Appendix D

Investigation and Analyses Report

Some documents included in this are provided as they were originally produced and may not fully comply with Section 508 of the Rehabilitation Act. These materials include third-party reports, historical documents, maps, and technical drawings that cannot be readily converted into accessible formats.

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D.1 National Economic Development Analysis

National Economic Development Analysis

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1. Introduction

This appendix provides a National Economic Development (NED) analysis that evaluates the costs and benefits of the Modernization Alternatives over the Future Without Federal Investment (No Action) Alternative for the Central Oregon Irrigation District (COID, hereafter also referred to as "District") Environmental Impact Statement (EIS) Infrastructure Modernization Project (herein referred to as the "Project"). The analysis uses Natural Resources Conservation Service (NRCS) guidelines for evaluating NED benefits as outlined in the NRCS Natural Resources Economics Handbook and the U.S. Department of Agriculture's (USDA) Guidance for Conducting Analyses Under the Principles, Requirements, and Guidelines (PR&Gs) for Water and Land Related Resources Implementation Studies and Federal Water Resource Investments (DM 9500-013).

The Modernization Alternatives represent the future with federal funding through Pub. L. No. 83-566. The Future Without Federal Investment (No Action) Alternative represents the future if the District does not receive federal funding through Pub. L. No. 83-566 and continues operations and maintenance activities with current infrastructure.

This NED analysis is divided into two sections. The first section provides a general overview of the project location, baseline condition and challenges, purpose and need, Action Alternatives, and analysis parameters. The second section discusses the costs and benefits under the Modernization Alternative compared to the Future Without Federal Investment (No Action) Alternative.

All economic benefits and costs are provided in 2025 dollars and have been discounted to present value and then amortized over the evaluation period (100 years) to average annual values using the fiscal year 2025 federal water resources planning rate of 3 percent.

1.1. Project Location

The Pilot Butte Canal is an irrigation canal that runs for more than 18 miles through the Central Oregon counties of Deschutes and Jefferson. The Pilot Butte Canal stretches from the Deschutes River on the northern part of Bend to the northeast of Redmond. The planning area consists of the canal itself and its immediate surroundings. NUID is also considered in the planning area, since it would benefit from water conserved by the Project. NUID is located north of the Project area and supplies irrigation water to nearly 59,000 acres in Jefferson County.

1.2. Baseline Conditions and Challenges

COID is one of several irrigation districts in Central Oregon. The District delivers water to roughly 45,000 acres that lie within a 180,000-acre area across Deschutes and Jefferson counties. COID maintains more than 700 miles of canals, including the Pilot Butte Canal (the focus of Project construction) that runs through the population centers of Bend, Redmond, and Terrebonne.

The District's water supply comes from live flow in the Deschutes River and supplemental storage in Crane Prairie Reservoir. The lands served by COID typically receive less than 12 inches of precipitation per year, and most of that is in the non-irrigation season. Most crops grown in the area require at least 18 inches of water for their evapotranspiration needs in an average year (some require over 30 inches), making water for irrigation a critical resource to growers. In addition to irrigators, water in the Deschutes Basin supports other economic activities and fish and wildlife habitat, which provide economic, cultural, recreational, and environmental value to local residents, Tribes, and visitors.

Water in the Deschutes Basin supports fish and wildlife species, including the Oregon Spotted Frog (OSF), a species that is classified as endangered in Washington and Canada and threatened in Oregon. To protect the habitat of OSF and other species, a habitat conservation plan (HCP) was finalized for the Deschutes Basin in late 2020. The HCP changes management of Crane Prairie Reservoir and increases wintertime releases of water from the Reservoir. This reduces the amount of stored water available for Central Oregon irrigation districts and their patrons. On top of this, in recent years, the Basin has experienced numerous years of drought conditions which have also reduced the amount of water available to Central Oregon irrigators. Forecasts of future climate conditions in the Basin predict less snowpack in the winter and drier and hotter conditions in the winter, which would tend to increase irrigation water demand and decrease available irrigation water supply, increasing the likelihood and severity of irrigation water shortages.

HCP instream flow requirements and drought have particularly reduced irrigation water supplies in North Unit Irrigation District (NUID) as it has junior water rights. Consequently, due to the lack of sufficient water supply, in recent years there has been an increase in fallowed lands in NUID (see Figure D-1 on page 10). NUID has some of the most diversified and productive agricultural lands in the Basin and produces not only forage and grain crops but also mint, grass seed, and vegetable seed crops. The HCP instream flow requirements increase through 2033, further decreasing water supplies available to NUID and the associated value of agricultural production. Other Central Oregon irrigation districts (including COID) have agreed to pass their own conserved water (from Projects such as the Proposed Action Alternatives) through to NUID to reduce NUID shortages that could otherwise result from the HCP requirements and hydrological and climate changes in the basin.

1.1.1. Existing Conditions in the Study Area

COID faces several challenges along the Pilot Butte Canal. More than 18 miles of the Pilot Butte Canal consists of open canal, much of it constructed into porous basalt rock. The canal's high permeability results in substantial amounts of water seepage, which in combination with losses from evaporation, is estimated to total more than 45,000 acre-feet per year (see Section 2.2.1.1). Other water users in the Deschutes Basin (NUID, in particular) currently experience water shortages and could benefit from use of this water if the seepage and evaporation were avoided.

Irrigation water shortages are also a challenge in the study area. Currently, the HCP minimum winter instream flow requirement in the Deschutes River below Wickiup Reservoir is 100 cubic feet per second (cfs). This is mandated to increase to 300 cfs for years 8 through 12 of the HCP (2028–2032), and finally increases to 400 cfs at year 13, in 2033. As explained above, this requirement particularly impacts water available to NUID due to their junior water rights. From 2020 to 2023, due to water shortages, the average amount of land fallowed in NUID was 19,500 acres, up from an average of less than 4,000 acres from 2009 to 2015 (see Figure D-1 on page 10).

Maintaining the Pilot Butte Canal is costly to the District in terms of staff time, equipment, and materials (see Section 2.2.1.3). Sections of the Pilot Butte Canal run through the urban centers of Bend and Redmond, which increases the frequency of physical damage to the canal, which can lead to canal failures. Past canal failures have caused flood damages ranging from over $500,000 to more than $2.3 million (see Section 2.2.1.4.

1.1.2. Future Conditions in the Study Area

The problems associated with water lost to seepage, high maintenance costs, and canal failures are likely to get more severe in the future in the Future Without Federal Investment (No Action) Alternative. As the HCP instream flow requirements increase to 300 cfs in 2028 and to 400 cfs in 2033, the water available to Central Oregon irrigation districts (NUID, especially) will decrease. This will likely increase the amount of fallowed land in NUID and reduce crop production. The frequency and intensity of droughts is likely to increase as the global climate continues to change, which will further exacerbate future water shortages.

The cities of Bend and Redmond have grown steadily over the last 20 years, which has resulted in urban development near the canal. As mentioned above, the presence of urban activity increases the frequency of physical damage and obstruction to the canal (from debris, rodents, etc.) and public safety incidents (such as drownings or car accidents in the canal). Because Bend and Redmond are expected to continue growing in the coming decades, it is likely that development will continue to intensify along the Pilot Butte Canal, which is likely to further increase the frequency of public safety incidents and damage to the canal. Canal failures, such as overtopping due to debris blockages or canal bank breaks due to rodent burrowing, are likely to increase and may cause substantial damages if they occur in urban areas (see Section 2.2.1.4). The District plans to increase operations and maintenance (O&M) expenditures in the future in an effort to reduce the likelihood of these incidents, but even with higher O&M effort and costs, canal failures are still expected.

1.1.3. Project Area Challenges and Opportunities

Piping the Pilot Butte canal offers the opportunity to conserve water for Central Oregon irrigators, reduce current and future O&M costs, reduce public safety risks, and avoid future canal failures and associated property damage. However, this opportunity is constrained by the District's limited ability to fund piping projects.

1.3. Project Purpose and Need

The Project's primary purpose of agricultural water management is conservation of irrigation water in COID-owned infrastructure, improvement of water delivery reliability to COID patrons, and reduction in long-term operation and maintenance costs on approximately 18 miles of the COID-owned canal. The Project is needed to address water loss in COID conveyance systems and water delivery, operation, and maintenance inefficiencies. Specifically, the Project will address water loss due to seepage and evaporation. It will also support local agricultural land use and increase public safety.

1.4. Project Overview

The Project is an Agricultural Water Management project that would pipe between 17.8 and 18.1 miles of open canal on the Pilot Butte Canal (depending on the alignment options under consideration) and replace up to 0.2 miles of existing pipe.

1.5. EIS Alternatives

1.5.1. Future Without Federal Investment (No Action) Alternative

Under the Future Without Federal Investment (No Action) Alternative, federal funding through Pub. L. No. 83-566 would not be available to implement the Project. The District would continue to operate and maintain infrastructure consistent with past and current operations. COID would continue to experience high O&M costs, water loss due to seepage and evaporation, and canal failures, which have the potential to cause extensive damage, especially in the Redmond project group.

1.5.2. Modernization Alternatives

The Modernization Alternatives are COID's desired alternatives. Under these alternatives, federal funding through Pub. L. No. 83-566 would be available, and the District would perform the following actions:

- Pipe the King Way project group.
- Pipe one of three alignment options in the Redmond project group (referred to as "Pilot Butte Canal," "Watermaster Road," and "Northwest Canal Road").
- Pipe the Veterans Way project group.
- Pipe the Canal project group.

- Pipe the Deschutes Market project group.
- Pipe one of three alignment options in the Rivers Edge project group (referred to as "18th Street," "Pilot Butte Canal," and "Old Deschutes Road").

In the Redmond and Rivers Edge project groups, three of the alignment options refer to different routes where piping could take place in the same section.

1.6. Analysis Parameters

1.6.1. Funding

In the Future Without Federal Investment (No Action) Alternative, the District would continue to seek grants for piping projects, which in the past have consisted of Water Smart and Regional Conservation Partnership Program (RCPP) grants. Water Smart grants typically require COID to match grant amounts (Horrell, 2022). The type, amount, and timing of funding under the Future Without Federal Investment (No Action) Alternative is uncertain, and no funding for piping the Project canals has been secured thus far. Because funding from other sources is not reasonably foreseeable, the No Action Alternative assumes no alternative funding.

Under the Modernization Alternative, funding levels would vary depending on the alignment option. Pub. L. No. 83-566 funds would cover between $273,454,000 and $295,580,000. COID would fund between $90,608,000 and $97,733,000. In every alignment option, Pub. L. No. 83-566 funds would cover up to 75 percent of the construction costs and COID would secure funding to cover the remaining 25 percent of costs.[1] COID received a RCPP grant in 2024; this grant funding would not be used for the 25 percent Pub. L. No. 83-566 match obligation. Total federal funding for any portion of Modernization Alternative construction would not exceed the 75 percent construction cost-share limit.

1.6.2. Evaluation Unit

The proposed project is comprised of six project groups, which are the evaluation units for this analysis. Two project groups (Redmond and Rivers Edge) have four alignment options. These project groups and alignment options are summarized in Table D-1.

1.6.3. Project Implementation Timeline

Under the Modernization Alternatives, the District expects that construction would likely be completed over approximately three years as summarized in the table below. While this schedule represents the District's current best estimate of the construction timeline, the actual execution of the project could differ from current plans due to unforeseen circumstances. Although the exact timeline of Project construction is uncertain, this analysis models the start of Project construction (Year 1) in 2025. For each project group, this analysis assumes that full benefits would be realized the year after construction is completed (e.g., for Project Group 1, which would complete construction in Year 1, full benefits would be realized in Year 2).

[1] COID would secure other non-federal funding to cover the 25 percent match obligation for construction of the project, as required. But because Pub. L. No. 83-566 funding covers the additional costs of project admin and technical assistance, Pub. L. No. 83-566 funding would cover slightly more than 75 percent of the total project costs.

Table D-1. Summary of Project Group Construction Under the Modernization Alternatives, Deschutes Watershed, Oregon

Project Group / Alignment Option	Project Group	Construction Start Year	Construction Duration (Years)	1st Year Benefits Accrue
King Way	1	1	1	2
Redmond				
Pilot Butte Canal	2a	2	1	3
Watermaster Rd	2b	2	1	3
NW Canal Blvd	2c	2	1	3
Veterans Way	3	3	1	4
Canal	4	3	1	4
Deschutes Market	5	2	1	3
Rivers Edge				
18th Street	6a	1	1	2
Pilot Butte Canal	6b	1	1	2
Old Deschutes Rd	6c	1	1	2

1.6.4. Analysis Period

The analysis period is defined as the implementation period plus the period of time over which any alternative would have meaningful beneficial or adverse effects (up to a maximum of 100 years). The analysis period for this NED is 103 years (Year 1 to Year 103) since the installation period is 3 years and 100 years is the expected project life of buried high-density polyethylene (HDPE) pipe, which is expected to provide meaningful benefits throughout its useful life. Under the Modernization Alternatives, the District expects to complete two project groups per year (construction and installation of Project Groups 1 and 6 are assumed to start in Year 1 and finish in Year 1, with project life from Year 2 through Year 101; Project Groups 2 and 5 would begin construction in Year 2, finish in Year 2, and have a project life from Year 3 through Year 102; etc.).

2. Modernization Alternative

This section evaluates the costs and benefits of the Modernization Alternatives over the Future Without Federal Investment (No Action) Alternative (i.e., the NED costs and benefits).

2.1. Costs of the Modernization Alternative

2.1.1. Modernization Alternatives Costs

The installation costs of the Modernization Alternative include engineering, surveying, construction management, mobilization and staging of construction or installation equipment, delivery of construction materials to project areas, dewatering (where necessary), installation/construction of equipment, excavation (where necessary), compaction of backfill that is native material, restoration and reseeding of the disturbed areas, cultural mitigation, utility rerouting, and contingency.[2] Table 8-8 in the EIS (corresponding to NWPM 506.12, Economic Table 1) summarizes the installation cost distribution of the Modernization Alternatives by payer and federal/non-federal land. Table 8-9 in the EIS (corresponding to NWPM 506.12, Economic Table 2) displays the components of the installation costs, which include construction, engineering, project administration, and permitting.

Table 8-10 in the EIS (corresponding to NWPM 506.18, Economic Table 4) summarizes the annualized costs of each Modernization Alternative. In total, the annualized costs of the Modernization Alternatives range from $10,721,000 to $11,593,000, with the Preferred Alternative (highlighted in gray in the tables) having estimated annualized costs of $10,721,000. The subsections below provide details on the derivation of the values in the table.

2.1.2. Project Installation Costs

The estimated total installation costs of the Modernization Alternatives range from $356.6 million to $385.2 million, with a Preferred Alternative installation cost of $356.6 million. The associated annualized installation costs range from $10.7 million to $11.5 million, with the Preferred Alternative annualized costs of $10.7 million. In addition to the installation costs, each Modernization Alternatives has O&M costs, which are further described in the next section. These costs, combined with the installation costs, result in estimated total annualized costs that range from $10.7 million to $11.6 million, with a Preferred Alternative total annualized cost of $10.7 million.

2.1.3. Operations and Maintenance Costs

The District expects some O&M will be required to maintain the piped canals. Specifically, the District estimates that each additional mile of pipe will require O&M expenditures of $100,000 every 20 years, starting 20 years after installation (these costs are based on the District's O&M expenditures on its existing piped canals) (Horrell, 2023). The Project would pipe between 17.8 miles and 18.1 miles of canal, with the Preferred Alternative (highlighted in gray) piping 17.8 miles of canal.[3] Given this, the cost of associated O&M would be approximately $1.8 across all project groups every 20 years. When discounted and annualized, the costs of additional O&M under the Modernization Alternatives range from $62,000 to $64,000 ($62,000 for the Preferred Alternative), as shown in the table below.

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[2] There is no interest during construction as the first year of construction is defined as the base year.

[3] The total lengths differ slightly from the overall project length because some project groups contain existing pipeline that would be replaced under the project.

Table D-2. O&M Costs for Modernization Alternative, Deschutes Watershed, Oregon, 2025$.[1]

Project Group	Canal Length to be Piped (mi) [2]	Undiscounted O&M Costs (per 20 years)	Annualized O&M Costs under Piping Alt
King Way	2.1	$207,000	$7,000
Redmond			
Pilot Butte Canal	2.3	$235,000	$8,000
Watermaster Rd	2.3	$235,000	$8,000
NW Canal Blvd	2.3	$235,000	$8,000
Veterans Way	3.2	$315,000	$11,000
Canal	2.6	$262,000	$9,000
Deschutes Market	4.2	$417,000	$15,000
Rivers Edge			
18th Street	3.7	$366,000	$13,000
Pilot Butte Canal	3.4	$343,000	$12,000
Old Deschutes Rd	3.8	$375,000	$14,000
Minimum total	**17.8**	**$1,779,000**	**$62,000**
Maximum total	**18.1**	**$1,811,000**	**$64,000**
Preferred Alternative	**17.8**	**$1,779,000**	**$62,000**

Note: Total may not sum due to rounding. Prepared September 2025
1/Price base: 2025 dollars amortized over 100 years at a discount rate of 3.0 percent.
2/ The total lengths differ slightly from the overall project length because some project groups contain existing pipeline that would be replaced under the project.

2.1.4. Other Direct Costs

Other direct costs include disruptions to the surrounding community during construction and changes to aesthetic resources and other resources in the long-term due to the Modernization Alternatives.[4] The Modernization Alternatives would result in short-term disruptions to transportation and access to recreational facilities; disturbances to vegetation, wildlife, and community quality of life; and potential long-term impacts to cultural resources. However, the overall change in associated values from construction is expected to be negligible to minor. In the long-term, as described in the cultural resources analysis, effects on historic resources will vary by alignment option, but historic sections of the canal and a railway bridge will be removed or affected in all alignments with potential adverse effects on local socioeconomic values for these historic resources that may be important to sense of place, aesthetics, and community identity. However, these adverse socioeconomic effects are anticipated to be mitigated (and the mitigation costs are included in the installation costs presented above), as described in the cultural resources analysis. As such, these other direct costs are expected to be either minor or mitigated, such that long term effects on socioeconomic value is minimal. As such, no other direct costs associated with changes in resource quality or quantity are quantified in this NED analysis.

Aesthetic effects could impact local property values. As described in detail in the *Neighborhoods and Socioeconomics Technical Report*, residential property values could be positively or adversely affected by piping the PBC. While some homeowners and homebuyers likely view the canal as a scenic amenity (in which case the Modernization Alternatives could reduce home value), piping also provides several benefits to nearby

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4 Section 2.12.7(b), Principles and Guidelines (1983) notes that other direct costs include uncompensated losses incurred due to the installation, operation, maintenance, or replacement of project or plan measures.

residential areas that may offset any declines in value and/or actually increase property values. These benefits include revegetated green space, removal of the potential safety hazard that the open canal currently poses, and removal of flood risk from failure of the canal. As such, the potential aesthetic cost to residential landowners is not quantified. Please see the *Neighborhoods and Socioeconomics Technical Report* for a more detailed discussion.

2.2. Benefits of the Modernization Alternative

This section presents on-site damage reduction benefits that would accrue to agriculture and the local rural community, including reductions in agricultural damages, patron costs, property damage, and District costs. It also presents off-site quantified benefits, which include the value of avoiding carbon emissions from energy use. Other benefits not included in the analysis that may result indirectly from the Modernization Alternatives include potential additional savings on patron pump operations, maintenance, and replacement (OMR) costs (greater than modeled in Section 2.2.1.2).

Table 8-11 in the EIS (corresponding to NWPM 506.20, Economic Table 5a) summarizes annual average NED project benefits of the Modernization Alternatives. Table 8-12 in the EIS (corresponding to NWPM 506.21, Economic Table 6) compares annual NED benefits and costs of the Modernization Alternatives.

2.2.1. Benefits Considered and Included in Analysis

2.2.1.1. Agricultural Damage Reduction Benefits

Piping the District's canals would avoid seepage during conveyance and increase the supply of irrigation water available to the District and NUID. Under the Modernization Alternative, COID would conserve 43,544 AFY of water. The District plans to use all this water to enhance irrigation water supply in NUID. The increase in water availability is expected to reduce the agricultural damages associated with water shortages currently experienced in NUID, as well as mitigate future larger water shortages in NUID that are expected to occur due to changes in water management required as part of the Deschutes Basin HCP. As a result of seepage in the conveyance system to NUID, roughly 26 percent of the conserved water would be lost during conveyance leaving 32,161 AF for use on NUID fields (Farmers Conservation Alliance, 2024).

Historically, NUID has experienced water shortages in which water supply is less than total water demand in the district (Britton, 2020). Since the adoption of the 2016 Settlement Agreement, which includes provisions for irrigation districts in Central Oregon to increase instream flows to support the Oregon Spotted Frog (which reduces water availability for irrigation), water supply reliability to NUID irrigators has been further decreased. While water year type and market conditions also affect acreage planted in any given year, Figure D-1 shows that the average fallowed acreage in NUID nearly doubled from the 2009–2015 period to the 2016-2018 period, and more than tripled from the 2016-2018 period to the 2020–2023 period. figure D2 shows the crop mix over this same time period. Assuming approximately 15,000 acres fallowed due to water shortages and applied water of 2.4 AF per acre (which is the weighted average full water allocation in NUID[5]), recent water shortages may be approximately 36,000 AFY. Interviews with COID and analysis of changes in NUID water supply in the EIS for the HCP (Oregon Fish and Wildlife, 2020) indicate that NUID current water shortages may be even higher. Further, as the instream flow requirement increases through time under the HCP, water shortages in NUID will also increase, even after accounting for water conserved from other piping projects in the Basin. Based on the current and predicted future shortages in NUID, NUID

[5] Water allocations in NUID differ depending on the source: Deschutes River water rights get 2.5 AF per acre while Crooked River water rights get 1.5 AF per acre. Because there are 53,721 acres supplied by the Deschutes River and 5,164 acres supplied by the Crooked River, the weighted average allocation District-wide is 2.4 AF per acre (Britton, 2020).

would be able to use all the water conserved by the Project (32,161 AFY). [6] The rest of this section describes the economic benefit of this water to NUID farms.

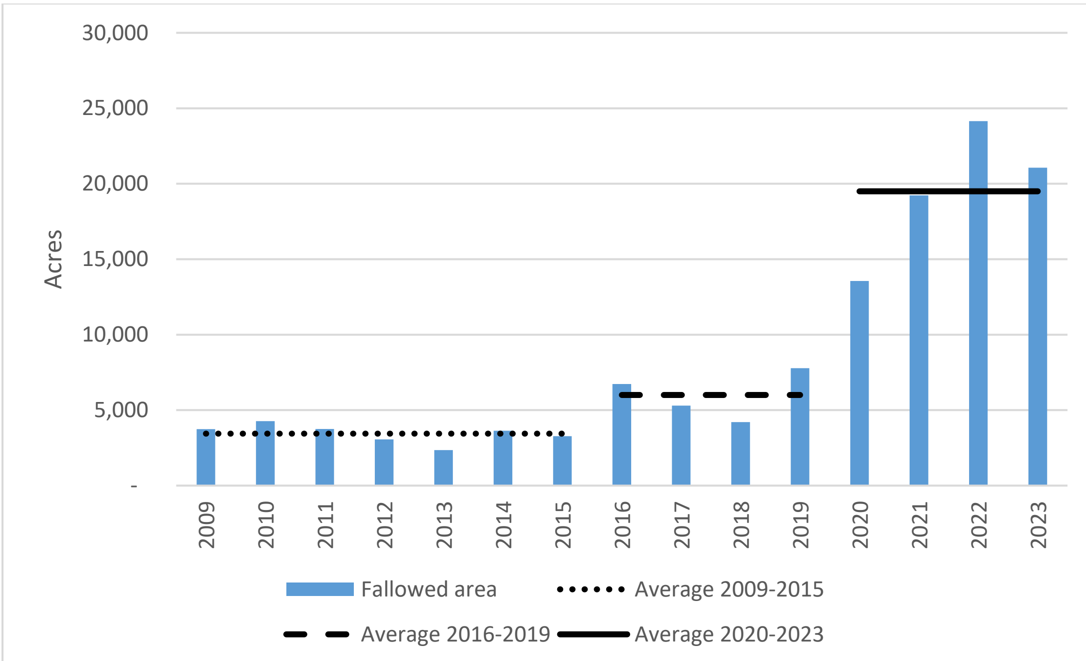

Figure D-1. NUID Agricultural Area Fallowed [7]

[6] If 32,161 AF of additional water were distributed (accounting for conveyance losses) at 2.4 AF per acre (as is assumed in this analysis), 13,400 acres could receive additional water. From 2019 to 2023, NUID averaged about 19,500 acres fallowed, which the net returns analysis is meant to represent (North Unit Irrigation District, 2024).

[7] Source: (North Unit Irrigation District, 2024)

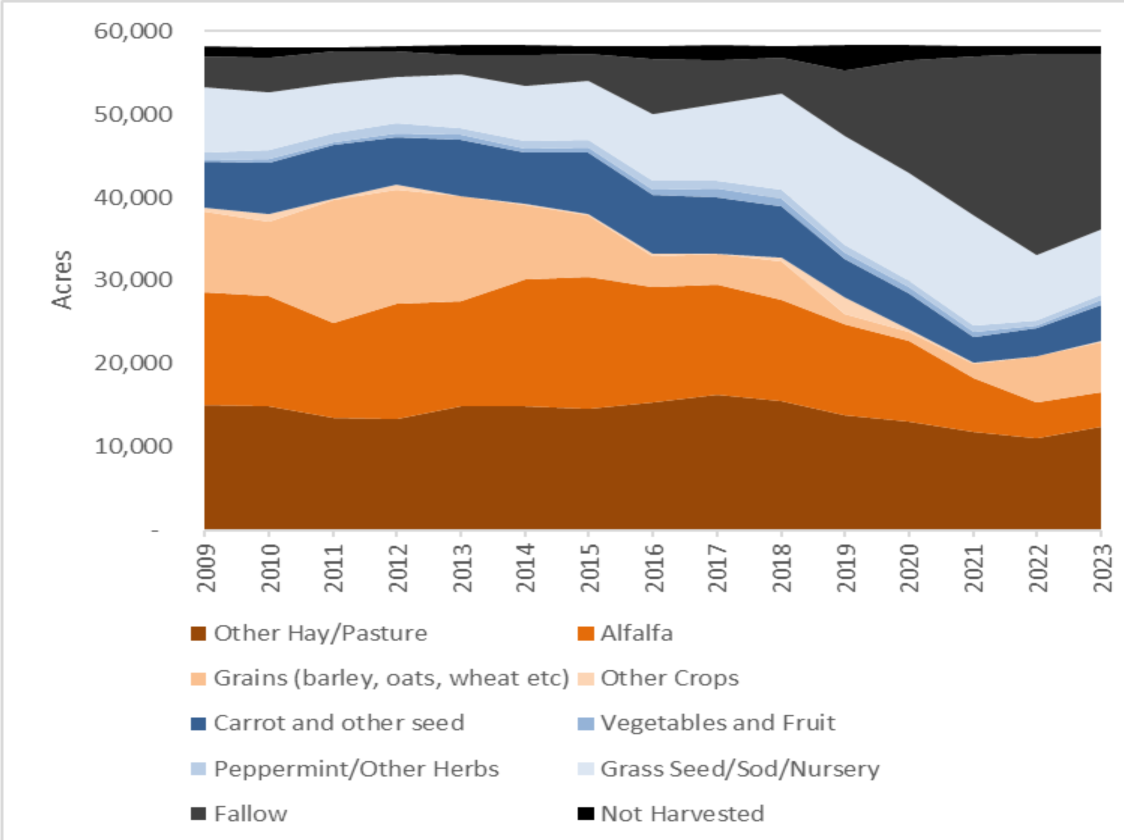

Figure D-2. NUID Cropping Pattern 2009-2023 [8]

This analysis estimates the economic benefit of additional water to NUID in reducing agricultural damages. Specifically, the analysis estimates the benefits of reduced fallowing and increased alfalfa hay and carrot seed production. Roughly one-quarter of NUID's irrigated acres are dedicated to high-value specialty crops, including carrot seed, grass seed, peppermint, and other crops. The remainder of crop acreage is hay and grains.[9] Recent declines in water deliveries have corresponded with reduced acreage in both hay and high-value crops in NUID (North Unit Irrigation District, 2024). As such, this analysis analyzes the economic benefit of additional water using two representative crop types: alfalfa hay and carrot seed. Approximately 70 percent of irrigation water demand in NUID is for alfalfa hay and other feed crops, 15 percent is for grains, and 15 percent is for high value specialty crops (10 percent to peppermint/grass seed/other and 5 percent to carrot seed). In modeling the benefits of enhanced water supply to NUID, this analysis assumes that 95 percent of water conserved by the Project will be used to support NUID alfalfa hay production and 5 percent will be used to support NUID carrot seed production.

To estimate the value of reduced damages from fallowing of alfalfa hay, we adapted two crop budgets: one to model the costs of fallowing and one to model the costs and revenues of producing alfalfa. The fallowing costs are adapted from a fallow crop budget (associated with winter wheat production) from Oregon State University. The alfalfa budget is based on an alfalfa budget published by Washington State University. The carrot seed budget is based on a carrot seed budget published by Oregon State University. We adapted these source budgets to model the costs of fallowing and the net returns to alfalfa hay and carrot seed production

8 Source: (North Unit Irrigation District, 2024).
9 Source: Ibid.

under full irrigation. All budgets are provided in Section 3 beginning on page D-3123. Section 3 also has a detailed explanation of the methods used to update revenues and costs to 2025-dollar values.

The alfalfa hay yield used in this analysis is likely an underestimate of yield under full irrigation, which would tend to result in an underestimate of agricultural damage reduction benefits. To be conservative, the analysis uses NASS-reported recent county average hay yields as the expected "full irrigation" yield, although these yields are from a period when irrigators were experiencing some water shortages. Interviews with local agricultural extension agents also indicate that the yield for full irrigation in NUID used in this analysis may be an underestimate (Bohle, 2018; Jones, 2024).

Results from the analysis in Section 3 indicate that the annual cost of fallowing is roughly $202 per acre, which covers operational costs to control weeds and fixed costs of land and machinery. Conversely, alfalfa production generates average annual net returns of approximately $379 per acre. Therefore, the annual net benefit of alfalfa production over fallowing is approximately $581 per acre (avoided costs of $202 plus net revenues of $379). The weighted average full water allocation in NUID is 2.4 AFY per acre.[10] Dividing the annual marginal net returns ($581 per acre) by the amount of additional water (2.4 AFY per acre) provides the marginal net returns to water: $242 per AFY. For carrot seed production, the average annual net returns are estimated at approximately $2,369 per acre; including the avoided annual cost of fallowing of $202 per acre, the net annual benefit of water used to grow carrot seed is approximately $2,572 annually. Carrot seed requires approximately 1.0 AFY per acre[11], providing a marginal net return to water of approximately $2,572 per AFY. Assuming 5 percent of conserved water goes to carrot seed and 95 percent goes to alfalfa hay, this translates to a weighted average value of approximately $359 per AFY. We use this amount to estimate the damage-reduction benefit of each AF of water going to NUID under the Modernization Alternative.

Valued at $359 per AF, saved water would result in an undiscounted annual agricultural damage reduction value of over $11.5 million. When discounted to present value and annualized over 100 years, the value of the Modernization Alternatives (Preferred Alternative alignment highlighted in gray) in avoiding agricultural damages in NUID totals just under $10.9 million (as shown in Table D-3).

[10] Water allocations in NUID differ depending on the source: Deschutes River water rights get 2.5 AF per acre while Crooked River water rights get 1.5 AF per acre. Because there are 53,721 acres supplied by the Deschutes River and 5,164 acres supplied by the Crooked River, the weighted average allocation District-wide is 2.4 AF per acre (Britton, 2020). Due to shortages, the allocation has been lower than 2.4 AF/acre in recent years ; for example in 2023 the final allotments were 0.85 acre-feet (Deschutes) and 0.43 acre-feet (Crooked River). However, we use 2.4 AFY/acre as an estimate of the amount of water available to alfalfa as it is the full water allocation received by growers who only grow alfalfa. Further, for growers who grow other crops and can shift more water to alfalfa to better meet its full ET requirement, the reported and modeled current yield of 5.4 tons matches water application of approximately 2.4 AFY (i.e., a yield of 5.4 tons and water application of 2.4 acre-feet is approximately 70% of full yield that is possible in this region of 8.0 tons per acre and alfalfa crop water demand of 3.2 AFY respectively).

[11] Evapotranspiration requirement is approximately 1.0 AFY per the US Bureau of Reclamation Agrimet station in Madras, Oregon.

Table D-3. Avoided Damages to NUID Agriculture Resulting from Modernization Alternatives by Project Group, Deschutes Watershed, Oregon, 2025$ 1

Project Group	Water contributed to NUID farms (AFY)	Undiscounted Annual Benefit	Annualized Average Net Benefits of Piping
King Way	2,900	$843,000	$843,000
Redmond	1,494	$536,000	$505,000
Veterans Way	6,361	$2,282,000	$2,088,000
Canal	6,507	$2,334,000	$2,136,000
Deschutes Market	6,203	$2,225,000	$2,097,000
Rivers Edge	8,694	$3,119,000	$3,028,000
Total	**32,161**	**$11,536,000**	**$10,864,000**

Note: Totals may not sum due to rounding. Prepared September 2025
1/ Price base: 2025 dollars amortized over 100 years at a discount rate of 3 percent.

Avoided agricultural damage is the largest source of benefits under the Modernization Alternative, and the benefit cost ratios for many project groups are sensitive to the estimated net value to irrigators of water conserved through the Modernization Alternatives. This analysis uses the best available data on past cropping patterns, water use, production costs, yields, and prices to project likely future benefits. However, actual avoided damage benefits experienced in any given future year are uncertain and will vary due to fluctuations in these variables (i.e., changes in crop prices, crop yields, production costs, water availability, and cropping pattern would affect net value per acre-foot of conserved water in future years). The period of analysis 100 years; over this period there may be substantial variation in each of these market and agricultural variables, which in turn would affect the agricultural benefits.

The farmers of North Unit Irrigation District have historically adapted to changing market and agricultural conditions by adjusting their crop mix and farming practices to maximize net returns; they also have a history of growing a variety of high value crops ranging from grass seed to carrot seed to vegetables. Based on this history of agricultural adaptability, coupled with the expected rise in water scarcity in the region for all water users (due to projected increased frequency and severity of drought, projected increased warming temperatures, and continued population growth), we expect that the future value of water for agriculture and other uses in the Basin will likely rise over time during the period of analysis. If the value of conserved water rises as expected over the 100-year period of the analysis, the benefit cost ratio of the Project would be higher than estimated. Conversely, if the value of conserved water is lower than estimated over the 100-year period of the analysis, then the benefit cost ratio of the Project would be lower than estimated in this analysis.

2.2.1.2. Patron Irrigation Pumping Cost Savings

Pressurization under the Modernization Alternatives would reduce the power required to pump water onto farm fields. This benefit would save COID patrons between 877,430 and 881,438 kWh annually in the project group service areas. In addition to power savings in the project group service areas, piping of the King Way and Redmond and associated pressurization would benefit irrigators in the Smith Rock service area within COID as well as irrigators in the Lone Pine Irrigation District (LPID), reducing their power needs by an additional 2,121,592 kWh annually.[12] These energy cost savings are evaluated using Central Electric Cooperative's 2025 Agricultural Irrigation Rate (Schedule C) for irrigation pumping: $0.04720 per kWh (Central Electric Cooperative, 2025). At this price, the energy savings would provide approximately to

[12] This is a based on an FCA analysis of COID data on energy savings (Farmers Conservation Alliance, 2023).

$141,000 in (undiscounted) annual savings once all project groups are completed.[13] Table D-4 presents the energy use and cost savings to COID patrons under the Modernization Alternative. Accounting for discounting and that it takes several years before these energy saving benefits are realized for some project groups, the average annualized energy savings under the Modernization Alternatives would be $134,000.

Table D-4. Annual Increased Average Energy Cost Savings to COID Patrons under Modernization Alternative, Deschutes Watershed, Oregon, 2025$ [1]

Project Group	Energy Savings (kWh)[2]	Energy Savings Outside COID (kWh)[2]	Undiscounted Annual Energy Cost Savings	Average Annual Benefit of Energy Reduction
King Way	3,282	231,279	$11,000	$11,000
Redmond	656,500	1,890,314	$120,000	$113,000
Veterans Way	68,647	0	$3,000	$3,000
Canal	88,072	0	$4,000	$4,000
Deschutes Market	34,474	0	$2,000	$2,000
Rivers Edge[3]	26,455 to 30,462	0	$1,000	$1,000
Total	**877,430 to 881,438**	**2,121,592**	**$141,000**	**$134,000**

Note: Totals may not sum due to rounding. Prepared September 2025

1/ Price base: 2025 dollars amortized over 100 years at a discount rate of 3 percent.

2/ As estimated by FCA (Farmers Conservation Alliance, 2023).

3/Depending on Rivers Edge Alignment, the patron power savings is expected to differ slightly.

2.2.1.3. Avoided Costs of District Operations and Maintenance

O&M cost savings under the Modernization Alternative would come from installing Project components that would reduce O&M expenses. District O&M expenses on average over the last five years have been $1.1 million per year. According to the District, the Modernization Alternatives would reduce COID's O&M costs by an estimated $380,000 per year based on the following cost savings: labor costs for one ditch rider ($130,000 per year), avoided preventative and reactionary canal maintenance ($200,000 per year), and avoided ditch cleaning ($50,000 per year) (Horrell, 2022).[14] Across the total original canal length of 17.8 miles,[15] the savings translate to approximately $21,500 per mile in cost savings.

This analysis applies the projected cost savings to the project groups according to the length of canal replaced with pipe under each project group. (Horrell, 2023)2.2.1.4 When discounted and annualized, the avoided O&M costs under the Modernization Alternatives would generate benefits of $358,000, as shown in the table below.

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13 The energy-saving benefits of Smith Way and LPID are split between Redmond and King Way project groups, since they are necessary for pressurization in these areas. Overall, King Way is responsible for decreased energy use of 231,279 kWh and Redmond is responsible for decreased energy use of 1,861,314 kWh. FCA's analysis also shows that the alignment options in Redmond project group bring additional energy savings of 28,800 kWh to King Way. Because of the complexity of pressurization, some benefits attributed to the Redmond project group in this analysis may be attributable to the King Way project group.

14 While the Project may reduce the need for ditch riding labor, COID may not reduce its staff under the Modernization Alternative. If staffing levels are maintained, staff that previously conducted ditch riding tasks would instead spend time completing other valuable tasks for the District.

15 The total lengths differ slightly from the overall project length because some project groups contain existing pipeline that would be replaced under the project.

Table D-5. Annual Average Reduction in O&M Costs of Modernization Alternative, Deschutes Watershed, Oregon, 2025$[1]

Project Group	Original Canal Length to be Piped (mi) [2]	Undiscounted O&M Savings (per 20 years)	Annualized O&M Savings under Piping Alt
King Way	2.1	$43,000	$43,000
Redmond	2.3	$50,000	$47,000
Veterans Way	3.2	$67,000	$62,000
Canal	2.6	$56,000	$51,000
Deschutes Market	4.2	$89,000	$84,000
Rivers Edge	3.4	$73,000	$71,000
Total	**17.8**	**$379,000**	**$358,000**

Note: Totals may not sum due to rounding. Prepared September 2025
1/ Price base: 2025 dollars amortized over 100 years at a discount rate of 3.0 percent.
2/ The total lengths differ slightly from the overall project length because some project groups contain existing pipeline that would be replaced under the project.

2.2.1.4. Avoided Property Damage

Irrigation canals can fail, which can result in flooding of nearby areas. These failures can be costly, both in terms of canal repairs and surrounding property flood damage. In contrast, piped conveyance has a negligible probability of failure, and no damages associated with failure are projected after piping due to the negligible probability and associated negligible risk. This section estimates the benefit of piping in terms of avoided flood damages from canal failure.

Irrigation canals can fail and cause significant damage. COID has experienced at least two canal failures in the last two decades. In 2005, a COID canal breach caused flood damage to 10 homes totaling roughly $2.35 million (Horrell, 2022).[16] In 2022, a COID canal failed and caused property damage of roughly $522,000 (Horrell, 2022).[17] On average, these two incidents caused damages of $1.45 million per incident. The probability of canal failure was 8 percent per year from 2000 to 2025. The total annual average damage from canal failure during this period was about $111,500 (8 percent of $1.45 million). On average per mile of canal, the average annual damage was just over $6,300. This analysis assumes that these incidents represent the average cost and likelihood of canal failure in the absence of the Modernization Alternatives in Year 1.

Accordingly, this analysis apportions the annual risk ($6,300 per mile in Year 1) to each project group according to the length of piping in each project group, with the exception of the Redmond project group, which carries a higher risk. The Redmond project group has a higher probability of canal failure than the other project groups and failure has the potential to cause much higher property damage in this project group area. These two factors together translate to high risk of flooding in this project group. The Redmond project group is located in an urban area, which has higher populations of people and rodents (which contribute to the degradation of canal banks, increasing the chance of failure) and higher-value infrastructure and property (Horrell, 2023). As the city continues to grow and develop, the risk will likely increase. The District estimates that the current probability of canal failure is 15 to 20 percent each year (Horrell, 2023). Accordingly, this analysis assumes the annual probability of canal failure in Redmond is 17.5 percent in Year 1.

16 The original damage estimate of $1.5 million in 2005 dollars was adjusted to 2025 dollars using the IPDGDP (Bureau of Economic Analysis, 2025).
17 The original damage estimate of $500,000 in 2020 dollars was adjusted to 2025 dollars using the IPDGDP (Bureau of Economic Analysis, 2025).

Because canal infrastructure degrades over time, which increases the probability of failure, the District expects the probability of canal failure to increase under the Future Without Federal Investment (No Action) Alternative during the period of analysis. Specifically, the District estimates that the probability of canal failure will double every 25 years (Horrell, 2023). This equates to an annual increased probability of 2.8 percent. Accordingly, this analysis increases the probability of canal failure by 2.8 percent annually. These probabilities are projected even considering the increased inspections and preventative measures the District would undertake in the absence of piping (as discussed in Section 2.2.1.3).

A recent analysis of the Redmond project area found that a canal failure in the Redmond project group could result in 330 homes experiencing 1 foot of flooding, with additional flooding impacts to the Ridgeview High School (Black Rock Consulting, 2023). According to the Federal Emergency Management Agency (FEMA), the total potential loss to an average home (a one-story 2,500-square-foot home with $50,000 worth of possessions)[18] of a 1-foot inundation is roughly $87,500 (Federal Emergency Management Agency, 2019).[19] If 330 homes were damaged at this level, the total cost would likely be $28.9 million. Because Ridgeview High School would also experience flood damages, and those damages are not included in this analysis, the estimate of avoided flood damages in Redmond project group of this type of flood event is likely an underestimate. Additionally, further urban development in the City of Redmond could increase the structures (and associated value) at risk from canal flooding.

Under these damage and probability assumptions, the total estimated damage from canal failure in the Redmond project group accumulates to over $200 million in less than 30 years. Under such high costs, it is likely that the property owners and the government entities would take actions to limit future damages, such as relocating.[20] As such, we cap the cumulative damages to the projected cost of relocating residents in all 330 homes, which includes a buyout value of $500,000 per house plus an additional 25 percent for administering the relocation program.[21] At a cost of $625,000 per house, the total cost of relocation could be approximately $206,250,000. Under Future Without Federal Investment (No Action) Alternative, this limit would be reached in Year 28, after which we model no future damages from flooding.

Given these assumptions, average annual avoided damages at project group completion are just under $5.2 million. As the District estimates that the probability of canal failure would increase annually by 2.8 percent, we therefore model the costs of canal failure continuing to grow throughout the period of analysis under the Future Without Federal Investment (No Action) Alternative. When discounted and annualized, the expected annual average benefit of avoiding canal failure is nearly $4.2 million, as shown in Table D-6 below.

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18 An unstructured visual survey of houses surrounding the canal in the Redmond project group using Zillow data indicated houses were generally between 1,600 and 3,000 square feet (Zillow, 2024).

19 The original estimated damage of $72,162 in 2019 dollars was adjusted to 2025 dollars using the Engineering News-Record Construction Cost Index and the GDPIPD (Engineering News-Record, 2022; Bureau of Economic Analysis, 2025). No depreciation was included in the estimate as homes in this area are very recently constructed and, as described in this section, other costly flooding such as at Ridgeview High School, were not included in the damage estimates.

20 Per the District's engineers, there are no good alternatives to piping or re-locating to mitigate flood risk (Melle, 2024; Crew, 2024). Specifically, the engineers noted that other alternatives to mitigate the risk of canal failure (including rerouting the canal to avoid high-value structures, adding an upstream lateral discharge to mitigate flooding in the event of a failure, or installing a shotcrete canal liner) are infeasible, ineffective at completely avoiding flood damages, or had important downsides, such as increasing risks to public safety. These alternatives also would not meet the purpose and need of the project.

21 An unstructured visual survey of houses surrounding the canal in the Redmond project group using Zillow data indicated an average market price of roughly $500,000 per home (Zillow, 2024).

Table D-6. Annual Average Reduction in Property Damage Costs of Modernization Alternative, Deschutes Watershed, Oregon, 2025$[1]

Project Group	Length of Original Canal Piped Under Project (miles) [2]	Average Annual Canal Failure Cost in Year 0	Discounted Annualized Canal Failure Damage Savings
King Way	2.1	$13,000	$37,000
Redmond	2.3	$5,053,000	$3,895,000
Veterans Way	3.2	$20,000	$57,000
Canal	2.6	$16,000	$47,000
Deschutes Market	4.2	$26,000	$75,000
Rivers Edge	3.4	$21,000	$62,000
Total	**17.8**	**$5,149,000**	**$4,173,000**

Note: Totals may not sum due to rounding. Prepared September 2025
1/ Price base: 2025 dollars amortized over 100 years at a discount rate of 3.0 percent.
2/ The total lengths differ slightly from the overall project length because some project groups contain existing pipeline that would be replaced under the project.

2.2.2. Benefits Considered but Not Included in Analysis

2.2.2.1. Public Safety Avoided Costs

Conveying irrigation water through pipes removes the hazard of drowning posed by irrigation canals, particularly those in urban areas. The history of recent drownings in Central Oregon irrigation canals indicates that fast-moving water in irrigation canals, often with steep and slippery banks, can be a threat to public safety. In 2004, a toddler drowned in a Central Oregon Irrigation District canal, and in 1996 and 1997, respectively, a 12-year-old boy and a 28-year-old man drowned in North Unit Irrigation District canals (Flowers, 2004). Other drownings may have occurred in the past, as a comprehensive list of drownings in Central Oregon irrigation canals was not available from the Bureau of Reclamation or other sources. However, the available data indicates at least three drownings over the 21-year period from 1996 to 2016, or 0.143 deaths per year. As the population in Central Oregon continues to grow and areas surrounding irrigation canals continue to urbanize, the risk to public safety would increase.

This analysis estimates the public safety hazard of open canals in COID based on past drownings in unpiped canals in Central Oregon. Based on data from the Oregon Water Resources Department (OWRD) on canals in Central Oregon, there are 1,072 miles of irrigation canals in Central Oregon districts (see Table D-7). Starting in the late 1980s and early 1990s, sections of these canals began to be piped, with the result that in 2017, the OWRD database records showed that approximately 209 miles had been piped. Assuming piping occurred uniformly across the 21-year period from 1996 to 2016, approximately 9.9 miles were piped each year, leaving approximately 973 miles unpiped on an average annual basis during this period. Given that an average of 0.143 drowning deaths occurred annually during this period (three deaths over 21 years as described above), the annual drowning risk per mile of exposed canal was 0.000147 (0.143 divided by 973). This may be an overestimate of risk if there were an abnormally high number of drownings in the 21-year period.

Under Future Without Federal Investment (No Action) Alternative, COID would continue to have 17.8 to 18.1 miles of unpiped canal.[22] Assuming that the three drownings from 1996 to 2016 are representative of future drowning risk, and that the 0.000147 deaths per mile of exposed canal experienced during this period

[22] The total lengths differ slightly from the overall project length because some project groups contain existing pipeline that would be replaced under the project.

is an appropriate estimate of future risk, piping the Redmond project group under the Modernization Alternatives would reduce the risk of drownings by 0.0022 to 0.0027 deaths per year. We do not estimate the value of these benefits under the Modernization Alternatives.

Table D-7. Irrigation Canal Mileage by District

District	Canal and Lateral Mileage
North Unit Irrigation District	47.3
Central Oregon Irrigation District	430.0
Lone Pine	2.4
North Unit Irrigation District	300.1
Ochoco Irrigation District	100.3
Swalley Irrigation District	27.6
Tumalo Irrigation District	95.8
Three Sisters Irrigation District	68.7
Total	**1,072.2**

Note: Totals may not sum due to rounding. Prepared September 2025

Source: Oregon Water Resources Department, database maintained and provided by Jonathon LaMarche on March 9, 2017.

1.1.3.1. Carbon Emission Reductions

Changes in energy use are expected to result in changes in carbon dioxide emissions from power generation. Every MWh of reduced energy use is estimated to translate into an estimated reduction of 0.7525 metric tons (Mt) of carbon emissions.[23] The Modernization Alternatives would decrease carbon emissions by eliminating some pumping energy use by COID patrons. Within the District, the annual energy savings (described in Section 2.2.1.2) would reduce annual CO_2 emissions by approximately 660 to 663 metric tons (Mt) (approximately 877 to 881 MWh multiplied by 0.7525). This is shown in Table D-8.**Error! Reference source not found.**

The benefit of reduced carbon emissions is based on the social cost of carbon (SCC), which is the total cost to society of emitting carbon related to the expected damages associated with future climate change. There are many estimates of the SCC, and the estimates vary based on what types of damages are included, the discount rate chosen, the geographic area under consideration (such as global damages versus U.S. domestic damages), and the projected level of global warming and associated damages. SCC damage values used by federal agencies have varied over the years. At first, federal agencies developed and applied their own estimates. Then, the Office of Management and Budget convened an Interagency Working Group (IWG) on the Social Costs of Greenhouse Gases, which in 2013 developed a set of SCC estimates that could be used across federal agencies (Interagency Working Group on Social Cost of Greenhouse Gases, 2013). In

[23] This assumes that marginal changes in energy demand are met with fossil fuel-based production (renewable energy is typically used first and then fossil fuel powered generation is used), such that 100 percent of energy use reduction and green energy production result in reduced fossil fuel powered generation. Furthermore, this estimate assumes 0.7521 metric tons of carbon emitted from one MWh of fossil fuel powered electricity generation based on 1) the current proportion of fuel sources–oil, natural gas, and coal–for fossil fuel powered electrical power generation in the West, and 2) the associated metric tons of CO_2 produced per MWh powered by each fossil fuel source, as reported by the Energy Information Administration.

February 2021, the IWG updated its estimates of the SCC. They estimated that in the year 2022, at a 3-percent discount rate, the SCC value was $51 per Mt in 2020 dollars (Interagency Working Group on Social Cost of Greenhouse Gases, 2021). However, in January 2025, by Executive Order 14154 the IWG was disbanded and in May of 2025 the Office of Information and Regulatory Affairs in consultation with the U.S. Environmental Protection Agency issued guidance regarding greenhouse gases that federal agencies "should not monetize the impacts from such emissions”. As such, this analysis does not quantify in dollar terms the value of reduced carbon emissions.

Table D-8. Annual Average Reduction in Carbon Costs of Modernization Alternative, Deschutes Watershed, Oregon, 2025$[1]

Project Group	Annual Avoided Emissions (Reduced COID Patron Energy Use, Mt Carbon)
King Way	2
Redmond	
Pilot Butte Canal	494
Watermaster Rd	494
NW Canal Blvd	494
Veterans Way	52
Canal	66
Deschutes Market	26
Rivers Edge	
18th Street	20
Pilot Butte Canal	23
Old Deschutes Rd	23
Minimum total	**660**
Maximum total	**663**
Preferred Alternative	**663**

Note: Totals may not sum due to rounding. Prepared September 2025

2.2.2.2. Patron Irrigation Pump Cost Savings

By providing a pressurized piping conveyance system, the Modernization Alternatives could allow some irrigators to eliminate the need for pumping altogether. This would reduce pump OMR costs to some COID patrons. Any pumps that are eliminated would represent savings to patrons in the form of avoided power company service charges, repair costs, and replacement costs.

Central Electric Cooperative charges a monthly service fee of $71.77 for agricultural pumping service under Schedule C for each month the pump is operating (Central Electric Cooperative, 2023). Over seven months of irrigation operations, the total annual charge would be $500. Interviews with irrigation pump professionals indicated that surface irrigation pumps typically require maintenance every 3 to 5 years, which costs $380 to $1,010 per instance (Scarborough, 2019; Mark, 2019). Based on interviews with irrigation pump experts and published sources, replacement costs for a 10-horsepower irrigation pump are roughly $3,800 (including installation), and replacement is required on average every 10 years (Haun, 2019; Fey, 2019). In total, we estimate the annual OMR costs of an irrigation pump to be roughly $1,100 (not including electricity costs).

It is unclear how many patron pumps could be eliminated by the Modernization Alternative, and for this reason, we do not quantify these potential benefits. However, these unquantified benefits are expected to be positive for some COID patrons under the Modernization Alternative.

2.3. Incremental Analyses

The Modernization Alternatives are evaluated using an incremental analysis, which identifies how total NED costs and benefits change as project groups are added. This analysis for the Preferred Alternative is summarized in the table below.

Table D-9. Incremental Analysis of Annual NED Costs and Benefits Under Piping Alternatives for COID, Deschutes Watershed, Oregon, 2025$.[1]

Project Groups	Total Costs	Incremental Costs	Total Benefits	Incremental Benefits	Net Benefits
2	$1,732,000		$4,560,000		$2,828,000
2,4	$3,057,000	$1,325,000	$6,798,000	$2,238,000	$3,741,000
2,4,3	$4,695,000	$1,638,000	$9,008,000	$2,210,000	$4,313,000
2,4,3,6	$7,442,000	$2,747,000	$12,170,000	$3,162,000	$4,728,000
2,4,3,6,1	$8,501,000	$1,059,000	$13,271,000	$1,101,000	$4,770,000
2,4,3,6,1,5	$10,721,000	$2,220,000	$15,529,000	$2,258,000	$4,808,000

1/Price Base: 2025 dollars amortized over 100 years at a discount rate of 3.0 percent. Prepared September 2025

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3. NED Appendix

3.1. Crop Enterprise Budgets

This appendix presents the crop enterprise budgets used to estimate the benefits of avoiding agricultural damage to NUID under the Piping and Future Without Federal Investment (No Action) Alternative (described in Section 2.2.1.1). The analysis uses a total of four crop budgets:

Table D-10. Summary of Crop Budgets

Scenario	Production Year [1]	Budget Table
Alfalfa	Year 1	Table D-11
	Years 2-6	Table D-12
Fallow	All	Table D-13
Carrot Seed	All	Table D-14

1/ These refer to years in the alfalfa rotation and are not the same as the years measuring the study period in the analysis.

We estimate the costs and benefits of agricultural production using an enterprise budget that represents typical costs and returns of producing crops in the Deschutes Watershed of Central Oregon. Enterprise budgets aim to reflect common practices and relevant costs for production in the region, but do not necessarily represent the conditions of any particular farm. As a starting point for the crop budgets in this analysis, we used four crop budgets: Two for alfalfa hay developed by Washington State University (WSU), and one for fallowing (preceding winter wheat) from Oregon State University (OSU), and one for carrot seed from OSU. We adjusted values in the budgets to account for changes in prices through time and local conditions in NUID. The following sections outline the data and assumptions used in adjusting the budgets.

3.2. Alfalfa Enterprise Budgets

The alfalfa hay enterprise budgets were based on a 2012 budget developed by WSU for establishing and producing alfalfa hay in the Washington Columbia Basin (Norberg & Neibergs, 2012). We selected these budgets as the basis for NUID crop production costs because they are the most recent crop budgets developed for producing alfalfa hay in an area that is relatively close to Central Oregon. We updated the costs presented in the original budgets to account for changing values over time and to reflect conditions specific to NUID.

3.2.1. Modeled Farm

The modeled farm is 120 acres. The hay field is seeded in the fall following a grain crop such as wheat or barley and is harvested using one-ton bales. Other than labor for irrigation, all labor is provided by hiring custom work (includes harvest, fertilizer application, and herbicide application). Irrigation is delivered by a center pivot. Because this analysis models a farm that transitions from fallow to alfalfa production, the machinery complement is the same under both the fallow and alfalfa budget. Consequently, we add machinery fixed costs from the fallowing budget to the alfalfa budget (for a mower and pull sprayer), since all machinery work in the alfalfa budget is done through custom hire.

3.2.2. Input Costs

For fertilizers, we adjust the amount used proportionally according to differences in yield from the original budget. For example, the original budget calls for 92 pounds (lbs) of dry phosphate to produce 8 tons of hay per acre; in the Years 2-6 Production Budget (Table D-12), we model a yield of only 5.4 tons per acre (68 percent of the original yield), so we reduce the amount of dry phosphate to 62.6 lbs (68 percent of 92 lbs).

One exception to this method is the amount of dry sulfur applied, which is held constant at 30 lbs per acre during production years per guidance from an OSU Extension Agent in Central Oregon (Bohle, 2020). We also remove the original costs of zinc fertilizer, since these are not typically applied on alfalfa fields in Central Oregon (Turner & Bohle, 1995; Jones, 2024).

All prices are adjusted from the original values in the WSU budget. We used area-specific values for fuel prices, irrigation charges, and land costs. For costs that did not have area-specific values, we adjusted the value in the original budget using the national Producer Price Indices (PPI) produced by the National Agricultural Statistics Services (NASS), which are published for a variety of farm expenses (NASS, 2023). For example, there are price indices for fertilizer, herbicides, supplies, tractors, custom work, as well as one for the farm sector in general. The PPI cost adjustments range from a 15-percent decrease in the price of Nitrogen to a 62-percent increase in Labor costs.

For land costs in the establishment budget, we use NASS data on rental rates for irrigated cropland in Jefferson County ($153 per acre) (NASS, 2023).[24] Because alfalfa is seeded in the fall after another crop has been harvested, we only ascribe 25 percent of the land costs and 25 percent of the irrigation assessment costs to establishing alfalfa.

3.2.3. Labor Costs

Because most of the labor is provided by custom work, the only direct labor costs are for irrigation labor. For the cost of this labor, we use the median hourly wage rate for the farmworkers occupation in Central Oregon in 2022 and adjust to 2025 dollars using the "Labor, Wage Rates" PPI.[25] We further adjust this wage rate up by 20 percent to account for non-wage employment costs, such as health care and insurance.[26] This results in total costs of $20.69 per hour for irrigation labor.

We adjusted the cost of custom work using the "Ag Services, Custom Rates" PPI. For the production budgets, we adjusted some labor costs (including custom bailing, hauling, staking, and tarping) proportionally to the change in yield (e.g., if yield falls by 10 percent, the amount of labor also falls by 10 percent). To the extent that labor costs fall less than this, our results will underestimate benefits (and vice versa). Management labor costs are estimated at 5 percent of total costs (following the original budget). Other custom labor, including swathing and raking, are adjusted based on the number of hay cuttings. The original budget modeled four cuttings, while the adapted budgets used in this analysis model three cuttings.

3.2.4. Revenues

To estimate the gross revenues of alfalfa hay, we use the average price per ton for alfalfa hay in Oregon from 2022 to 2024 and adjusted this average price to 2025 dollars using the IPDGDP (Bureau of Economic Analysis, 2025). This results in an average price of $282.23 per ton. For yields in NUID, we use the average yield in Jefferson County from 2013 to 2017: 5.4 tons per acre (NASS, 2023).

3.2.5. Alfalfa Enterprise Budget Tables

The tables below present alfalfa hay enterprise budgets used to estimate the costs and returns under different irrigation levels.

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[24] For Jefferson County, we took the average price from 2022-2024.

[25] This is the average wage for the Farmworkers and Laborers, Crop, Nursery, and Greenhouse (occupation code 45-2092) in the Central Oregon non-metropolitan area according to the Bureau of Labor Statistics' Occupational Employment and Wage Estimates data in May 2022 (Bureau of Labor Statistics, 2022).

[26] This is roughly the average proportion of non-wage labor costs for all private, part-time workers in the U.S. in December 2018 (Bureau of Labor Statistics, 2018).

Table D-11. Alfalfa Net Returns, Production Year 1

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	5.4	ton	$282.23	$1,535.32
VARIABLE COSTS				
Custom - Swath	3.0	ac	$27.86	$83.59
Custom - Rake	3.0	ac	$13.93	$41.80
Custom - Bail	5.4	ton	$23.68	$128.84
Custom - Haul & Stack	5.4	ton	$12.54	$68.21
Custom - Tarping	5.4	ton	$6.97	$37.90
Irrigation - power	1.0	ac	$50.73	$50.73
Irrigation - water access	1.0	ac	$90.05	$90.05
Irrigation - repairs	1.0	ac	$21.49	$21.49
Irrigation - labor	0.5	ac	$20.69	$10.35
Gopher control	1.0	ac	$6.95	$6.95
Fuel	2.3	gal	$3.45	$7.87
Lubricants	1.0	ac	$1.11	$1.11
Machinery repairs	1.0	ac	$2.58	$2.58
Haystack Insurance	5.4	ton	$2.54	$13.80
Overhead	1.0	ac	$32.39	$32.39
Operating interest	1.0	ac	$30.59	$30.59
Total variable costs				$628.25
FIXED COSTS				
Machinery depreciation	1.0	ac	$8.48	$8.48
Machinery interest	1.0	ac	$4.87	$4.87
Machinery insurance, taxes, housing, license	1.0	ac	$3.54	$3.54
Management (5% of total cost)	1.0	ac	$45.19	$45.19
Establishment cost	1.0	ac	$105.90	$105.90
Land cost	1.0	ac	$152.67	$152.67
Total fixed costs				$320.64
Total costs				$948.89
NET RETURNS PER ACRE				**$586.44**

Table D-12. Alfalfa Net Returns, Production Years 2-6

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	5.4	ton	$282.23	$1,535.32
VARIABLE COSTS				
Dry Phosphate	62.6	lb	$0.91	$57.09
Dry Potash	95.2	lb	$0.65	$61.77
Dry Sulfur	30.0	lb	$0.29	$8.58
Boron	1.4	Lb	$6.54	$8.89
Custom Application	1.0	ac	$12.54	$12.54
Soil Test	1.0	ac	$0.42	$0.42
Herbicide	2.0	lb	$21.91	$43.83
Custom Application	1.0	ac	$12.54	$12.54
Custom - Swath	3.0	ac	$27.86	$83.59
Custom - Rake	3.0	ac	$13.93	$41.80
Custom - Bail	5.4	ton	$23.68	$128.84
Custom - Haul & Stack	5.4	ton	$12.54	$68.21
Custom - Tarping	5.4	ton	$6.97	$37.90
Irrigation - power	1.0	ac	$57.07	$57.07
Irrigation - water access	1.0	ac	$90.05	$90.05
Irrigation - repairs	1.0	ac	$21.49	$21.49
Irrigation - labor	0.5	ac	$20.69	$10.35
Haystack insurance	5.4	ton	$2.54	$13.80
Gopher control	1.0	ac	$6.95	$6.95
Fuel	2.3	gal	$3.45	$7.87
Lubricants	1.0	ac	$1.11	$1.11
Machinery repairs	1.0	ac	$2.58	$2.58
Overhead	1.0	ac	$48.77	$48.77
Operating interest	1.0	ac	$39.49	$39.49
Total variable costs				$865.52
FIXED COSTS				
Machinery depreciation	1.0	ac	$8.48	$8.48
Machinery interest	1.0	ac	$4.87	$4.87
Machinery insurance, taxes, housing, license	1.0	ac	$3.54	$3.54
Management (5% of total cost)	1.0	ac	$57.05	$57.05
Establishment cost	1.0	ac	$105.90	$105.90
Land cost	1.0	ac	$152.67	$152.67
Total fixed costs				$332.50
Total costs				$1,198.02
NET RETURNS PER ACRE				**$337.30**

3.3. Fallow Enterprise Budget

We based the fallow enterprise budget on a 2021 budget for winter wheat by OSU (Powell & Seavert, 2021). We selected this budget as the basis for NUID fallowing costs because it was recently published and is modeled on North Central Oregon, a region that borders Jefferson County. In the original budget, the wheat is planted following a fallow cycle, and the budget separates the production costs associated with fallowing from the costs associated with wheat production. As in the alfalfa budgets, we updated the costs presented in the original budget to account for changing values over time and to reflect conditions specific to NUID.

3.3.1. Modeled Farm

The modeled farm is assumed to be the same size and have the same complement of machinery as the alfalfa budget (which would include the mower and pull sprayer necessary to maintain the fallow fields). Accordingly, we adopt the same fixed machinery costs as the alfalfa budget, while excluding the management fee and establishment costs that would only be incurred under alfalfa production.

3.3.2. Input Costs

Input costs for fallowing in the original budget include the cost of running and maintaining the mower and pull sprayer (i.e., variable costs) and the cost of the herbicides. As in the alfalfa budgets, we adjusted all costs in the fallowing budget from their original dollar year (2021) to 2025 dollars using the PPI. We adjusted equipment costs using the "Machinery, Totals" PPI category and the cost of herbicides using the "Herbicides" PPI category. We set land costs equal to those under the alfalfa budget ($153 per acre).

3.3.3. Labor Costs

Because the original budget provided labor costs on a per-acre basis (rather than the number of labor hours), we adjusted the total labor costs by the relative difference in labor rates. The original budget used a total labor cost of $20.50 per hour while ours used $23.54 per hour, resulting in an increase in total labor costs of 14.8 percent.

3.3.4. Revenues

Fallowing produces no saleable products, and therefore generates no revenues.

3.3.5. Fallowing Enterprise Budget Table

The table below presents the fallowing enterprise budget used to estimate the costs of fallowing land in NUID.

Table D-13. Costs of Fallowing

Item	Quantity	Unit	$/Unit	Total
VARIABLE COSTS				
Labor	1.0	ac	$0.76	$0.76
Machinery	1.0	ac	$2.63	$2.63
Herbicide	1.0	ac	$29.51	$29.51
Total variable costs				$32.90
FIXED COSTS				
Land rent - irrigated	1.0	ac	$152.67	$152.67
Machinery depreciation	1.0	ac	$8.48	$8.48
Machinery interest	1.0	ac	$4.87	$4.87
Machinery insurance, taxes, housing, license	1.0	ac	$3.54	$3.54
Total fixed costs				$169.55
Total costs				**$202.45**

1.2. Carrot Seed Enterprise Budget

The carrot seed enterprise budget (presented in full below) is an enterprise budget for carrot seeds developed by OSU in 2010 to represent the costs and benefits of producing carrot seeds in Central Oregon (Butler & Weber, 2010). We updated the costs and revenues presented in the budgets to account for changing values over time and to reflect values specific to NUID.

1.2.1. Modeled Farm and Equipment

The farm modeled in the original OSU budget is 600 acres total, of which 40 acres is dedicated to carrot seed. The budgets are based on producing hybrid carrot seed under drip irrigation. Power equipment units used in production include a combine, ATV, three two-wheel-drive tractors, one four-wheel-drive tractor, and a tractor with a loader. The implements and equipment include a swather, bedder bar, carrot roller, chisel, cultimulcher, cultipacker, disk, flail mower, flamer, flex harrow, land leveler, mint planter, mint rake, paper roller, pasture harrow, precision planter, roller, rolling cultivator, row sprayer, and tool bar with shovels.

1.2.2. Input Costs

All costs are adjusted from the original values in the OSU budget. Wherever possible, we adopted area-specific values, which was the case for fuel prices and irrigation charges. For water allotment charges and land costs, we use the same value as the alfalfa budget. For costs that did not have area-specific values, we used the same PPI adjustment method described in the alfalfa budget.

1.2.3. Labor Costs

We model labor costs for carrot seed using the same values described above for alfalfa: $20.69/hour for general labor and $23.54 machine operators.

1.2.4. Revenues

To estimate the gross revenues of carrot seeds under full irrigation, we use the yield from the original OSU carrot seed budget (400 pounds per acre) because it is specific to Central Oregon and reflects the likely yield under drip irrigation (and thus matches the costs of production modeled in the published enterprise budget). We use the average price per pound received by farmers for carrot seed in Central Oregon from 2023 to 2025 (adjusted for inflation in 2025 dollars), according to data from Central Oregon Seeds: $17.75 (Stout, 2025).

1.2.4.1. Carrot seed Enterprise Budget Tables

The table below presents the enterprise budget used to estimate the net returns to carrot seed in NUID.

Table D-14. Carrot Seed Enterprise Budget

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Carrot seeds	400.0	lbs	$17.75	$7,100.29
VARIABLE COSTS				
Insecticides	1.0	acre	$186.36	$186.36
Herbicides	1.0	acre	$305.57	$305.57
Fungicides	1.0	acre	$171.61	$171.61
Fertilizer	1.0	acre	$148.25	$148.25
Other	1.0	acre	$222.58	$222.58
Custom applications	1.0	acre	$208.57	$208.57
Rentals	1.0	lbs	$373.95	$373.95
Seed	1.0	lbs	$37.13	$37.13
Irrigation lot charge	1.0	acre	$90.05	$90.05
Install drip irrigation	1.0	acre	$456.43	$456.43
Hand Labor	6.7	hours	$20.69	$139.25
Irrigation labor	10.0	hours	$20.69	$207.33
Operator labor	11.5	hours	$23.54	$271.18
Roguing labor	20.0	hours	$20.69	$413.83
Diesel fuel	27.6	gal	$4.43	$122.36
Gasoline	4.7	gal	$3.45	$16.11
Repair & maintenance	1.0	acre	$202.65	$202.65
Interest on operating capital	1.0	acre	$155.63	$155.63
Total variable costs				$3,728.84
FIXED COSTS				
Implements	1.0	acre	$140.02	$140.02
Tractors	1.0	acre	$251.49	$251.49
Self-propelled equipment	1.0	acre	$275.24	$275.24
Trucks	1.0	acre	$17.52	$17.52
Pickup & misc equipment	1.0	acre	$83.20	$83.20
Land cost	1.0	acre	$152.67	$152.67
Irrigation systems	1.0	acre	$81.90	$81.90
Total fixed costs				$1,002.03
Total costs				$4,730.87
NET RETURNS PER ACRE				**$2,369.41**