Memo (JDE 2024 – Attached in Appendix E of the Plan-EA) identifies reduced consumptive use from implementation of water metering. The Weber Basin Water Conservancy District documented reduced residential irrigation consumptive use between 20 to 29% after metering was installed in the system. The Memo notes that metering and improved leak detection and repair is anticipated to further conserve water at Site 4 Dry Gulch Class B Canal System and Site 6 Red Cap Extension Canals/Laterals.

Converting open channel canals to pipelines with minimal to no leakage will nearly eliminate transmission losses (JDE 2024). An estimate of pre and post Project canal seepage was compared to quantify how much additional water may remain in the natural stream channel instead of being diverted and seeping onto the shallow groundwater system. Table 14-3 provides the existing and the proposed canal seepage estimates. The total seepage is broken out for seepage contributed to phreatophyte consumptive use and the seepage that infiltrates into the ground to contribute to the shallow groundwater aquifer. Table 14-4 provides the estimated seepage reduction.

Table 14-3. Existing and Proposed Annual Seepage

Site No.	Existing Canal Seepage (ac-ft)			Action Alternative Canal Seepage (ac-ft)		
	Phreatophyte Consumption	To Shallow Groundwater	Total	Phreatophyte Consumption	To Shallow Groundwater	Total
Site 1	1,776	1,184	2,960	661.2	441	1,102
Site 2	354.6	236	591	172.8	115	288
Site 3	487.2	325	812	0	0	0
Site 4	12,103.2	8,069	20,172	512.4	342	854
Site 5	2,797.2	1,865	4,662	0	0	0
Site 6	2,870.4	1,914	4,784	0	0	0
Site 7	7,632.6	5,088	12,721	1,960.8	1,307	3,268
Total	**28,021**	**18,681**	**46,702**	**3,307**	**2,205**	**5,512**

Table 14-4. Project Annual Seepage Reduction

Site Name	Phreatophyte Seepage Reduction	Canal to Groundwater Seepage Reduction	Total Seepage Reduction from Action Alternative
Site 1 Yellowstone Feeder Canal	1,115	743	1,858
Site 2 Coyote Canal	182	121	303
Site 3 South Boneta Canal	487	325	812
Site 4 Class B Canal System	11,591	7,727	19,318
Site 5 Class C Canal System	2,797	1,865	4,662
Site 6 Red Cap Extension Canals/Laterals	2,870	1,914	4,784
Site 7 Gray Mountain Canal	5,672	3,781	9,453
Total	**24,714**	**16,476**	**41,190**

The total reduction in seepage was calculated by JDE at 41,190 ac-ft annually. The phreatophyte consumptive use is removed from the water savings streamflow assessment as it is addressed in Section D14.1 for depletion and accretion. Irrigation diversion for the improved systems would be reduced from canal to groundwater seepage reduction resulting in more water left in the natural stream systems. Approximately 16,476 ac-ft or 1.6% of the total annual streamflow volume from Table 14-2, could remain in the natural system.

The combined metering and reduced canal seepage is anticipated to increase flows in the natural stream systems. Quantifying these increases during the planning stage is not reasonable based on the unknown variables related to the hydraulic conditions of shallow groundwater aquifer flow and variability in water conservation percentages of metering. Post Project flows will be monitored to track diverted irrigation flows and will be reported on the Duchesne Rivers and Tributaries of Utah website (http://www.duchesneriver.org/).

D.15. Decision-Making Process

The decision-making process for this Project followed the Principles, Requirements, and Guidelines for Federal Investments in Water Resources (PR&G) (Council of Environmental Quality [CEQ] 2013 and 2014), and the National Planning Procedures Handbook (NRCS 2021). The PR&G followed an eight-step evaluation process and NRCS planning followed a nine-step process. The PR&G eight-step planning process completed for the Project is documented in the PR&G Analysis Memorandum included in Appendix E of the Plan-EA. A summary of the NRCS nine-step planning process completed for the Project is provided in Section 1.1.1 of the Plan-EA.

D.16. PR&G Evaluation and Preliminary Economic Analysis

The PR&G evaluation process includes guiding principles to assist in decision making and weighing tradeoffs of Project alternatives, and the use of an ecosystem services framework to describe the comprehensive set of benefits that people receive from nature characterized as ecological goods and services provided by a healthy, functioning environment. The PR&G analysis for the Project is documented in the PR&G Analysis Memorandum included in Appendix E of the Plan-EA.

The National Watershed Program Manual (NRCS 2015b) was used as a reference for preliminary economic analysis, along with PR&G (CEQ 2013 and 2014), and the NRCS Decision Memorandum for PR&G (NRCS 2018). The preliminary economic analysis was completed by Long Watershed Planning Economics, LLC. Seven project areas, or sites were analyzed in the evaluation. The analysis included the Future with Federal Investment (FWFI) alternatives and the Future Without Federal Investment (FWOFI) alternative or the No Action Alternative. The analysis supported the decision-making process for selection of the preferred alternative and National Economic Efficiency (NEE) Alternative for the Project.

D.17. Economic Analysis for Preferred Alternative

A revised economic analysis for the preferred alternative was conducted by AECOM following the guidance in the Principles, Requirements, and Guidelines for Federal Investment in Water Resources (CEQ 2013 and 2014). The benefit categories evaluated were: (1) agricultural benefits; (2) water quality benefits; and (3) sediment reduction.

This section describes the methods used by AECOM to quantify benefits and costs of the alternatives being evaluated as part of the Project. The purpose of the Project is to provide agricultural water management improvements for irrigation, water delivery efficiency, and water conservation in the existing irrigation systems of the Eastern Duchesne Watershed. Under existing conditions, there is a need to reduce water loss, improve system reliability and safety, provide pressurized irrigation capabilities, improve water quality, and reduce problematic and costly operations and maintenance issues in the current system.

The preferred alternative for the Project is the Action Alternative which was also determined to be the National Environmental Efficiency Alternative and includes seven sites of proposed improvements. Proposed modifications would include lining segments of the Yellowstone Feeder and Gray Mountain Canals, and installation of pipeline replacing open canal systems at South Boneta Canal, Dry Gulch Class B and Class C Canal Systems, and Red Cap Extension Canals/Laterals. The preferred alternative was determined to be the least cost alternative that successfully meets the goals for the agricultural water management project purpose. Table 17-1 describes the seven sites and proposed work at each under the Action Alternative.

Table 17-1. Description of Project Components

Project Component	Description
Site 1: Yellowstone Feeder Canal	Line ten sections of the Yellowstone Feeder Canal with concrete, totaling approximately 13,926 linear feet.
Site 2: Coyote Canal	Pipe approximately 4,413 linear feet of open canal and armor 477 linear feet of canal.
Site 3: South Boneta Canal	Pipe approximately 12,883 linear feet of open canal.
Site 4: Dry Gulch Class B Canal System	Pipe sections of the existing open canal system, installing approximately 79,293 linear feet of pipe.
Site 5: Dry Gulch Class C Canal System	Pipe sections of the existing open canal system, installing approximately 33,292 linear feet of pipe.
Site 6: Red Cap Extension Canals/Laterals	Convert and open canal system into a pressurized irrigation system, installing approximately 106,161 linear feet of pipe.
Site 7: Gray Mountain Canal	Line three sections of the Gray Mountain Canal with concrete, totaling approximately 10,475 linear feet.

Economic feasibility for a project alternative is determined by comparing the average annual benefits to the average annual costs. If the average annual benefits for a project alternative exceed the average annual costs, then the project alternative is considered economically feasible. The economic analysis considers the No Action Alternative (hereafter Future Without Federal Investment [FWOFI]) as the baseline condition, which does not have any benefits associated with it, but does have maintenance costs. Changes resulting from implementation of a Future With Federal Investment (FWFI) alternative (i.e., the Project) in relation to the FWOFI would be measured as a cost or a benefit.

Because benefits are calculated based on the changes between the FWOFI and the FWFI(s), it is important to understand the FWOFI. Altogether, the FWFI alternative would increase the quality, quantity, and reliability of water that is available within the watershed. Benefits result from an increase in agricultural production due to an increase in overall water supply, a decrease in water salinity, and a decrease in canal maintenance costs. The benefit categories are evaluated in average annual terms. Benefits and costs over the period of analysis are annualized to allow for a direct comparison of average annual benefits to average annual costs. The benefits and costs were evaluated over the 1-, 2-, or 3-year installation period and 50-year evaluation period (project life). While the period of analysis for the Project components varied from 51 years to 53 years, the costs and benefits were annualized over the 50-year period of evaluation using a 2.75% discount rate.

D.17.1. Benefit Analysis

The analyses of benefits associated with all Project components include damages or costs incurred for a range of benefit categories. The benefits evaluated include agricultural production, salinity reduction, reduced sedimentation, and decreased O&M costs. Table 17-2 identified the primary benefit evaluated for each project site.

Table 17-2. Benefit Categories Evaluated for Each Project Component

Project Component	Agricultural Production	Canal Failure	Salinity Damage	Sediment Damage	Reduced O&M
Site 1: Yellowstone Feeder Canal	X		X		X
Site 2: Coyote Canal	X		X	X	X
Site 3: South Boneta Canal	X		X		X
Site 4: Dry Gulch Class B Canal System	X		X		X
Site 5: Dry Gulch Class C Canal System	X	X	X		X
Site 6: Red Cap Extension Canals/Laterals	X	X	X		X
Site 7: Gray Mountain Canal	X		X		X

Below is a brief description of the benefit categories that were evaluated:

- **Agricultural Production** – the canal improvement and piping measures would reduce seepage from the irrigation system, allowing additional water for irrigation and crop production.
- **Canal Failure** – the measures would stabilize some of the irrigation canals that are at risk of failure, which would result in the loss of all irrigation water to a project area and significantly reduce agricultural production.
- **Salinity Damage** – the Project measures would reduce water seepage that leads to salt and selenium build-up and leaching into the larger water system, which causes damage to downstream users.
- **Sediment Damage** – Project measures would reduce erosion along one of the irrigation canals, which has led to increased sedimentation in a downstream reservoir (Brown's Draw Reservoir).
- **Reduced O&M** – the Project measures would reduce annual O&M cost of the canals, leading to lower expenses associated with providing irrigation water. While reduced O&M is a benefit, the impacts are evaluated in the Section D.17.2.

17.1.1 Agricultural Production

The Project provides long-term benefits for water and agriculture in the Eastern Duchesne Watershed. It conserves agricultural water by reducing water lost to canal seepage.

The Project would increase crop productivity on approximately 24,000 acres of agricultural land. Costly and problematic O&M issues for the irrigation systems would also be alleviated. The Project would increase the quality, quantity, and reliability of water available for irrigation in the area, resulting in a longer growing season. The more reliable water would also allow farmers to switch from hay grass to alfalfa. The analysis completed to estimate the impact to agricultural production are provided below.

17.1.1.1 Water Quantity

The Project will reduce a significant amount of water lost to canal seepage, thereby extending the growing season and allowing for a third-cutting of alfalfa. The existing seepage, proposed seepage, and saved irrigation water by acre-feet (ac-ft) for each Project component is presented in Table 17-3.

Table 17-3. Irrigation Seepage for FWOFI and Project

Project Component	Annual Amounts (ac-ft)		
	Seepage - FWOFI	Seepage - Project	Reduction in Seepage
Site 1: Yellowstone Feeder Canal	2,960	1,102	1,858
Site 2: Coyote Canal	591	288	303
Site 3: South Boneta Canal	812	0	812
Site 4: Dry Gulch Class B Canal System	20,172	854	19,318
Site 5: Dry Gulch Class C Canal System	4,662	0	4,662
Site 6: Red Cap Extension Canals/Laterals	4,784	0	4,784
Site7: Gray Mountain Canal	12,721	3,268	9,453
Total	46,702	5,512	41,190

Source: JDE

17.1.1.2 Agricultural Yield

The seven Project components predominantly grow alfalfa and grass hay with a variation of irrigation methods and dry cropping. Table 17-4 presents the existing acres, crop types, and irrigation methods by Project component.

Table 17-4. FWOFI Irrigated Acres and Crop Types

Project Component	Flood	Sprinkler	Dry Crop	Sub-irrigated	Total	Crop Types
Site 1: Yellowstone Feeder Canal	22,425	12,088	999	1,204	36,716	Alfalfa, grass hay, stock production, various grains
Site 2: Coyote Canal	5,015	3,268	310	278	8,871	Grass/pasture and other hay crops
Site 3: South Boneta	688	949	38	18	1,693	Grass/pasture and other hay crops
Site 4: Dry Gulch Class B Canal System	3,935	6,597	97	41	10,670	Grass/pasture, alfalfa, other hay crops
Site 5: Dry Gulch Class C Canal System	3,266	8,425	259	237	12,187	Grass/pasture, alfalfa, other hay crops
Site 6: Red Cap Extension Canals/Laterals	1,804	1,160	51	20	3,035	Grass/pasture, alfalfa, other hay crops
Site 7: Gray Mountain Canal	1,834	10,941	456	925	14,156	Grass/pasture, alfalfa, grass other hay crops
Total	38,967	43,428	2,210	2,723	87,328	

Source: JDE

Alfalfa is planted in April and farmers in Duchesne County typically get two cuttings per year because of limited water. The additional water provided through the reduction in seepage will be stored in existing reservoirs. Canal lining would increase water availability and reliability, allowing farmers in Project service areas to support a third cutting of alfalfa annually.

The existing distribution of irrigation methods are not expected to change with the Project, rather the growing season will be extended with the additional water and produce a third cutting of alfalfa. It is estimated that 2.0 ac-ft of water is required to produce 1 ton of alfalfa (Sall et. al 2023). The data from the National Agricultural Statistics Center (NASS) was used to estimate the average alfalfa and hay yield over the last six years for Utah (USDA 2024), which is presented in Table 17-5.

Table 17-5. Utah Alfalfa and Hay Yield (tons per acre)

Year	Hay (not alfalfa)	Alfalfa
2018	2.3	3.7
2019	2.5	4.3
2020	2.5	3.8
2021	2.2	3.7
2022	3.3	4.1
2023	3.1	4.0
Average	**2.7**	**3.9**

Source: USDA 2024

The average yield of 3.9 tons per acre for alfalfa closely matched an analysis by Keith (2009) for the first and second cutting of 4.0 tons per acre (Table 17-6). Keith also provided a yield for a third cutting of alfalfa of 1.25 tons per acre.

Table 17-6. Alfalfa Yield by Cutting (tons per acre)

Cutting	Month	Yield (Tons/Acre)
1st Cutting	June	2.5
2nd Cutting	July	1.5
3rd Cutting	September	1.25

Source: Keith, 2009

Six-year average prices, updated to a 2024 price level, were used to value the additional harvest for alfalfa and hay. The prices per ton are shown in Table 17-7.

Table 17-7. Utah Alfalfa and Hay Prices per Ton

Year	Hay (not alfalfa)	Hay (not alfalfa) 2024$	Alfalfa	Alfalfa 2024$
2018	$133	$163	$172	$211
2019	$144	$173	$182	$219
2020	$122	$145	$187	$222
2021	$180	$207	$236	$271
2022	$247	$265	$297	$314
2023	$178	$183	$222	$228
Average		**$189**		**$244**

Source: USDA 2024

17.1.1.3 Operating Costs

The third cutting will not require more land and therefore additional operating costs, but would incur additional harvest and irrigation costs. Harvesting includes swathing, raking, baling, loading, and hauling. Table 7-8 provides the estimated cost per ton to hay or alfalfa, updated to a 2024 price level of $54.95.

Table 17-8. Alfalfa/Hay Harvest Costs

Expense	Cost per Ton (2017/2018)	Cost per Ton (2024$)
Swathing	$11.14	$13.66
Raking	$4.10	$5.03
Baling	$21.45	$26.30
Loading	$3.13	$3.84
Hauling	$5.00	$6.13
Total Cost per Ton	**$44.82**	**$54.95**

Source: 2018 Custom Rate Survey, Utah State University Agriculture Extension

17.1.1.4 Net Agricultural Production

To maximize returns, the economic analysis assumed that the irrigation water saved from reduction in seepage would be applied using existing irrigation equipment to fields already planted in alfalfa, and the water would only be applied to enough acres to obtain a third cutting. Therefore, only a portion of each Project service area would receive enough irrigation water for a third cutting.

The net agricultural production values (total production value minus operating costs) are shown in Table 17-9 for each of the Project components. The production value was estimated by dividing the water saved by 1.38 (The Salt Lake Tribune 2023) (the amount of water needed in ac-ft to produce one ton of alfalfa) to estimate the increased alfalfa production in tons, which was then multiplied by $244 per ton. This was considered to be a conservative calculation as some estimates for water requirements for alfalfa are much lower at 0.6 ac-ft (Utah State University Extension 2024). The production cost was estimated by multiplying the increased alfalfa production by $54.95 per ton. The net production value is the difference between the production value and production cost.

Table 17-9. Net Agricultural Production by Project Site

Project Components	Water Saved (ac-ft)	Increased Alfalfa (tons)	Land Impacted (acres)	Production Value	Production Cost	Net Production Value
Site 1 - Yellowstone Feeder Canal	1,860	1,350	1,080	$329,000	$74,000	$255,000
Site 2 - Coyote Canal	300	220	180	$54,000	$12,000	$42,000
Site 3 - South Boneta	810	590	470	$144,000	$32,000	$111,000
Site 4 - Dry Gulch Class B Canal System	19,320	14,000	11,200	$3,417,000	$769,000	$2,648,000
Site 5 - Dry Gulch Class C Canal System	4,660	3,380	2,700	$825,000	$186,000	$639,000
Site 6 - Red Cap Extension Canals/Laterals	4,780	3,470	2,770	$846,000	$191,000	$656,000
Site 7 - Gray Mountain Canal	9,450	6,850	5,480	$1,672,000	$376,000	$1,296,000

17.1.2 Canal Failure

The current canal infrastructure for both Site 5 – Dry Gulch Class C Canal System and Site 6 – Red Cap Extension Canals/Laterals are in imminent danger of failing. For Site 5, part of the canal system runs adjacent to a gully. Due to seepage over the years, the downward slope into the gully has eroded and is in danger of breaching the irrigation canal. If that occurs, any irrigation water in the canal would run into the gully and could not be used for irrigation. For Site 6, erosion has been undercutting the concrete drop structure, even extending to a point underneath the headgates that service the Midview drop and also the Red Cap Extension. When this fails, the steepness of the slope and the erodible material underneath will immediately start head cutting back up the canal, failing the entire structure and making a repair very difficult. In each case, the failure of the system would result in a total loss of irrigation water to the respective project service areas (see Table 17-4 for acres irrigated). It is estimated that both Site 5 and Site 6 will fail within 10 years.

For the canal failure analysis approach, it was assumed that under the FWOFI conditions that the canals would be allowed to fail and no preventive measure would be implemented. Following failure, the canals would not be rebuilt. This approach is consistent with guidance from the National Water Management Center on the definition of the No Action Alternative provided in Title 309 – National Instructions, Part 303 – Clarification and Instructions for the No Action Alternative in Supplemental Watershed Rehabilitation Plans (December 2022). While the guidance is directed toward dam rehabilitation studies, the concept of no intervention until failure is the same.

To estimate the impacts of a failure, it was assumed that following failure, the cropland would be converted to dry crop grasslands since other crops would be difficult to maintain without irrigation. Therefore, the crop production would decrease significantly following failure. The crop production for the conditions until failure were assumed to be the exiting production. For the economic analysis, it was assumed that the irrigated acres were a mix of alfalfa and other hay (not alfalfa), which is consistent with the overall crop distribution for Duchesne County being predominantly alfalfa and other hay. Detailed GIS analysis identified that for Site 5, all of the agricultural land was either hay (alfalfa or other) or pasture, while Site 6 showed that over 90 percent of the land was other field crops. For the economic analysis it was assumed that pastureland would have the same forage production as grass hay since the fields could be either grazed or harvested. Based on GIS analysis it was estimated that the mix of forage was 50 percent alfalfa and 50 percent other hay for Site 5, and 60 percent alfalfa and 40 percent hay for Site 6.

The production value for the two sites used the same assumptions provides in the previous section, with each acre able to produce 3.9 tons of alfalfa or 2.7 ton of hay (see Table 17-5). For dry crop hay, it was estimated that each acre would produce 1.4 tons (Utah State University Extension 2024). The same revenue and harvesting costs assumptions were used as Table 17-7 and Table 17-8, respectively. The net revenue per acre was estimated for both pre-fail and post-fail conditions.

Under the Project conditions, the canals would not fail and the project service area would be the same as described in the previous section, including the additional production from the reduction in seepage. The benefits for each year were estimated through the 50-year period of evaluation. Because the benefits were not consistent throughout the period of evaluation, the benefits for each year were discounted to a present value using a 2.75 percent discount rate. The present value was then amortized over the 50-year period of evaluation to estimate the equivalent average annual benefit for each site (Table 17-10).

Table 17-10. Avoided Canal Failure Benefits

Project Component	Net Production Benefits
Site 5 - Dry Gulch Class C Canal System	$3,927,000
Site 6 - Red Cap Extension Canals/Laterals	$3,119,000

17.1.3 Salinity

The Project area is part of the Upper Colorado River Basin, which encompasses about 112,000 square miles and discharges more than 6 million tons of dissolved solids (salt) annually to the lower Colorado River Basin. High salt concentrations (salinity) in the Colorado River are a concern because they result in substantial economic damages to water users, primarily in reduced agricultural crop yields and corrosion of water systems for irrigation and public supply. Therefore, reducing the amount of salt discharged can have benefits throughout the Colorado River Basin, which includes portions of seven states (Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming) and Mexico.

The Project components would reduce water leakage and the accompanying build-up of salt and selenium, which impacts the groundwater and discharge into local surface water systems. This water will not impact the agricultural fields within the Project area but will eventually reach the Colorado River and impact the environment and users downstream. To evaluate the economic impacts of salinity throughout the Colorado River Basin and the benefits of salinity reduction projects, the Bureau of Reclamation (Reclamation) developed the Salinity Economic Impact Model (SEIM). The SEIM takes into consideration impacts to seven economic sectors: residential; commercial; industrial; water utilities; groundwater; recycled water and publicly owned treatment works; and agriculture. The SEIM was developed in the early 2000s and is regularly updated. Reclamation works closely with the Colorado River Basin Salinity Control Forum when completing the updates.

The Colorado Salinity Control Forum used SEIM to estimate remaining damages following various salt reduction scenarios. Based on the results presented in a 2020 report (Colorado River Basin Salinity Control Forum 2020), an incremental analysis was used to estimate the economic impact (i.e., damages reduced) from a reduction in salt. The analysis estimated the economic impact of reducing salt as $275 per ton. The updated impact in 2024 dollars using the GDP deflator is $327 per ton. Further detail on this calculation can be found in the Value of Salinity Reduction Analysis included in Section D.17.4.

The estimated reduction in damages from salt and selenium was estimated for each Project component based on the annual tons of salt removed and the value of the damages per ton (Table 17-11).

Table 17-11. Value of Salt and Selenium Reduction

Project Component	Reduction in Salinity (tons)	Damages from Salt (per ton)	Annual Damage Reduction
Site 1 - Yellowstone Feeder Canal	66	$327	$22,000
Site 2 - Coyote Canal	67	$327	$22,000
Site 3 - South Boneta	195	$327	$64,000
Site 4 - Dry Gulch Class B Canal System	2,127	$327	$695,000
Site 5 - Dry Gulch Class C Canal System	434	$327	$142,000
Site 6 - Red Cap Extension Canals/Laterals	2,030	$327	$663,000
Site 7 - Gray Mountain Canal	475	$327	$155,000

17.1.4 Sediment

Approximately 9.42 ac-ft (15,200 CY) of sediment has eroded from the Coyote Canal and deposited in Brown's Draw Reservoir. There is potential for an additional 6.76 ac-ft (10,900 CY) of material to be eroded over the next approximately 28 years and deposited in the reservoir. The Site 5 - Coyote Canal Project component will significantly reduce the excess sediment build-up in the Reservoir.

Brown's Draw Reservoir is a popular public fishing destination. It is approximately 151 acres in size. Most anglers here bait cast, fly fish, spin cast, and still fish (rainbow, tiger, and brown trout). It is open to underwater spearfishing for game fish from January 1 through December 31. No estimate could be found on annual visits or usage.

To estimate the benefit of sediment reduction measures, the cost of the FWOFI was calculated by assuming a dredging cost of $31.02 (2024$) per cubic yard in year 30. Multiplying 10,900 cubic yards times $31.02 per cubic yard equates to $338,000. This amount was discounted to a present value and annualized over the 50-year evaluation period equating to an annual benefit of $6,000.

17.1.5 Benefits Not Quantified

Several additional benefits of the Project were not quantified for the economic analysis.

The Project will allow for the increased use of pressurized irrigation systems, which use water more efficiently than flood irrigation system. This would allow for further increases in yields as the irrigation water can be used more effectively for crop production. In addition, the Project will increase the water pressure to some existing pressurized irrigation systems, which will decrease the use of electricity to pump water into the systems, thus reducing production costs.

Brown's Draw Reservoir is impacted by the sediment deposited by Coyote Canal. The reservoir is a popular public fishing destination and is approximately 151 acres in size. Most anglers here bait cast, fly fish, spin cast, and still fish (rainbow, tiger, and brown trout). It is open to underwater spearfishing for game fish from January 1 through December 31. No estimate could be found on annual visits or usage, but the current sedimentation negatively impacts the reservoirs recreational use.

Improved water quality and quantity in the natural stream systems would benefit Endangered Species Act (ESA) fish species, Utah species of greatest conservation need (SGCN) fish species, and associated designated critical habitat/suitable habitat that are located in the downstream receiving waters. The alternative measures also increase resilience to climate change stressors to better adapt to projected heightened water variability.

17.1.6 Benefit Summary

Benefits of the Project include agricultural production, salinity reduction, and reduced sedimentation. Benefits for each Project component is shown in Table 17-12. The benefits summary do not include the benefits of the canal failure analysis. Because of the uncertainty of the failure of the canals, the benefits were estimated separately in the Section D.17.3.

Table 17-12. Benefit Summary by Project Component

Project Component	Agricultural Production	Salinity Damage	Sediment Reduction	Annual Benefits
Site 1 - Yellowstone Feeder Canal	$255,000	$22,000	$0	$277,000
Site 2 - Coyote Canal	$42,000	$22,000	$6,000	$70,000
Site 3 - South Boneta	$111,000	$64,000	$0	$175,000
Site 4 - Dry Gulch Class B Canal System	$2,648,000	$695,000	$0	$3,343,000
Site 5 - Dry Gulch Class C Canal System	$639,000	$142,000	$0	$781,000
Site 6 - Red Cap Extension Canals/Laterals	$656,000	$663,000	$0	$1,319,000
Site 7 - Gray Mountain Canal	$1,296,000	$155,000	$0	$1,451,000
Total	**$5,647,000**	**$1,763,000**	**$6,000**	**$7,416,000**

Notes: 2024 price level, 2.75% discount rate, dollars are rounded to the nearest thousand.

D.17.2. Cost Analysis

Average annual costs associated with the Project components include costs for installation and O&M.

17.2.1 Installation Costs

The total installation costs for each Project component are detailed in Section D.7.2 and include construction, engineering, permitting, real property rights, and administrative costs. The installation costs for each site are listed in Table 17-13. Interest during construction was estimated based on the length of the design and construction period for each Project component (if the construction period was a year or less, no interest during construction was added). The costs were evaluated over the 1-, 2-, or 3-year installation period (calendar years) and 50-year evaluation period (project life). While the period of analysis for the Project components varied from 51 years to 53 years, the costs and benefits were annualized over the 50-year period of evaluation using a 2.75% discount rate. Table 17-13 provides the costs for each Project component.

Table 17-13. Installation Costs

Project Component	Installation Period	Installation Cost	Annual Installation Cost
Site 1 - Yellowstone Feeder Canal	Dec 25 - Apr 26	$3,082,000	$117,000
Site 2 - Coyote Canal	Mar 25 - May 25	$1,803,000	$67,000
Site 3 - South Boneta	Feb 25 - Apr 25	$803,000	$30,000
Site 4 - Dry Gulch Class B Canal System	Nov 25 - Apr 27	$5,941,000	$225,000
Site 5 - Dry Gulch Class C Canal System	Oct 25 - Apr 26	$15,793,000	$597,000
Site 6 - Red Cap Extension Canals/Laterals	Oct 25 - Apr 27	$9,258,000	$351,000
Site 7 - Gray Mountain Canal	Oct 25 - Apr 26	$4,369,000	$165,000
Total		**$41,049,000**	**$1,552,000**

Notes: 2024 price level; amortized over 50-year evaluation period using a discount rate of 2.75%; interest during construction was incorporated into the Annual Installation Cost.

17.2.2 Operations and Maintenance Costs

The Project components would result in a reduction in the O&M costs associated with each of the Project sites. This reduction was accounted for in the net O&M (FWOFI O&M – Project O&M) for each Project component (Table 17-14).

Table 17-14. Annual Operation and Maintenance Costs

Project Component	FWOFI O&M	Project O&M	Annual O&M
Site 1 - Yellowstone Feeder Canal	$18,000	$2,000	-$16,000
Site 2 - Coyote Canal	$17,000	$1,000	-$16,000
Site 3 - South Boneta	$9,000	$2,000	-$7,000
Site 4 - Dry Gulch Class B Canal System	$23,000	$9,000	-$14,000
Site 5 - Dry Gulch Class C Canal System	$64,000	$4,000	-$60,000
Site 6 - Red Cap Extension Canals/Laterals	$42,000	$12,000	-$30,000
Site 7 - Gray Mountain Canal	$51,000	$1,000	-$50,000
Total	**$224,000**	**$31,000**	**$193,000**

Notes: 2024 price level; dollars are rounded to the nearest thousand.

17.2.3 Cost Summary

A discount rate of 2.75% was used to calculate average annual costs. Table 17-15 shows the cost summary for each Project component.

Table 17-15. Cost Summary

Project Component	Annual Installation Costs	Annual O&M	Average Annual Costs
Site 1: Yellowstone Feeder Canal	$117,000	-$16,000	$101,000
Site 2: Coyote Canal	$67,000	-$16,000	$51,000
Site 3: South Boneta Canal	$30,000	-$7,000	$23,000
Site 4: Dry Gulch Class B Canal System	$225,000	-$14,000	$211,000
Site 5: Dry Gulch Class C Canal System	$597,000	-$60,000	$537,000
Site 6: Red Cap Extension Canals/Laterals	$351,000	-$30,000	$321,000
Site 7: Gray Mountain Canal	$165,000	-$50,000	$115,000
Total	**$1,552,000**	**-$193,000**	**$1,359,000**

Notes: 2024 price level; amortized over 50-year evaluation period using a 2.75% discount rate; %; interest during construction was incorporated into the Annual Installation Cost; dollars are rounded to the nearest thousand.

D.17.3. Results

Table 17-16 summarizes the average annual benefits, average annual costs, and the benefit-cost ratio for each Project component and the whole of the Project. The results in Table 17-16 do not include the benefits of the canal failure analysis, which are presented following Table 17-16.

Table 17-16. Benefit-Cost Analysis Summary

Project Component	Average Annual Benefits	Average Annual Costs	Benefit-Cost Ratio	Net Benefits
Site 1: Yellowstone Feeder Canal	$277,000	$101,000	2.7:1.0	$176,000
Site 2: Coyote Canal	$70,000	$51,000	1.4:1.0	$19,000
Site 3: South Boneta Canal	$175,000	$23,000	7.6:1.0	$152,000
Site 4: Dry Gulch Class B Canal System	$3,343,000	$211,000	15.8:1.0	$3,132,000
Site 5: Dry Gulch Class C Canal System	$781,000	$537,000	1.5:1.0	$244,000
Site 6: Red Cap Extension Canals/Laterals	$1,319,000	$321,000	4.1:1.0	$998,000
Site 7: Gray Mountain Canal	$1,451,000	$115,000	12.6:1.0	$1,336,000
Total	**$7,416,000**	**$1,359,000**	**5.5:1.0**	**$6,057,000**

Notes: 2024 price level; dollars are rounded to the nearest thousand.

Because of the uncertainty associated with the failures of the canals in Site 5 and Site 6, the results are being presented separately. The canals were estimated to fail in 10 years, but they may fail sooner. Table 17-17 presented the results of the economic analysis if the canal failure analysis is included in the economic analysis.

Table 17-17. Benefit-Cost Analysis Summary with Canal Failure

Project Component	Average Annual Benefits	Average Annual Costs	Benefit-Cost Ratio	Net Benefits
Site 1: Yellowstone Feeder Canal	$277,000	$101,000	2.7:1.0	$176,000
Site 2: Coyote Canal	$70,000	$51,000	1.4:1.0	$19,000
Site 3: South Boneta Canal	$175,000	$23,000	7.6:1.0	$152,000
Site 4: Dry Gulch Class B Canal System	$3,343,000	$211,000	15.8:1.0	$3,132,000
Site 5: Dry Gulch Class C Canal System	$4,069,000	$537,000	7.6:1.0	$3,532,000
Site 6: Red Cap Extension Canals/Laterals	$3,783,000	$321,000	11.8:1.0	$3,462,000
Site 7: Gray Mountain Canal	$1,451,000	$115,000	12.6:1.0	$1,336,000
Total	**$13,168,000**	**$1,359,000**	**9.7:1.0**	**$11,809,000**

D.17.4. Value of Salinity Reduction Analysis

When completing a watershed study, often alternatives being considered have the potential to reduce salinity in adjacent ground and water (e.g., piping an open irrigation canal), which can reduce salinity-related damages in the study area and far downstream. While the benefits of reducing salinity are well known, there is currently no accepted monetary value to use when evaluating the economic feasibility of an alternative. This discussion presents how salinity damage modeling completed by Reclamation can be used in watershed studies for planning-level economic analyses of alternatives.

17.4.1 Salinity Damage Modeling

Salinity-related damages have been extensively studied in the Colorado River Basin. The Upper Colorado River Basin encompasses about 112,000 square miles and discharges more than 6 million tons of dissolved solids (salt) annually to the Lower Colorado River Basin. High salt concentrations in the Colorado River are a concern because they result in substantial economic damages to water users, primarily in reduced agricultural crop yields and corrosion of water systems for irrigation and public supply. Therefore, reducing the amount of salt discharged can have benefits throughout the Colorado River Basin, which includes portions of seven states and Mexico.

To evaluate the economic impacts of salinity throughout the Colorado River Basin and the benefits of salinity reduction projects, Reclamation developed the Salinity Economic Impact Model (SEIM). The SEIM takes into consideration impacts to seven economic sectors: residential; commercial; industrial; water utilities; groundwater; recycled water and publicly owned treatment works; and agriculture. The SEIM was developed in the early 2000s and is updated every three years to account for changing conditions and standards. Reclamation works closely with the Colorado River Basin Salinity Control Forum when completing the updates. The results from the most recent update were presented in the 2020 Review: Water Quality Standards for Salinity, Colorado River System (Colorado River Basin Salinity Control Forum 2020). Table 17-18 summarizes the results for various salinity reduction scenarios (targets/goals from implementing various mitigation measures). The Total Quantified Damages in Table 17-18 represent the damages resulting from the salt that is remaining in the system after meeting the salinity reduction of the scenario. Therefore, as more salt is removed through mitigation measures, the total damages decrease. The scenario for 1.59M tons removed was based on the controls associated with current projected programming funding level through 2040.

Table 17-18. Annual Damages and Damage Reduction for Plan of Implementation Scenarios

Scenarios	Salinity Reduction at Imperial Dam in 2040 (mg/L)	Total Quantified Damages ($M, 2019 Dollars)	Annual Damage Reductions as Compared to No Additional Future Controls Beyond 2020 ($M)
1.22M tons removed	--	670.6	--
1.59M tons removed	36	567.6	103.0
1.70M tons removed	47	537.5	133.1
2.35M tons removed	106	370.0	300.6

Source: Table 5 from Colorado River Basin Salinity Control Forum 2020

Reviewing results of the SEIM model, the total amount of damages from salt varies by economic sector, with the agricultural economic sector estimated to have the largest percentage of damages (Table 17-19).

Table 17-19. Salinity Damage by Economic Sector

Economic Sector	% of Damages
Agricultural	50%
Residential	27%
Commercial	9.6%
Industrial	3.5%
Utility	0.4%
Groundwater	4.9%
Recycled Water	4.6%

Source: Obtained from SEIM output report for a scenario with 1.66 M tons of salt removed

17.4.2 Approach

One of the values available to economists conducting an economic analysis of project alternatives is tons of salt removed from the system annually. However, since the total damage values in Table 17-18 represent the amount of damage from the salt remaining in the system, as opposed to the decrease in damages from removing the salt, a direct comparison of dollars per ton of salt removed was not appropriate.

To address that issue, the incremental differences between the scenarios were used to estimate the damage in dollars per ton. The incremental difference in damages provides a direct correlation to the difference in the amount of salt removed for each scenario. Table 17-20 shows the results using the increments between each scenario. Based on the analysis, it is recommended that the economic impact of reducing salt be valued at $275 per ton.

Table 17-20. Result of Incremental Analysis

Scenarios (tons of salt removed)	Total Quantified Damages	Incremental Tons Removed	Incremental Damages	Dollars/ton (by increment)
1,220,000	$670,600,000	--	--	--
1,590,000	$567,600,000	370,000	$103,000,000	$278
1,700,000	$537,500,000	110,000	$30,100,000	$274
2,350,000	$370,000,000	650,000	$167,500,000	$258

17.4.3 Use of Results for NRCS Projects

The salt reduction value ($275 per ton) would be appropriate to use when an alternative would lead to a reduction in salt buildup in soils or ground/surface water. This could be for a project focused on water supply, such as agriculture improvement and ecosystem restoration. Typically, reducing salt would only be one component of the overall benefits being analyzed for an alternative. For example, piping an open irrigation canal has the benefit of increasing the amount of water available for irrigation by reducing leakage and the benefit of reducing salt concentrations in the soils, which can make its way to streams and rivers.

The salt reduction value estimated from the SEIM model measures the damages for a large portion of the southwestern U.S. and would therefore be considered a national impact (i.e., NEE benefit). While the distribution of the damages across economic sectors presented in Table 17-19 were for a specific scenario, they provide a general representation of the sectors that would benefit from an alternative that reduces salinity, with the agricultural sector representing about 50 percent of the benefits.

Because the salinity reduction value ($275) and damage distribution were estimated from a broad area, the values would not be applicable as a benefit to an individual landowner or study area, and they may not capture all the benefits of an alternative. Therefore, site specific impacts of salt reduction would be measured separately as potential additional benefits.

The value of $275 per ton would be revised as appropriate based on the regular updates of the SEIM.

D.18. References

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