Appendix D. Investigations and Analyses Report

Investigation and Analyses Report for the Cimarron River-Lower Uncompahgre Watershed Project Plan and Environmental Assessment

Appendix D

Cimarron River and Lower Uncompahgre Watershed

Montrose and Gunnison County, Colorado

The purpose of the Investigation and Analyses Appendix is to present information that supports the evaluation and conclusions of the Watershed Plan and Environmental Assessment (Plan-EA). Refer to the Administrative Record for the copies of the studies referred to in this Appendix.

November 2023

Table of Contents

List of Tables

D.1 Introduction

The Cimarron River-Lower Uncompahgre Watershed Project is located within the Cimarron River and Lower Uncompahgre Watershed and is sponsored by the Bostwick Park Water Conservancy District (BPWCD). The Uncompahgre Valley Water Users Association (UVWUA), the Cimarron Canal and Reservoir Company (CC&RC), and Trout Unlimited (TU) are also project sponsors.. This Watershed Plan and Environmental Assessment (Plan-EA) has been prepared as required under the NRCS PL 83-566 Program. The watershed boundary is contained within the Colorado counties of Gunnison, Montrose, Ouray, and Delta; the proposed work of this contract is in Montrose and Gunnison Counties. The project focuses on discrete areas within local irrigation systems that are currently susceptible to failure, contribute to system water losses, and significantly impact salt and selenium loadings of the Colorado River system. The areas of focus are:

- The “Wells Basin” section of the Cimarron Canal
- The “Coal Hill” section of the Cimarron Canal
- The “Slide Point” section of the Vernal Mesa Canal
- The Bostwick Park East Lateral
- The Bostwick Park West Lateral
- The Montrose and Delta (M&D) Canal

The initial selection of canals and reaches to be addressed in the Proposed Project were the result of consultation with the project sponsors while referencing previous master planning efforts. Such efforts include the BPWCD System Optimization Plan (J-U-B 2016) and the Westside Optimization Analysis Final Report (Irrigation Training and Research Center 2017) for the BPWCD and Uncompahgre Valley Water Users Association (UVWUA), respectively. The planning efforts identified and prioritized projects in both BPWCD and UVWUA systems is based on numerous factors, including water savings, salinity reduction, improved water security, and project feasibility. For example, Table 9 of the BPWCD System Optimalization Plan provided facility needs within Bostwick Park; the table listed piping/lining as necessary on the Cimarron Canal, Vernal Mesa Canal, East Lateral, and West Lateral. The Westside Optimization Analysis Final Report identified necessary improvements on the M&D Canal pertaining to the reach between 6500 Rd and Ranger Rd. Situations in both the UVWUA and BPWCD water systems have changed since these master planning efforts were undertaken; therefore, the projects included in this Plan-EA may not correspond to the highest priority projects in the planning efforts. The projects in the Plan-EA, however, represent the canal reaches and laterals that the sponsors identified as the most important for agricultural water management of their systems.

The Sponsors indicated that irrigation water security and irrigation efficiency were their top concerns and objectives for the Proposed Project. Areas of operational concern (i.e., reaches where irrigation operations could be jeopardized if appropriate measures were not taken) were identified by project Sponsors and were prioritized for inclusion into the Plan-EA. These reaches include Wells Basin, Coal Hill, Slide Point, and the selected reach of the M&D Canal. The secondary goal for project Sponsors was irrigation efficiency to preserve late season

irrigation water. Piping the Bostwick Park East Lateral and West Lateral is expected to provide the greatest increase in efficiency as service laterals allow for water to be more efficiently delivered, in addition to the benefit of seepage reduction. Pressurized service laterals assist in creating an on-demand irrigation system, thereby reducing unnecessary reservoir drawdown and prolonging irrigation seasons. Piping further increases the conveyance efficiency of a system and reduces water lost to seepage and evaporation. Bostwick Park has five service laterals: Shinn Park, Waterdog, Kinikin, East, and West. Piping projects on Shinn Park and Waterdog are ongoing; a smaller project to route Kinikin water through the piped Shinn Park Lateral and eliminate a significant portion of the Kinikin Lateral is under consideration. If East Lateral and West Lateral are piped, all service laterals within the BPWCD would be piped. Improvement measures on the selected reaches are expected to meet the threshold of what the Sponsors are willing to undertake at this time, as the Sponsors have limited financial resources for providing matching funds. For this reason, additional reaches within the watershed were excluded from consideration.

A significant amount of the water savings within the Cimarron River drainage are anticipated to remain in the high mountain reservoirs of BPWCD and the Cimarron Canal and Reservoir Company (CC&RC). The savings has the potential to positively impact both the agricultural users and the local fishery within the Cimarron River. A temperature sensor in the river will allow irrigation water allocated specifically to supporting in-stream uses to be utilized efficiently while ensuring it supports improved water quality viable habitat for the native fisheries.

This document summarizes the investigations and analyses completed for the planning and engineering for the Plan-EA. Preliminary engineering design and analysis for the Plan-EA was done to a level that would allow for determination of both the feasibility of proposed improvement measures and the sizing of the measures, such as pipe sizing. Survey to obtain information necessary for preliminary design was conducted on existing facilities, including spatial data on canal flowlines with periodic canal cross sections. Preliminary design on proposed improvement measures was performed in accordance with relevant NRCS practice standard criteria. The 30% Plans are in Appendix C and the 30% Design Report is in Appendix E of the Plan-EA. The preliminary survey, hydraulic analyses, and resultant plans/reports are contained in the project record.

D.2 Agricultural Water

Agricultural water uses represent the majority of water use within the Cimarron River and Lower Uncompahgre Watershed. The systems of the UVWUA and the BPWCD account for most of the agricultural water use within the watershed. These systems, as described below, have areas where significant water loss (seepage) occurs; historically, some of these areas also have issues with breaches, posing a risk to irrigation water delivery. A qualitative narrative describing the water loss and breach potential of these areas is discussed below, while the economic analyses of section D.5 use quantitative figures for both water loss and breach potential. The water loss analysis is outlined in the water loss memo in Appendix E of the Plan-EA, while the breach analysis, based on historical frequency, is contained in the project record.

The Cimarron Canal is the primary conveyance canal within the BPWCD system and is primarily open and unlined (small sections of culvert exist where the canal intersects roadways and drainages). The canal is approximately 23.5 miles and has a suite of water rights from the Cimarron River and its tributary creeks that total 185 cubic feet per second (cfs). The canal begins at its diversion on the Cimarron River and terminates at a division box near the top of Cerro Summit where it splits into the Vernal Mesa Canal and the Hairpin Canal. While there are turnouts along the canal, its primary function is to convey water to smaller canals and laterals which take the diverted irrigation water closer to the irrigated acreage. Two discrete sections of the canal have notable breach potential from a relatively higher risk of landslides along their lengths. These sections are Wells Basin and Coal Hill. A breach at either location would inhibit irrigation deliveries to the 8,439 acres of grass pasture within Bostwick Park, Shinn Park, Kinikin Heights, and Waterdog Mesa. As an unlined canal, water loss through seepage is present along its entire length and is notable in both the Wells Basin and Coal Hill sections of the canal.

The Vernal Mesa Canal begins at its split from the Cimarron Canal and conveys irrigation water from the Cerro Summit area to the smaller laterals (East, West, and Siphon) that irrigate the lands of Bostwick Park. Approximately 0.4 miles from the split, the Vernal Mesa Canal crosses under U.S. Hwy 50; it then travels along the north side of the highway in a parallel fashion for approximately 2.5 miles before it starts to head in a more northerly direction away from the highway. A portion of where the canal parallels the highway is known as the “Slide Point” section. Slide Point breached in the 1960s and caused significant damage to the highway. A 48” steel pipe was installed to mitigate seepage issues believed to be contributing toward causing a slide. No slides have occurred since, indicating the efficacy of the remediation. In recent years, however, new seeps have been observed just upstream of the existing piped section. Degradation of the existing steel pipe has also been observed, furthering concern of a breach risk. A breach of the Vernal Mesa Canal would inhibit irrigation of the 3,411 acres of grass pasture in Bostwick Park.

The Vernal Mesa Canal terminates at the split between the Bostwick Park East Lateral and West Lateral. These laterals, along with the piped Siphon Lateral which splits from the East Lateral, irrigate most of the lands of Bostwick Park. East Lateral is an unlined, earthen ditch of approximately 22,500 feet in length. It has 16 headgates distributed throughout its length; tailwater not used by the final headgate diffusely flows northwest until reaching the drainage in nearby Red Rock Canyon.

Recent projects have piped the first mile of West Lateral, approximately. After the piped segments, West Lateral consists of approximately 21,000 feet of unlined earthen ditch and has 13 headgates. Tailwater from West Lateral also discharges into Red Rock Canyon if not used for irrigation. In both the East Lateral and West Lateral, water losses in the form of seepage and “push water”, result in faster reservoir drawdown. This limits late season water for both irrigation and aquatic habitat. Continual seepage in the canals results in significant salt and selenium loading in the Watershed and the greater Colorado River Basin.

A large percentage of the lands in the Lower Uncompahgre Watershed are irrigated by the UVWUA. UVWUA operates multiple canals that irrigate the Uncompahgre Valley on both sides of the river. The largest canal on the West side of the Uncompahgre River is the M&D Canal. The M&D Canal diverts approximately 627 cfs and irrigates over 20,000 acres spanning from Montrose, Colorado to Delta, Colorado. There is an unstable hillside above the canal approximately 4 miles from the M&D diversion; potential sloughing of the hillside threatens to block, overtop, and breach the canal. The instability is believed to be a function of seepage from other canals above the M&D, irrigation above the M&D, and the steep slope of the hillside. The section of canal in the immediate vicinity has significant water loss due to seepage, which results in faster depletion of UVWUA reservoir water and contributes to the salt and selenium loading in the watershed and the greater Colorado River Basin.

The proposed measures described in the sections below utilize design rates based on current water rights and water use. While there is a chance that water use may increase in the future (and subsequently causes infrastructure to be undersized), the risk is minimal. Without pumping, significant expansion of irrigated lands is unlikely due to regional topography, thereby decreasing the risk of additional use. Additionally, projected population growth in the watershed would likely decrease future agricultural needs. The 30% Plans are included in Appendix C and the 30% Design Report in contained in Appendix E of the Plan-EA.

D.2.1 Wells Basin

It is anticipated that a breach (landslide) in the Wells Basin section of the Cimarron Canal would likely come from saturation of the soil profile on the steep banks on the downhill side (right side) of the canal. Piping or lining the canal would help to mitigate this risk factor. In the event that a slide still occurred, encapsulation (piping) of the canal would decrease the risk of a canal breach. Utilization of a resilient, monolithic pipe such as solid wall HDPE, would further mitigate the risk of a canal breach due to a landslide. Canal lining was not evaluated as an alternative, as potential damage from actively grazing cattle or damage from minor shifts in the soil profile make it less preferrable than HDPE pipe.

The Proposed Project would pipe the Wells Basin section of the Cimarron Canal with approximately 8,590 feet of 63” solid wall HDPE pipe. Piping within Wells Basin was sized to carry the maximum rate anticipated in that section of the Cimarron Canal, 135 cfs (rate provided by BPWCD and CC&RC staff). Canal flowline slopes obtained in preliminary design survey indicate that 63” DR 41 HDPE pipe can adequately convey the maximum anticipated flow rate without exceeding 70% of the pipe pressure rating or backing water into the upstream un-piped canal (which could result in overtopping). Table D-1 describes the proposed pipeline characteristics for Wells Basin.

Table D-1. Wells Basin Proposed Pipeline Characteristics

Station Start	Station End	Slope	Proposed Pipe Size	Flow Condition	Notes
10+00	12+00	1.87%	63” DR 41	Open Channel	Open channel from inlet will prevent backup into unlined canal
12+00	22+72	0.33%	63” DR 41	Open Channel	Pressurization from downstream sections extends approximately 200 feet into this section

22+72	36+00	0.10%	63” DR 41	Pressurized	Pressurized due to slope
36+00	46+26	0.23%	63” DR 41	Pressurized	HGL from downstream sections forces pressurization in this section
46+26	73+50	0.11%	63” DR 41	Pressurized	Pressurized due to slope
73+50	88+13	0.21%	63” DR 41	Open Channel	Pressurized from downstream section extends approximately 200 feet into this section
88+13	95+88	0.10%	63” DR 41	Pressurized	Pressurized due to slope

Three concrete structures are likely required in the proposed pipeline. Simple concrete headwalls are anticipated at both the upstream and downstream ends of the pipeline. A natural drainage intersects the existing canal midway through the alignment (at approximately station 57+92). There is currently a “wasteway” on the canal at this location, which allows the drainage water to be intercepted by the canal, or “wasted” and spilled below the canal into the historic drainage path toward the Cimarron River. Preliminary design assumes replacement of the steel wasteway with a new concrete wasteway. Further design will analyze the need for the structure.

The large diameter and relatively thin walls of the proposed pipe require a high degree of compaction around the pipe to prevent pipe deformation from external loadings. 3/4” crushed rock is proposed for the area immediately around the pipe, from the trench bottom to a height of 7/10 of the pipe diameter. The large canal prism through the Wells Basin area would require a substantial quantity of fill to properly bed and backfill a pipeline. Site investigations have indicated that the site has sufficient borrow areas immediately adjacent to the proposed alignment to limit the need for imported fill. It is anticipated, however, that the pipe would be embedded in crushed rock to prevent excessive vertical deflection; the quantity of crushed rock has been estimated based on a standard trench detail for large diameter pipe.

All material quantities and estimated labor costs for the described project section are provided as part of the preferred Cost Estimate presented in Section D.5.

D.2.2 Coal Hill

Similar to Wells Basin, it is anticipated that a breach in the Coal Hill section of the Cimarron Canal would likely come from saturation of the soil profile on the steep banks on the downhill side (right side) of the canal. Unlike Wells Basin, however, Coal Hill has steep banks on the uphill side of the canal. This makes canal encapsulation (piping) particularly beneficial, as it would both stop saturation beneath the canal, and reduce the risk of canal overtopping and breaching due to slides above of the canal. Use of a monolithic pipe would reduce the risk of pipeline failure in the case of landslides in the vicinity of the canal.

The Proposed Project would pipe the Coal Hill section of the Cimarron Canal with approximately 6,180 feet of 63” solid wall HDPE pipe. Pipe within the Coal Hill section was sized to carry the maximum rate (135 cfs) anticipated in that section of the Cimarron Canal (rate provided by BPWCD and CC&RC staff). Preliminary design survey indicates that 63” DR 41 HDPE pipe can adequately convey the maximum anticipated flow rate while maintaining free flow from the canal into the pipeline and experiencing only minor

pressurization. Table D-2 describes the proposed pipeline characteristics for the Coal Hill section of the Cimarron Canal.

Table D-2.Coal Hill Proposed Pipeline Characteristics

Station Start	Station End	Slope	Proposed Pipe Size	Flow Condition	Notes
10+00	20+01	-0.25%	63” DR 41	Open Channel	Open channel from inlet will prevent backup into canal
20+01	29+60	-0.20%	63” DR 41	Open Channel	Pressurization from downstream sections extends approximately 335 feet into this section
29+60	33+76	-0.56%	63” DR 41	Pressurized	Pressurized due to downstream HGL
33+76	46+00	-0.22%	63” DR 41	Pressurized	Pressurized due to downstream HGL
46+00	52+49	-0.20%	63” DR 41	Pressurized	Pressurized due to downstream HGL
52+49	71+80	-0.10%	63” DR 41	Pressurized	Returns to unlined canal after station 71+80. Water level in canal is above pipeline outlet and is the control point for the HGL

The proposed Coal Hill Pipeline would begin at the start of an existing steel wasteway. Modifications to the wasteway structure are anticipated and are likely to consist of replacing the existing steel gated headwall with a concrete gated headwall. A concrete headwall is anticipated to be suitable for pipeline termination at the downstream end of the project. No other structures are anticipated to be required. The canal has an existing headgate at Station 61+15; a 10” turnout discharging into historic user infrastructure would be included with the piping project.

As with Wells Basin, the large diameter and relatively thin walls of the proposed pipe require a high degree of compaction around the pipe to prevent pipe deformation from external loadings. 3/4” crushed rock is proposed for the area immediately around the pipe, from the trench bottom to a height of 7/10 of the pipe diameter. Additional material for canal fill is anticipated to come from the adjacent hillsides as required; imported fill material (except for the crushed rock) is not expected. Canal lining was not evaluated as an alternative, as potential damage from actively grazing cattle or damage from minor shifts in the soil profile make it less preferrable than HDPE pipe.

All material quantities and estimated labor costs for the described project section are provided as part of the preferred Cost Estimate presented in Section D.5.

D.2.3 Slide Point

Following the initial breach at slide point in 1960s, mitigation of breach and landslide potential was performed by piping approximately 1,440 feet of the Vernal Mesa Canal. To-date, this mitigation appears to have been successful. In recent years, however, new seeps have been observed just upstream of the existing piped section. The previously installed pipe is aging and would ideally be replaced during an extension of the piped area. Since decreasing canal seepage with a monolithic pipe appears to have positive results in this area, it is recommended that the Proposed Project also utilize monolithic pipe to reduce seepage. Canal lining was not evaluated as an alternative, as potential damage from actively grazing cattle or damage from minor shifts in the soil profile make it less preferrable than HDPE pipe.

The proposed Slide Point piping project would begin at an existing wasteway structure about 3,440 feet upstream of the start of the existing concrete structure and would end at the current termination of the existing pipeline (approximately 4,900 feet in total). Discussions with the project Sponsors indicate that the pipeline must convey 85 cfs, to remain consistent with current capabilities. The proposed pipeline was sized to convey the necessary rate; Table D-3 provides proposed pipeline flow characteristics at 85 cfs for the Slide Point section of the Vernal Mesa Canal.

Table D-3. Slide Point Proposed Pipeline Characteristics

Station Start	Station End	Slope	Proposed Pipe Size	Flow Condition	Notes
10+00	12+30	-0.35%	54” DR 32.5	Open Channel	Open channel from inlet will prevent backup into unlined canal
12+30	19+00	-0.30%	54” DR 32.5	Open Channel	Open channel flow
19+00	29+00	-0.15%	54” DR 32.5	Open Channel	Open channel flow
29+00	38+00	-0.15%	54” DR 32.5	Open Channel	Open channel flow
38+00	42+00	-0.10%	48” DR 32.5	Pressurized	Pressurized due to pipe size reduction and slope
42+00	46+00	-0.25%	48” DR 32.5	Open Channel	Open channel flow
46+00	58+78	-0.43%	48” DR 32.5	Open Channel	Returns to unlined canal after station 58+78. Water level in canal will be at the same elevation as water level in pipeline or lower

Slide Point piping would begin at an existing canal wasteway structure, which would require partial removal and replacement with a gated concrete headwall. From that point, the first 2,800 feet of 54” DR 32.5 HDPE pipe would be needed to convey the 85 cfs. 48” DR 32.5 HDPE for the remaining 2,100 feet of the alignment would provide adequate capacity. Removal of the existing 48” pipeline and intake structure would be required for the final 1,440 feet of the alignment. Removal of the pipeline, intake structure, and canal wasteway structure are factored into project costs.

The large pipe dimeter and relatively thin walls of the pipeline would require a high degree of compaction to prevent excessive pipe deformation from external loading. 3/4” crushed rock is proposed for the area immediately around the pipe, from the trench bottom to a height of 7/10 of the pipe diameter. Additional material for canal fill is anticipated to come from the adjacent hillsides as required; imported fill material (except for the crushed rock) is not expected.

All material quantities and estimated labor costs for the described project section are provided as part of the preferred Cost Estimate presented in Section D.5. As described in Section D.6, piping the Vernal Mesa Canal has a benefit cost ratio greater than one, meaning

that a longer segment could be considered for piping, providing further water conservation and salinity reduction benefit. The extents considered for improvement measures were preferred by the Sponsor, as they sufficiently address the larger issue of high canal breach potential.

D.2.4 Bostwick Park East Lateral

To improve watershed water quality and efficiency, it is proposed that the Bostwick Park East Lateral be piped. Piping the East Lateral immediately after the split with the West Lateral would eliminate approximately 22,500 feet of open, unlined ditch. The proposed pressurized irrigation system would eliminate canal seepage and provide the added benefit of eliminating excess discharge from the end of the lateral into Red Rock Canyon. While lining the East Lateral would reduce seepage, it would not eliminate excess discharge into Red Rock Canyon. Therefore, lining was not considered as an alternative. The discharge quantity that would be eliminated is unknown, however, it is anticipated to be significant in quantity, reduce unnecessary diversion from the Cimarron River, and reduce reservoir drawdown during the latter stages of the irrigation season.

The proposed piping project would begin with construction of a concrete headwall/trashrack attached to approximately 1,150 feet of 36” DR 32.5 HDPE. 30” DR 32.5 HDPE would provide adequate capacity for the next 2,600 feet of pipeline, at which point the Siphon Lateral would split from the East Lateral. It is anticipated that the existing screening structure at the Siphon Lateral/East Lateral split would need to be heavily modified or replaced. A hydraulic spill structure approximately 1,250 feet downstream of the split structure would set a maximum water surface elevation for the pipeline downstream of the split, allowing for significantly thinner walled pipe to be used for the downstream pipeline. Excess water at the spill structure would empty into an emergency drainpipe that would be installed by BPWCD, separately from and completed before the PL 83-566 project.

The East Lateral proposed pipeline would contain two unpressurized turnouts (located upstream of the screen/split structure). Downstream of the hydraulic spill structure, 14 pressurized turnouts will be needed causing demand to decrease along the length of the pipeline. The pipeline downstream of the spill structure would gradually taper from 30” DR 32.5 to 18” DR 26 pipe. The Table D-4 provides preliminary pipe sizing and flow characteristics for the proposed East Lateral pipeline.

Table D-4. East Lateral Proposed Pipeline Characteristics

Station Start	Station End	Slope	Proposed Pipe Size	Flow Condition**	Pressure*	Notes
10+00	21+58	0.48%-2.82%	36” DR 32.5	Open Channel	Max Operating: 0 psi Hydrostatic: N/A Pipe Rating: 64 psi	Open channel from inlet will prevent backup into open canal
21+58	26+00	3.58%-6.70%	30” DR 32.5	Open Channel	Max Operating: 0 psi Hydrostatic: N/A Pipe Rating: 64 psi	Open channel due to pipe slopes

Station Start	Station End	Slope	Proposed Pipe Size	Flow Condition**	Pressure*	Notes
26+00	40+60	0.49%-3.58%	30” DR 32.5	Pressurized	Max Operating: 2.6 psi Hydrostatic: N/A Pipe Rating: 64 psi	Pipe pressurizes due to 0.49% slope and forces pressurization up to 3.58% section
40+60	47+00	1.28%-11.61%	30” DR 32.5	Open Channel	Max Operating: 0 psi Hydrostatic: N/A Pipe Rating: 64 psi	Open channel due to pipe slopes
47+00	59+50	0.43%-9.82%	30” DR 32.5	Open Channel	Max Operating: 0 psi Hydrostatic: N/A Pipe Rating: 64 psi	Open channel from split structure from sections due to pipe slopes
59+50	164+00	0.39%-1.54%	30” DR 32.5	Pressurized	Max Operating: 15.2 psi Hydrostatic: 24.0 psi Pipe Rating: 64 psi	Pressurized due to closed pipeline design
164+00	185+00	0.44%-0.64%	24” DR 32.5	Pressurized	Max Operating: 16.1 psi Hydrostatic: 28.5 psi Pipe Rating: 64 psi	Pressurized due to closed pipeline design
185+00	215+00	0.26%-0.49%	24” DR 26	Pressurized	Max Operating: 16.2 psi Hydrostatic: 32.7 psi Pipe Rating: 81 psi	Pressurized due to closed pipeline design
215+00	234+75	0.13%-0.59%	18” DR 26	Pressurized	Max Operating: 15.2 psi Hydrostatic: 36.2 psi Pipe Rating: 81 psi	Pressurized due to closed pipeline design

**Maximum operating pressures listed are at maximum flow rate. Pipeline flow rates subtract turnouts which are not shown in the table.*
***Flow condition assumes available intake equals or exceeds demand. Pipeline design rates vary along length based on downstream demand.*

Installation of the pipeline in accordance with NRCS specifications would be critical for infrastructure longevity; this includes compaction around the pipe. The smaller diameters likely do not necessitate importation of crushed rock, but some imported material is still anticipated. The imported material, pipe quantities, and all other anticipated expenditures are included in the estimate provided in Section D.5.

D.2.5 Bostwick Park West Lateral

Piping the remaining 21,000 feet of open ditch of the Bostwick Park West Lateral would provide significant improvements to watershed water quality and efficiency. The proposed pressurized irrigation system will eliminate canal seepage and provide the added benefit of eliminating discharge into Red Rock Canyon. The improvements in efficiency would help reduce reservoir drawdown during the later stages of the irrigation season. While lining the

West Lateral would reduce seepage, it would not eliminate excess discharge into Red Rock Canyon. Lining, therefore, was not considered as an alternative.

The Proposed Project would begin with a hydraulic overflow structure at the end of the previously piped section. The pipeline would be pressurized for the entire duration and would provide pressurized turnouts to the 13 headgates downstream of the overflow structure. The capped pipeline end would allow for design rate reduction as the pipeline moves downstream of turnouts. This, in-turn, allows for a pipe sizing to be tapered. 24" DR 32.5 HDPE is anticipated for the initial 12,250 feet of the pipeline. From there, 7,300 feet of 18" DR 32.5 followed by 1,500 feet of 16" DR 32.5 are anticipated to provide adequate capacity and pressure rating for the remainder of the pipeline. Table D-5 describes the proposed pipeline characteristics of the proposed West Lateral piping project.

Table D-5. West Lateral Proposed Pipeline Characteristics

Station Start	Station End	Slope	Proposed Pipe Size	Flow Condition**	Pressure*	Notes
4+50	127+00	0.04%-1.78%	24" DR 32.5	Pressurized	Max Operating: 21.3 psi Hydrostatic: 31.3 psi Pipe Rating: 64 psi	Pressurized due to closed pipeline design
127+00	200+00	0.04%-1.13%	18" DR 32.5	Pressurized	Max Operating: 20.7 psi Hydrostatic: 39.6 psi Pipe Rating: 64 psi	Pressurized due to closed pipeline design
200+00	215+07	0.13%-4.11%	16" DR 32.5	Pressurized	Max Operating: 19.8 psi Hydrostatic: 46.6 psi Pipe Rating: 64 psi	Pressurized due to closed pipeline design

**Maximum operatis listed are at a maximum flow rate.*
***Flow condition assumes available intake equals or exceeds demand. Pipeline design rates vary along length based on downstream demands.*

Installation of the pipeline in accordance with NRCS specifications would be critical for infrastructure longevity; this includes adequate compaction around the pipe, particularly under the pipe haunches. The smaller diameters likely do not necessitate importation of crushed rock, but some imported material is still anticipated. The imported material, pipe quantities, and all other anticipated expenditures are included in the estimate provided in Section D.5.

D.2.6 M&D Canal

Improvement designs for the M&D Canal are focused on mitigating a risk of breach due to the adjacent hillside sloughing into the canal, decreasing water loss from seepage, and decreasing salinity loading of the nearby Uncompahgre River due to canal seepage. Two viable options were considered:

- Lining the canal while taking measures to stabilize the unstable hillside

- Piping the canal.

Both options would eliminate local seepage in the canal. Heavy earthwork to reduce the slope of the adjacent hillside would be used to stabilize the hillside. Piping the canal would provide encapsulation, so that a slide of the adjacent hillside would not threaten to overtop or breach the canal. Both options were designed to convey the full 627 cfs water right of the M&D Canal.

D.2.6.1 Lining and Hillside Stabilization

The Proposed Project would line approximately 394,979 square feet of the M&D Canal and stabilize the hillside to mitigate the adjacent hillside sloughing into the canal. The M&D Canal lining design utilizes a 30 mil PVC membrane between two layers of geotextile fabric, covered with a 3" layer of shotcrete. An underdrain allows seepage from upgradient irrigation to drain away from the lining. Proposed canal prisms were sized to convey the 627 cfs water right of the M&D Canal while maintaining at least 12" of freeboard. Site conditions (slope changes and a concrete wall in approximately 1,100 feet of the canal section) require the use of different canal prisms within the project bounds. Table D-6 describes the geometry of the various prism shapes; Table D-7 provides the anticipated flow characteristics in the M&D lining project.

Table D-6. Proposed M&D Canal Prism Shapes

Shape Name	Left Slope	Bottom Width	Right Slope	Top Width	Depth of Canal
Trapezoid 1	1:2	11 ft	1:2	37 ft	6.5 ft
Half Trapezoid	1:2	13 ft	Existing Vertical Wall	26 ft	6.5 ft
Trapezoid	1:2	15 ft	1:2	41 ft	6.5 ft

Table D-7. Flow Characteristics in Proposed M&D Canal Lining

Station Start	Station End	Slope	Lining Shape	Velocity	Flow Depth	Freeboard	Notes
10+00	61+50	-0.10%	Trapezoid 1	5.27 fps	5.42 ft	1.08 ft	Considerations need to be made about the effects of upstream unlined canal. Grades may need to be changed or the shape of the lining may need to be made depending on modeling.
61+50	72+51	-0.13%	Half Trapezoid	6.22 fps	5.44 ft	1.06 ft	Considerations need to be made about the transition of the two shapes of linings.

Station Start	Station End	Slope	Lining Shape	Velocity	Flow Depth	Freeboard	Notes
72+51	92+00	-0.07%	Trapezoid 2	4.45 fps	5.42 ft	1.08 ft	Considerations need to be made about the effects of existing the canal lining back to unlined canal and the water surface level. Grades and/or shapes of canal lining may need to be adjusted.

A significant amount of the lining cost is expected to come from borrow material. Borrow material would be needed for shaping the existing canal to the proposed prims. Quantities for borrow material were calculated based on the initial site survey conducted for the alternatives analysis.

UVWUA recently performed hillside stabilization on a limited section of the M&D Canal that involved benching and grading the hillside to mitigate the chance of slope failure. Initial earthwork estimates indicate that replicating the previous mitigation on the unimproved hillside will require removal of approximately 200,000 CY of material. While this effort is expected to have significant cost, it is expected to effectively mitigate slide potential.

D.2.6.2 Piping

The M&D Canal piping would pipe 8,200 feet of the M&D Canal with approximately 16,400 feet of 120” double barrel HDPE pipe. Initial design on M&D Canal piping is expected to require double barrel 120” pipe due to the high rate and mild slope of the canal. Material options for 120” pipe are limited, however, initial cost estimates indicate that profile wall HDPE pipe is likely a cost effective piping alternative. Piping the canal would eliminate significant earthwork on the project as hillside improvement would likely not be required. The cost of the pipe, however, is significantly more expensive than the combination of canal lining and hillside stabilization.

Table D-8. Flow Characteristics in Proposed M&D Canal Piping

Station Start	Station End	Slope	Proposed Pipe Size	Flow Condition	Notes
10+00	61+50	-0.10%	120” RSD 160	Open Channel	Open channel from inlet will prevent backup into unlined canal
61+50	72+51	-0.13%	120” RSD 160	Open Channel	Open channel flow
72+51	92+00	-0.07%	120” RSD 160	Open Channel	Returns to unlined canal after station 92+00. Considerations will have to be made about water surface level in pipeline and canal. Grades may need to be changed.

D.2.7 Cimarron River Temperature Sensor

The Cimarron Basin is notable for (among other things) its significant snowpack and high elevation reservoir storage. Silver Jack Reservoir, whose elevation is approximately 8,950 feet above sea level, has approximately 12,820 ac-ft of contracted storage volume. The large volume and high elevation of Silver Jack make water stored there cold and clean. Of this storage, 1,500 ac-ft is dedicated to maintaining streamflow in the river downstream of the Cimarron Canal Diversion. Typically, releases from this 1,500 ac-ft pool are used to maintain a minimum flow rate in the Cimarron River for the survival of downstream fish populations.

The Cimarron River is home to a population of native cutthroat trout (*Oncorhynchus clarkii*). As a cold-water fish species, the survival and prosperity of this population depends largely upon maintaining low water temperatures. By installing a temperature sensor with real-time monitoring capabilities, reservoir water can be released at rates required to maintain temperatures to keep the Cimarron River viable for cutthroat trout. Presumably, releasing reservoir water to maintain river water temperature rather than attempting to maintain a rate could extend the 1,500 ac-ft pool and aid in the survival of the population.

The improvement measure considered would install a temperature sensor on an existing bridge abutment and mount a small, steel cabinet to the existing bridge, or a metal post, to house the electronics for the temperature sensor. The temperature sensor would be located on the Cimarron River upstream of the Cimarron Diversion, within USFS land. Alternative locations were not considered as this location provided necessary infrastructure required for hardware mounting that would require extra costs in other locations.

Current stream management protocols release water into the Cimarron River with the goal of maintaining specific flow rates for fish habitat and is determined by Colorado Parks and Wildlife (CPW). The temperature sensor would monitor water temperatures as an indicator of fish habitat conditions to best utilize water conserved in the Bostwick Park/Cimarron Canal system through reduced seepage. The Proposed Project would not reduce water delivery to customers, as CPW has a dedicated pool within Silver Jack Reservoir to supply the stream. New protocols would need to be developed prior to project implementation. Discussions with staff have indicated that CPW would be amenable to adjusting their management of the reservoir pool (a subset of irrigation water volume allocated to fisheries benefit) by using the temperature sensor. It is expected that a memorandum of agreement or understanding would be executed prior to project design to help project benefits accrue as intended.

D.3 Alternatives

The three primary alternatives investigated were the No Action Alternative, Alternative 1 (preferred), and Alternative 2. Alternative 2 is the same as Alternative 1, except for the M&D Canal measure. Alternative 1 is preferred because it mitigates breach risks, conserves reservoir water, improves water quality within the watershed, and provides pressurized irrigation to irrigators, all at a lower cost than Alternative 2. The No Action Alternative does

not provide these needed benefits and is therefore not preferred. Table D-9 provides a breakdown of the actions of Alternative 1 and Alternative 2.

Table D-9. Breakdown of Actions of Alternative 1 and Alternative 2

Watershed Location	Action Alternative 1	Action Alternative 2
Wells Basin	Piping	Piping
Coal Hill	Piping	Piping
Slide Point	Piping	Piping
Bostwick Park East Lateral	Piping	Piping
Bostwick Park West Lateral	Piping	Piping
M&D Canal	Lining and Hillside Stabilization	Piping
Cimarron River	Temperature Monitoring Upstream of Cimarron Diversion	Temperature Monitoring Upstream and Downstream of Cimarron Diversion

D.4 Action Alternative Cost Estimates

Project costs for the action alternatives include all expenses incurred as part of the development, installation, operation, and maintenance of a project. In addition, there are other direct costs and adverse effects that must be accounted for. Costs were estimated for each structure included as part of the action alternatives. Note that site reclamation costs (including revegetation), as well as costs associated with BMPs, are included as part of the mobilization line item and are not explicitly stated.

The estimated cost for Alternative 1 (Preferred Alternative) is $25,178,335.18. This estimate describes the various Agricultural Water Management project elements (Table D-10). The unit costs used in the estimates for Alternative 1 were based on bids from similar projects in the region, when available.

Table D-10. Estimated Cost for Agricultural Water Management Project Elements (Alternative 1)

Item No.	Description	Unit	Quantity	Unit Cost	Total
	Wells Basin				
1	Mobilization	LS	1	$329,000.00	$329,000.00
2	Remove and Dispose of Steel Wasteway	LS	1	$5,000.00	$5,000.00
3	New Concrete Structure Wasteway Poured in Place	CY	18	$2,000.00	$36,400.00
4	63" C-10 Canal Gates for Wasteway	EA	2	$15,000.00	$30,000.00
5	Inlet Structure	EA	1	$35,000.00	$35,000.00
6	Furnish 63" SDR 41 HDPE	LF	8590	$262.10	$2,251,439.00
7	Install 63" SDR 41 HDPE	LF	8590	$110.25	$947,047.50
8	Outlet Structure	EA	1	$35,000.00	$35,000.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
9	3/4" Crushed Rock to Bed Pipe to 70% of Pipe Dia	TON	5011	$40.00	$200,440.00
10	HDPE Mainline Pipe Fittings	EA	22	$5,000.00	$110,000.00
11	Air Vents	EA	8	$2,000.00	$16,000.00
12	P77 Road Crossing	LS	1	$50,000.00	$50,000.00
13	End of Pipeline Riprap	LS	1	$10,000.00	$10,000.00
	Coal Hill				
14	Mobilization	LS	1	$230,000.00	$230,000.00
15	Removal and Reconstruction of 10" Turnout	LS	1	$10,000.00	$10,000.00
16	Inlet Structure Modification	EA	1	$20,000.00	$20,000.00
17	Furnish 63" SDR 41 HDPE	LF	6180	$262.10	$1,619,778.00
18	Install 63" SDR 41 HDPE	LF	6180	$110.25	$681,345.00
19	Outlet Structure Headwall	EA	1	$20,000.00	$20,000.00
20	3/4" Crushed Rock to Bed Pipe to 70% of Pipe Dia	TON	3605	$40.00	$144,200.00
21	HDPE Mainline Pipe Fittings	EA	6	$5,000.00	$30,000.00
22	Air Vents	EA	6	$2,000.00	$12,000.00
23	Turnout	EA	1	$13,500.00	$13,500.00
24	End of Pipeline Riprap	LS	1	$10,000.00	$10,000.00
	Slide Point				
25	Mobilization	LS	1	$161,000.00	$161,000.00
26	Remove and Dispose of 48" Steel Pipe	LF	1438	$58.20	$83,691.60
27	Remove and Dispose of Steel Inlet Structure	LBS	5496	$0.90	$4,946.40
28	Remove and Dispose of Steel Inlet Structure	CY	5.92	$1,000.00	$5,920.00
29	Replacement of Inlet Structure	EA	1	$40,000.00	$40,000.00
30	Furnish 54" SDR 32.5 HDPE	LF	2800	$241.11	$675,108.00
31	Install 54" SDR 32.5 HDPE	LF	2800	$94.50	$264,600.00
32	Furnish 48" SDR 32.5 HDPE	LF	2078	$190.47	$395,796.66
33	Install 48" SDR 32.5 HDPE	LF	2078	$72.00	$149,616.00
34	Outlet Structure	EA	1	$15,000.00	$15,000.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
35	3/4" Crushed Rock to Bed Pipe to 70% of Pipe Dia	TON	2913	$40.00	$116,520.00
36	HDPE Mainline Pipe Fittings	EA	7	$5,000.00	$35,000.00
37	Air Vents	EA	5	$2,000.00	$10,000.00
38	End of Pipeline Riprap	LS	1	$10,000.00	$10,000.00
	East Lateral				
39	Mobilization	LS	1	$280,000.00	$280,000.00
40	Clearing, Grubbing, Rock Removal	FT	22475	$5.43	$121,994.30
41	Trash Screen Structure	CY	20	$2,300.00	$46,000.00
42	Screen/Split/Spill Structure	LS	1	$200,000.00	$200,000.00
43	Hydraulic Spill Structure	CY	25	$2,000.00	$50,000.00
44	Furnish 36" DR 32.5 HDPE	LF	1160	$107.16	$124,307.92
45	Install 36" DR 32.5 HDPE	LF	1160	$45.00	$52,200.00
46	Furnish 30" DR 32.5 HDPE	LF	14250	$74.39	$1,060,086.00
47	Install 30" DR 32.5 HDPE	LF	14250	$37.50	$534,375.00
48	Furnish 24" DR 32.5 HDPE	LF	2100	$47.52	$99,800.40
49	Install 24" DR 32.5 HDPE	LF	2100	$30.00	$63,000.00
50	Furnish 24" DR 26 HDPE	LF	3000	$58.90	$176,712.00
51	Install 24" DR 26 HDPE	LF	3000	$30.00	$90,000.00
52	Furnish 18" DR 26 HDPE	LF	1975	$33.14	$65,451.50
53	Install 18" DR 26 HDPE	LF	1975	$27.00	$53,325.00
54	Import Pipe Embedment/Foundation Material	YD	1800	$28.75	$51,750.00
55	HDPE Mainline Pipe Fittings	LS	1	$38,000.00	$38,000.00
56	Air Vents	EA	20	$2,000.00	$40,000.00
57	Unpressurized Turnout (TO#1 and TO #2)	EA	2	$13,500.00	$27,000.00
58	Pressurized Turnout (TO#3 through TO#16)	EA	14	$13,500.00	$189,000.00
59	CO-347 Highway Crossing	LS	1	$25,000.00	$25,000.00
	West Lateral				
60	Mobilization	LS	1	$167,000.00	$167,000.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
61	Clearing, Grubbing, Rock Removal	FT	21060	$5.43	$114,313.68
62	Furnish 24" DR 32.5 HDPE	LF	12290	$47.52	$584,069.96
63	Install 24" DR 32.5 HDPE	LF	12290	$30.00	$368,700.00
64	Furnish 18" DR 32.5 HDPE	LF	7300	$26.74	$195,202.00
65	Install 18" DR 32.5 HDPE	LF	7300	$27.00	$197,100.00
66	Furnish 16" DR 32.5 HDPE	LF	1510	$21.12	$31,894.22
67	Install 16" DR 32.5 HDPE	LF	1510	$24.00	$36,240.00
68	Intake Structure	YD	25	$2,000.00	$50,000.00
69	Import Pipe Embedment/Foundation Material	YD	1200	$25.00	$30,000.00
70	HDPE Mainline Pipe Fittings	LS	1	$20,000.00	$20,000.00
71	Air Vents	EA	16	$1,500.00	$24,000.00
72	Pressurized Turnout (TO#5 through TO#17)	EA	16	$12,000.00	$192,000.00
73	Overflow Termination Structure	YD	4	$2,000.00	$8,000.00
74	Bostwick Park Road Crossing	LS	1	$5,000.00	$5,000.00
	M&D Canal				
75	Mobilization	LS	1	$351,000.00	$351,000.00
76	Dewatering System Rental	LS	1	$100,000.00	$100,000.00
77	Canal Excavation	CY	6834	$3.50	$23,919.00
78	Import Borrow Material	CY	17750	$65.00	$1,153,750.00
79	Place, Compact and Shape Top 6" of Finish Grade	CY	6204	$7.00	$43,428.00
80	Furnish and Install 30 mil PVC liner	SF	394979	$0.80	$315,983.20
81	Furnish and Install 12 oz Lower Layer Geotextile	SF	394979	$0.50	$197,489.50
82	Furnish and Install 10 oz Upper Layer Geotextile	SF	394979	$0.40	$157,991.60
83	Furnish and Apply 3" Shotcrete Lining	SY	43887	$25.00	$1,097,175.00
84	Excavation for Underdrain	CY	684	$12.00	$8,208.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
85	Furnish and Install Underdrain Geotextile	SF	61500	$0.40	$24,600.00
86	Furnish and Install Underdrain Perforated Pipe (6")	LF	8200	$9.00	$73,800.00
87	Earthwork for Hill Stabilization	CY	200000	$3.50	$700,000.00
	Temperature Sensor Installation				
88	Temperature Sensor	EA	1	$2,000.00	$2,000.00
89	Building	EA	1	$4,000.00	$4,000.00
90	Installation	EA	1	$8,000.00	$8,000.00
	Construction Subtotal				$18,486,214.44
	Construction Contingency	15%			$2,772,932.17
	Construction Total				$21,259,146.61
	Design (8%)	8%			$1,478,120.00
	Construction Engineering (8%)	8%			$1,478,120.00
	Project Administration (NRCS)	4%			$739,448.58
	Project Administration (Sponsor)	LS	1	$11,000.00	$11,000.00
	Permitting (Sponsor)	LS	1	$212,500.00	$212,500.00
	Total Agriculture Water Management				$25,178,335.18

The estimated cost for Alternative 2 is $39,772,629.91. This estimate is divided between Agricultural Water Management project elements (Table D-11). The unit costs used in the estimates for Alternative 2 were based on bids from similar projects in the region, when available.

Table D-11. Estimated Cost for Agricultural Water Management Project Elements (Alternative 2)

Item No.	Description	Unit	Quantity	Unit Cost	Total
	Wells Basin				
1	Mobilization	LS	1	$329,000.00	$329,000.00
2	Remove and Dispose of Steel Wasteway	LS	1	$5,000.00	$5,000.00
3	New Concrete Structure Wasteway Poured in Place	CY	18.2	$2,000.00	$36,400.00
4	63" C-10 Canal Gates for Wasteway	EA	2	$15,000.00	$30,000.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
5	Inlet Structure	EA	1	$35,000.00	$35,000.00
6	Furnish 63" SDR 41 HDPE	LF	8590	$262.10	$2,251,439.00
7	Install 63" SDR 41 HDPE	LF	8590	$110.25	$947,047.50
8	Outlet Structure	EA	1	$35,000.00	$35,000.00
9	3/4" Crushed Rock to Bed Pipe to 70% of Pipe Dia	TON	5011	$40.00	$200,440.00
10	HDPE Mainline Pipe Fittings	EA	22	$5,000.00	$110,000.00
11	Air Vents	EA	8	$2,000.00	$16,000.00
12	P77 Road Crossing	LS	1	$50,000.00	$50,000.00
13	End of Pipeline Riprap	LS	1	$10,000.00	$10,000.00
	Coal Hill				
14	Mobilization	LS	1	$230,000.00	$230,000.00
15	Removal and Reconstruction of 10" Turnout	LS	1	$10,000.00	$10,000.00
16	Inlet Structure Modification	EA	1	$20,000.00	$20,000.00
17	Furnish 63" SDR 41 HDPE	LF	6180	$262.10	$1,619,778.00
18	Install 63" SDR 41 HDPE	LF	6180	$110.25	$681,345.00
19	Outlet Structure Headwall	EA	1	$20,000.00	$20,000.00
20	3/4" Crushed Rock to Bed Pipe to 70% of Pipe Dia	TON	3605	$40.00	$144,200.00
21	HDPE Mainline Pipe Fittings	EA	6	$5,000.00	$30,000.00
22	Air Vents	EA	6	$2,000.00	$12,000.00
23	Turnout	EA	1	$13,500.00	$13,500.00
24	End of Pipeline Riprap	LS	1	$10,000.00	$10,000.00
	Slide Point				
25	Mobilization	LS	1	$161,000.00	$161,000.00
26	Remove and Dispose of 48" Steel Pipe	LF	1438	$58.20	$83,691.60
27	Remove and Dispose of Steel Inlet Structure	LBS	5496	$0.90	$4,946.40
28	Remove and Dispose of Steel Inlet Structure	CY	5.92	$1,000.00	$5,920.00
29	Replacement of Inlet Structure	EA	1	$40,000.00	$40,000.00
30	Furnish 54" SDR 32.5 HDPE	LF	2800	$241.11	$675,108.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
31	Install 54" SDR 32.5 HDPE	LF	2800	$94.50	$264,600.00
32	Furnish 48" SDR 32.5 HDPE	LF	2078	$190.47	$395,796.66
33	Install 48" SDR 32.5 HDPE	LF	2078	$72.00	$149,616.00
34	Outlet Structure	EA	1	$15,000.00	$15,000.00
35	3/4" Crushed Rock to Bed Pipe to 70% of Pipe Dia	TON	2913	$40.00	$116,520.00
36	HDPE Mainline Pipe Fittings	EA	7	$5,000.00	$35,000.00
37	Air Vents	EA	5	$2,000.00	$10,000.00
38	End of Pipeline Riprap	LS	1	$10,000.00	$10,000.00
	East Lateral				
39	Mobilization	LS	1	$280,000.00	$280,000.00
40	Clearing, Grubbing, Rock Removal	FT	22475	$5.43	$121,994.30
41	Trash Screen Structure	CY	20	$2,300.00	$46,000.00
42	Screen/Split/Spill Structure	LS	1	$200,000.00	$200,000.00
43	Hydraulic Spill Structure	CY	25	$2,000.00	$50,000.00
44	Furnish 36" DR 32.5 HDPE	LF	1160	$107.16	$124,307.92
45	Install 36" DR 32.5 HDPE	LF	1160	$45.00	$52,200.00
46	Furnish 30" DR 32.5 HDPE	LF	14250	$74.39	$1,060,086.00
47	Install 30" DR 32.5 HDPE	LF	14250	$37.50	$534,375.00
48	Furnish 24" DR 32.5 HDPE	LF	2100	$47.52	$99,800.40
49	Install 24" DR 32.5 HDPE	LF	2100	$30.00	$63,000.00
50	Furnish 24" DR 26 HDPE	LF	3000	$58.90	$176,712.00
51	Install 24" DR 26 HDPE	LF	3000	$30.00	$90,000.00
52	Furnish 18" DR 26 HDPE	LF	1975	$33.14	$65,451.50
53	Install 18" DR 26 HDPE	LF	1975	$27.00	$53,325.00
54	Import Pipe Embedment/Foundation Material	YD	1800	$28.75	$51,750.00
55	HDPE Mainline Pipe Fittings	LS	1	$38,000.00	$38,000.00
56	Air Vents	EA	20	$2,000.00	$40,000.00
57	Unpressurized Turnout (TO#1 and TO #2)	EA	2	$13,500.00	$27,000.00
58	Pressurized Turnout (TO#3 through TO#16)	EA	14	$13,500.00	$189,000.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
59	CO-347 Highway Crossing	LS	1	$25,000.00	$25,000.00
	West Lateral				
60	Mobilization	LS	1	$167,000.00	$167,000.00
61	Clearing, Grubbing, Rock Removal	FT	21060	$5.43	$114,313.68
62	Furnish 24" DR 32.5 HDPE	LF	12290	$47.52	$584,069.96
63	Install 24" DR 32.5 HDPE	LF	12290	$30.00	$368,700.00
64	Furnish 18" DR 32.5 HDPE	LF	7300	$26.74	$195,202.00
65	Install 18" DR 32.5 HDPE	LF	7300	$27.00	$197,100.00
66	Furnish 16" DR 32.5 HDPE	LF	1510	$21.12	$31,894.22
67	Install 16" DR 32.5 HDPE	LF	1510	$24.00	$36,240.00
68	Intake Structure	YD	25	$2,000.00	$50,000.00
69	Import Pipe Embedment/Foundation Material	YD	1200	$25.00	$30,000.00
70	HDPE Mainline Pipe Fittings	LS	1	$20,000.00	$20,000.00
71	Air Vents	EA	16	$1,500.00	$24,000.00
72	Pressurized Turnout (TO#5 through TO#17)	EA	16	$12,000.00	$192,000.00
73	Overflow Termination Structure	YD	4	$2,000.00	$8,000.00
74	Bostwick Park Road Crossing	LS	1	$5,000.00	$5,000.00
	M&D Canal				
75	Mobilization	LS	1	$1,243,000.00	$1,243,000.00
76	Inlet Structure (2x) Outlet Structure (x2)	EA	2	$45,000.00	$90,000.00
77	120" RSC160 Profile Wall HDPE Pipe Double Barrel	LF	16400	$539.09	$8,841,076.00
78	Install 120" Pipe Double Barrel	LF	16400	$210.00	$3,444,000.00
79	3/4" Crushed Rock to Bed Pipelines to Spring Line	TON	35990	$40.00	$1,439,600.00
	Temperature Sensor Installation				
80	Temperature Sensor	EA	1	$2,000.00	$2,000.00
81	Building	EA	1	$4,000.00	$4,000.00

Item No.	Description	Unit	Quantity	Unit Cost	Total
82	Installation	EA	1	$8,000.00	$8,000.00
	Construction Subtotal				$29,296,546.14
	Construction Contingency	15%			$4,394,481.92
	Construction Total				$33,691,028.06
	Design (8%)	8%			$2,343,120.00
	Construction Engineering (8%)	8%			$2,343,120.00
	Project Administration (NRCS)	4%			$1,171,861.85
	Project Administration (Sponsor)	LS	1	$11,000.00	$11,000.00
	Permitting	LS	1	$212,500.00	$212,500.00
	Total Agriculture Water Management				$39,772,629.91

Table D-12 identifies other direct costs for the action alternatives, which include O&M costs. Once the structures are built, overheads for O&M will be required for the structures to continue generating the benefits for which they were designed. BBC Research & Consulting (BBC) estimated that O&M costs were about 0.75% of each structure's construction costs, with the exceptions of Wells Basin, Coal Hill, and Slide Point, which use a multiplier of 0.18% to reflect their simpler design. Estimated annual O&M costs for each structure are shown in Table D-12, below.

Table D-12. Estimated Annual Operations and Maintenance Costs for Structures Included in the Action Alternatives (2022 Dollars)

Alternative(s)	Name	Construction Cost	Annual O&M Costs
Alternatives 1 and 2	Wells Basin Piping Project	$5,522,089	$9,940
Alternatives 1 and 2	Coal Hill Piping Project	$3,800,829	$6,841
Alternatives 1 and 2	Slide Point Piping Project	$2,679,216	$4,823
Alternatives 1 and 2	East Lateral Piping Project	$4,614,373	$34,608
Alternatives 1 and 2	West Lateral Piping Project	$2,756,939	$20,677
Alternative 1	M&D Canal Lining and Hill Stabilization Project (Lining)	$5,783,990	$43,380

Alternative(s)	Name	Construction Cost	Annual O&M Costs
Alternative 2	M&D Canal Lining and Hill Stabilization Project (Piping)	$20,378,284	$152,837
Alternatives 1 and 2	Cimarron River Temperature Monitoring System	$20,900	$357[1]
Total – Alternative 1		**$25,178,335**	**$120,626**
Total – Alternative 2		**$39,772,630**	**$230,083**

Note: 1. The temperature monitoring system has a design life and must be replaced after 50 years at a cost of $10,000. The cost of the replacement is factored into the analysis on an annual basis. Annual O&M costs are assumed to equal 0.75% of structure construction costs, with the exceptions of Wells Basin, Coal Hill, and Slide Point projects, which use a multiplier of 0.18% based on feedback from the project sponsors. Construction costs reflect materials and labor only. Numbers may not sum to totals due to rounding.

D.5 Economic Evaluation

An Economic Report was prepared by BBC to evaluate the benefits and costs of two potential action alternatives – Alternative 1 (BPWCD's preferred alternative) and Alternative 2. The information in the following sections was obtained from the Economic Report prepared by BBC, which is also included as a separate report in Appendix E.

Both action alternatives considered include six measures intended to improve agricultural water management and reduce the risk of breaches in the irrigation distribution system and one measure intended to improve the quality of fish habitat and recreational fishing in the Cimarron River. The proposed measures are evaluated in conformance with the Principles, Requirements and Guidelines (PR&G) for federal investments in water resource projects for watershed projects (USDA 2017).

Specifically, the economic evaluation uses an ecosystem services framework to consider the benefits and costs of the action alternatives. Those benefits and costs are compared against a baseline of no action, which is also referred to as the Future Without Federal Investment (FWOFI).

The National Economic Efficiency Benefit-Cost Analysis (NEE BCA) conducted as part of the economic evaluation uses federal water resource project and Natural Resources Conservation Service (NRCS) guidelines for the evaluation of benefits and costs of the no action and action alternatives, relying primarily on the PR&G (USDA 2017), the NRCS Natural Resources Economics Handbook (NRCS 1998), and the National Watershed Program Manual (NRCS 2014b).

D.5.1 Ecosystem Services

As described by BBC, the PR&G requires benefits and costs to be evaluated in an ecosystem service framework. An ecosystem is a natural unit of living and non-living things that function

together to create goods and services valued by people (Olander et al. 2016). Ecosystem services is a broad term used to describe the benefits humanity receives from ecosystems as a byproduct of their functioning.

BBC states that by putting nature at the center, ecosystem service frameworks give economic, social, and environmental costs and benefits equal standing in decision making processes and therefore help to accomplish the federal objective of maximizing NEE, helping to ensure federal investments protect and restore ecosystem functions and values and avoid irreversible impacts (USDA 2017). Economic efficiency requires that resources are used in their highest valued use. Projects that create more benefits than costs utilize resources more efficiently than baseline conditions and therefore increase NEE. The ecosystem framework used in the economic report is shown in Table D-13.

Table D-13. Ecosystem Service Framework Used to Evaluate Benefits and Costs

Service Type	Examples
Provisioning	The supply of food, fuel, fiber, water, timber, genetic resources, etc.
Regulating	The regulation of air, climate, natural hazards, water quality, pests, and disease
Cultural	Services that enhance cultural values, like aesthetics, recreation, tourism, and spiritual or religious values
Supporting	Nutrient cycling, soil formation, and primary production

Source: USDA 2017

As Table D-13 shows, ecosystem services can be placed into one of four categories. Provisioning services supply goods that directly benefit people. The production of crops, fuel, water, timber, and other raw materials are all provisioning services. Regulating services describe the benefits people receive from an ecosystem's ability to regulate things like air quality, climate, and hazards, both natural and humanmade. Cultural services describe the benefits people derive from an ecosystem's ability to provide a good view, a recreation opportunity, a place to travel and visit, or spiritual or religious values. Table D-14 provides a summary of the ecosystem services quantified and valued as part of the NEE analysis. Ecosystem services values are reported in average annualized values (AAV).

Table D-14. Summary of Project Alternatives and Associated Ecosystem Services

	Alternatives		
	FWOFI	**Alternative 1**	**Alternative 2**
Alternatives			
Locally Preferred	The FWOFI would maintain the existing conditions and would not improve agricultural infrastructure.	Alternative 1 is locally preferred as the community in the project area is agriculturally focused; therefore, agricultural	Although Alternative 2 would provide similar agricultural infrastructure improvements as Alternative 1,

	Alternatives		
	FWOFI	**Alternative 1**	**Alternative 2**
		infrastructure improvements would provide the greatest benefit to the community. Alternative 1 would optimize water delivery against costs. No public comments were received during the scoping period.	Alternative 2 is not the locally preferred alternative due to the high cost of piping the M&D Canal and hydraulic considerations. Piping the M&D Canal under Alternative 2 would decrease hydraulic energy available at the downstream end of the project and could result in reduced water delivery to water users downstream of the project. No public comments were received during the scoping period.
Non-structural	The FWOFI is the non-structural alternative. The FWOFI would maintain the existing conditions and would not implement structural changes.	Alternative 1 would implement structural changes.	Alternative 2 would implement structural changes.
Environmentally Preferable	The FWOFI would maintain existing conditions in the project area. Water would continue to be lost to seepage and evaporation and salinity and selenium loading would continue to occur.	Alternative 1 is the environmentally preferred alternative. Alternative 1 would improve agricultural water delivery, conserve water, improve water quality, and would not result in significant impacts to human health or the environment.	Alternative 2 would improve agricultural water delivery, conserve water, improve water quality, and would not result in significant impacts to human health or the environment. However, Alternative 2 would result in the loss of M&D Canal as an open water feature. Therefore, Alternative 2 is

	Alternatives		
	FWOFI	**Alternative 1**	**Alternative 2**
			somewhat less favorable than Alternative 1 from an environmental perspective.
National Economic Efficiency	The FWOFI would require no project investment.	Alternative 1 would require an investment of $25,178,335, provide $1,118,366 in net benefits, representing a benefit to cost ratio of 1.5.	Alternative 2 is not the National Economic Efficiency Alternative, as Alternative 2 would require an investment of $39,772,630, provide $1,124,368 in net benefits, representing a benefit to cost ratio of 0.9.
Total Project Investment	**$-**	**$25,178,335**	**$39,772,630**
Monetized Net Benefits (AAV)	**$-**	**$1,118,368**	**$1,124,071**
Regulating Services (AAV)			
Reduced infrastructure damages	$-	$84,674	$84,674
Reduced income loss	$-	$439,745	$439,745
Reduced downstream damages	$-	$441,817	$447,520
Provisioning Services (AAV)			
Increased agricultural income	$-	$144,806	$144,806
Riparian vegetation		Reduction of 82 acres	Reduction of 82 acres
Water access for wildlife		Loss of a water source	Loss of a water source
Wetlands		Possible adverse impacts to 5.69 acres of existing wetlands; No mitigation anticipated	Possible adverse impacts to 5.69 acres of existing wetlands; No mitigation anticipated
Cultural Services (AAV)			
Increased recreation benefits	$-	$7,326	$7,326

Note: The benefits of the Action Alternatives are calculated as the additional value that would be created because of the proposed actions. The benefits of the Action Alternatives are not estimates of total damages under the FWOFI and proposed conditions.

D.5.2 Economic Benefits

Section D.5.2 considers the impact of each component separately, beginning with the most beneficial component and ending with the least beneficial component, as part of the incremental analysis (390-NWPH, Part 606, Subpart B, Section 606.20).

D.5.2.1 Reduced Costs for Emergency Repairs and Agricultural Income Losses Due to Canal Breaches

Reduced costs for breaches of Bostwick Park and UVWUA canals were estimated by BBC based on the historical experience of the system and the number of acres, by crop type, that would lose their irrigation supply due to such breaches in the system. Table D-15 describes the annual costs for emergency repairs to the BPWCD and UVWUA systems. The methodology for estimating the reduced emergency repair costs is described in detail in the Economic Report found in Appendix E.

Table D-15. Annual Costs for Emergency Repairs to Bostwick Park and UVWUA Irrigation Distribution Systems

Canal/Component	Emergency Repair Cost	Annual Probability	Annual Cost
Cimarron Canal – Wells Basin	$471,336	5.8%	$27,337
Cimarron Canal – Coal Hill	$471,336	5.8%	$27,337
Vernal Mesa Canal – Slide Point	$435,600	3.5%	$15,284
M&D Canal	$623,170	2.7%	$16,842
Total	**$2,001,441**		**$86,800**

Source: J-U-B ENGINEERS 2022

Table D-16 illustrates the annual agricultural income losses from failures of the BPWCD and UVWUA systems. The methodology for estimating the annual agricultural income losses is described in detail in the Economic Report found in Appendix E.

Table D-16. Probable Annual Income Losses from Failures of Bostwick Park and UVWUA Irrigation Distribution System Components

Canal/ Component	Estimated Acreage Lost to Production	Primary Crops	Income/ acre		Annual Damage Probability	Probable Annual Income Loss	
			Gross	Net		Gross	Net
Cimarron Canal – Wells Basin	8,439	Grass Hay	$455	$284	5.8%	$222,705	$139,007
Cimarron Canal – Coal Hill	8,439	Grass Hay	$455	$284	5.8%	$222,705	$139,007
Vernal Mesa Canal – Slide Point	3,411	Grass Hay	$455	$284	3.5%	$54,320	$33,905

Canal/ Component	Estimated Acreage Lost to Production	Primary Crops	Income/ acre		Annual Damage Probability	Probable Annual Income Loss	
			Gross	Net		Gross	Net
M&D Canal	20,349	Grass Hay, Corn & Alfalfa	$571	$253	2.7%	$313,721	$139,004
Total	**40,638**					**$813,451**	**$450,923**

Note: Annual benefits are reported as the values received in one year. They differ from the values reported in the economic structural tables shown in the watershed plan, which have been discounted over the time horizon of the benefit cost analysis, summed, and amortized.
Source: J-U-B ENGINEERS, Inc. 2022; BBC Research & Consulting 2020; and BLS Consumer Price Index Calculator May 2022

Table D-17. Average Annual Damages Under Existing Conditions, Cimarron River & Lower Uncompahgre Watershed Project, Colorado (2022 Dollars)

Alternative			Average Annual Damages
	Repairs	Crop Yield Damages	Total
FWOFI	$86,800	$450,923	$537,723
Total	**$86,800**	**$450,923**	**$537,723**

Source: J-U-B ENGINEERS 2022 and BBC Research & Consulting 2022

D.5.2.2 Reduced Salinity Control Costs

As described in the Economic Report prepared by BBC, the effects of salinity in the Colorado River system are a major concern in both the United States and Mexico. As of 2014, annual salinity damages were estimated to be about $382 million per year despite 1.2 million tons of annual salinity controls from programs sponsored by Reclamation and NRCS. NRCS began implementing salinity control projects in the Lower Gunnison Basin in 1988, including piping or lining irrigation ditches and small laterals and improving the on-farm irrigation systems. The Economic Report in Appendix E describes the approach for estimating the annual benefits from the salinity reductions that would result from the Proposed Project action alternatives. Table D-18 illustrates the annual benefits from the action alternative salinity reductions.

Table D-18. Annual Benefits from Bostwick Park Action Alternatives Salinity Reductions (2022 Dollars)

Project Component	Salinity Reduction (tons)	Reduced Costs of Control (Value per Ton)		Annual Benefit	
		Low	High	Low	High
Cimarron Canal - Wells Basin	NA*				

Project Component	Salinity Reduction (tons)	Reduced Costs of Control (Value per Ton)		Annual Benefit	
		Low	High	Low	High
Cimarron Canal - Coal Hill	NA*				
Vernal Mesa Canal - Slide Point	267	$202	$206	$53,820	$55,093
East Lateral Piping	786	$202	$206	$158,436	$162,183
West Lateral Piping	637	$202	$206	$128,402	$131,439
M&D Canal – Alternative 1	557	$202	$206	$112,276	$114,931
M&D Canal -- Alternative 2	586	$202	$206	$118,121	$120,915
Total Alternative 1	**2,247**			**$452,933**	**$463,646**
Total Alternative 2	**2,276**			**$458,779**	**$469,630**

Note: Annual benefits are reported as the values received in one year. They differ from the values reported in the economic structural tables shown in the watershed plan, which have been discounted over the time horizon of the benefit cost analysis, summed, and amortized.
Source: J-U-B ENGINEERS 2022; Quality of Water. Colorado River Basin. Progress Report No. 25. U.S. Bureau of Reclamation. 2017; Colorado River Salinity Control Program. State of Colorado Salinity Control Unit Summary. Fiscal Year 2020. NRCS. 2020.; and BLS Consumer Price Index Calculator, May 2022.
**Piping of the Cimarron Canal will likely reduce salinity in the Colorado River System. Salinity impacts from the Cimarron Canal, however, have not been published by Reclamation and are therefore not included in this analysis.*

D.5.2.3 Recreation Benefits from Regulation of Stream Temperature

Under either of the two action alternatives, a temperature sensor would be installed to monitor water temperatures as an indicator of fish habitat conditions to best utilize water conserved in the Bostwick Park/Cimarron Canal system through reduced seepage. By timing releases of the conserved water to help lower high summer temperatures, habitat in the Cimarron River would be improved and the chance of fishing success would increase for recreational visitors. While improved fishing quality could result in an increase in the number of visitors to the recreation facilities near Silver Jack Reservoir, that effect is uncertain and difficult to quantify. However, the value of the recreation experience, measured in terms of consumer surplus, is likely to increase. Consumer surplus is defined as the economic value of a recreation activity above what must be paid by the recreationist to enjoy the activity.

The BBC Economic Report (Appendix E) explains that the U.S. Army Corps of Engineers (USACE) unit-day values, which measure the consumer surplus recreationists receive from participating in an activity for a period of one day, were used to value the recreational experience under existing conditions and with improved fishing quality (USACE 2021). The NRCS urges caution when using the USACE values because they have been found to systematically undercount recreation benefits (NRCS n.d.). The travel cost method is an alternative way of estimating changes in recreation values, but no existing data were available to implement the method, and collecting new data was beyond the scope and budget for this effort. Still, the USACE values can provide a conservative, lower-bound estimate of the impacts on recreation values. Moreover, if recreation benefits estimated with the USACE values outweigh the project costs, it provides a strong indicator that realized impacts on recreation values would be likely to exceed estimates.

The USACE unit-day method provides a range of daily recreation values for general and specialized recreation that range from $4.50 to $53.46 in 2022 dollars (Table D-19). General recreation refers to recreation activities that are accessible to the majority of a site's visitors without any specialized planning, equipment, or skills. General recreation often refers to activities like hiking, swimming, boating, picnicking, and fishing. Specialized recreation, in contrast, refers to activities where participation is limited by requiring some combination of special facilities, equipment, and skill. More specialized versions of fishing, boating, hunting, and similar activities are included in the USACE definition of specialized recreation (USACE 2021).

The exact amount used to value recreation user days relies on the evaluation of the type of recreation experience and the quality of experience available at a site. Sites are evaluated based on the number of recreation activities available, the number of alternative sites nearby, and the site's carrying capacity, accessibility, and environmental quality. Each criterion is associated with a score range. Once each criterion has been evaluated, the scores are added, and the point total is used to select a daily use value that is applied to the number of annual recreation user days to estimate the total consumer surplus of recreational visitors.

Table D-19. User Day Values for General and Specialized Recreation Based on Site Point Values (2022 Dollars)

Site Point Values	General Recreation Values	Specialized Fishing and Hunting Values
0	$4.50	$31.51
10	$5.35	$32.35
20	$5.91	$32.92
30	$6.75	$33.76
40	$8.44	$34.61
50	$9.57	$37.98
60	$10.41	$41.36
70	$10.97	$43.89
80	$12.10	$47.27
90	$12.94	$50.64
100	$13.50	$53.46

Source: USACE 2021

The Economic Report by BBC (Appendix E) explains that based on the definitions of the five components of the USACE's recreation value system and the characteristics of the Bostwick Park recreation facilities on Cimarron River, the current site point value is conservatively estimated to be about 54 out of 100 possible points. Each additional point of value is worth

about $0.34 per person, per day[1]. The last known annual visitor count for the facilities close to Silver Jack Reservoir dates back to 1992, when 22,000 visits occurred. Assuming no increase in visitation in the last 30 years and a one-point increase in recreation value from 54 to 55 points resulting from advantageous timing of releases using the temperature monitoring system that would be installed under the action alternatives, the annual benefit of a one-point increase in the specialized recreation value of the Gold Medal fishery would be $7,500 per year[2].

D.5.2.4 Additional Agricultural Income from Use of Conserved Water

Piping or lining the canals in the Bostwick Park and UVWUA irrigation distribution system is expected to save substantial amounts of water that are currently lost to leakage and seepage. In total, more than 2,600 acre-feet per year are projected to be saved and to become available to provide additional irrigation.

The economic benefit of additional irrigation supplies depends on total yield of crops grown with the water, and the financial characteristics of crop production in the area. The additional water could be used to bring new areas under cultivation or to add additional water to existing areas currently using deficit irrigation. However, this analysis models the economic benefit of the additional irrigation water assuming it is applied to fields under deficit irrigation, where it would generate marginal income. The methodology used to determine the acres that could be irrigated, the crops likely grown on those lands, and the financial characteristics of crop production are detailed in the Economic Report prepared by BBC (Appendix E). Table D-20 illustrates the estimated agricultural income generated from the use of conserved water.

Table D-20. Estimated Agricultural Income Generated from Use of Conserved Water from the Action Alternatives

Canal/ Project	Conserved Water (AFY)	Net Income Per AF	Annual Income Benefit
			Net Income
Cimarron Canal – Wells Basin	530.4	$56.15	$29,782
Cimarron Canal – Coal Hill	137.4	$56.15	$7,715
Vernal Mesa Canal – Slide Point	121.2	$56.15	

[1] The unit-day value of 50 points is $37.98 and the unit-day value of 60 points is $41.36. The difference between the points is $3.38, meaning each additional point is worth $3.38/10 = $0.34.
[2] Annual benefits are reported as the values received in one year. They differ from the values reported in the economic structural tables shown in the watershed plan, which have been discounted over the time horizon of the benefit cost analysis, summed, and amortized.

Canal/ Project	Conserved Water (AFY)	Net Income Per AF	Annual Income Benefit
			Net Income
			$6,805
East Lateral	475.3	$56.15	$26,688
West Lateral	239.0	$56.15	$13,420
M&D Canal Lining	1,195.0	$56.15	$67,099
Total	**2,698**		**$151,493**

D.5.3 Benefit Cost Ratio

Benefits and costs were calculated based on the expected effects of the action alternatives on the ecosystem services shown in Table D-13 as compared against the FWOFI or No Action Alternative. The NEE analysis evaluated the costs of the action alternatives based on cost estimates from J-U-B ENGINEERS, Inc. (J-U-B), which included costs for property, permitting, engineering, construction, administration, and O&M of proposed improvements to the irrigation delivery systems (see Section D.4). These were compared against benefits received by regulating costs associated with breaches to the system, salinity loading to the river and adverse impacts on local trout habitat due to high temperatures.

Effects of both action alternatives were evaluated over a 102-year time horizon including the two-years required to complete installation. This analysis period is equal to the length of time over which the structures are expected to have significant beneficial effects. Benefits are expected to begin accruing the year after the improvements included in the action alternatives are installed and continue to accrue until the end of the 102-year time horizon. Since most of the project elements have design lives of 100-years, replacement costs were only included in the analysis for project elements with design lives less than 100 years (PR&G Section 9, NWPM 501.37.B and the Economics Handbook, Part 611, 1.12.). The temperature sensor included in the action alternatives has a design life of 50 years. As a result, its replacement cost was included in the analysis. Should installation take longer, the project costs and benefits would be discounted by an additional year. While this would change the results, the conclusions would still hold.

The NEE analysis used this information to quantify and value the benefits and costs associated with the action alternatives as discussed in more detail below.

Projected benefits and costs are based on a full employment economy and assume no change in relative prices during the period of analysis. Benefits and costs are discounted at the rate for federal projects of 2.25% for 2022 (NRCS 2022). Results are reported in both annual terms and as annualized averages in 2022 dollars.

The unit of analysis in this study is the system of projects combined under the action alternatives. For this study, costs and benefits are estimated jointly for all seven components of the action alternatives.

Table D-21. Estimated Average Annual NEE Costs, Cimarron River & Lower Uncompahgre Watershed Project, Colorado (2022 Dollars)

Action Alternative Component	Project Outlays (Amortization of Installation Cost)	Other Direct Costs[2]	Total Cost	Adverse Effects
Wells Basin Piping	$136,235	$9,695	$145,930	82-acre reduction in habitat supporting riparian vegetation; A source of water for wildlife is removed
Coal Hill Piping	$93,770	$6,673	$100,443	
Slide Point Piping	$66,099	$4,823	$70,922	
East Lateral Piping	$113,840	$33,754	$147,594	
West Lateral Piping	$68,016	$20,167	$88,183	
M&D Canal Lining and Hill Stabilization (Alternative 1)	$142,696	$42,310	$185,006	
M&D Canal Lining and Hill Stabilization (Alternative 2)	$502,749	$149,067	$651,816	
Temperature Sensor	$516	$348	$864	
Total (Alternative 1)	**$621,172**	**$117,770**	**$738,942**	**-82 acres of riparian habitat; Reduction in water sources for wildlife**
Total (Alternative 2)	**$981,225**	**$224,527**	**$1,205,752**	

Note: Totals may not sum due to rounding. Prepared December 2022.
1. Price base: 2022 dollars. Other direct costs have been discounted using a discount rate of 2.25% and annualized over a 100-year time period relative to their values as shown in Table D-17.
2. Other direct costs include annual operations and maintenance associated with installation, operation or replacement of project structures.

The impact of the action alternatives on ecosystem flows and values is shown in Table D-22, below. The action alternatives would positively impact regulating services in the watershed by reducing costs of catastrophic repairs, reducing farm income losses due to failures in the irrigation distribution system, and reducing costs from salinity in the Gunnison River basin and the Colorado River basin. Salinity reductions are the largest single benefit of the action alternatives, closely followed by reduced losses in farm and ranch net income. In total,

Alternative 1 would create average annual gross benefits of approximately $1,118,366 per year. Alternative 2 would create slightly larger annual gross benefits of about $1,124,368 per year.

These are “conservative” estimates of the benefits from the action alternatives for several reasons. Benefits from reducing crop losses due to canal breaches and from additional crop production using conserved water supplies were estimated on a net income rather than gross income basis, though it could be argued that a large portion of the variable costs that are excluded in the net income calculations would be spent locally and would benefit the regional economy. The calculation of net income from the use of conserved water also assumes a relatively low irrigation efficiency of about 38% between the locations where the water is conserved and the consumptive use by the crops. The benefits of salinity reductions were estimated based on the reduced cost of salinity control measures, rather than the greater benefit of reduced salinity damages to downstream users. Finally, the estimated benefit of additional consumer surplus for recreational users was based on an annual visitation count that is now 30 years old and likely underestimates current visitation given population growth in the region and across Colorado since 1992.

Using the resulting benefits and costs from the previous two tables, Table D-22 (NWPM 506.21, Economic Table 6, NRCS 2014b) presents a comparison of the NEE average annual benefits and average annual costs for the action alternatives. In total, BPWCD’s preferred alternative (Alternative 1) will generate average annual benefits of $1,118,366 compared to average annual costs of $738,942, for a benefit-cost ratio of 1.5. Action Alternative 2 would generate slightly larger annual benefits of $1,124,071 at a substantially higher annual cost of $1,205,752, for a benefit-cost ratio of 0.9.

Table D-22. Economic Table 6 - Comparison of Average Annual NEE Costs, Reduced Damages and Benefits, Cimarron River & Lower Uncompahgre Watershed Project, Colorado (2022 Dollars)

	Agriculture-related			Non-agriculture Related		Average Annual Benefits		
Works of Improvement	Reduced Property Loss, Critical Facility Loss, and Income Loss	Reduced Crop Yield Damages	Increased Water Supply	Reduced Salinity Control Costs	Increased Recreation Consumer Surplus	Total	Average Annual Cost	Benefit Cost Ratio
Wells Basin Piping	$26,672	$135,553	$28,022			$190,247	$145,930	1.3
Coal Hill Piping	$26,672	$135,553	$7,281			$169,506	$100,443	1.7
Slide Point Piping	$14,903	$33,049	$6,400	$51,693		$106,045	$70,922	1.5
East Lateral Piping			$25,110	$153,310		$178,420	$147,594	1.2
West Lateral Piping			$12,624	$124,151		$136,775	$88,183	1.6
M&D Canal Lining and Hill Stabilization	$16,427	$135,590	$65,367	$112,663		$190,247	$185,006	1.3

Works of Improvement	Agriculture-related			Non-agriculture Related		Average Annual Benefits	Average Annual Cost	Benefit Cost Ratio
	Reduced Property Loss, Critical Facility Loss, and Income Loss	Reduced Crop Yield Damages	Increased Water Supply	Reduced Salinity Control Costs	Increased Recreation Consumer Surplus	Total		
(Alternative 1)								
M&D Canal Lining and Hill Stabilization (Alternative 2)	$16,427	$135,590	$65,367	$118,366		$335,750	$651,816	0.5
Temperature Sensor					$7,326	$7,326	$864	8.5
Total (Alternative 1)	**$84,674**	**$439,745**	**$144,806**	**$441,817**	**$7,326**	**$1,118,368**	**$738,942**	**1.5**
Total (Alternative 2)	**$84,674**	**$439,745**	**$144,806**	**$447,520**	**$7,326**	**$1,124,368**	**$1,205,752**	**0.9**

Note: Totals may not sum due to rounding. Prepared: December 2022. The values presented here may differ from the benefit values presented in Section 5.2 due to the fact that the values from Section 5.2 were discounted at a rate of 2.25 percent, projected over the analysis period of 102-years, summed, and amortized so they could be reported in terms of annualized averages.
1. Price base: 2022 dollars

D.6 Sources

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