Appendix A

Comments and Responses

Table A-1. Topics and Associated Codes.

[To be completed after public review of the Draft Plan-EA.]

Table A-2. Responses to Comments Received During the Public Comment Period for East Fork Irrigation District Watershed Plan-EA.

[To be completed after public review of the Draft Plan-EA.]

Appendix B

Project Maps

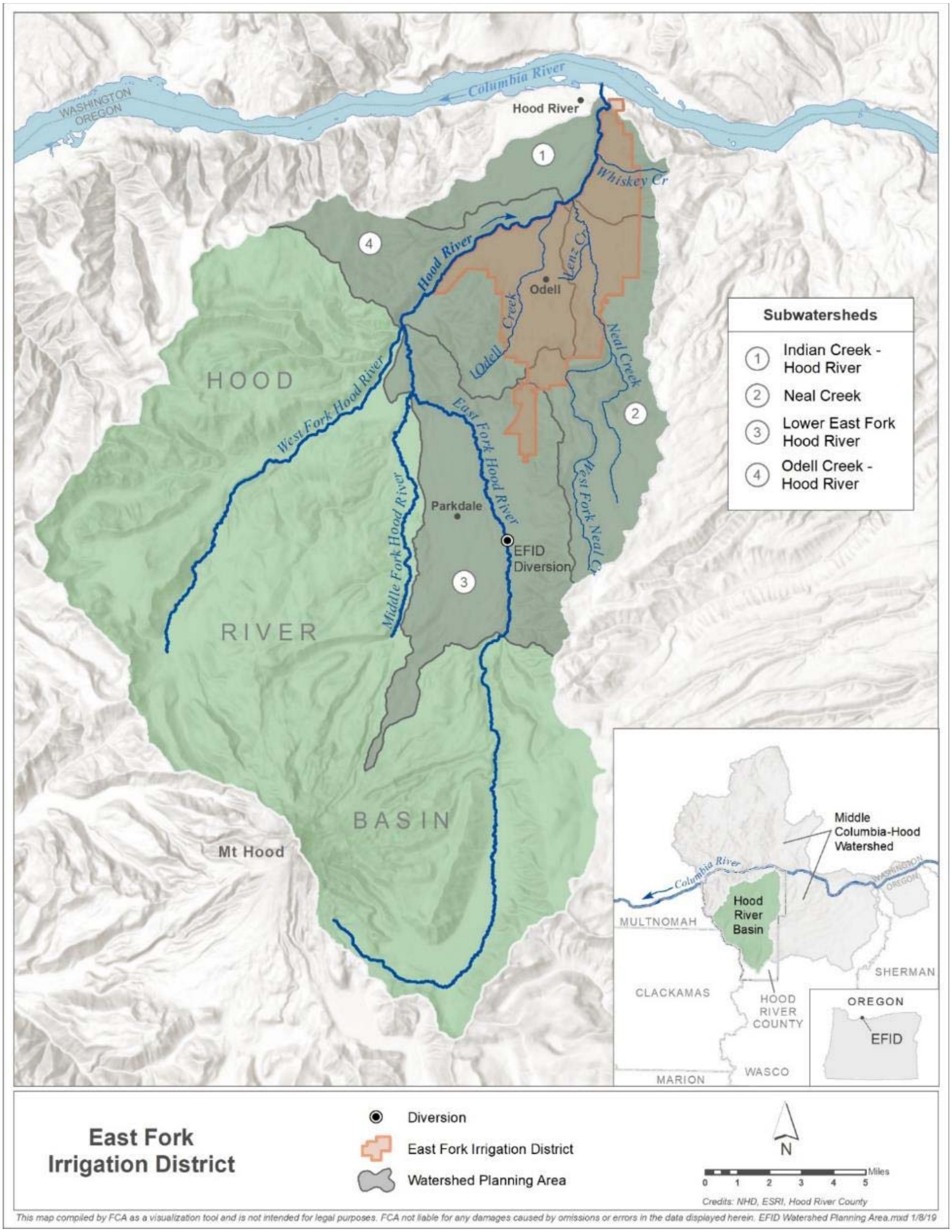

Figure B-1. The four watersheds within the East Fork Irrigation District watershed planning area.

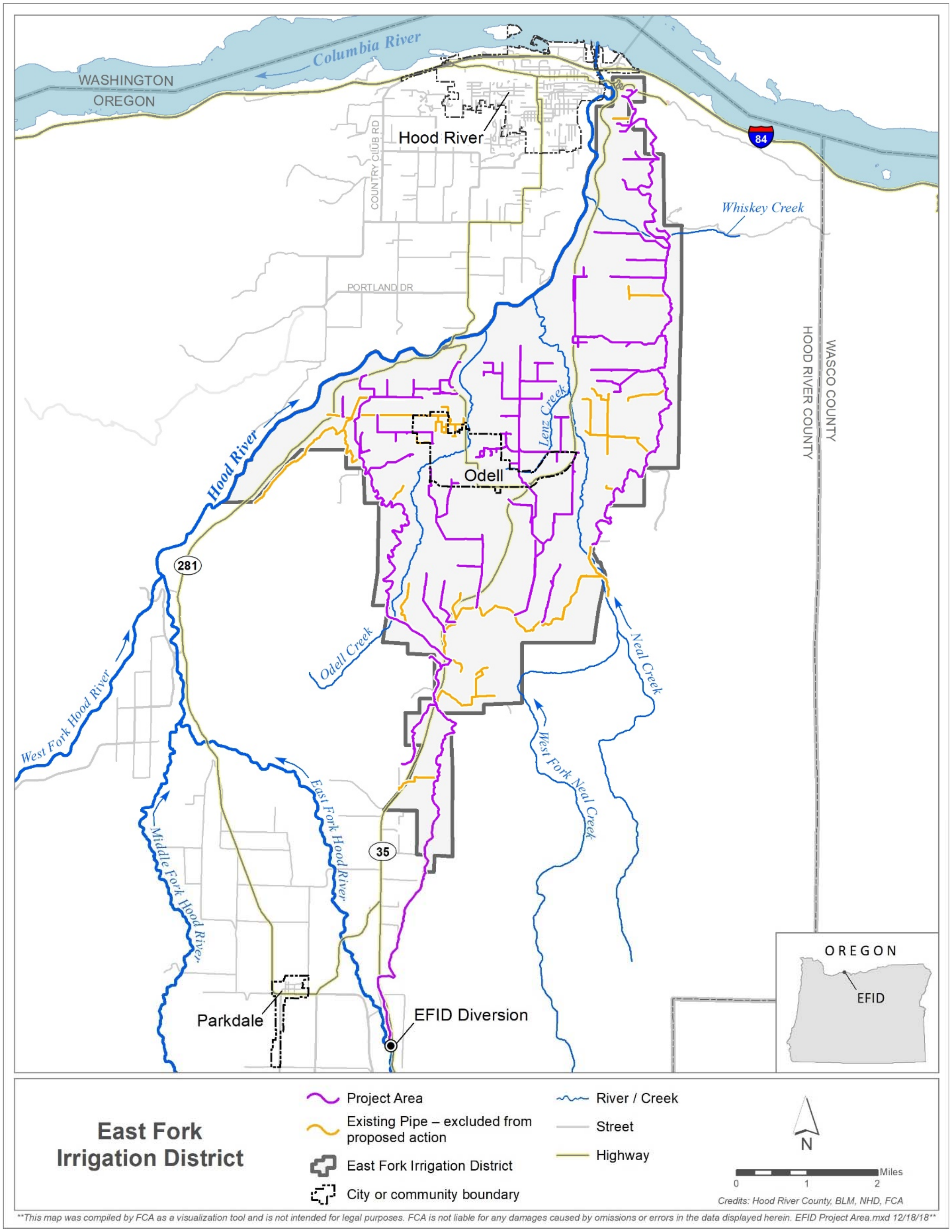

Figure B-2. Location of the East Fork Irrigation District Infrastructure Modernization Project area.

Appendix C

Supporting Maps

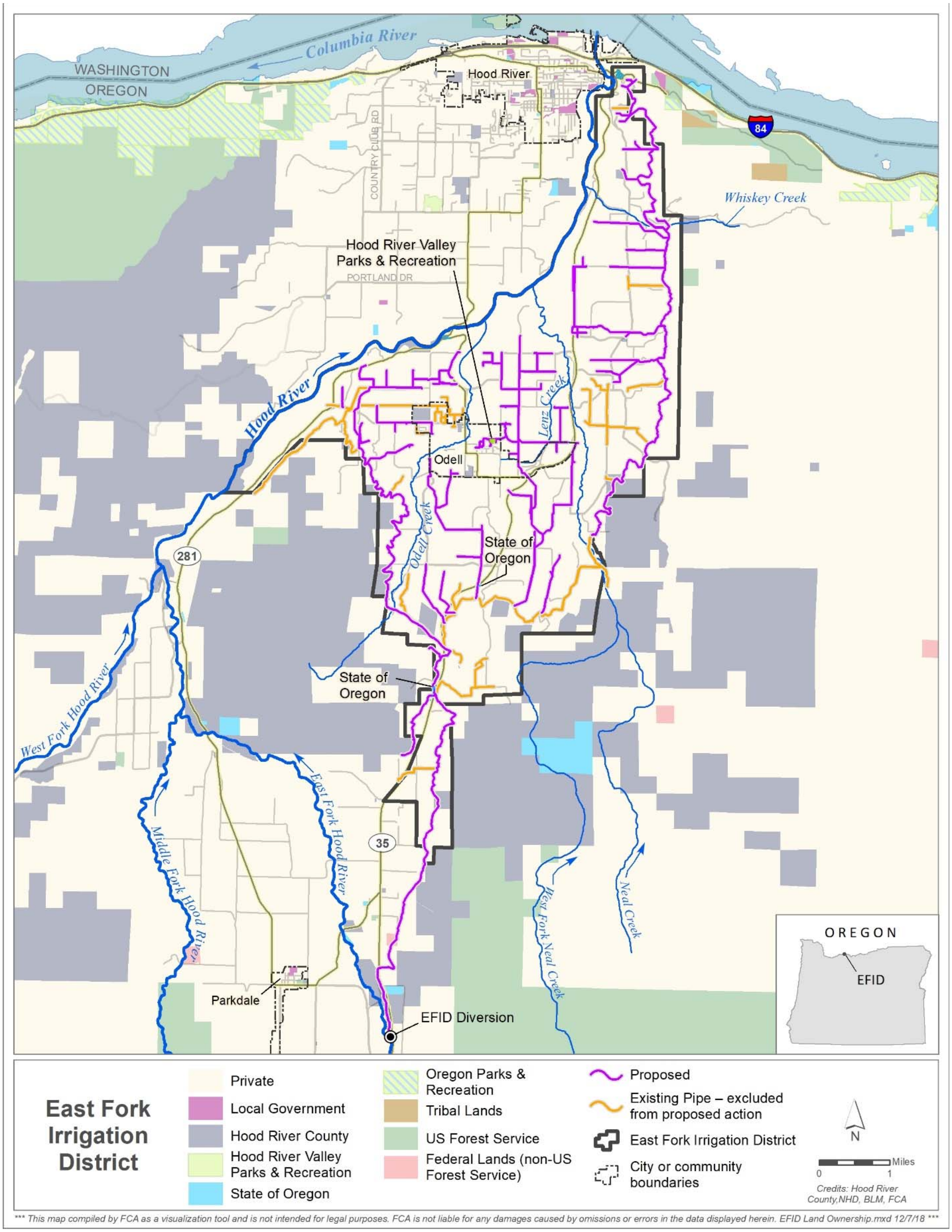

Figure C-1. Land ownership within and in the vicinity of East Fork Irrigation District.

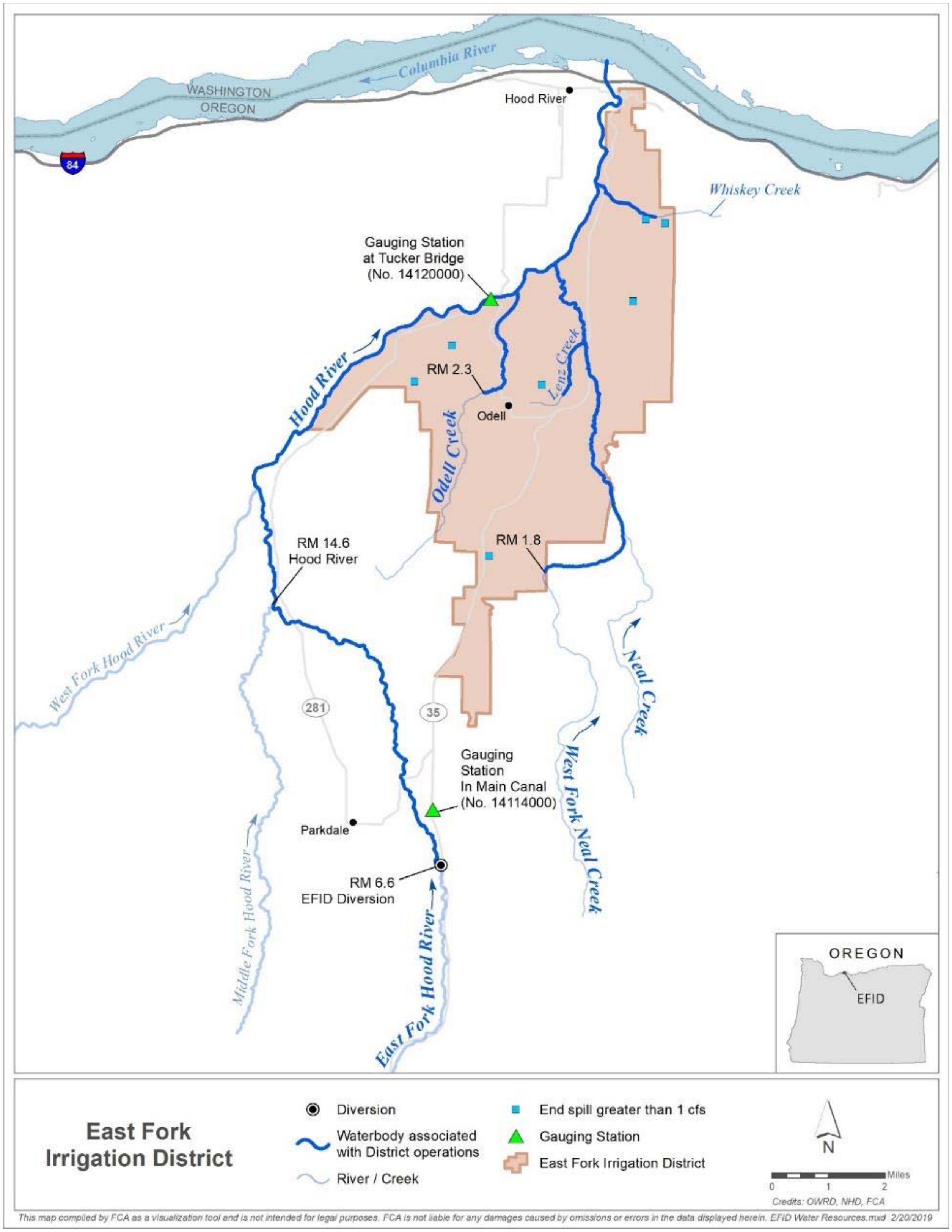

Figure C-2. Waterbodies associated with District operations and locations of streamflow gaging stations.

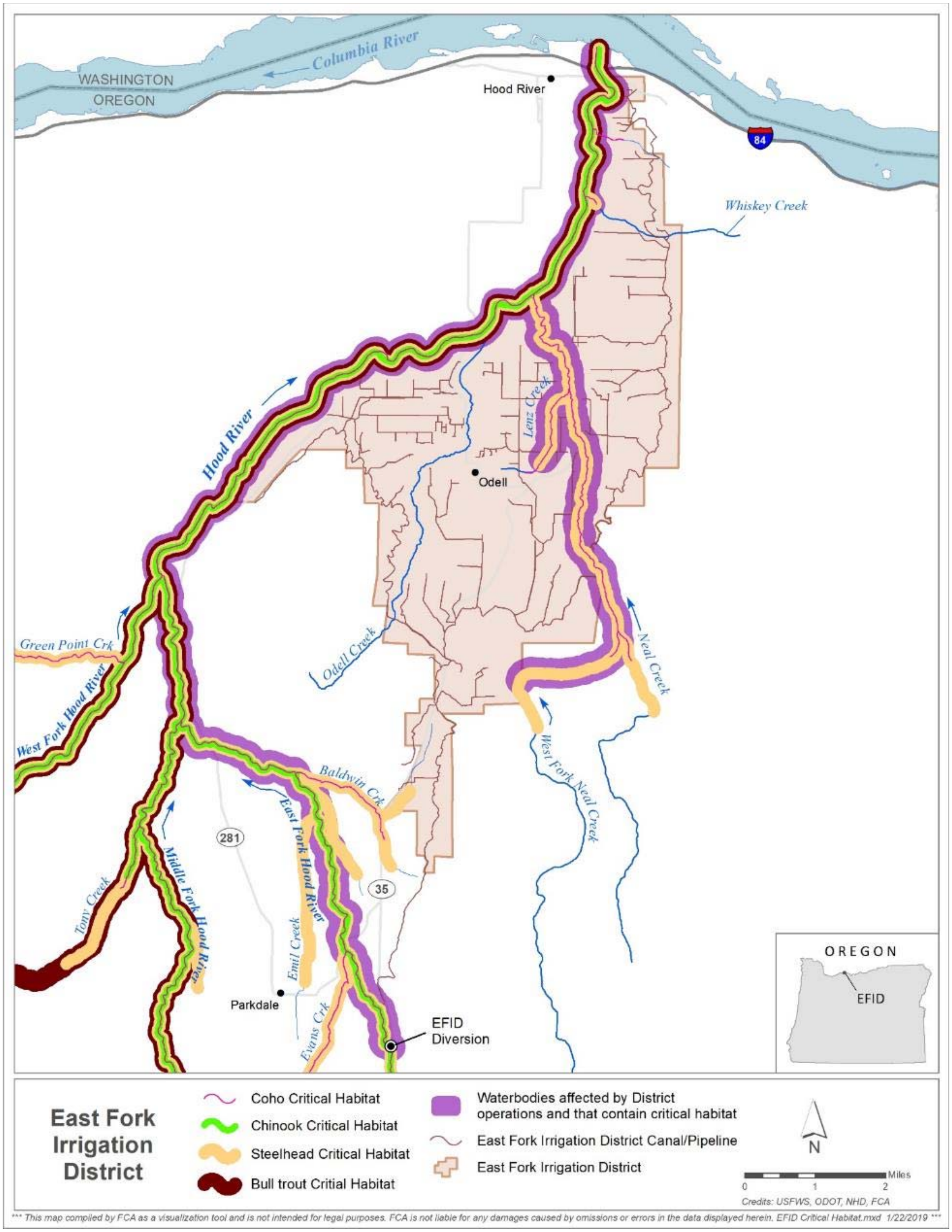

Figure C-3. Critical habitat designated for bull trout, coho, steelhead, and Chinook in the East Fork Irrigation District watershed planning area.

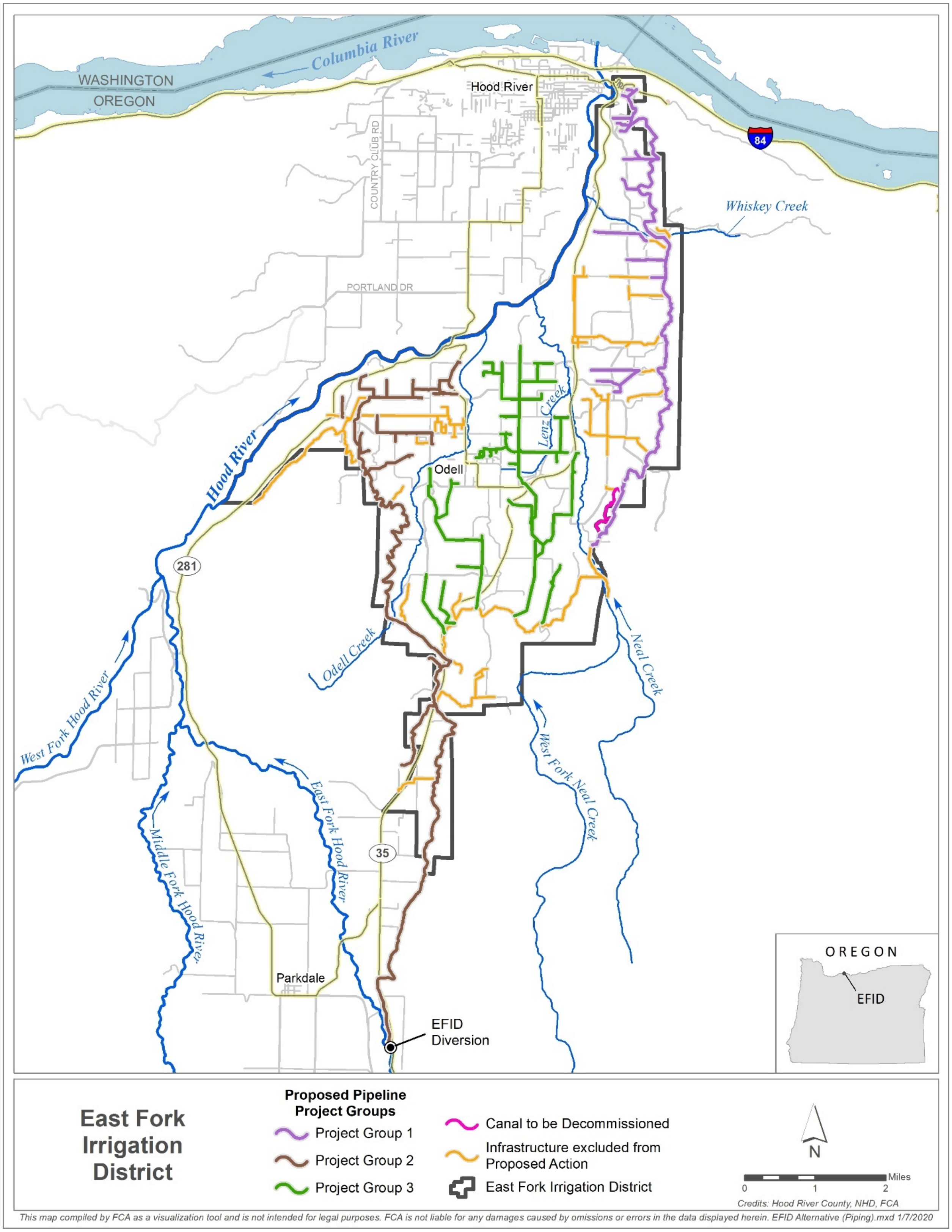

Figure C-4. The Piping Alternative project groups for the East Fork Irrigation District Infrastructure Modernization Project.

Appendix D

Investigation and Analysis Report

Highland Economics LLC

National Economic Efficiency Analysis

Barbara Wyse and Winston Oakley
12/23/2019

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Acronyms, Abbreviations, and Short-forms

AF	acre-foot
BOR	United States Bureau of Reclamation
cfs	cubic feet per second
EA	Environmental Assessment
EFID	East Fork Irrigation District
FCA	Farmers Conservation Alliance
gpm	gallon per minute
HDPE	high-density polyethylene
hp	horsepower
IWG	Interagency Working Group
kWh	kilowatt hour
Mt	metric ton
MWh	megawatt hour
NASS	National Agricultural Statistics Services
NEE	National Economic Efficiency
NRCS	Natural Resources Conservation Service
O&M	operation and maintenance
OMR	operate, maintain, and replace
OSU	Oregon State University
PPI	Producer Price Indices
project	East Fork Irrigation District Infrastructure Modernization Project
PR&G	Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies
PRV	pressure reducing valve
SCC	social cost of carbon
SIP	System Improvement Plan
U.S./US	United States
USDA	United States Department of Agriculture
WSU	Washington State University

D.1 Piping Alternative

D.1.1 Costs of the Piping Alternative

This section provides a National Economic Efficiency (NEE) analysis that evaluates the costs and benefits of the Piping Alternative over the No Action Alternative for the East Fork Irrigation District (EFID) Infrastructure Modernization Project (herein referred to as project). The analysis uses Natural Resources Conservation Service (NRCS) guidelines for evaluating NEE 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 for Water and Land Related Resources Implementation Studies and Federal Water Resource Investments (DM 9500-013).

All economic benefits and costs are provided in 2019 dollars and have been discounted and amortized to average annualized value using the fiscal year 2019 federal water resources planning rate of 2.75 percent.

D.1.1.1 Analysis Parameters

This section describes the general parameters of the analysis, including funding sources and discount rates, the evaluation unit, the project implementation timeline, the period of analysis, and the project purpose.

Evaluation Unit

The proposed project is divided into three project groups. While some of the project groups depend on other project groups to produce water-saving benefits, as long as the project groups are implemented in the proposed order, each of the project groups could be completed as stand-alone projects and have a positive net-benefit. As such, each project group is defined as the evaluation unit. Note that for the incremental analysis, costs for constructing any given project group would not change if it were the only project group constructed.

Project Timeline

Construction is expected to begin in October 2020 and be completed in 10 years. For all Works of Improvement, the analysis assumes that full benefits would be realized the following year after construction is completed (e.g., for Project Group 1 construction begins in Year 0, is completed in Year 2, and full benefits are realized in Year 3). The analysis also assumes that project groups are completed in numeric order (i.e., Project Group 1 is completed first, followed by Project Group 2, and so on). A table showing the order of installation and timeframes can be found in Section 8.6.2 of the Draft Watershed Plan-Environmental Assessment (Plan-EA).

Analysis Period

The analysis period for each individual project group is defined as 102 to 105 years since the installation period is 2 to 5 years for each project group, and 100 years is the expected project life of buried high-density polyethylene (HDPE) pipe. Across the three project groups, the installation period is anticipated to be 10 years and the overall analysis period is thus defined as 110 years (Year 0 to Year 109).

Project Purpose

The piping infrastructure is multipurpose: it provides habitat benefits, agricultural production benefits, energy cost saving benefits, and operation and maintenance (O&M) cost savings. Because no project cost items serve a single purpose separately, this analysis does not allocate costs or benefits by purpose.

D.1.1.2 Proposed Project Costs

NWPM 506.11, Economic Table 1, NWPM 506.12, Economic Table 2, and NWPM 506.18, Economic Table 4 found in Section 8.8 of the Plan-EA summarize installation costs, distribution of costs, and total annual average costs for the Piping Alternative. (Note that Economic Table 3, Structural Data—Dams with planned storage capacity, is omitted as dams are not proposed). In addition to the installation costs, the Piping Alternative would entail costs to maintain and replace the sedimentation basin and costs to replace steel pipe. These costs are included as "Other Direct Costs." The subsections included in this report provide detail on the derivation of the values in the tables found in the Plan-EA. Based on East Fork Irrigation District (EFID or District) past experience of piping irrigation canals, the District expects cost savings, not cost increases for infrastructure maintenance, repair, and replacement of the Piping Alternative (Buckley, 2019).

D.1.1.3 Project Installation Costs

According to the most recent estimates by engineering professionals at Watershed Professional Network LLC and Black Rock Consulting, the cost of piping and associated farm turnouts is roughly $60,220,000 (in 2018 dollars). We adjusted this price to 2019 dollars using the RSMeans construction cost index (an effective increase of 2 percent) (RSMeans, 2019). With the cost adjustment and the additional cost of the sedimentation basin ($767,000), the total construction cost is $62,178,000 in 2019 dollars. See Appendix D.3 for detailed cost derivation by pipe size, cost category, etc. All values in this analysis are presented in 2019-dollar values and rounded to the nearest $1,000 value. Of total estimated costs, Farmers Conservation Alliance (FCA) estimated that roughly 96 percent would go to construction and the remaining 4 percent would go to engineering.

Adding an additional 3 percent for in-kind project administration from EFID, 8 percent technical assistance from NRCS, and permitting costs of $1,865,000, the total cost for the Piping Alternative in 2019 dollars is estimated at $68,711,000. The average annual cost by project group is shown in Section 8 of the Plan-EA, in 2019 dollars, with an average annual cost of $1,864,000 for the Piping Alternative (assuming piping projects are completed in order).

D.1.1.4 Other Direct Costs

Other direct costs under the Piping Alternative consist of the costs to operate, maintain, and replace (OMR) the sedimentation basin, and the costs to replace steel pipe.

Sedimentation Basin OMR Costs

Since the Piping Alternative would eliminate three existing in-canal settling basins, a new sedimentation basin would be installed immediately downstream of the sand trap. To continue to function properly, the sedimentation basin would require regular removal of sediment. The labor, logistic, and replacement costs of the basin would depend on its design, which has not yet been finalized. However, the EFID District Manager estimated the potential costs of maintaining the basin based on historic costs of maintaining the District's existing sand trap (which requires similar maintenance). The District Manager estimated the annual costs of maintaining the basin, which due to its larger size, could be as much as three times the cost of maintaining the sand trap, which requires 6 labor hours every 2.5 weeks from March to October, which totals 67.2 hours per year (Buckley, 2019). In years where sediment levels are extraordinarily high, the sand trap requires an excavator. We assume that the sedimentation basin would require an excavator for the same number of hours as normal labor (67.2 hours per year), which is likely an overestimate (Buckley, 2019). Maintenance labor costs the District $39.46 per hour, while excavator work costs $84.46 per hour.[1] Allowing for periodic excavator work, this brings the total maintenance cost estimate of the sand trap to roughly $4,450 per year. At three times this cost, the estimated annual cost to maintain the sedimentation basin is around $14,000.

In addition to the O&M costs, the sedimentation basin would require replacement before the end of the 100-year project period. Because the final design has not been established, the costs to replace the sedimentation basin are uncertain. Therefore, in order to estimate the replacement costs, we used the full cost of constructing the basin ($767,000, including contingency costs), which is likely to be an overestimate of the replacement costs. We assume the basin would have a useful life of 50 years, based on an estimate by an NRCS Engineer (Cronin, 2019). The sediment basin is expected to be completed in Year 5, with a replacement needed in Year 56. As such, annual costs begin in Year 6 and replacement cost of the sediment basin is assumed to be incurred in Year 56, with annual costs then being incurred again after that. We apportion both the maintenance and replacement costs among the project groups using the proportion of irrigated acres in each project group, as shown in Table 1. When discounted and annualized, the cost of maintaining and replacing the sedimentation basin totals approximately $18,000 per year.

Table 1. Costs of Maintaining and Replacing the Sedimentation Basin Under the Piping Alternative, Hood River Watershed, Oregon, 2019$.[1]

Project Group	Irrigated Acres	Apportioned Cost of Replacement	Apportioned Annual Cost of Maintenance[2]	Total Annualized Costs
1	599	$48,000	$1,000	$1,000
2	5,196	$414,000	$8,000	$10,000
3	3,820	$305,000	$6,000	$7,000
Total	**9,615**	**$767,000**	**$14,000**	**$18,000**

Note: Totals may not sum due to rounding. Prepared April 2019
[1] Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.
[2] Total maintenance costs were estimated by the EFID District Manager (Buckley, 2019).

STEEL PIPE REPLACEMENT

The Piping Alternative would require a relatively short section of steel piping. Unlike HDPE pipe, steel pipe has an expected life of 50 years, and would therefore need to be replaced during the period of this analysis (Crew, Black Rock Consulting, 2018). Experts estimate that around 25 percent of the total steel pipe would need to be replaced in Year 50, and the remaining 75 percent would need to be replaced in Year 75 (Crew, Black Rock Consulting, 2018). We assume that these costs would be incurred 50 and 75 years after the construction of each project group, and the cost to replace the steel pipe would be the same as the cost to install it in 2019. Table 2 shows the costs of replacing steel pipe under the Piping Alternative. Because the replacement costs are relatively small and would occur in the distant future, the present value of the replacement cost is effectively zero when discounted and rounded to the nearest $1,000 (as shown in the last column of the table).

[1] The District pays maintenance labor about $26 per hour and incurs another $13.46 per hour in benefits and other labor costs. An excavator costs $71 per hour plus the same additional labor costs.

Table 2. Other Direct Costs of Steel Pipe Replacement Under the Piping Alternative, Deschutes Watershed, Oregon, 2019$.[1]

Works of Improvement	Feet of Steel Pipe Replaced	Total Replacement Cost in 2019	Annual Average NED Cost
Project Group 1	-	$0	$0
Project Group 2	38	$32,500	$0
Project Group 3	-	$0	$0
Total	**38**	**$32,500**	**$0**

Note: Totals may not sum due to rounding. Prepared June 2019
[1]Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.

D.1.2 Benefits of the Piping Alternative

The Plan-EA Section 8.8, (NWPM 506.21, Economic Table 6) compares the project benefits (over baseline conditions) to the annual average project costs presented in NWPM 506.18, Economic Table 4. The remainder of this section provides detail on these project benefits.

The on-site benefits that would accrue to agriculture and the local rural community include increased agricultural production, reduced power costs, and reduced O&M costs. The off-site quantified benefits include the value of reduced carbon emissions and the value of instream flow for enhanced fish and wildlife habitat. Other benefits not included in the analysis that may result indirectly from the Piping Alternative include the potential for increased on-farm investment in irrigation efficiency (as patrons would have more funds available due to increased yields and reduced pumping costs) and potential recreation benefits.

D.1.2.1 Benefits Considered and Included in Analysis

Agricultural Damage Reduction Benefit

Of the 5,287 acre-feet (AF) projected to be conserved under the Piping Alternative, 75 percent would be dedicated to instream flow (approximately 3,965 AF per year) and the remaining 25 percent would be available for use within the District (approximately 1,322 AF per year). The conserved water going to the District would be used in dry water years (approximately 10 percent of the time) to enhance the reliability of water supply for existing irrigated lands. In this section, we model the benefits of this conserved water that would be available to District patrons to supplement existing irrigation waters supplies.

During previous dry periods, the EFID District Manager has requested voluntary irrigation cutbacks, which to-date have proven sufficient to avoid mandatory water curtailments within the District (Buckley, 2019). In these voluntary curtailments, grass hay growers in particular have cut back their water use, often missing the last cutting of hay (Buckley, East Fork Irrigation District Manager, 2019; Nakamura, 2019).

To date, this management response has minimized the adverse effect of dry years on orchards, which can be significantly affected by insufficient irrigation. Insufficient irrigation water to orchards can adversely affect yield and quality in the year of insufficient water and in future years. Young trees in the establishment period can be particularly affected, so growers typically prioritize water application to these young trees (Buckley, East Fork Irrigation District Manager, 2019; Nakamura, 2019; Marsal, Girona, & Naor, 2012). However, as discussed in more detail below, a recent study from the U.S. Bureau of Reclamation (BOR) projects that future streamflow volumes and irrigation water supplies will be lower in the East Fork of the Hood River, resulting in greater shortages to EFID in dry water years (i.e., in 10 percent or more of years). The conserved water from piping, both by reducing District end spill losses and increasing the amount of water available to irrigators by 1,322 AF per year, would reduce the adverse effects of these projected future dry year shortages and provide a crop damage reduction benefit. However, as the District is projected to have a shortfall only in approximately 10 percent of water years, the District would likely keep this 1,322 AF of conserved water instream for approximately 90 percent of water years (Buckley, 2019).

According to the BOR study, by the year 2030, climate change is expected to cause water supply shortages in EFID of 10 to 12 percent from July to September in the 10th percentile water year (i.e., a dry water year will occur roughly 1 out of every 10 years) (Bureau of Reclamation, 2014), with even greater shortages in the 0 to 10th percentile water years.[2] EFID water rights total 117 cubic feet per second (cfs). The BOR report thus indicates that the District will face shortages of roughly 12.87 cfs (11 percent of 117 cfs) in at least 1 year every decade. The actual shortage is expected to be larger since the BOR study did not account for a recent agreement between EFID and the Confederated Tribes of the Warm Springs Reservation to maintain 15 cfs instream in the East Fork Hood River. The BOR study did account for a 2.1 cfs instream water right, so the currently agreed upon instream flow is 12.9 cfs larger than was projected in the BOR study (Christensen, 2019). Adding together these effects (12.87 cfs and 12.9 cfs), and in absence of the Piping Alternative, the total EFID water supply shortage in 1 out of 10 years will be 25.77 cfs beginning in 2030. This would bring the District's total water supply down from 117 cfs to 91.2 cfs (a 22 percent reduction).

As noted above, some EFID growers have voluntarily reduced their total water consumption by 20 to 25 percent in past water shortages, with low-value crops such as hay and pasture bearing a large share of the reductions (Buckley, 2019). We conservatively assume that all growers of low-value crops will reduce their total water consumption by 30 percent, which the EFID District Manager agrees is plausible (Buckley, 2019). We model the economic returns to low-value crops using grass hay a representative crop. The impact of losing 30 percent of their water would likely cause grass hay growers to forego their third and final cutting of the season, which has an average yield of roughly 1 ton per acre in EFID (Buckley, 2019). We estimate the impact to growers' net returns using crop enterprise budgets developed by Oregon State University (OSU) and Washington State University (WSU), which we inflated to current dollars and slightly adapted to match EFID conditions (a process described in detail in Appendix D.2). Based on the crop enterprise budgets for grass hay (shown in Table 19 and Table 20), this loss is expected to reduce net returns by just over $100 on each acre of low-value crops. Since low-value crops are estimated to comprise 1,635 acres in the District,[3] the economic impact of these water shortages will be to reduce net returns of low-value crops by roughly $172,000 in the 10 percent of years this water shortage occurs.

With the low-value crop growers absorbing a 30 percent water curtailment, this would leave high-value crop growers with an overall water deficit of 20 percent.[4] We used pears to estimate the reduced net returns to high-value crops in the District. A compilation of studies has shown that, on average, decreasing the water available to producing pear trees by 1 percentage point results in a 1.3 percent decrease in gross revenue (Marsal, Girona, & Naor, 2012). Incorporating this relationship into the crop budget for pears (shown in Table 17) indicates that, in the absence of the Piping Alternative, the 20 percent water shortages facing high-value crop growers would result in a loss of just under $2,758 for each acre of high-value crops. As high-value crops comprise approximately 7,981 acres in the District, the loss of net returns to all high-value crops is projected to be $22,008,000 in the 10 percent of years this water shortage is expected to occur. When combined with the loss to low-value crops ($172,000), the total economic loss from climate change is expected to be $22.180 million in 10 percent of years starting in the year 2030 if the Piping Alternative is not

[2] There would also be shortages of a smaller magnitude in slightly wetter water years (i.e., water years in the 10th to 20th percentiles). We conservatively apply the 10th percentile shortages to just the driest 10 percent of water years.
[3] Low-value crops occupy roughly 17 percent of the District's 9,615 total acres, as explained in the section above. (17 percent x 9,615 acres = 1,635 acres).
[4] A total shortage of 22 percent, subtracting a 30 percent cutback on 17 percent of acres, leaves a 20 percent cutback on the remaining 83 percent of acres. (0.22 - 0.17 x 0.3) / 0.83 = 0.2.

implemented. The summary of this analysis is presented in Table 3 under the No Action Alternative. In this analysis, we assume that the projected decreased yield in EFID would not affect pear prices received by EFID farmers.[5]

Table 3. Climate Change Impacts to EFID Agricultural Production.

	No Action Alternative		Piping Alternative	
EFID demand	117 cfs		100.4 cfs	
EFID supply	91.2 cfs		91.2 cfs	
EFID total water shortage	22%		9%	
	Low-value crops	High-value crops	Low-value crops	High-value crops
Acreage	1,635	7,981	1,635	7,981
Irrigation deficit by crop type	30%	20%	30%	5%
Loss of net returns per acre	$105	$2,758	$105	$657
Total loss in net returns by crop	$172,000	$22,008,000	$172,000	$5,245,000
EFID loss in net returns	$22,180,000		$5,417,000	
Avoided loss in net returns under piping in 10% of years[1]	$16,763,000			
Annual average net benefit under piping	$1,676,000			

[1] Full climate change impacts are projected to begin in the year 2030 (Marsal, Girona, & Naor, 2012), with benefits phasing in between 2020 and 2030.

The Piping Alternative would reduce the effect of future water shortages, reducing yield losses and providing economic benefits. Under piping, the District would face the same water supply that is available for diversion as under No Action: 91.2 cfs. However, under the Piping Alternative, the District's total water demands would experience a net decline of 16.6 cfs as a result of water conserved from piping (decreasing the total demand to 100.4 cfs).[6] This suggests that EFID would face a total supply shortage of approximately 9.2 cfs (100.4 cfs to 91.2 cfs), or 9 percent.[7] This compares to a 22 percent water supply shortage in the No Action Alternative.

[5] There is no historic data from the area for the relationship between price and production levels, and interviews indicate that water reliability to date has not reduced orchard yield. The pear market is an international market with significant U.S. fresh pear production exports and imports from other countries (imports of fresh pears comprise about 21 percent of U.S. production, while exports represent about 44 percent of national production). Considering just the national pear market, the projected change in yield for EFID under No Action as a percent of national pear production is under 5 percent, while the projected change in yield under the Piping Alternative represents approximately 2 percent of national production. Given that this is a relatively small change and that there is not a clear relationship between changes in national production and price over the last several years (it is a complex market with many factors affecting price), we assume no price change for pears due to this level of change in EFID production.

[6] Because EFID uses all of its water rights in dry years, when piping conserves 16.6 cfs, the District would no longer need that water for conveyance (i.e., the water lots to seepage or end losses would no longer be required in order to supply District patrons).

[7] 9.2 cfs / 100.4 cfs = 9 percent

As in the No Action Alternative, we assume that low-value crop growers would curtail their total water use by 30 percent in extremely dry years. With each of the 1,635 acres of low-value crops losing a little over $100 in net returns, the total economic loss to low-value crops is projected to be the same as in the No Action Alternative: $172,000 in 10 percent of years.

With the low-value crop growers curtailing their water use by 30 percent, high-value crop growers would face total water shortages of 5 percent.[8] Given the water deficit/gross revenue relationship of pears described above (1.3 percent reduction in gross revenue per 1 percent reduction in water), this shortage is expected to decrease pear yield revenues by 5 percent. Incorporating the change into the pear crop budget (shown in Table 18), the water shortage will cause net returns to decline by just under $660 for each acre of high-value crop. As in the No Action Alternative, the District's total area of high-value crops is expected to be 7,981 acres. Accordingly, the total loss of net revenues to high-value crops is projected to be roughly $5.245 million. When combined with the impacts to low-value crops ($172,000), the total economic loss resulting from climate change under the Piping Alternative is around $5.417 million, which is expected to occur in 10 percent of years beginning in the year 2030.

Given that the total annual economic loss in a dry water year under No Action is projected to be $22.180 million, while the corresponding total economic loss under the Piping Alternative is projected to be reduced to $5.417 million, the total economic loss avoided by piping (i.e., the net benefit of piping) is approximately $16.763 million per dry water year. These net benefits are expected to be realized in the driest 10 percent of years. Therefore, the average annual net benefit of piping is expected to be $1.676 million beginning in the year 2030 (10 percent of $16.763 million). We assume that the impacts of climate change will gradually increase from 2020 to the 2030 predicted levels; as such we linearly increase the risk of climate change from the year 2020 to 2030 (i.e., 2021 has 10 percent of the damage projected in 2030, 2022 has 20 percent of the damage projected in 2030, etc.). When discounted and annualized, the avoided damage of climate change under the Piping Alternative is expected to bring average annual benefits of $1.37 million (as shown in Table 4 below).

Table 4. Annual Avoided Loss in Agricultural Production Under the Piping Alternative by Project Group, Hood River Watershed, Oregon, 2019$.[1]

Works of Improvement	Total Future Acres by Project Group	Average Annual Avoided Climate Change Impacts in the year 2030	Average Annual NEE Benefit
Project Group 1	599	$104,000	$91,000
Project Group 2	5,196	$906,000	$760,000
Project Group 3	3,820	$666,000	$522,000
Total	**9,615**	**$1,676,000**	**$1,372,000**

Note: Totals may not sum due to rounding. Prepared April 2019
[1]Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.

As noted above, when the District is not using its full 25 percent allocation of the water conserved by piping, it expects the water would be kept instream (Buckley, 2019). Because we only model the District using its full allotment of conserved water rights in the 10 percent of years EFID is expected to face a severe water

[8] A total shortage of 9 percent, subtracting a 30 percent cutback on 17 percent of acres, leaves a 5 percent cutback on the remaining 83 percent of acres. (0.09 - 0.17 x 0.3) / 0.83 = 0.05

shortage, we model the District's water going instream the remaining 90 percent of years. The value of this water is further described in the section below, titled the Value of Conserved Water.

Operation and Maintenance Cost Savings Benefit

The District currently incurs a number of costs associated with the O&M of open canals, which would be avoided under the Piping Alternative. These costs include the expense of manually adjusting water deliveries and end spills, inspecting and repairing canals, maintaining stormwater drains, dredging District-owned sediment ponds, and cleaning and excavating canals. Including consideration of the O&M costs of the piped canals, the EFID District Manager estimates that piping the canals would reduce total canal O&M expenses by a total of roughly $283,000 each year (Buckley, East Fork Irrigation District Manager, 2019), of which nearly all expenses are labor cost savings.

Should the Piping Alternative be implemented, the District does not plan to reduce staff or staff time in response to the avoided O&M costs. Instead, the District plans to assign staff to other activities that would benefit the District and its patrons. We assume that these activities will generate additional benefits that are at least equal to the cost of the staff's time, implying that the value of avoiding canal O&M will bring benefits at least equal to its current cost. In other words, if the District no longer has to pay $283,000 to maintain canals, it will be able to generate at least $283,000 in benefits by reallocating that labor to other valuable tasks. We apportioned the benefits among the project groups using the relative lengths of open canal that would be piped in each project group. As shown in Table 5, when discounted over the study period, these O&M savings are expected to average $250,000 annually.

Table 5. Annual Reduced Operation and Maintenance Costs to EFID Under the Piping Alternative by Project Group, Hood River Watershed, Oregon, 2019$.[1]

Works of Improvement	Length of Open Canal Being Piped	Percent of Total Open Canal Being Piped	Undiscounted O&M Cost Savings Per Year	Discounted Annualized Benefit (OMR Cost Reduction)
Project Group 1	6.1	35%	$98,000	$93,000
Project Group 2	11.4	65%	$184,000	$157,000
Project Group 3	0	0%	$0	$0
Total	**17.5**	**100%**	**$282,000**	**$250,000**

Note: Totals may not sum due to rounding. Prepared April 2019
[1]/Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.

District patrons also engage in O&M activities for the canals, primarily cleaning algae from screens. There are approximately 25 canal screens in the District that require regular maintenance by patrons, and each screen takes roughly 4 hours to clean every day from about June through the first week in September (Buckley, 2019). In total, the effort requires an estimated 9,800 hours per year. We value this time at the average wage for farmworkers in Central Oregon: $15.89 per hour.[9] At this rate, the value of reduced patron O&M costs is roughly $156,000 per year. The Piping Alternative is expected to reduce the need for this maintenance by 50 percent (Buckley, 2019). Accordingly, the potential savings from piping is approximately $78,000 per year. We

[9] This is based on the mean hourly wage for the Farmworkers and Laborers, Crop, Nursery, and Greenhouse occupation (45-2092) in the Central OR non-metropolitan area in May 2017 ($12.84) (Bureau of Labor Statistics, 2017). This was the closest geography to Hood River County with available data. We adjusted the wage upward 20 percent to account for non-wage costs of labor, and adjusted for inflation to 2019 dollars using the Consumer Price Index.

apportion this total among the piping groups according to the length each group would be piped under the Piping Alternative (see Table 6 below). When discounted, the annualized value of O&M savings to EFID patrons is roughly $69,000.

Table 6. Annual Reduced Operation and Maintenance Costs to EFID Patrons Under the Piping Alternative by Project Group, Hood River Watershed, Oregon, 2019$.[1]

Works of Improvement	Length of Open Canal Being Piped	Percent of Total Open Canal Being Piped	Undiscounted O&M Cost Savings Per Year	Discounted Annualized Benefit (O&M Cost Reduction)
Project Group 1	6.1	35%	$27,000	$26,000
Project Group 2	11.4	65%	$51,000	$43,000
Project Group 3	0	0%	$0	$0
Total	**17.5**	**100%**	**$78,000**	**$69,000**

Note: Totals may not sum due to rounding. Prepared April 2019
[1]Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.

IRRIGATION PUMPING COST SAVINGS

Compared to the No Action Alternative, the system improvements associated with the Piping Alternative are estimated to reduce patron energy needs by 1,169,706 kilowatt hours (kWh) per year (due to patrons receiving pressurized water rather than pressurizing it themselves) (Farmers Conservation Alliance, 2018). The cost associated with this energy is estimated at $0.0830 per kWh, which is the marginal cost of electricity to irrigators using electricity from the Hood River Electric Cooperative (the power company with the greatest coverage in the District) (Hood River Electric Co-op, 2019). Table 7 presents the estimated savings to EFID patrons for each project group under the Piping Alternative. Once all project groups are complete, the average annual NEE savings to EFID patrons would be approximately $86,000 each year.

Table 7. Annual Increased Average Energy Cost Savings to EFID Patrons Under the Piping Alternative by Project Group, Hood River Watershed, Oregon, 2019$.[1]

Works of Improvement	Annual Energy Savings Under Piping Alternative (kWh)	Undiscounted Annual Energy Cost Savings	Average Annual NEE Benefits (Avoided Energy Costs)
Project Group 1	614,911	$51,000	$48,000
Project Group 2	253,041	$21,000	$18,000
Project Group 3	301,754	$25,000	$20,000
Total	**1,169,706**	**$97,000**	**$86,000**

Note: Totals may not sum due to rounding. Prepared April 2019
[1] Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.
[2] As estimated by FCA (Farmers Conservation Alliance, 2018).

By providing a pressurized piping conveyance system, the Piping Alternative would allow some irrigators to eliminate the need for pumping altogether. This would reduce pump maintenance costs to irrigators. An analysis by FCA estimated that there are 457 total irrigation pumps within EFID; of those, 287 would be eliminated after pressurization. Table 8 shows the distribution of those pumps by project group.

To estimate the avoided maintenance costs of pumping, we add the average annual power company fixed service charge and the estimated annual repair costs. Hood River Electric Co-op charges $29 per horsepower (hp) of the irrigation pump. With an average irrigation pump size in EFID of 10 hp, the average annual charge is $290 (Hood River Electric Co-op, 2019; Walker C. , 2019). For annual repair costs, interviews with irrigation pump professionals indicated that surface irrigation pumps typically require maintenance every 3 to 5 years, which costs $300 to $800 per instance (Scarborough, 2019; Mark, 2019). From this, we assume the average irrigation pump receives maintenance once every 4 years, costing $550 (the midpoint of the cost range), resulting in an average annual cost of approximately $140 per year. Based on interviews with irrigation pump experts and published sources, we estimate replacement costs for a 10-hp irrigation pump at $3,000 (including installation), and assume replacement is required on average every 10 years (Haun, 2019; Fey, 2019). Amortizing this at the 2.75 annual rate, the annualized cost of replacing a 10-hp pump is about $350.

Combining the service charge, repair costs, and annualized replacement costs, we get an estimated total annual cost of approximately $780 per year per pump. We apply this cost to each eliminated pump to derive the annual benefit. Using this method, the 287 pumps eliminated would provide annual benefits of roughly $222,000, as shown in Table 8. When discounted, the avoided maintenance cost would provide annualized benefits of $193,000 over the No Action Alternative.

Table 8. Annual Increased Pump Maintenance Cost Savings to EFID Patrons Under the Piping Alternative by Project Group, Hood River Watershed, Oregon, 2019$.[1]

Works of Improvement	Total Irrigation Pumps under Baseline Conditions [2]	Pumps Eliminated under the Piping Alternative [2]	Undiscounted Annual Maintenance and Replacement Costs Avoided	Discounted Annualized Maintenance and Replacement Costs Avoided
Project Group 1	131	118	$91,000	$86,000
Project Group 2	225	114	$88,000	$73,000
Project Group 3	101	55	$43,000	$34,000
Total	**457**	**287**	**$222,000**	**$193,000**

Note: Totals may not sum due to rounding. Prepared April 2019
[1] Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.
[2] As estimated by FCA (Farmers Conservation Alliance, 2018).

Carbon Benefits

Reduced energy use also reduces carbon dioxide emissions from power generation. Every megawatt hour (MWh) of reduced on-farm energy use is estimated to translate into an estimated reduction of 0.75251 metric ton (Mt) of carbon emissions.[10] Accordingly, on average compared to Baseline conditions, the annual net energy savings of the Piping Alternative would reduce carbon dioxide emissions by approximately 880 Mt (approximately 1,169 MWh multiplied by 0.7525).

[10] 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 results in reduced fossil fuel-powered generation. Furthermore, this estimate assumes 0.75251 metric tons of carbon emitted from 1 MWh of fossil fuel-powered electricity generation based on 1) the current proportion of fuel source–oil, natural gas, and coal–for fossil fuel-powered electrical power generation in the West, and 2) the associated metric tons of carbon dioxide produced per MWh powered by each fossil fuel source, as reported by the Energy Information Administration.

To value the reduced carbon emissions, this analysis uses an estimate of the social cost of carbon (SCC), which is the estimated 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 developed a set of SCC estimates that could be used across federal agencies. In the year 2020 (the closest estimate available for the current year), the IWG estimate for SCC was estimated to be approximately $51.20 per Mt (2019 dollars) (Interagency Working Group on Social Cost of Greenhouse Gases, 2013).[11] However, in 2017, Executive Order 13783 disbanded the IWG, indicated that IWG estimates were not representative of government policy, and removed the requirement for a harmonized federal policy for SCC estimates in regulatory analysis. Since this time, the U.S. Environmental Protection Agency (USEPA) and other federal agencies have developed interim alternative estimates of the SCC, largely relying on the methodology used by the IWG, but using different discount rates and focusing on direct damages projected to occur within the borders of the United States. For example, the USEPA developed interim SCC values for the *Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units* published in June of 2019 (Environmental Protection Agency, 2019). As these interim USEPA SCC estimates are indicative of current federal agency policy on SCC applications for federal cost benefit analysis, they are employed in this analysis. This analysis uses the USEPA interim value of the SCC for 2020 based on a 3 percent discount rate, $7 per metric ton of carbon. At this value, the avoided carbon emissions from the Piping Alternative provide an estimated average annual benefit of approximately $5,000, as shown in Table 9.

Table 9. Annual Increased Average Carbon Cost Savings Under the Piping Alternative by Project Group, Hood River Watershed, Oregon, 2019$.[1]

Works of Improvement	Energy Savings Under Piping Alternative (kWh)	Average Annual Mt of Carbon Avoided from Reduced Pumping	Undiscounted Annual Benefit of Avoided Carbon	Discounted Average Annual NEE Benefit
Project Group 1	614,911	463	$3,000	$3,000
Project Group 2	253,041	190	$1,000	$1,000
Project Group 3	301,754	227	$2,000	$1,000
Total	**1,169,706**	**880**	**$6,000**	**$5,000**

Note: Totals may not sum due to rounding. Prepared April 2019

[1] Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.

VALUE OF CONSERVED WATER

The value of the conserved irrigation water can be looked at in two ways, depending on where the conserved water is used: the value of increased water instream, or the value of maintaining irrigated agricultural production. Of the 16.6 cfs conserved under the Piping Alternative, the District would receive 25 percent (1,322 AF per year) to augment District irrigation, while 75 percent (3,965 AF per year) would be used to augment instream flows. Additionally, in 90 percent of water years, the District's allotment of conserved

[11] We adjusted the original cost of $42 in 2007 dollars to 2019 dollars using the Consumer Price Index.

water will enhance instream flow (or an annual average of 1,190 AF per year). This section explores the value of 5,155 AF per year of average enhanced instream flows.

This section provides several types of information on the value of instream flow. First, this analysis examines the value that environmental groups, federal agencies, and other funders of conservation have been willing to pay for water conservation projects that restore flow in the Hood River Basin. While these values are in fact costs rather than a measurement of benefit, the amounts paid in the past for water conservation projects to enhance instream flow represent the minimum value to the funding entities of conserved water projects (benefits as perceived by funding entities are expected to at least equal costs or funding would not be provided). Similarly, there are some limited water market data available for what environmental or governmental groups have paid to directly purchase water rights and dedicate the water to instream flow. These values also represent the cost of increasing instream flow, similar to the data on costs of water conservation projects, and may significantly underestimate the full value of instream flow augmentation. This analysis also presents market information on the value of water rights to irrigators in EFID, as this indicates the potential cost of purchasing water rights from these irrigators. While there have been relatively small amounts of water temporarily leased between EFID irrigators, the prices of these transactions (or other water transactions in the basin) were not available for this study (Nakamura, 2019). Prices of water rights are very basin-specific and often based on the value of water to agriculture (as agriculture is the most common seller of water rights for environmental or other water uses). We therefore rely on the agricultural value of water in the local basin as well as transaction prices for environmental water in other basins in the West to provide a basis for the economic value of instream flow augmentation.

Based on the following discussion, we assume that the economic benefit of instream flow augmentation would be at least $75 per AF per year, such that this enhanced instream flow is estimated to have a value of approximately $387,000 per year once all project groups are completed under the Piping Alternative (because of the timing, on an average annualized basis the NEE benefit is roughly $335,000 as presented in Table 11). As most water right transactions for environmental purchases are to enhance fish habitat, this value is expected to be a conservative proxy for the value to the public of enhanced fish habitat and fish populations. (The full measure of the economic benefit of enhanced instream flow is the benefit to the public of enhanced fish and wildlife populations, water quality, ecosystem function, etc.).

Values published in the economic literature are often quite high for enhancements to salmon, trout, and other fish and wildlife populations (see Table 10), such as those that would benefit from the instream flows provided by the Piping Alternative. As quantitative information on how instream flows would improve fish and wildlife populations is not available, the analysis is not able to directly measure the economic benefit of enhanced instream flow. As such, the value of conserved water is estimated in this section using the prices of water from transactions in the Western United States. Table 11 shows the estimated average annual benefits of enhanced instream flow for the Piping Alternative.

Table 10. Studies and Values Used to Estimate the Value of Fish Enhancement.

Author(s)	Study Year	Original Value Per Household (Dollar Year)	Value Per Household Adjusted to 2019 dollars	Restoration Location	Fish Enhancement	Survey Respondents
Bell, Huppert, & Johnson	2003	$24 - $122 (2000$)	$36 - $179	Coastal WA and OR	Annual willingness to pay (WTP) per household to increase local Coho salmon populations by 100%	Households in Grays Harbor, WA; Willapa Bay, WA; Coos Bay, OR; Tillamook Bay, OR; Yaquina Bay, OR
Olsen, Richards, & Scott	1991	$43 (2006$)	$54	Columbia River Basin	Annual WTP per household to increase salmon and steelhead populations by 100%	Pacific Northwest households that never fish
Loomis	1996	$59 - $73 (1994$)	$101 - $125	Elwha River, Olympic Peninsula, WA	Annual WTP per household to restore a salmon and steelhead population in its historic habitat on the Elwha River	Households in Clallam County, WA; WA state; U.S.
Layton, Brown, & Plummer	1999	$119 - $250 (1998$)	$185 - $388	Eastern WA and Columbia River; Western WA and Puget Sound	Annual WTP per household to increase migratory fish populations by 50%	Households in WA state

Prepared April 2019

Sources: (Bell, Huppert, & Johnson, 2003); (Loomis, 1996); (Layton, Brown, & Plummer, 2001); (Olsen, Richards, & Scott, 1991) as cited in (Richardson & Loomis, 2009).

Table 11. Annual Estimated Instream Flow Value of Piping Alternative by Project Group, Hood River Watershed, Oregon, 2019$.[1]

Project Group	Water Conservation Going Instream (AF/year)	Undiscounted Annual Benefit to Instream Flow	Discounted Annualized Benefit to Instream Flow
Project Group 1	1,607	$121,000	$115,000
Project Group 2	2,605	$195,000	$166,000
Project Group 3	943	$71,000	$56,000
Total	**5,155**	**$387,000**	**$337,000**

Note: Totals may not sum due to rounding. Prepared April 2019

[1] Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.

This value of $75 per AF per year is based on the following information (see Table 12):

1. *Prices paid for water by environmental buyers throughout the Western United States.* In the period 2000 to 2009, the purchase price of environmental water varied from just over $0 to nearly $1,676 per AF per year, with an average permanent sale transaction price of $166 per AF per year. Among the 51 permanent water right purchases with the sales price and volume recorded in the database, the permanent sales price value in 27 transactions (53 percent) was above $75 per AF per year. As discussed in detail below, these values paid are expected to provide a low range estimate of instream flow value to society.
2. *Value of water to irrigators in EFID.* For low-value crop irrigators (likely the first to sell water for environmental purposes), this is estimated at approximately $60 to $100 per AF per year. This value is important as the value of water to local agriculture is a key factor determining water sales and lease prices to environmental buyers in the project area (i.e., the marginal value of water to agriculture determines the willingness of the agricultural sellers to accept a price for water), and because conserved water avoids potential future reductions in EFID deliveries.

Table 12. Value per AF per Year of Water (Market Prices and Value to Agriculture), Hood River Watershed, Oregon, 2019$.

Type of Value	Low Value	High Value	Median Value	Average Value
Permanent water right transaction in western U.S., 2000 to 2009 (*Converted to Annual Values*)	~$0	$1,676	~$75	$166
Value of water to EFID hay and pasture irrigators (*Income Capitalization Approach*)	$60	$100	~$80	

PAST COSTS PAID AS A PROXY FOR VALUE

Past piping projects in the Hood River Basin highlight the willingness of funding entities to pay for instream flow augmentation. These values are evidence of the *minimum* benefit of the instream flows purchased, as perceived and experienced by these entities. Project costs paid are indicative of the *minimum* perceived benefit, as (barring very unusual circumstances) entities only pay for projects for which they believe benefits exceed costs. Furthermore, funding organizations do not necessarily represent all individuals who value instream flow benefits. Only if all people who value instream flow were to pay their maximum willingness to pay for instream flow restoration would the value paid equal the benefits received. Finally, it is important to recognize that these values fundamentally represent *costs* and not benefits; the values paid are based on the cost to conserve water or for agriculture to reduce their use of water (as evident through water right transactions from agriculture to environmental flows).

There are five irrigation districts in the Hood River Basin: Dee, East Fork, Farmers, Middle Fork, and Mount Hood. These irrigation districts have implemented a variety of projects to enhance instream flow (and provide other benefits), including piping open canals and promoting on-farm irrigation efficiencies. Six basin piping projects, along with their associated costs and water savings, are shown in Table 13. The costs range from $754,000 to $6.15 million per cfs conserved, and an estimated $2,100 to $17,000 per AF conserved.

Table 13. Cost and Water Savings of Piping Projects in the Hood River Basin.

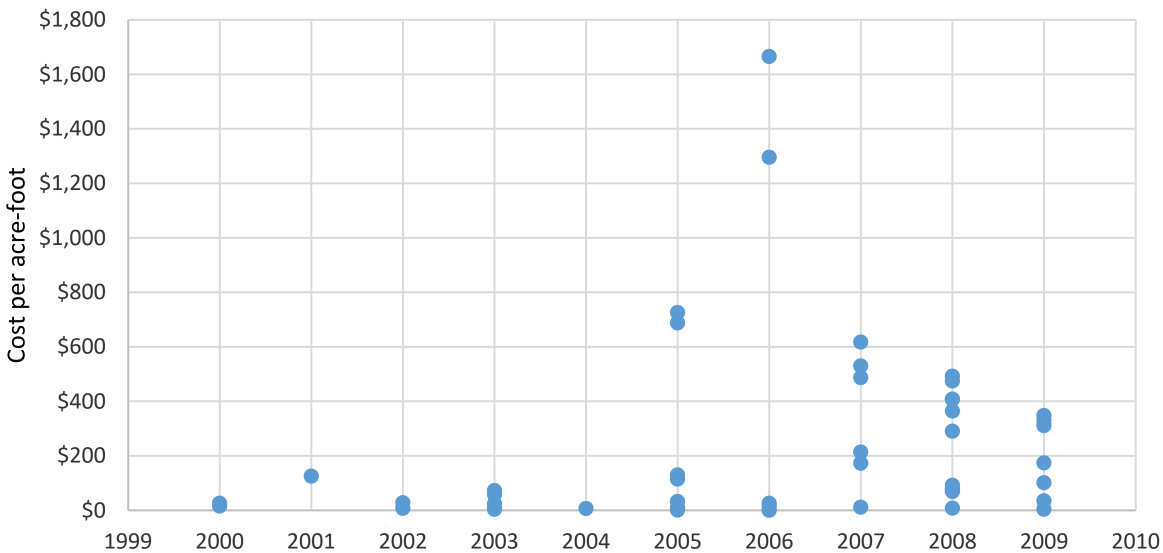
Project	Year Complete	Water Saved (cfs)	Total Cost (2019$)[1]	Cost per Amount of Water Conserved ($/cfs)	Cost per Amount of Water Conserved ($/AF)
DID Piping Project	2013	3.0	$2,528,000	$843,000	$2,300
EFID Central Lateral Piping	2008	2.1	$12,915,000	$6,150,000	$17,000
FID Green Point Pipeline Project	2016	1.5	$1,264,000	$843,000	$2,300
EFID Highline Canal Pipeline	2016	0.5	$826,000	$1,652,000	$4,600
FID Lower District Pressurization Project	2009	7.5	$5,656,000	$754,000	$2,100
MFID Glacier Ditch Pipeline Phase 3	2012	0.3	$595,000	$1,983,000	$5,500

[1] Total costs were adjusted to 2019 dollars using the Consumer Price Index. Prepared April 2019
Sources: (Hood River Watershed Group, 2014; Hood River News, 2014; Christensen & Salminen, Hood River Basin Water Use Assessment, 2013; Farmers Irrigation District, 2019; Oregon Department of Agriculture, Hood River Local Advisory Committee, 2016; Oregon Water Resources Department, 2018; Craven Consulting Group, 2005).

Water rights can be purchased or leased in Oregon. It is important to note that the value paid per AF depends on many variables, including the value of water to the seller, funding available to the buyer, characteristics of the affected stream/river (including current flow levels, flow targets, and presence of threatened or endangered species), characteristics of the water right (seniority, time of use, point of diversion, etc.), and the size of the water right.

Water right leases and purchases for environmental purposes across the Western United States were analyzed in a 2003 paper (Loomis, Quattlebaum, Brown, & Alexander, 2003). During the period between 1995 and 1999, six transactions of water right purchases averaged $362 per AF in Oregon, while five water right leases averaged $115 per AF per year. The paper also shows lease and purchase price by environmental use, including for riparian areas, wetlands, recreation, and instream flow. For instream flows, the average purchase price across 18 transactions per AF was $1,121, while across 35 lease transactions the annual price was $68 per AF.

The Bren School of Environmental Science and Management at the University of California, Santa Barbara, maintains a database of water transfers in the Western United States, and distinguishes between the terms of the transaction (i.e., sale or lease) and the sector of the buyer and seller (e.g., agricultural or environmental) (Bren School of Environmental Science & Management, University of California, Santa Barbara, 2017). The two graphs shown below in Figure D-1 and Figure D-2 show more recent (from 2000 to 2009) sales and leases of water rights by environmental buyers on a price per AF per year basis. The figures show how water right transaction values vary widely, but sale prices (amortized to an annual price) typically are less than $200 per year while 1-year leases typically fall below $800 per AF per year (with several transactions showing prices rising over a $1,000 per AF per year). Among the 51 permanent water right purchases with the sales price and volume recorded in the database, the sales price value in 27 transactions (53 percent) was above $75 per AF per year. However, it is also important to note that the amount paid per AF tends to decline with an increase in water volume traded; weighting the purchase price by the water volume sold decreases the average permanent sale transaction price to $20 per AF per year.



Note that dollar per AF purchase prices were amortized using a 2.75 percent interest rate and a 100-year period to derive dollar per AF per year values.

Figure D-1. Western water right purchases for environmental purposes, 2000 to 2009, price paid per acre-foot per year.

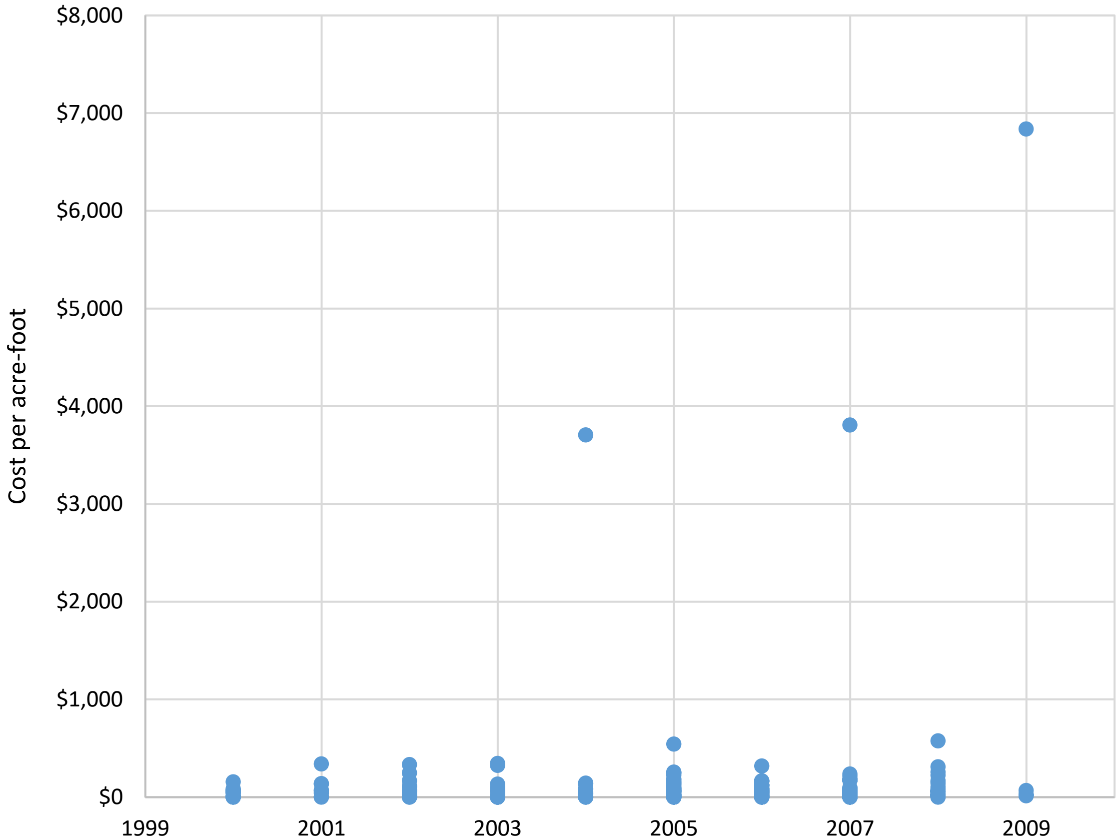


Figure D-2. 1-year water leases for environmental purposes, price paid per acre-foot in Western United States.

D.1.2.2 Benefits Considered but Not Included in Analysis

PUBLIC SAFETY AVOIDED COSTS

Piping irrigation water removes the hazard of drownings in canals, and also eliminates the potential for canals to fail, causing potential damages to downstream property and lives. While EFID canal failure is very possible, the extent of damage varies dramatically depending on the timing and location of failure. Given the limited amount of available data on the cost of these canal failures, the public safety (and property damage reduction) benefit of piping is not analyzed in this analysis. However, past drownings in the District have demonstrated the danger inherent to open canals, which can have fast-moving water and present a threat to public safety. Between 1983 and 1985, two drownings occurred in District canals; one an adult male, the other a child (Buckley, 2019). There have been no drownings since that time. This means that from 1983 to 2018, there was an average of 0.057 deaths per year in District canals. As the population in Hood River County continues to grow, the risks to public safety will increase.

The Piping Alternative would pipe the remaining open canals in the system. This section qualitatively discusses the potential magnitude of the public safety benefit of piping the remaining exposed canals in EFID. The analysis presents some information on the potential public safety hazard of the existing irrigation canals in EFID that are proposed for piping (based on the recent history of drownings and the mileage of exposed canals).

Level of Public Safety Hazard

This analysis estimates the public safety hazard of unlined canals in EFID based on past drownings in unlined canals in East Fork. The EFID System Improvement Plan (SIP) details how the District currently has approximately 17.9 miles of open canals, 17.5 miles of which would be piped under the Piping Alternative (6.1 miles in the Eastside Canal, 6.4 miles in the Main Canal, and 5.0 miles in the Dukes Valley Canal). In 2007, the 4.5-mile Central Canal was piped, meaning that from 1983 to 2007 there were 22.4 miles of open canals (Farmers Conservation Alliance, 2018). Accordingly, the length of open canals averaged 21 miles between 1983 and 2018. Given that two drowning deaths occurred during this time period (an average of 0.057 deaths per year, as described above), the annual drowning risk per mile of open canal was 0.0027. This may be an overestimate of risk if there were an abnormally high number of drownings in the last 25 years, but may also be an underestimate of risk as the population of Hood River continues to grow.

Under the No Action Alternative, EFID would continue to have about 17.5 more miles of open canals than under the Piping Alternative. Assuming that the three drownings over the past 25 years are representative of the future drowning risk, and that the 0.0027 deaths per mile of exposed canal experienced during this period is an appropriate estimate of future risk, the unpiped canals in EFID carry a risk of 0.05 deaths per year.

D.1.3 Summary of Benefits

Table 8-6 (NWPM 506.20, Economic Table 5a) summarizes annual average NEE project benefits of the Piping Alternative that exceed the benefits under the No Action Alternative. In the table, the benefits from irrigating new acres (described in the Agricultural Damage Reduction Benefit section) and the benefits of having additional water for existing irrigated acres (described in the Agricultural Damage Reduction Benefit section) are grouped together under “Increased Agricultural Production” benefits. Avoided O&M costs to the District and to patrons (in the Operation and Maintenance Cost Savings Benefit section) are grouped under “Other - Reduced O&M” benefits. Avoided pump costs, including energy, maintenance, and replacement costs, are grouped under “Other - Pump Cost Savings.”

D.1.4 Incremental Analysis

The Piping Alternative is also evaluated using an incremental analysis, which identifies how total costs and benefits change as project groups are added. In the incremental analysis, project group pipe sizes and costs remain the same for each project group assessed.

The engineering pipeline design (pipe diameters, pressure ratings, etc.) is independent of the number of project groups and the order that the project groups are installed. The District’s SIP describes how the District designed modern pipelines to replace its open canals and laterals (Farmers Conservation Alliance, 2018). The District mapped and collected digital elevation data along its entire delivery system. The District is obligated to deliver water to patrons at 4.49 gallons per minute (gpm) but designed the system to be able to deliver 5.62 gpm.

As the pipeline is installed from the “top down” (from the diversion at higher elevations to the lowest elevations in the district), the design had to account for all the irrigation demand in the system. That is, the system had to be designed for the future full demand rather than the current project group demand.

For example, assume that two planned project groups would replace a leaky canal with a 2-mile pipeline. Project Group 1 construction is the upper 1 mile of pipeline starting at the diversion gate. Project Group 2 construction is the lower 1 mile. The irrigation demand (water right) for the Project Group 1 construction is 5 cfs. The irrigation demand for the Project Group 2 construction is 15 cfs. Total irrigation demand for the pipeline equals 20 cfs.

If the engineer designs a pipeline for 5 cfs for Project Group 1, this would be a relatively small pipeline. This small pipeline would then be connected to the larger Project Group 2 pipeline. The small Project Group 1 pipeline would have to convey 20 cfs of flow through a pipeline designed for 5 cfs. This would result in a pipeline that does not meet NRCS design standards and would likely not function and meet the project goals.

Pipelines typically decrease in size as the irrigation demand decreases with the number of acres served at lower elevations in the system. Project groups are not considered when determining when to reduce from a larger to a smaller pipe.

The District used the information and assumptions above to create a hydraulic model that determined pipe sizes for each pipeline (canal or lateral to be piped) in the system. The District designed each pipeline to deliver water under its existing water rights, and these pipelines are not designed to deliver water under any additional water rights.

While costs are the same for each project group in the incremental analysis (as shown in Table 14), the District aims to provide a piping pressure of at least 40 pounds per square inch wherever possible. Table 14 shows the incremental analysis of the project groups.

Table 14. Incremental Analysis of Annual NEE Costs and Benefits Under the Piping Alternative for East Fork Irrigation District, Hood River Watershed, Oregon, 2019$.[1]

Groups	Total Costs	Incremental Costs	Total Benefits	Incremental Benefits	Net Benefits
1	$407,000		$462,000		$55,000
1,2	$1,469,000	$1,062,000	$1,680,000	$1,218,000	$211,000
1,2,3	$1,808,000	$339,000	$2,313,000	$633,000	$505,000

Note: Totals may not sum due to rounding Prepared April 2019

[1] Price Base: 2019 dollars amortized over 100 years at a discount rate of 2.75 percent.

D.1.5 References

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D.2 NEE Crop Enterprise Budgets

This section presents the crop enterprise budgets used in estimating agricultural NEE benefits under the Piping Alternative resulting from reduced damages associated with water shortages expected due to climate change. The agricultural production benefits are estimated using enterprise budgets that represent typical costs and returns of producing crops in the Hood River Watershed of Oregon. Enterprise budgets aim to reflect common practices and relevant costs for production in the region, but do not necessarily represent conditions of any particular farm.

We used crop budgets for pears and alfalfa hay developed, respectively, by OSU and WSU, and then adjusted values in these budgets to account for changes in prices through time and local conditions in EFID. An existing grass hay budget for Hood River County or the Columbia Basin was not available from OSU or WSU. In comparing grass hay to alfalfa hay budgets, the production costs tend to be higher for alfalfa hay per ton of production due to higher machinery, pest management, and establishment costs (Painter, 2015 Enterprise Budget: District 1 Alfalfa, 2015; Painter, 2015 Enterprise Budgets: District 1 Grass Hay, 2015; Turner & Mylen Bohle, 1995; McNeley, Williams, Carr, & Turner, 1995). As such, by using an alfalfa hay budget we expect that our estimated production costs for grass hay may be higher than typical in EFID, resulting in conservative estimates of net returns to grass hay production.

Due to the need to model years with different irrigation water availability, we developed five crop budgets. There are three budgets for pears to represent high-value crops: one for full production years under full irrigation, and two for full production years under different irrigation deficit scenarios. There are two budgets for grass hay to represent low-value crops: one for full production years under full irrigation and one for full production years under an irrigation deficit. We use the budgets of irrigation deficits to estimate the net benefits of piping to agricultural production under climate change (in the Agricultural Damage Reduction Benefit section). The following two sections outline the data and assumptions used in adjusting the Oregon State and Washington State pear and alfalfa hay budgets. Table 15 summarize the net returns to pears and grass hay modeled in the enterprise budgets.

Table 15. Per-Acre Net Returns to Crops Under Climate Change Scenarios.

Production Year	Pears	Grass Hay
Full Irrigation[1]	$3,957	$160
22% total water shortage at EFID	$1,199	$55
9% total water shortage at EFID	$3,300	$55

[1]These are the full production net returns with the amortized establishment costs subtracted out.

D.2.1 Pear Enterprise Budgets

The pear enterprise budgets (presented in full below) were primarily based on enterprise budgets for pears developed by OSU in 2016 to represent the costs and benefits of full production for pears in Hood River County (Halliday, Seavert, & Castagnoli, Enterprise Budget, Pears, d'Anjou & Fresh Bartlett, North Central Region, 2016; Halliday, Seavert, & Castagnoli, 2016). We updated the costs and revenues presented in the budgets to account for changing values over time and to reflect values specific to the District.

To model benefits of increased water supply reliability to existing orchards in the deficit irrigation budgets, we include establishment costs since we do not explicitly model the establishment years.[12]

D.2.1.1 Modeled Farm

The farm modeled in the original OSU budget is 70 acres total, which comprised 50 acres of pears, 5 acres of apples, 5 acres of cherries or wine grapes, and 10 acres are orchards under establishment. The budgets are based on 8 acres producing d'Anjou and fresh Bartlett pears, with 242 trees per acre.

D.2.1.2 Facilities and Equipment

Irrigation is delivered through a mix of solid set and handlines. Housing (sufficient for 10 people) is provided for summer labor and has a productive life of 30 years. Foreman housing is also provided. A 70-hp tractor is used for shredding brush, flailing, pulling the airblast sprayer, and harvesting. A 50-hp tractor is used to auger holes for new trees, spread fertilizer, pull an older air-blast sprayer, apply gopher bait, and assist during harvest. The 35-hp tractor is used to spray weeds, assist in harvest, and as a general utility tractor.

D.2.1.3 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. EFID charges a flat rate of $175 for each tax lot supplied with District water and $59 per acre supplied (East Fork Irrigation District, 2018). As the average tax lot size in EFID is 10 acres, the flat rate is divided by 10 to derive the per-acre cost of the flat irrigation fee. For land costs, we use the average value of non-producing pear orchards in the area ($15,000 per acre) and multiplied it by the discount rate (2.75 percent), to generate the estimated annual cost of owning the land.

For costs that did not have area-specific values, we adjusted the value in the original budget using the national Producer Price Indices (PPIs) produced by the National Agricultural Statistics Services (NASS), which are published for a variety of farm expenses (NASS, 2018). For example, there are prices indices for fertilizer, herbicides, supplies, tractors, custom work, as well as one for the farm sector in general. The PPI cost adjustments range from an 8 percent decrease in the price of fertilizer to a 10 percent increase in building materials. For the deficit irrigation budgets, the orchard establishment costs are amortized over the 25-year full production years assumed in the original OSU budget. We adjusted the establishment cost by using a discount rate of 2.75 percent (instead of the 5 percent from the original budget), and also adjusted the cost to 2019 dollars using the general Farm Sector PPI.

D.2.1.4 Labor Costs

For general farm labor, we use the average wage rate for farmworkers in the Central Oregon non-metropolitan area.[13] For equipment operator labor, we use the mean hourly wage rate for this occupation in

[12] In years requiring deficit irrigation, we also assume that water supply shortages would primarily affect only full-production orchards (growers prioritize watering young trees being established to protect their long-term productivity).

[13] This is the average wage for the Farmworkers and Laborers, Crop, Nursery, and Greenhouse occupation (45-2092) according the Bureau of Labor Statistics Occupational Employment Statistics data in May 2017 (Bureau of Labor Statistics, 2017). We adjust wage for inflation to 2019 dollars using the Consumer Price Index.

Oregon.[14] In both cases, we adjust the average wage rate up by 20 percent to account for non-wage employment costs, such as health care and insurance. This results in total labor costs of $15.89 and $18.13 per hour for laborers and equipment operators, respectively. The two pear budgets modeled under deficit irrigation (Table 17 and Table 18) have their harvest labor costs adjusted downward in order to account for lower yields.

The original OSU pear budget did not include a cost for an orchard manager. To estimate the economic net benefits of the agricultural production, rather than the net returns to the time spent self-managing an orchard, we added the cost of managing the orchard to the budget. To estimate this cost, we used the wage rate for agricultural managers in Eastern Oregon (which is adjusted upward by 20 percent, similar to the other labor), resulting in a total cost of $39.77 per hour.[15] To estimate the amount of time spent per acre, we use a pear budget developed by the University of California, Davis, which models an orchard manager effectively running a 400-acre orchard (Ingles & Klonsky, 2012). Assuming this manager works 40-hour workweeks 48 weeks out of the year, each acre would require roughly 4.8 hours per week. At $39.77 per hour, we estimate that hiring an orchard manager would cost roughly $191 per acre.

D.2.1.5 Revenues

To estimate the gross revenues of pears under full irrigation, we use the full production year yield from the original OSU pear budget (50 bins of 1,050-lbs per acre) because it is specific to Hood River County and is specific to full production years. We use the average price per bin in the area as reported by an EFID board member and Quality Control Manager of Duckwall-Pooley Fruit Company, one of the largest fruit packing companies in the area: $250 per bin (Mallon, 2019). This price may be conservative given that, from 2013 to 2017, the average price in Oregon for Bartlett pears was the equivalent of $325 per bin and $353 per bin for other pears (Oregon Department of Agriculture, 2018; USDA and NASS, 2018). For the gross revenues under deficit irrigation, we adjust the original yield downward using the yield/water relationship for pears described in the Agricultural Damage Reduction Benefit section.

D.2.1.6 Pear Enterprise Budget Tables

The tables below present the pear enterprise budgets used to estimate the net returns to high-value crops in the District under full water allocation (Table 16), under a 20 percent deficit irrigation (Table 17), and under a 5 percent deficit irrigation (Table 18).

[14] This is the average wage for the Agricultural Equipment Operators (45-2091) according the Bureau of Labor Statistics Occupational Employment Statistics data in May 2017 (Bureau of Labor Statistics, 2017). We adjust wage for inflation to 2019 dollars using the Consumer Price Index.

[15] This is the average wage for the Farmers, Ranchers, and Other Agricultural Managers (11-9013) according the Bureau of Labor Statistics Occupational Employment Statistics data in May 2017 (Bureau of Labor Statistics, 2017). We adjust wage for inflation to 2019 dollars using the Consumer Price Index.

Table 16. Pear Enterprise Budget Under Full Irrigation (Years 8–32).

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Pears	50	bins	$250	$12,500
VARIABLE COSTS				
Pruning and training labor	25.0	hrs	$15.89	$397.23
Thinning labor	18.0	hrs	$15.89	$286.01
Tree removal & replacement	1.0	ac	$17.20	$17.20
Raking and shredding bush labor	0.4	hrs	$18.13	$6.52
Fertilizer & lime	1.0	ac	$290.89	$290.89
Herbicide strip maintenance	1.0	ac	$53.35	$53.35
Insecticides & fungicides	1.0	ac	$820.80	$820.80
Pheromone disruption	1.0	ac	$112.86	$112.86
Bee rental	1.0	ac	$111.68	$111.68
Flailing/mowing orchard floor labor	2.9	hrs	$18.13	$52.13
Rodent control	1.0	ac	$43.01	$43.01
Frost protection labor	2.0	hrs	$15.89	$31.78
Irrigation water charge	1.0	ac	$59.00	$59.00
Ladders, pruning, & picking equipment	1.0	ac	$13.10	$13.10
Harvest labor	50.0	bins	$38.40	$1,920.04
Harvest - hauling fruit	50.0	bins	$3.55	$177.67
Pickup, truck & Gator	1.0	ac	$180.37	$180.37
Seasonal housing facilities	1.0	ac	$124.65	$124.65
Misc. and overhead	1.0	ac	$131.65	$131.65
Interest: operating capital	1.0	ac	$34.49	$34.49
Other general labor	7.3	hrs	$15.89	$115.99
Other tractor driver labor	8.7	hrs	$18.13	$157.16
Other machinery costs	1.0	ac	$411.88	$411.88
Total variable costs				$5,549.45
FIXED COSTS				
Irrigation service charge	1.0	ac	$17.50	$17.50
Property insurance	1.0	ac	$26.33	$26.33
Property taxes	1.0	ac	$63.19	$63.19
Management cost	1.0	ac	$190.91	$190.91
Machinery & equipment: depreciation and interest	1.0	ac	$610.53	$610.53
Pickup, truck & Gator: depreciation and interest	1.0	ac	$96.13	$96.13
Foreman housing	1.0	ac	$188.16	$188.16
Seasonal housing facilities	1.0	ac	$274.40	$274.40
Land cost	1.0	ac	$412.50	$412.50
Total fixed costs				$1,879.64
Total costs				$7,429.09
NET RETURNS PER ACRE				**$5,070.91**

Table 17. Pear Enterprise Budget Under 20-Percent Irrigation Deficit.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Pears	36.7	bins	$250	$9,186
VARIABLE COSTS				
Pruning and training labor	25.0	hrs	$15.89	$397.23
Thinning labor	18.0	hrs	$15.89	$286.01
Tree removal & replacement	1.0	ac	$17.20	$17.20
Raking and shredding bush labor	0.4	hrs	$18.13	$6.52
Fertilizer & lime	1.0	ac	$290.89	$290.89
Herbicide strip maintenance	1.0	ac	$53.35	$53.35
Insecticides & fungicides	1.0	ac	$820.80	$820.80
Pheromone disruption	1.0	ac	$112.86	$112.86
Bee rental	1.0	ac	$111.68	$111.68
Flailing/mowing orchard floor labor	2.9	hrs	$18.13	$52.13
Rodent control	1.0	ac	$43.01	$43.01
Frost protection labor	2.0	hrs	$15.89	$31.78
Irrigation water charge	1.0	ac	$59.00	$59.00
Ladders, pruning, & picking equipment	1.0	ac	$13.10	$13.10
Harvest labor	36.7	bins	$38.40	$1,411.04
Harvest - hauling fruit	36.7	bins	$3.55	$130.57
Pickup, truck & Gator	1.0	ac	$180.37	$180.37
Seasonal housing facilities	1.0	ac	$124.65	$124.65
Misc. and overhead	1.0	ac	$131.65	$131.65
Interest: operating capital	1.0	ac	$34.49	$34.49
Other general labor	7.3	hrs	$15.89	$115.99
Other tractor driver labor	8.7	hrs	$18.13	$157.16
Other machinery costs	1.0	ac	$411.88	$411.88
Total variable costs				$4,993.35
FIXED COSTS				
Irrigation service charge	1.0	ac	$17.50	$17.50
Property insurance	1.0	ac	$26.33	$26.33
Property taxes	1.0	ac	$63.19	$63.19
Management cost	1.0	ac	$190.91	$190.91
Machinery & equipment: depreciation and interest	1.0	ac	$610.53	$610.53
Pickup, truck & Gator: depreciation and interest	1.0	ac	$96.13	$96.13
Foreman housing	1.0	ac	$188.16	$188.16
Seasonal housing facilities	1.0	ac	$274.40	$274.40
Land cost	1.0	ac	$412.50	$412.50
Amortized establishment costs	1.0	ac	$1,045.99	$1,045.99
Total fixed costs				$2,925.63
Total costs				$7,918.98
NET RETURNS PER ACRE				**$1,267.26**

Table 18. Pear Enterprise Budget Under 5-Percent Irrigation Deficit.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Pears	46.8	bins	$250.00	$11,710
VARIABLE COSTS				
Pruning and training labor	25.0	hrs	$15.89	$397.23
Thinning labor	18.0	hrs	$15.89	$286.01
Tree removal & replacement	1.0	ac	$17.20	$17.20
Raking and shredding bush labor	0.4	hrs	$18.13	$6.52
Fertilizer & lime	1.0	ac	$290.89	$290.89
Herbicide strip maintenance	1.0	ac	$53.35	$53.35
Insecticides & fungicides	1.0	ac	$820.80	$820.80
Pheromone disruption	1.0	ac	$112.86	$112.86
Bee rental	1.0	ac	$111.68	$111.68
Flailing/mowing orchard floor labor	2.9	hrs	$18.13	$52.13
Rodent control	1.0	ac	$43.01	$43.01
Frost protection labor	2.0	hrs	$15.89	$31.78
Irrigation water charge	1.0	ac	$59.00	$59.00
Ladders, pruning, & picking equipment	1.0	ac	$13.10	$13.10
Harvest labor	46.8	bins	$38.40	$1,798.75
Harvest - hauling fruit	46.8	bins	$3.55	$166.44
Pickup, truck & Gator	1.0	ac	$180.37	$180.37
Seasonal housing facilities	1.0	ac	$124.65	$124.65
Misc. and overhead	1.0	ac	$131.65	$131.65
Interest: operating capital	1.0	ac	$34.49	$34.49
Other general labor	7.3	hrs	$15.89	$115.99
Other tractor driver labor	8.7	hrs	$18.13	$157.16
Other machinery costs	1.0	ac	$411.88	$411.88
Total variable costs				$5,416.93
FIXED COSTS				
Irrigation service charge	1.0	ac	$17.50	$17.50
Property insurance	1.0	ac	$26.33	$26.33
Property taxes	1.0	ac	$63.19	$63.19
Management cost	1.0	ac	$190.91	$190.91
Machinery & equipment: depreciation and interest	1.0	ac	$610.53	$610.53
Pickup, truck & Gator: depreciation and interest	1.0	ac	$96.13	$96.13
Foreman housing	1.0	ac	$188.16	$188.16
Seasonal housing facilities	1.0	ac	$274.40	$274.40
Land cost	1.0	ac	$412.50	$412.50
Amortized establishment costs	1.0	ac	$1,045.99	$1,045.99
Total fixed costs				$2,925.63
Total costs				$8,342.57
NET RETURNS PER ACRE				**$3,367.75**

D.2.2 Grass Hay Enterprise Budgets

The grass hay enterprise budgets were based on 2012 budgets developed by WSU for establishing and producing alfalfa hay in the Washington Columbia Basin (Norberg & Neibergs, 2012). These budgets include two budgets for the establishment year and one full production year budget. We selected these budgets as the basis for EFID crop production costs because they are the most recent crop budgets developed for agriculture in the Columbia Basin. As noted above, in comparing grass hay to alfalfa hay budgets, the production costs tend to be higher for alfalfa hay per ton of production due to higher machinery, pest management, and establishment costs (Painter, 2015 Enterprise Budget: District 1 Alfalfa, 2015; Painter, 2015 Enterprise Budgets: District 1 Grass Hay, 2015; Turner & Mylen Bohle, 1995; McNeley, Williams, Carr, & Turner, 1995). As such, by using an alfalfa hay budget we expect that our estimated production costs for grass hay may be higher than typical in EFID, resulting in conservative estimates of net returns to grass hay production.

As in the pear budgets, we updated the costs presented in the original budgets to account for changing values over time and to reflect conditions specific to EFID. Returns to grass hay were based on locally reported hay yields and Oregon State 5-year normalized average hay prices. We developed two hay budgets in total: one budget for hay under full production years and full irrigation (Table 19), and one budget where a 30 percent irrigation deficit causes the grower to forego the third and final hay cutting at a loss of 1 ton of hay per acre (Table 20). This results in a reduced net revenue of $105 per acre compared to a full water year.

D.2.2.1 Modeled Farm

The farm modeled in the original WSU budget was meant to represent typical per-acre costs of hay production in the years after establishment (second and third years). 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 -ton bales beginning the following spring. Other than labor for irrigation, all labor is provided by hiring custom work (including harvest, fertilizer application, and herbicide application). Irrigation is delivered by a center pivot.

D.2.2.2 Input Costs

All costs are adjusted from the original values in the WSU budget. As with the pear budgets, we used area-specific values for fuel prices, irrigation charges, and land costs. Irrigation charges are the same as those presented in the pear budget. The original WSU budget did not include the costs of land, however, we added it to the budget used in this analysis. We adopted the land value used an enterprise budget for irrigated corn in the northcentral region of Oregon in 2014, adjusted it to 2019 dollars using the CPI, and then used an annual interest rate of 2.75 percent to derive the estimated land ownership costs (Seavert & Horneck, 2014).

For costs that did not have area-specific values, we adjusted the value in the original budget using the same PPIs as were used in the pear budgets. Establishment costs are amortized over 7 years, which is roughly the average productive life of hay stands in the area (Mallon, 2019). We adjusted this cost by the general Farm Sector PPI and used a 2.75 percent interest rate. For the hay budget under deficit irrigation (Table 25), we adjust some inputs to account for the reduction in costs associated with reductions in yield, including chemical treatments and fuel costs.

D.2.2.3 Labor Costs

Because most of the labor is provided by custom work, the only direct labor costs are for an agricultural equipment operator to move the center pivots. The per hour total labor costs for this equipment operator are the same as the per hour equipment operator costs presented in the pear budget ($18.13 per hour). We adjusted the cost of custom work using the Custom Work PPI. For the hay budget under deficit irrigation

(Table 20), we adjust the labor costs (including custom, management, and other labor) 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 under-estimate benefits (and vice versa).

D.2.2.4 Revenues

To estimate the gross revenues of grass hay, we use the average yield reported by an EFID board member: 4.5 tons per acre (Mallon, 2019). To estimate the gross revenues per ton, we use the normalized average price per ton for hay in Oregon reported by the Economic Research Service of the USDA in 2018 (Economic Research Service, 2018). For hay under deficit irrigation, we assume that the impact of losing 30 percent of their water would cause grass hay growers to forego their third and final cutting of the season, which has an average yield of roughly 1 ton per acre in EFID (Buckley, 2019).

D.2.2.5 Grass Hay Enterprise Budget Tables

The tables below present the two grass hay enterprise budgets used to estimate the net returns to low-value crops in the District: one budget under full irrigation (Table 19), and one budget modeling returns under a 30 percent irrigation deficit (Table 20).

Table 19. Grass Hay Enterprise Budget Under Full Irrigation (Years 1 - 6).

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Grass Hay	4.5	ton	$209.63	$943.34
VARIABLE COSTS				
Dry Nitrogen	0.0	lb	$0.34	$0.00
Dry Phosphate	51.8	lb	$0.58	$29.94
Dry Potash	78.8	lb	$0.41	$32.40
Dry Sulfur	14.1	lb	$0.20	$2.75
Zinc	2.8	lb	$1.98	$5.58
Boron	1.1	lb	$4.47	$5.03
Custom Application	1.0	ac	$9.90	$9.90
Soil Test	1.0	ac	$0.33	$0.33
Herbicide	1.1	lb	$19.14	$21.53
Custom Application	1.0	ac	$9.90	$9.90
Custom - Swath	2.5	ac	$22.00	$55.00
Custom - Rake	2.5	ac	$11.00	$27.50
Custom - Bail	4.5	ton	$18.70	$84.15
Custom - Haul & Stack	4.5	ton	$9.90	$44.55
Custom - Tarping	4.5	ton	$5.50	$24.75
Irrigation - water charge	1.0	ac	$59.00	$59.00
Irrigation - service charge	1.0	ac	$17.50	$17.50
Irrigation - repairs	1.0	ac	$16.53	$16.53
Irrigation - labor	0.5	ac	$18.13	$9.06
Haystack insurance	4.5	ton	$2.20	$9.91
Gopher control	1.0	ac	$5.58	$5.58
Fuel	2.3	gal	$2.79	$6.37
Lubricants	1.0	ac	$0.89	$0.89
Machinery repairs	1.0	ac	$1.98	$1.98
Overhead	1.0	ac	$42.33	$42.33
Operating interest	1.0	ac	$13.74	$13.74
Total variable costs				$536.20
FIXED COSTS				
Machinery depreciation	1.0	ac	$6.31	$6.31
Machinery interest	1.0	ac	$3.68	$3.68
Machinery insurance, taxes, housing, license	1.0	ac	$2.62	$2.62
Management (5% of total cost)	1.0	ac	$36.98	$36.98
Establishment cost	1.0	Ac	$56.61	$56.61
Land cost	1.0	ac	$190.86	$190.86
Total fixed costs				$297.07
Total costs				$833.27
NET RETURNS PER ACRE				**$110.07**

Table 20. Grass Hay Enterprise Budget Under 30-Percent Irrigation Deficit.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Grass Hay	3.5	ton	$209.63	$733.71
VARIABLE COSTS				
Dry Nitrogen	0.0	lb	$0.34	$0.00
Dry Phosphate	40.3	lb	$0.58	$23.29
Dry Potash	61.3	lb	$0.41	$25.20
Dry Sulfur	10.9	lb	$0.20	$2.14
Zinc	2.2	lb	$1.98	$4.34
Boron	0.9	lb	$4.47	$3.91
Custom Application	0.8	ac	$9.90	$7.70
Soil Test	1.0	ac	$0.33	$0.33
Herbicide	0.9	lb	$19.14	$16.75
Custom Application	0.8	ac	$9.90	$7.70
Custom - Swath	1.5	ac	$22.00	$33.00
Custom - Rake	1.5	ac	$11.00	$16.50
Custom - Bail	3.5	ton	$18.70	$65.45
Custom - Haul & Stack	3.5	ton	$9.90	$34.65
Custom - Tarping	3.5	ton	$5.50	$19.25
Irrigation - water charge	1.0	ac	$59.00	$59.00
Irrigation - service charge	1.0	ac	$17.50	$17.50
Irrigation - repairs	0.8	ac	$16.53	$12.85
Irrigation - labor	0.4	ac	$18.13	$7.05
Haystack insurance	3.5	ton	$2.20	$7.71
Gopher control	1.0	ac	$5.58	$5.58
Fuel	1.8	gal	$2.79	$4.95
Lubricants	1.0	ac	$0.89	$0.89
Machinery repairs	1.0	ac	$1.98	$1.98
Overhead	1.0	ac	$42.33	$42.33
Operating interest	1.0	ac	$13.74	$13.74
Total variable costs				$433.79
FIXED COSTS				
Machinery depreciation	1.0	ac	$6.31	$6.31
Machinery interest	1.0	ac	$3.68	$3.68
Machinery insurance, taxes, housing, license	1.0	ac	$2.62	$2.62
Management (5% of total cost)	1.0	ac	$34.69	$34.69
Establishment cost	1.0	ac	$56.61	$56.61
Land cost	1.0	ac	$190.86	$190.86
Total fixed costs				$294.78
Total costs				$728.57
NET RETURNS PER ACRE				**$5.14**

D.3 Alternatives Considered During Formulation

This appendix section presents the alternatives considered in the formulation phase.

During the formulation phase, alternatives were evaluated based on meeting both National Environmental Policy Act and environmental review requirements specific to NRCS federal investments in water resources projects (Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies [PR&G]) (Table 21). According to the National Environmental Policy Act, "agencies shall rigorously explore and objectively evaluate all reasonable alternatives" (40 Code of Federal Regulations 1502.14). According to the PR&G, alternatives should reflect a range of scales and management measures and be evaluated against the Federal Objective and Guiding Principles; against the extent to which they address the problems and opportunities identified in the purpose and need; and against the criteria of completeness, effectiveness, efficiency, and acceptability:

1. Completeness is the extent to which an alternative provides and accounts for all features, investments, and/or other actions necessary to realize the planned effects, including any necessary actions by others. It does not necessarily mean that alternative actions need to be large in scope or scale.
2. Effectiveness is the extent to which an alternative alleviates the specified problems and achieves the specified opportunities.
3. Efficiency is the extent to which an alternative alleviates the specified problems and realizes the specified opportunities at the least cost.
4. Acceptability is the viability and appropriateness of an alternative from the perspective of the Nation's general public and consistency with existing federal laws, authorities, and public policies. It does not include local or regional preferences for particular solutions or political expediency.

Alternatives eliminated during formulation are discussed below the table. Alternatives selected for further evaluation are discussed in the Plan-EA.

Table 21. Alternatives Considered During the Formulation Phase.

Alternative	Which criteria in the PR&G does the alternative achieve?				Selected for Further Evaluation
	Completeness	Effectiveness	Efficiency	Acceptability	
Pipeline Realignment	X	X			
Conversion to Dryland Farming			X		
Fallowing Farm Fields			X		
Voluntary Duty Reduction			X		
Partial Use of Groundwater					
On-Farm Efficiency Upgrades		X		X	X

Alternative	Which criteria in the PR&G does the alternative achieve?				Selected for Further Evaluation
	Completeness	Effectiveness	Efficiency	Acceptability	
Canal Lining	X	X		X	X
Piping District Infrastructure with Steel	X	X		X	X
Piping District Infrastructure with Polyvinyl Chloride (PVC)	X	X	X	X	X
No Action (Future without Project)			X		X
Piping Alternative	X	X	X	X	X

D.3.1 Pipeline Realignment

Pipeline realignment would convert the District's system to pipes. However, in some places, instead of following the same path as the existing canals and laterals, the pipes would be laid in a new alignment (or path across the landscape). New alignments would be selected to serve all patrons, but would take a more direct route to decrease the piping length needed where possible. Approximately 91 percent of land within the District is privately owned. Realignment would involve acquiring new easements across these private lands. Depending on the proposed alignment, a right-of-way across public land could potentially be necessary.

New easements would disrupt prime farmland and residential living areas, and the easements would be difficult to secure from enough landowners to be feasible. Pipeline realignment outside the existing easements would require EFID to pay market price for the easements and negotiate with many landowners, which would be a complex, expensive, and time-consuming process. Pipeline realignment was eliminated from further evaluation due to its lack of efficiency arising from high legal costs; its low acceptability, particularly with private landowners; and because it would not achieve the Federal Objective and Guiding Principles.

D.3.2 Conversion to Dryland Farming

Dryland farming is a non-structural alternative. This method of farming uses no irrigation and drought-resistant crops and practices to conserve moisture. Since fruit trees, which make up 75 percent of the irrigated acres in the District, can sustain long-term damage if they are not watered sufficiently each summer, dryland farming would not be effective in the District.

Conversion to dryland farming was eliminated from further evaluation because it would not meet the project purpose and need; its effectiveness would be uncertain since conversion to dryland farming would be voluntary and only successful for a limited number of irrigated acres in the District; it would not be acceptable because it is inconsistent with public policy supporting and maintaining existing agricultural land use; and because it would not achieve the Federal Objective and Guiding Principles.

D.3.3 Fallowing Farm Fields

Fallowing farm fields is a non-structural alternative that includes permanently transferring or temporarily leasing water rights from irrigated lands or otherwise not using water rights appurtenant to irrigated lands. Fallowing farm fields would use less irrigation water within the District and would therefore allow more water to be kept instream for fish, wildlife, and habitat. This water would be legally protected instream if the associated water rights were leased or transferred instream.

Fruit trees, which comprise 75 percent of the irrigated acres in EFID, can sustain long-term damage if they are not watered sufficiently. This precludes fallowing these crops during dry years. A portion of the remaining irrigated acres in the District, particularly annual crops like pasture, may be fallowed successfully.

Fallowing farm fields was eliminated from further evaluation because: it would not meet the project purpose and need; its effectiveness would be uncertain since fallowing fields would be voluntary and only successful for a limited number of irrigated acres in the District; it would not be acceptable because it is inconsistent with public policy supporting and maintaining existing agricultural land use; and because it would not achieve the Federal Objective and Guiding Principles.

D.3.4 Voluntary Duty Reduction

Voluntary duty reduction refers to patrons voluntarily accepting less than their full water delivery rate from the District. A reduction in duty could mean the District diverts less water, which would leave more water instream. This water would not be permanently protected instream through a new instream water right.

Voluntary duty reduction was eliminated from further evaluation because: it would not meet the project purpose and need; its effectiveness would be uncertain since duty reduction would be voluntary; it would not be acceptable because it is inconsistent with public policy supporting and maintaining existing agricultural land use; and because it would not achieve the Federal Objective and Guiding Principles.

D.3.5 Partial Use of Groundwater

The conversion from surface water sourced to groundwater sourced irrigation, for some of the District, was also initially considered as a possible alternative. The use of groundwater for irrigation would have logistical and legal constraints. The District would need the authority from each patron to convert surface rights to groundwater rights; there would be no guarantee of gaining this approval from patrons. Converting from surface water rights to groundwater rights would also affect the seniority and, therefore, the reliability of the District's water rights. The District currently has senior surface water rights that minimize the chance of being impacted during drought years; however, new groundwater rights would be junior (dated the year of the application and construction) and could be subject to curtailment.

The partial use of groundwater was eliminated from further evaluation because it would not meet the project purpose and need; its effectiveness would be uncertain since conversion to groundwater would be voluntary; inefficiencies associated with logistical and legal constraints obtaining groundwater rights; low acceptability since converting to groundwater rights would result in junior water rights; and because it would not achieve the Federal Objective and Guiding Principles.

D.4 Capital Costs for the Preferred Alternative

This section presents capital costs for the Preferred Alternative, the Piping Alternative, as identified in the EFID SIP (2018$). Based on input from EFID, the total length of piping in Project Group 1 was decreased from the SIP and the costs for Project Group 1 were updated accordingly. Project costs in the Plan-EA were updated to 2019$.

Table 22. Capital Costs for the Preferred Alternative, the Piping Alternative (2018$).[1]

Item	Construction Cost	ECMS [2]	CMGC[3]	Contingency	Total Cost
Project Group 1					
Pipe	$7,545,000	$602,000	$754,000	$1,780,000	$10,681,000
Turnout	$688,000	$0	$0	$0	$688,000
PRV Station	$805,000	$0	$0	$0	$805,000
Project Group 1 Subtotal:	*$9,038,000*	*$602,000*	*$754,000*	*$1,780,000*	*$12,174,000*
Project Group 2					
Pipe	$18,810,000	$1,882,000	$2,633,000	$6,996,000	$30,321,000
Turnout	$1,264,000	$127,000	$178,000	$470,000	$2,039,000
PRV Station	$1,420,000	$145,000	$201,000	$529,000	$2,295,000
Project Group 2 Subtotal:	*$21,494,000*	*$2,154,000*	*$3,012,000*	*$7,995,000*	*$34,655,000*
Project Group 3					
Pipe	$5,009,000	$500,000	$701,000	$1,863,000	$8,073,000
Turnout	$1,120,000	$111,000	$157,000	$417,000	$1,805,000
PRV Station	$2,175,000	$221,000	$307,000	$810,000	$3,513,000
Project Group 3 Subtotal:	*$8,304,000*	*$832,000*	*$1,165,000*	*$3,090,000*	*$13,391,000*
Total Piping:	$31,364,000	$2,984,000	$4,088,000	$10,639,000	$49,075,000
Total Turnouts:	$3,072,000	$238,000	$335,000	$887,000	$4,532,000
Total PRV Station:	$4,400,000	$366,000	$508,000	$1,339,000	$6,613,000
Total Overall Costs:	**$38,836,000**	**$3,588,000**	**$4,931,000**	**$12,865,000**	**$60,220,000**

Note: These costs are from the SIP (2018$).

[1] For the Plan-EA, all costs were updated to 2019$. The length of pipe in project group 1 was also shortened and project group 2 includes an additional $735,000 for installation of the sedimentation basin.

[2] General Contractor Construction Management

[3] Engineering Construction Management, Survey

Table 23. Capital Costs for the Preferred Alternative, the Piping Alternative (2018$).[1]

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Project Group 1										
Eastside Canal	Pipe	18	21	302	feet	$19,205	$1,921	$2,689	$7,144	$30,959
Eastside Canal	Pipe	20	21	130	feet	$8,294	$829	$1,161	$3,085	$13,369
Eastside Canal	Pipe	20	26	452	feet	$23,438	$2,344	$3,281	$8,719	$37,782
Eastside Canal	Pipe	24	21	2,456	feet	$156,151	$15,615	$21,861	$58,088	$251,716
Eastside Canal	Pipe	26	21	784	feet	$49,846	$4,985	$6,978	$18,543	$80,352
Eastside Canal	Pipe	26	26	396	feet	$34,748	$3,475	$4,865	$12,926	$56,014
Eastside Canal	Pipe	28	26	3,274	feet	$333,104	$33,310	$46,635	$123,915	$536,964
Eastside Canal	Pipe	36	26	3,376	feet	$567,827	$56,783	$79,496	$211,232	$915,338
Eastside Canal	Pipe	42	26	20,922	feet	$4,787,066	$478,707	$670,189	$1,780,789	$7,716,751
Eastside Canal	Turnout	N/A	N/A	39	each	$312,000	$31,200	$43,680	$116,064	$502,944
Crag Rate Pipeline	Pipe	4	17	1,816	feet	$7,151	$715	$1,001	$2,660	$11,527
Crag Rate Pipeline	Pipe	4	21	1,823	feet	$115,909	$11,591	$16,227	$43,118	$186,845
Crag Rate Pipeline	Pipe	4	26	1,275	feet	$3,336	$334	$467	$1,241	$5,378
Crag Rate Pipeline	Pipe	4	32.5	54	feet	$113	$11	$16	$42	$183
Crag Rate Pipeline	Pipe	6	11	2,092	feet	$26,518	$2,652	$3,712	$9,865	$42,746

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Crag Rate Pipeline	Pipe	6	26	1,248	feet	$7,098	$710	$994	$2,641	$11,442
Crag Rate Pipeline	Pipe	8	21	1,531	feet	$97,314	$9,731	$13,624	$36,201	$156,869
Crag Rate Pipeline	Pipe	10	26	7	feet	$106	$11	$15	$40	$171
Crag Rate Pipeline	Turnout	N/A	N/A	10	each	$80,000	$8,000	$11,200	$29,760	$128,960
Crag Rate Pipeline	PRV Station	4	N/A	2	each	$150,000	$15,000	$21,000	$55,800	$241,800
Crag Rate Pipeline	PRV Station	6	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Dethman/Swyers Line	PRV Station	10	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Whiskey Creek Pipeline	Pipe	4	13.5	297	feet	$1,441	$144	$202	$536	$2,323
Whiskey Creek Pipeline	Pipe	4	21	1,400	feet	$88,985	$8,899	$12,458	$33,102	$143,444
Whiskey Creek Pipeline	Pipe	4	26	703	feet	$1,838	$184	$257	$684	$2,964
Whiskey Creek Pipeline	Pipe	4	32.5	1,287	feet	$2,713	$271	$380	$1,009	$4,374
Whiskey Creek Pipeline	Pipe	5.375	19	923	feet	$4,664	$466	$653	$1,735	$7,518
Whiskey Creek Pipeline	Pipe	6	11	1,144	feet	$14,506	$1,451	$2,031	$5,396	$23,384
Whiskey Creek Pipeline	Pipe	6	32.5	1,538	feet	$7,072	$707	$990	$2,631	$11,400
Whiskey Creek Pipeline	Pipe	8	21	3,359	feet	$213,530	$21,353	$29,894	$79,433	$344,210
Whiskey Creek Pipeline	Pipe	8	26	1,469	feet	$14,174	$1,417	$1,984	$5,273	$22,849
Whiskey Creek Pipeline	Pipe	8	32.5	2,025	feet	$15,742	$1,574	$2,204	$5,856	$25,376

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Whiskey Creek Pipeline	Pipe	10	26	765	feet	$11,459	$1,146	$1,604	$4,263	$18,471
Whiskey Creek Pipeline	Pipe	10	32.5	77	feet	$927	$93	$130	$345	$1,495
Whiskey Creek Pipeline	Pipe	12	13.5	771	feet	$30,087	$3,009	$4,212	$11,192	$48,500
Whiskey Creek Pipeline	Pipe	12	19	534	feet	$15,174	$1,517	$2,124	$5,645	$24,461
Whiskey Creek Pipeline	Pipe	12	21	1,384	feet	$87,964	$8,796	$12,315	$32,723	$141,798
Whiskey Creek Pipeline	Pipe	14	21	388	feet	$24,640	$2,464	$3,450	$9,166	$39,720
Whiskey Creek Pipeline	Pipe	16	15.5	4,202	feet	$227,353	$22,735	$31,829	$84,575	$366,493
Whiskey Creek Pipeline	Pipe	16	21	2,120	feet	$134,764	$13,476	$18,867	$50,132	$217,240
Whiskey Creek Pipeline	Pipe	20	13.5	286	feet	$27,420	$2,742	$3,839	$10,200	$44,200
Whiskey Creek Pipeline	Turnout	N/A	N/A	23	each	$184,000	$18,400	$25,760	$68,448	$296,608
Whiskey Creek Pipeline	PRV Station	4	N/A	2	each	$150,000	$15,000	$21,000	$55,800	$241,800
Whiskey Creek Pipeline	PRV Station	6	N/A	2	each	$150,000	$15,000	$21,000	$55,800	$241,800
Whiskey Creek Pipeline	PRV Station	12	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Whiskey Creek Pipeline	PRV Station	14	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Kelly Pipeline	Pipe	4	26	1,476	feet	$3,862	$386	$541	$1,437	$6,225
Kelly Pipeline	Pipe	4	32.5	1	feet	$3	$0	$0	$1	$4
Kelly Pipeline	Pipe	5.375	11	1,530	feet	$12,784	$1,278	$1,790	$4,756	$20,608

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Kelly Pipeline	Turnout	N/A	N/A	1	each	$8,000	$800	$1,120	$2,976	$12,896
Kelly Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Loop Pipeline	Pipe	4	21	996	feet	$63,334	$6,333	$8,867	$23,560	$102,094
Loop Pipeline	Pipe	4	26	3,081	feet	$8,061	$806	$1,128	$2,999	$12,994
Loop Pipeline	Pipe	4	32.5	454	feet	$957	$96	$134	$356	$1,542
Loop Pipeline	Pipe	6	26	1,867	feet	$10,622	$1,062	$1,487	$3,951	$17,122
Loop Pipeline	Pipe	8	32.5	636	feet	$4,941	$494	$692	$1,838	$7,966
Loop Pipeline	Pipe	10	21	1,712	feet	$108,830	$10,883	$15,236	$40,485	$175,434
Loop Pipeline	Pipe	10	26	655	feet	$9,820	$982	$1,375	$3,653	$15,829
Loop Pipeline	Pipe	12	21	1,815	feet	$115,400	$11,540	$16,156	$42,929	$186,025
Loop Pipeline	Pipe	16	21	1,209	feet	$76,832	$7,683	$10,757	$28,582	$123,854
Loop Pipeline	Pipe	16	26	155	feet	$5,155	$516	$722	$1,918	$8,310
Loop Pipeline	Pipe	18	13.5	765	feet	$59,440	$5,944	$8,322	$22,112	$95,818
Loop Pipeline	Pipe	18	26	2,791	feet	$117,274	$11,727	$16,418	$43,626	$189,045
Loop Pipeline	Pipe	18	32.5	16	feet	$546	$55	$76	$203	$880
Loop Pipeline	Pipe	20	21	75	feet	$4,765	$477	$667	$1,773	$7,681
Loop Pipeline	Pipe	24	21	1,903	feet	$120,980	$12,098	$16,937	$45,004	$195,019

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Loop Pipeline	Turnout	N/A	N/A	24	each	$192,000	$19,200	$26,880	$71,424	$309,504
Loop Pipeline	PRV Station	10	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Loop Pipeline	PRV Station	16	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Lower Highline Pressure Pipeline	Pipe	4	15.5	0	feet	$0	$0	$0	$0	$0
Lower Highline Pressure Pipeline	Pipe	4	17	1,039	feet	$4,090	$409	$573	$1,522	$6,594
Lower Highline Pressure Pipeline	Pipe	4	21	2,334	feet	$148,361	$14,836	$20,771	$55,190	$239,159
Lower Highline Pressure Pipeline	Pipe	4	26	1,861	feet	$4,869	$487	$682	$1,811	$7,849
Lower Highline Pressure Pipeline	Pipe	4	32.5	2,105	feet	$4,438	$444	$621	$1,651	$7,154
Lower Highline Pressure Pipeline	Pipe	5.375	15.5	440	feet	$2,682	$268	$376	$998	$4,324
Lower Highline Pressure Pipeline	Pipe	6	21	33	feet	$2,068	$207	$290	$769	$3,334
Lower Highline Pressure Pipeline	Pipe	6	26	2,291	feet	$13,037	$1,304	$1,825	$4,850	$21,015
Lower Highline Pressure Pipeline	Pipe	6	32.5	2	feet	$8	$1	$1	$3	$13
Lower Highline Pressure Pipeline	Pipe	8	32.5	102	feet	$794	$79	$111	$295	$1,279
Lower Highline Pressure Pipeline	Turnout	N/A	N/A	17	each	$136,000	$13,600	$19,040	$50,592	$219,232
Lower Highline Pressure Pipeline	PRV Station	4	N/A	3	each	$225,000	$22,500	$31,500	$83,700	$362,700
Lower Highline Pressure Pipeline	PRV Station	6	N/A	2	each	$150,000	$15,000	$21,000	$55,800	$241,800
Lower Highline Pressure Pipeline	PRV Station	8	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Paasch Pipeline	Pipe	6	21	5	feet	$330	$33	$46	$123	$532
Paasch Pipeline	Pipe	8	21	1,345	feet	$85,534	$8,553	$11,975	$31,819	$137,881
Paasch Pipeline	Pipe	10	13.5	1,078	feet	$29,906	$2,991	$4,187	$11,125	$48,209
Paasch Pipeline	Pipe	10	21	1,109	feet	$70,536	$7,054	$9,875	$26,239	$113,704
Paasch Pipeline	Pipe	10	32.5	587	feet	$7,113	$711	$996	$2,646	$11,467
Paasch Pipeline	Turnout	N/A	N/A	4	each	$32,000	$3,200	$4,480	$11,904	$51,584
Paasch Pipeline	PRV Station	10	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Rasmussen Pipeline	PRV Station	12	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Tallman Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900
Thomsen Pipeline	Pipe	4	21	1,183	feet	$75,193	$7,519	$10,527	$27,972	$121,212
Thomsen Pipeline	Pipe	4	32.5	0	feet	$1	$0	$0	$0	$1
Thomsen Pipeline	Pipe	5.375	21	2,963	feet	$188,395	$18,840	$26,375	$70,083	$303,693
Thomsen Pipeline	Pipe	8	32.5	3	feet	$21	$2	$3	$8	$34
Thomsen Pipeline	Pipe	10	13.5	1,196	feet	$33,187	$3,319	$4,646	$12,345	$53,497
Thomsen Pipeline	Pipe	10	32.5	685	feet	$8,301	$830	$1,162	$3,088	$13,381
Thomsen Pipeline	Turnout	N/A	N/A	4	each	$32,000	$3,200	$4,480	$11,904	$51,584
Thomsen Pipeline	PRV Station	10	N/A	1	each	$75,000	$7,500	$10,500	$27,900	$120,900

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Project Group 2										
Main Canal	Pipe	54	26	4,074	feet	$1,541,366	$154,137	$215,791	$477,824	$2,389,118
Main Canal	Pipe	54	41	47,470	feet	$11,565,373	$1,156,537	$1,619,152	$3,585,266	$17,926,328
Main Canal	Pipe	48	26	872	feet	$260,794	$26,079	$36,511	$80,846	$404,230
Main Canal	Pipe	48	41	18,820	feet	$3,622,999	$362,300	$507,220	$1,123,130	$5,615,649
Main Canal	Pipe	66	N/A	38	feet	$20,945	$2,094	$2,932	$6,493	$32,464
Main Canal	Turnout	N/A	N/A	50	each	$400,000	$39,200	$54,880	$121,520	$615,600
Main Canal	PRV Station	66	N/A	1	each	$280,000	$28,000	$39,200	$86,800	$434,000
Arens Lateral Pipeline	Pipe	4	32.5	0	feet	$0	$0	$0	$0	$0
Arens Lateral Pipeline	Pipe	6	32.5	1,334	feet	$6,135	$613	$859	$1,902	$9,509
Arens Lateral Pipeline	Turnout	N/A	N/A	2	each	$16,000	$1,600	$2,240	$4,960	$24,800
Bowcut Pipeline	Pipe	4	26	1	feet	$2	$0	$0	$1	$4
Bowcut Pipeline	Pipe	4	32.5	337	feet	$711	$71	$99	$220	$1,101
Bowcut Pipeline	Pipe	6	26	1,553	feet	$8,834	$883	$1,237	$2,738	$13,692
Bowcut Pipeline	Pipe	6	32.5	4,524	feet	$20,800	$2,080	$2,912	$6,448	$32,240
Bowcut Pipeline	Turnout	N/A	N/A	16	each	$128,000	$12,800	$17,920	$39,680	$198,400

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Christopher Pipeline	PRV Station	12	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Fisher Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Dukes Valley Canal	Pipe	30	21	2,480	feet	$157,651	$15,765	$22,071	$48,872	$244,359
Dukes Valley Canal	Pipe	32	21	13,166	feet	$837,030	$83,703	$117,184	$259,479	$1,297,397
Dukes Valley Canal	Pipe	32	26	1,327	feet	$176,368	$17,637	$24,692	$54,674	$273,371
Dukes Valley Canal	Pipe	32	32.5	1,499	feet	$160,740	$16,074	$22,504	$49,829	$249,147
Dukes Valley Canal	Pipe	34	17	1,637	feet	$367,025	$36,702	$51,383	$113,778	$568,889
Dukes Valley Canal	Pipe	34	21	6,430	feet	$408,813	$40,881	$57,234	$126,732	$633,661
Dukes Valley Canal	Turnout	N/A	N/A	22	each	$176,000	$17,600	$24,640	$54,560	$272,800
Dukes Valley Canal	PRV Station	16	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Dukes Valley Canal	PRV Station	30	N/A	1	each	$140,000	$14,000	$19,600	$43,400	$217,000
Cameron Hill Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Cameron Hill Pipeline	PRV Station	6	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Cameron Hill Pipeline	PRV Station	10	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Marsh/Chamberlin Pipeline	Pipe	4	21	5,367	feet	$341,199	$34,120	$47,768	$105,772	$528,858
Marsh/Chamberlin Pipeline	Pipe	4	26	6,178	feet	$16,164	$1,616	$2,263	$5,011	$25,054
Marsh/Chamberlin Pipeline	Pipe	4	32.5	2,085	feet	$4,396	$440	$615	$1,363	$6,814

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Marsh/Chamberlin Pipeline	Pipe	5.375	32.5	27	feet	$81	$8	$11	$25	$125
Marsh/Chamberlin Pipeline	Pipe	6	17	688	feet	$5,851	$585	$819	$1,814	$9,070
Marsh/Chamberlin Pipeline	Pipe	6	21	5	feet	$342	$34	$48	$106	$530
Marsh/Chamberlin Pipeline	Pipe	6	26	2,807	feet	$15,972	$1,597	$2,236	$4,951	$24,757
Marsh/Chamberlin Pipeline	Pipe	6	32.5	1,853	feet	$8,518	$852	$1,193	$2,641	$13,203
Marsh/Chamberlin Pipeline	Pipe	8	26	1,516	feet	$14,628	$1,463	$2,048	$4,535	$22,673
Marsh/Chamberlin Pipeline	Pipe	8	32.5	2,583	feet	$20,075	$2,007	$2,810	$6,223	$31,116
Marsh/Chamberlin Pipeline	Pipe	10	21	1,962	feet	$124,747	$12,475	$17,465	$38,671	$193,357
Marsh/Chamberlin Pipeline	Pipe	10	32.5	58	feet	$706	$71	$99	$219	$1,094
Marsh/Chamberlin Pipeline	Pipe	12	26	628	feet	$13,233	$1,323	$1,853	$4,102	$20,510
Marsh/Chamberlin Pipeline	Pipe	12	32.5	626	feet	$10,645	$1,065	$1,490	$3,300	$16,500
Marsh/Chamberlin Pipeline	Pipe	14	32.5	39	feet	$790	$79	$111	$245	$1,225
Marsh/Chamberlin Pipeline	Pipe	16	21	894	feet	$56,866	$5,687	$7,961	$17,629	$88,143
Marsh/Chamberlin Pipeline	Pipe	16	32.5	1,300	feet	$34,816	$3,482	$4,874	$10,793	$53,965
Marsh/Chamberlin Pipeline	Pipe	18	21	2,121	feet	$134,864	$13,486	$18,881	$41,808	$209,039
Marsh/Chamberlin Pipeline	Pipe	24	21	498	feet	$31,639	$3,164	$4,430	$9,808	$49,041
Marsh/Chamberlin Pipeline	Pipe	24	26	849	feet	$63,418	$6,342	$8,878	$19,659	$98,297

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Marsh/Chamberlin Pipeline	Pipe	24	32.5	392	feet	$23,646	$2,365	$3,311	$7,330	$36,652
Marsh/Chamberlin Pipeline	Pipe	26	21	1,828	feet	$116,198	$11,620	$16,268	$36,021	$180,107
Marsh/Chamberlin Pipeline	Turnout	N/A	N/A	63	each	$504,000	$50,400	$70,560	$156,240	$781,200
Marsh/Chamberlin Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Marsh/Chamberlin Pipeline	PRV Station	8	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Marsh/Chamberlin Pipeline	PRV Station	16	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Marsh/Chamberlin Pipeline	PRV Station	22	N/A	1	each	$100,000	$10,000	$14,000	$31,000	$155,000
Shute Road Pipeline	Turnout	N/A	N/A	1	each	$8,000	$0	$0	$0	$8,000
Shute Road Pipeline	PRV Station	6	N/A	2	each	$150,000	$15,000	$21,000	$46,500	$232,500
Sheirbon Hill Pipeline	Pipe	4	26	349	feet	$913	$91	$128	$283	$1,415
Sheirbon Hill Pipeline	Pipe	6	26	1,874	feet	$10,659	$1,066	$1,492	$3,304	$16,522
Sheirbon Hill Pipeline	Pipe	8	13.5	815	feet	$14,549	$1,455	$2,037	$4,510	$22,551
Sheirbon Hill Pipeline	Pipe	8	21	5	feet	$342	$34	$48	$106	$530
Sheirbon Hill Pipeline	Pipe	8	26	856	feet	$8,267	$827	$1,157	$2,563	$12,813
Sheirbon Hill Pipeline	Pipe	8	32.5	161	feet	$1,248	$125	$175	$387	$1,934
Sheirbon Hill Pipeline	Turnout	N/A	N/A	6	each	$48,000	$4,800	$6,720	$14,880	$74,400
Sedimentation Basin	Other	N/A	N/A	1	each	$735,000	$0	$0	$0	$735,000

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Project Group 3										
Central Lateral Pipeline	PRV Station	8	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Central Lateral Pipeline	PRV Station	30	N/A	3	each	$420,000	$42,000	$58,800	$130,200	$651,000
Allison Pipeline	Pipe	4	26	127	feet	$331	$33	$46	$103	$513
Allison Pipeline	Pipe	6	26	1,575	feet	$8,962	$896	$1,255	$2,778	$13,890
Allison Pipeline	Pipe	6	32.5	5	feet	$23	$2	$3	$7	$36
Allison Pipeline	Pipe	8	32.5	340	feet	$2,641	$264	$370	$819	$4,094
Allison Pipeline	Pipe	10	21	2,460	feet	$156,369	$15,637	$21,892	$48,475	$242,373
Allison Pipeline	Pipe	10	32.5	465	feet	$5,637	$564	$789	$1,747	$8,737
Allison Pipeline	Turnout	N/A	N/A	8	each	$64,000	$6,400	$8,960	$19,840	$99,200
Allison Pipeline	PRV Station	10	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Dethman Ridge Line	Pipe	4	21	5,242	feet	$333,270	$33,327	$46,658	$103,314	$516,569
Dethman Ridge Line	Pipe	4	26	3,756	feet	$9,827	$983	$1,376	$3,046	$15,232
Dethman Ridge Line	Pipe	4	32.5	2,065	feet	$4,352	$435	$609	$1,349	$6,746
Dethman Ridge Line	Pipe	5.375	26	261	feet	$980	$98	$137	$304	$1,519
Dethman Ridge Line	Pipe	6	19	1,659	feet	$12,725	$1,273	$1,782	$3,945	$19,724
Dethman Ridge Line	Pipe	6	21	5,038	feet	$320,324	$32,032	$44,845	$99,300	$496,502

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Dethman Ridge Line	Pipe	6	26	1,571	feet	$8,941	$894	$1,252	$2,772	$13,858
Dethman Ridge Line	Pipe	6	32.5	3,815	feet	$17,540	$1,754	$2,456	$5,437	$27,187
Dethman Ridge Line	Pipe	8	19	2,966	feet	$38,578	$3,858	$5,401	$11,959	$59,796
Dethman Ridge Line	Pipe	8	21	1,527	feet	$97,049	$9,705	$13,587	$30,085	$150,426
Dethman Ridge Line	Pipe	8	26	148	feet	$1,432	$143	$201	$444	$2,220
Dethman Ridge Line	Pipe	8	32.5	548	feet	$4,259	$426	$596	$1,320	$6,602
Dethman Ridge Line	Pipe	10	21	723	feet	$45,989	$4,599	$6,438	$14,257	$71,283
Dethman Ridge Line	Pipe	10	26	70	feet	$1,045	$104	$146	$324	$1,620
Dethman Ridge Line	Pipe	10	32.5	2,701	feet	$32,724	$3,272	$4,581	$10,144	$50,722
Dethman Ridge Line	Pipe	12	26	1,227	feet	$25,868	$2,587	$3,621	$8,019	$40,095
Dethman Ridge Line	Pipe	12	32.5	70	feet	$1,194	$119	$167	$370	$1,851
Dethman Ridge Line	Pipe	14	26	525	feet	$13,342	$1,334	$1,868	$4,136	$20,679
Dethman Ridge Line	Pipe	14	32.5	2,064	feet	$42,353	$4,235	$5,929	$13,129	$65,647
Dethman Ridge Line	Pipe	16	26	643	feet	$21,341	$2,134	$2,988	$6,616	$33,078
Dethman Ridge Line	Pipe	16	32.5	4	feet	$102	$10	$14	$32	$158
Dethman Ridge Line	Pipe	24	26	1,014	feet	$75,742	$7,574	$10,604	$23,480	$117,401
Dethman Ridge Line	Pipe	24	32.5	2,687	feet	$161,863	$16,186	$22,661	$50,178	$250,888

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Dethman Ridge Line	Pipe	26	32.5	230	feet	$16,260	$1,626	$2,276	$5,040	$25,202
Dethman Ridge Line	Pipe	28	32.5	923	feet	$75,798	$7,580	$10,612	$23,497	$117,487
Dethman Ridge Line	Pipe	30	21	2,984	feet	$189,685	$18,968	$26,556	$58,802	$294,011
Dethman Ridge Line	Pipe	30	32.5	337	feet	$31,768	$3,177	$4,448	$9,848	$49,241
Dethman Ridge Line	Pipe	34	11	0	feet	$37	$4	$5	$11	$57
Dethman Ridge Line	Turnout	N/A	N/A	75	each	$600,000	$59,200	$82,880	$183,520	$925,600
Dethman Ridge Line	PRV Station	6	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Dethman Ridge Line	PRV Station	8	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Dethman Ridge Line	PRV Station	12	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Dethman Ridge Line	PRV Station	24	N/A	1	each	$100,000	$10,000	$14,000	$31,000	$155,000
Oanna Pipeline	Pipe	4	19	541	feet	$1,910	$191	$267	$592	$2,961
Oanna Pipeline	Pipe	4	21	2,643	feet	$168,000	$16,800	$23,520	$52,080	$260,400
Oanna Pipeline	Pipe	4	32.5	490	feet	$1,033	$103	$145	$320	$1,602
Oanna Pipeline	Pipe	5.375	21	537	feet	$34,149	$3,415	$4,781	$10,586	$52,931
Oanna Pipeline	Pipe	6	17	1,719	feet	$14,630	$1,463	$2,048	$4,535	$22,677
Oanna Pipeline	Pipe	6	21	2,646	feet	$168,212	$16,821	$23,550	$52,146	$260,728
Oanna Pipeline	Pipe	6	26	1,932	feet	$10,992	$1,099	$1,539	$3,408	$17,038

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Oanna Pipeline	Pipe	6	32.5	626	feet	$2,878	$288	$403	$892	$4,461
Oanna Pipeline	Pipe	8	19	288	feet	$3,749	$375	$525	$1,162	$5,811
Oanna Pipeline	Pipe	8	21	382	feet	$24,275	$2,428	$3,399	$7,525	$37,627
Oanna Pipeline	Pipe	8	26	4,323	feet	$41,729	$4,173	$5,842	$12,936	$64,679
Oanna Pipeline	Pipe	8	32.5	1,006	feet	$7,822	$782	$1,095	$2,425	$12,125
Oanna Pipeline	Pipe	10	11	1,384	feet	$46,201	$4,620	$6,468	$14,322	$71,611
Oanna Pipeline	Pipe	10	26	5	feet	$68	$7	$9	$21	$105
Oanna Pipeline	Pipe	30	32.5	2	feet	$175	$18	$25	$54	$272
Oanna Pipeline	Pipe	32	13.5	2,661	feet	$653,911	$65,391	$91,548	$202,713	$1,013,563
Oanna Pipeline	Pipe	32	21	1,139	feet	$72,403	$7,240	$10,136	$22,445	$112,225
Oanna Pipeline	Pipe	32	32.5	3,310	feet	$354,907	$35,491	$49,687	$110,021	$550,106
Oanna Pipeline	Pipe	34	26	1,967	feet	$295,028	$29,503	$41,304	$91,459	$457,293
Oanna Pipeline	Pipe	34	32.5	0	feet	$1	$0	$0	$0	$2
Oanna Pipeline	Pipe	36	21	1,008	feet	$64,086	$6,409	$8,972	$19,867	$99,333
Oanna Pipeline	Turnout	N/A	N/A	28	each	$224,000	$22,400	$31,360	$69,440	$347,200
Oanna Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Oanna Pipeline	PRV Station	6	N/A	3	each	$225,000	$22,500	$31,500	$69,750	$348,750

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Oanna Pipeline	PRV Station	8	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Oanna Pipeline	PRV Station	30	N/A	1	each	$140,000	$14,000	$19,600	$43,400	$217,000
Oanna Pipeline	PRV Station	32	N/A	1	each	$140,000	$14,000	$19,600	$43,400	$217,000
Chipping Pipeline	Pipe	4	17	653	feet	$2,572	$257	$360	$797	$3,986
Chipping Pipeline	Pipe	4	21	1,820	feet	$115,721	$11,572	$16,201	$35,874	$179,368
Chipping Pipeline	Pipe	4	26	521	feet	$1,363	$136	$191	$422	$2,112
Chipping Pipeline	Pipe	4	32.5	1,009	feet	$2,128	$213	$298	$660	$3,299
Chipping Pipeline	Pipe	5.375	13.5	1,111	feet	$7,707	$771	$1,079	$2,389	$11,945
Chipping Pipeline	Pipe	6	21	902	feet	$57,365	$5,736	$8,031	$17,783	$88,915
Chipping Pipeline	Pipe	6	26	472	feet	$2,684	$268	$376	$832	$4,161
Chipping Pipeline	Pipe	6	32.5	2,422	feet	$11,133	$1,113	$1,559	$3,451	$17,256
Chipping Pipeline	Pipe	8	32.5	1,052	feet	$8,176	$818	$1,145	$2,535	$12,673
Chipping Pipeline	Pipe	10	19	339	feet	$6,852	$685	$959	$2,124	$10,621
Chipping Pipeline	Pipe	10	32.5	333	feet	$4,033	$403	$565	$1,250	$6,251
Chipping Pipeline	Pipe	12	21	1,542	feet	$98,048	$9,805	$13,727	$30,395	$151,974
Chipping Pipeline	Pipe	14	21	1,366	feet	$86,862	$8,686	$12,161	$26,927	$134,636
Chipping Pipeline	Pipe	14	26	1,376	feet	$34,947	$3,495	$4,893	$10,834	$54,168

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Chipping Pipeline	Pipe	18	26	1,156	feet	$48,585	$4,858	$6,802	$15,061	$75,306
Chipping Pipeline	Pipe	18	32.5	324	feet	$10,997	$1,100	$1,540	$3,409	$17,046
Chipping Pipeline	Pipe	20	26	596	feet	$30,904	$3,090	$4,327	$9,580	$47,901
Chipping Pipeline	Pipe	24	11	1,936	feet	$322,239	$32,224	$45,113	$99,894	$499,470
Chipping Pipeline	Pipe	24	15.5	1,148	feet	$139,707	$13,971	$19,559	$43,309	$216,545
Chipping Pipeline	Turnout	N/A	N/A	22	each	$176,000	$16,000	$22,400	$49,600	$264,000
Chipping Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Chipping Pipeline	PRV Station	10	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Chipping Pipeline	PRV Station	12	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Chipping Pipeline	PRV Station	18	N/A	1	each	$100,000	$10,000	$14,000	$31,000	$155,000
Gilkerson Pipeline	Pipe	4	11	1,307	feet	$7,633	$763	$1,069	$2,366	$11,831
Gilkerson Pipeline	Pipe	4	21	753	feet	$47,877	$4,788	$6,703	$14,842	$74,209
Gilkerson Pipeline	Pipe	6	21	2,089	feet	$132,821	$13,282	$18,595	$41,175	$205,873
Gilkerson Pipeline	Pipe	6	32.5	5	feet	$25	$2	$3	$8	$39
Gilkerson Pipeline	Turnout	N/A	N/A	5	each	$40,000	$4,000	$5,600	$12,400	$62,000
Gilkerson Pipeline	PRV Station	4	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Winklebleck Pipeline	Pipe	4	21	943	feet	$59,965	$5,997	$8,395	$18,589	$92,946

Pipeline Name	Item	Nominal Diameter (inches)	Pressure Rating	Quantity	Units	Construction Cost	Engineering, Construction Management, Survey	General Management, General Contractor	Contingency Costs	Total Costs
Winklebleck Pipeline	Pipe	4	32.5	246	feet	$518	$52	$72	$160	$802
Winklebleck Pipeline	Pipe	6	19	324	feet	$2,485	$248	$348	$770	$3,851
Winklebleck Pipeline	Pipe	6	26	473	feet	$2,690	$269	$377	$834	$4,170
Winklebleck Pipeline	Pipe	6	32.5	5	feet	$24	$2	$3	$7	$37
Winklebleck Pipeline	Pipe	8	13.5	1,380	feet	$24,646	$2,465	$3,450	$7,640	$38,202
Winklebleck Pipeline	Pipe	8	26	1,007	feet	$9,722	$972	$1,361	$3,014	$15,069
Winklebleck Pipeline	Pipe	8	32.5	594	feet	$4,617	$462	$646	$1,431	$7,156
Winklebleck Pipeline	Turnout	N/A	N/A	5	each	$40,000	$4,000	$5,600	$12,400	$62,000
Winklebleck Pipeline	PRV Station	6	N/A	2	each	$150,000	$15,000	$21,000	$46,500	$232,500
Winklebleck Pipeline	PRV Station	8	N/A	1	each	$75,000	$7,500	$10,500	$23,250	$116,250
Total						**$38,836,000**	**$3,588,000**	**$4,931,000**	**$12,865,000**	**$60,220,000**

D.5 Eliminated Alternatives

This appendix section presents dimensions and capital costs for the eliminated alternatives, which includes canal lining, steel piping, and polyvinyl chloride (PVC) piping.

D.5.1 Canal Lining Alternative

The capital cost of the Canal Lining Alternative (Table 24) was estimated by calculating the length of geotextile membrane in existing open canals, assuming an anchor of membrane extending 7 feet on either side. The membrane is covered by a 1-inch layer of shotcrete (fine-aggregate concrete sprayed in place). This estimate also includes fencing along both sides of the canal, and safety ladders every 750 feet in canals deeper than 2.5 feet. Costs related to earthwork and labor are estimated by a 1.5 construction cost multiplier. Turnouts were estimated at an average of $1,000 each. The cross section length of the canals was estimated based on cross section lengths found for an irrigation district in Central Oregon, which were calculated for each corresponding pipe diameter size using transects on a digital elevation model.

Table 24. Capital Costs for the Canal Lining Alternative.

	Cross section length (ft)	Canal Length (ft)	Turnout cost	Membrane cost	Membrane overlap cost	Shotcrete cost	Fencing cost	Ladder cost	Subtotal	ECMS [1]	CMGC[2]	Contingency	Total
Project Group 1													
Canal	10.70	1,305		$27,400	$110	$76,809	$0	$0	$156,478	$15,648	$21,907	$48,508	$242,541
Canal	12.74	807		$18,345	$73	$56,550	$11,074	$538	$129,871	$12,987	$18,182	$40,260	$201,299
Canal	14.52	273		$6,620	$26	$21,809	$3,747	$182	$48,578	$4,858	$6,801	$15,059	$75,295
Canal	22.17	525		$16,149	$65	$64,042	$7,207	$350	$131,719	$13,172	$18,441	$40,833	$204,165
Canal	23.77	2,572		$82,583	$330	$336,298	$35,291	$1,715	$684,325	$68,432	$95,805	$212,141	$1,060,703
Canal	23.61	1,017		$32,524	$130	$132,118	$13,958	$678	$269,112	$26,911	$37,676	$83,425	$417,124
Canal	23.61	3,301		$105,540	$422	$428,716	$45,292	$2,201	$873,257	$87,326	$122,256	$270,710	$1,353,548
Canal	22.21	3,686		$113,447	$454	$450,248	$50,572	$2,457	$925,767	$92,577	$129,607	$286,988	$1,434,938
Canal	25.33	18,606		$622,070	$2,488	$2,592,503	$255,273	$12,404	$5,227,107	$522,711	$731,795	$1,620,403	$8,102,016
Turnout			$39,000						$58,500	$5,850	$8,190	$18,135	$90,675
Project Group 2													
Canal	11.01	0.02		$0	$0	$1	$0	$0	$2	$0	$0	$1	$4
Canal	25.34	2,480		$82,920	$332	$345,605	$34,022	$1,653	$696,798	$69,680	$97,552	$216,007	$1,080,037
Canal	25.34	15,992		$534,766	$2,139	$2,228,858	$219,411	$10,661	$4,493,753	$449,375	$629,125	$1,393,063	$6,965,317
Canal	25.34	8,067		$269,765	$1,079	$1,124,359	$110,683	$5,378	$2,266,897	$226,690	$317,366	$702,738	$3,513,691
Canal	25.88	26,066		$883,579	$3,534	$3,710,228	$357,619	$17,377	$7,458,507	$745,851	$1,044,191	$2,312,137	$11,560,686
Canal	34.39	7,247		$298,080	$1,192	$1,370,707	$99,433	$4,832	$2,661,365	$266,137	$372,591	$825,023	$4,125,116
Canal	34.39	38		$1,549	$6	$7,125	$517	$25	$13,833	$1,383	$1,937	$4,288	$21,441
Turnout			$71,000						$106,500	$10,650	$14,910	$33,015	$165,075
Sedimentation Basin													$735,000
Grand Total		**91,983**	**$110,000**	**$3,095,337**	**$12,381**	**$12,945,976**	**$1,244,099**	**$60,452**	**$26,202,368**	**$2,620,237**	**$3,668,332**	**$8,122,734**	**$41,348,671**

Note: Totals may not sum due to rounding.
[1] Engineering, Construction Management, Survey
[2] Construction Management General Contractor

D.5.2 Steel Piping Alternative

The lengths, diameters, and range of pressure ratings used to calculate the capital costs for the Steel Piping Alternative (Table 25) were estimated based on the engineering analysis completed in the District's SIP. Spiral welded steel was selected that conforms to requirements of the American Water Works Association C200 standard. This pipe was selected because it is considered an industry consensus standard (Bambie and Keil 2013). Steel pipe typically has a design life of 50 years under irrigation water delivery applications (M. Thalacker, personal communication, November 8, 2017). Unlike HDPE, steel pipe cannot be shaped to conform into canal alignments; therefore, elbows would be required. Elbows were assumed every 100 feet of pipe. Similar to the Preferred Alternative, turnouts were costed at $8,000 and pressure reducing valve (PRV) stations ranged from $75,000 to $280,000 per station. These costs are based upon actual installed costs for turnouts and PRV stations in Central Oregon.

Table 25. Capital Costs for the Steel Piping Alternative.

	Length (ft)	Elbow Quantity	Construction Cost	ECMS[1]	CMGC[2]	Contingency	Total
Project Group 1							
Pipe							
Crag Rate Pipeline	8,315	83	$417,774	$33,422	$41,777	$98,595	$591,568
Eastside Canal	32,093	321	$10,837,020	$866,962	$1,083,702	$2,557,537	$15,345,220
Kelly Pipeline	3,007	30	$129,676	$10,374	$12,968	$30,604	$183,621
Lower Highline Pressure Pipeline	10,206	102	$484,802	$38,784	$48,480	$114,413	$686,479
Paasch Pipeline	1,078	11	$103,632	$8,291	$10,363	$24,457	$146,743
Thomsen Pipeline	4,150	42	$179,107	$14,329	$17,911	$42,269	$253,615
Whiskey Creek Pipeline	22,984	230	$2,259,834	$180,787	$225,983	$533,321	$3,199,924
Turnout							
Crag Rate Pipeline			$72,000				$72,000
Eastside Canal			$312,000				$312,000
Kelly Pipeline			$8,000				$8,000
Lower Highline Pressure Pipeline			$128,000				$128,000
Thomsen Pipeline			$40,000				$40,000
Whiskey Creek Pipeline			$136,000				$136,000
Valve							
Crag Rate Pipeline			$90,000				$90,000
Dethman/Swyers Line			$45,000				$45,000
Kelly Pipeline			$30,000				$30,000
Loop Pipeline			$85,000				$85,000
Lower Highline Pressure Pipeline			$190,000				$190,000
Paasch Pipeline			$40,000				$40,000
Rasmussen Pipeline			$45,000				$45,000
Tallman Pipeline			$30,000				$30,000
Thomsen Pipeline			$45,000				$45,000
Whiskey Creek Pipeline			$205,000				$205,000

	Length (ft)	Elbow Quantity	Construction Cost	ECMS[1]	CMGC[2]	Contingency	Total
Project Group 2							
Pipe							
Arens Lateral Pipeline	1,334	13	$81,112	$8,111	$11,356	$25,145	$125,724
Bowcut Pipeline	6,415	64	$383,958	$38,396	$53,754	$119,027	$595,136
Dukes Valley Canal	26,539	265	$7,806,323	$780,632	$1,092,885	$2,419,960	$12,099,801
Main Canal	66,611	666	$30,911,624	$3,091,162	$4,327,627	$9,582,603	$47,913,017
Marsh/Chamberlin Pipeline	34,304	343	$3,146,606	$314,661	$440,525	$975,448	$4,877,239
Sheirbon Hill Pipeline	4,060	41	$273,060	$27,306	$38,228	$84,649	$423,243
PRV Station							
Cameron Hill Pipeline			$225,000	$22,500	$31,500	$69,750	$348,750
Christopher Pipeline			$75,000	$7,500	$10,500	$23,250	$116,250
Dukes Valley Canal			$215,000	$21,500	$30,100	$66,650	$333,250
Fisher Pipeline			$75,000	$7,500	$10,500	$23,250	$116,250
Main Canal			$280,000	$28,000	$39,200	$86,800	$434,000
Marsh/Chamberlin Pipeline			$325,000	$32,500	$45,500	$100,750	$503,750
Sheirbon Hill Pipeline			$75,000	$7,500	$10,500	$23,250	$116,250
Shute Road Pipeline			$150,000	$15,000	$21,000	$46,500	$232,500
Turnout							
Arens Lateral Pipeline			$16,000	$1,600	$2,240	$4,960	$24,800
Bowcut Pipeline			$128,000	$12,800	$17,920	$39,680	$198,400
Dukes Valley Canal			$176,000	$17,600	$24,640	$54,560	$272,800
Main Canal			$392,000	$39,200	$54,880	$121,520	$607,600
Marsh/Chamberlin Pipeline			$504,000	$50,400	$70,560	$156,240	$781,200
Sheirbon Hill Pipeline			$48,000	$4,800	$6,720	$14,880	$74,400
Sedimentation Basin							$735,000
Project Group 3							
Pipe							
Allison Pipeline	4,971	50	$409,281	$40,928	$57,299	$126,877	$634,386
Chipping Pipeline	20,080	201	$2,168,875	$216,887	$303,642	$672,351	$3,361,756

	Length (ft)	Elbow Quantity	Construction Cost	ECMS[1]	CMGC[2]	Contingency	Total
Dethman Ridge Line	44,798	448	$4,540,914	$454,091	$635,728	$1,407,683	$7,038,417
Gilkerson Pipeline	4,154	42	$239,127	$23,913	$33,478	$74,129	$370,647
Oanna Pipeline	28,608	286	$4,200,799	$420,080	$588,112	$1,302,248	$6,511,238
Winklebleck Pipeline	4,972	50	$333,909	$33,391	$46,747	$103,512	$517,559
PRV Station							
Allison Pipeline			$75,000	$7,500	$10,500	$23,250	$116,250
Central Lateral Pipeline			$495,000	$49,500	$69,300	$153,450	$767,250
Chipping Pipeline			$325,000	$32,500	$45,500	$100,750	$503,750
Dethman Ridge Line			$325,000	$32,500	$45,500	$100,750	$503,750
Gilkerson Pipeline			$75,000	$7,500	$10,500	$23,250	$116,250
Oanna Pipeline			$655,000	$65,500	$91,700	$203,050	$1,015,250
Winklebleck Pipeline			$150,000	$15,000	$21,000	$46,500	$232,500
Turnout							
Allison Pipeline			$64,000	$6,400	$8,960	$19,840	$99,200
Chipping Pipeline			$160,000	$16,000	$22,400	$49,600	$248,000
Dethman Ridge Line			$592,000	$59,200	$82,880	$183,520	$917,600
Gilkerson Pipeline			$40,000	$4,000	$5,600	$12,400	$62,000
Oanna Pipeline			$224,000	$22,400	$31,360	$69,440	$347,200
Winklebleck Pipeline			$40,000	$4,000	$5,600	$12,400	$62,000
Grand Total	**328,682**	**3,287**	**$76,312,433**	**$7,192,906**	**$9,897,127**	**$22,125,068**	**$116,262,535**

Note: Totals may not sum due to rounding.
[1] Engineering, Construction Management, Survey
[2] Construction Management General Contractor

D.5.3 PVC Piping Alternative

Under the PVC Piping Alternative, PVC would be used for diameters up to 54 inches and steel would be installed for large diameter pipes, since PVC is not manufactured in large diameters. In the current design, steel pipe would only be used for approximately 30 feet.

The lifespan of a piping system depends on many different factors. Proper installation and operation of the piping system are key to achieving a long service life. Assuming a piping system is ideally installed and operated, the main factor affecting the pipe's service life is the number and magnitude of surge/water hammer events the system experiences. Surge/water hammer events are caused by valve operations, changing irrigation demand in the system, pump startup and shutdown, quick hydropower turbine shutdowns due to power failures, and any other factors causing fast changes in the piping system flow rate (B. Cronin, personal communication, July 27, 2018).

USDA-NRCS's practice standard lifespan for irrigation pipeline is 20 years (NRCS n.d.). This lifespan is based on long-term experience with primarily PVC pipe irrigation system installations (B. Cronin, personal communication, July 27, 2018). The Plastics Pipe Institute's online software indicates that with the average number of surge/water hammer events expected in a pipeline network, the lifespan of a typical 24-inch, 125 pounds per square inch pressure rated PVC pipe would be 14 years with a safety factor of two (Plastics Pipe Institute 2015). PVC is also more prone to failure under freezing conditions. During these periods, the PVC pipe system would be more likely to freeze and potentially rupture and fail. PVC piping has been installed in irrigation districts in the Deschutes Basin and experienced premature failure, especially in Districts where stock water is delivered during the winter (M. Thalacker, personal communication, November 8, 2017). Considering all the information above, a PVC design life of 33 years was assumed for purposes of this analysis. Steel pipe has a design life of 50 years (M. Thalacker, personal communication, November 8, 2017).

Capital costs for the PVC Piping Alternative (Table 26) account for additional elbow fittings that would be necessary for PVC pipe. The cost of elbow fittings was determined by assuming an elbow every 100 feet at a cost of $100 per 1 inch of pipe diameter. To account for additional PVC costs, an additional 5 percent cost was added. Similar to the Preferred Alternative, turnouts were costed at $8,000 and PRV stations ranged from $75,000 to $280,000 per station. These costs are based upon actual installed costs for turnouts and PRV stations in Central Oregon.

Table 26. Capital Costs for the PVC Piping Alternative.

	Length (ft)	Construction Cost	ECMS[1]	CMGC[2]	Contingency	Total
Project Group 1						
Pipe						
Crag Rate Pipeline	8,315	$119,048	$9,524	$11,905	$28,095	$168,572
Eastside Canal	32,093	$10,292,368	$823,389	$1,029,237	$2,428,999	$14,573,994
Kelly Pipeline	3,007	$38,456	$3,077	$3,846	$9,076	$54,454
Lower Highline Pressure Pipeline	10,206	$135,703	$10,856	$13,570	$32,026	$192,155
Paasch Pipeline	1,078	$39,783	$3,183	$3,978	$9,389	$56,332
Thomsen Pipeline	4,150	$55,600	$4,448	$5,560	$13,122	$78,730
Whiskey Creek Pipeline	22,984	$928,538	$74,283	$92,854	$219,135	$1,314,810
Turnout						
Crag Rate Pipeline		$72,000				$72,000
Eastside Canal		$312,000				$312,000
Kelly Pipeline		$8,000				$8,000
Lower Highline Pressure Pipeline		$128,000				$128,000
Thomsen Pipeline		$40,000				$40,000
Whiskey Creek Pipeline		$136,000				$136,000
Valve						
Crag Rate Pipeline		$90,000				$90,000
Dethman/Swyers Line		$45,000				$45,000
Kelly Pipeline		$30,000				$30,000
Loop Pipeline		$85,000				$85,000
Lower Highline Pressure Pipeline		$190,000				$190,000
Paasch Pipeline		$40,000				$40,000
Rasmussen Pipeline		$45,000				$45,000
Tallman Pipeline		$30,000				$30,000
Thomsen Pipeline		$45,000				$45,000
Whiskey Creek Pipeline		$205,000				$205,000
9Project Group 2						

	Length (ft)	Construction Cost	ECMS[1]	CMGC[2]	Contingency	Total
Pipe						
Arens Lateral Pipeline	1,334	$25,024	$2,502	$3,503	$7,757	$38,787
Bowcut Pipeline	6,415	$117,784	$11,778	$16,490	$36,513	$182,566
Dukes Valley Canal	26,539	$6,347,032	$634,703	$888,585	$1,967,580	$9,837,900
Main Canal	66,611	$42,317,893	$4,231,789	$5,924,505	$13,118,547	$65,592,733
Marsh/Chamberlin Pipeline	34,304	$1,460,344	$146,034	$204,448	$452,707	$2,263,533
Sheirbon Hill Pipeline	4,060	$88,970	$8,897	$12,456	$27,581	$137,903
PRV Station						
Cameron Hill Pipeline		$225,000	$22,500	$31,500	$69,750	$348,750
Christopher Pipeline		$75,000	$7,500	$10,500	$23,250	$116,250
Dukes Valley Canal		$215,000	$21,500	$30,100	$66,650	$333,250
Fisher Pipeline		$75,000	$7,500	$10,500	$23,250	$116,250
Main Canal		$280,000	$28,000	$39,200	$86,800	$434,000
Marsh/Chamberlin Pipeline		$325,000	$32,500	$45,500	$100,750	$503,750
Sheirbon Hill Pipeline		$75,000	$7,500	$10,500	$23,250	$116,250
Shute Road Pipeline		$150,000	$15,000	$21,000	$46,500	$232,500
Turnout						
Arens Lateral Pipeline		$16,000	$1,600	$2,240	$4,960	$24,800
Bowcut Pipeline		$128,000	$12,800	$17,920	$39,680	$198,400
Dukes Valley Canal		$176,000	$17,600	$24,640	$54,560	$272,800
Main Canal		$392,000	$39,200	$54,880	$121,520	$607,600
Marsh/Chamberlin Pipeline		$504,000	$50,400	$70,560	$156,240	$781,200
Sheirbon Hill Pipeline		$48,000	$4,800	$6,720	$14,880	$74,400
Sedimentation Basin						$735,000
Project Group 3						
Pipe						
Allison Pipeline	4,971	$148,208	$14,821	$20,749	$45,944	$229,722
Chipping Pipeline	20,080	$1,100,136	$110,014	$154,019	$341,042	$1,705,211
Dethman Ridge Line	44,798	$2,378,440	$237,844	$332,982	$737,316	$3,686,582
Gilkerson Pipeline	4,154	$72,269	$7,227	$10,118	$22,404	$112,018

	Length (ft)	Construction Cost	ECMS[1]	CMGC[2]	Contingency	Total
Oanna Pipeline	28,608	$2,862,932	$286,293	$400,810	$887,509	$4,437,544
Winklebleck Pipeline	4,972	$109,452	$10,945	$15,323	$33,930	$169,651
PRV Station						
Allison Pipeline		$75,000	$7,500	$10,500	$23,250	$116,250
Central Lateral Pipeline		$495,000	$49,500	$69,300	$153,450	$767,250
Chipping Pipeline		$325,000	$32,500	$45,500	$100,750	$503,750
Dethman Ridge Line		$325,000	$32,500	$45,500	$100,750	$503,750
Gilkerson Pipeline		$75,000	$7,500	$10,500	$23,250	$116,250
Oanna Pipeline		$655,000	$65,500	$91,700	$203,050	$1,015,250
Winklebleck Pipeline		$150,000	$15,000	$21,000	$46,500	$232,500
Turnout						
Allison Pipeline		$64,000	$6,400	$8,960	$19,840	$99,200
Chipping Pipeline		$160,000	$16,000	$22,400	$49,600	$248,000
Dethman Ridge Line		$592,000	$59,200	$82,880	$183,520	$917,600
Gilkerson Pipeline		$40,000	$4,000	$5,600	$12,400	$62,000
Oanna Pipeline		$224,000	$22,400	$31,360	$69,440	$347,200
Winklebleck Pipeline		$40,000	$4,000	$5,600	$12,400	$62,000
Grand Total	**328,682**	**$76,042,981**	**$7,222,008**	**$9,971,498**	**$22,248,911**	**$116,220,399**

Note: Totals may not sum due to rounding.
[1] Engineering, Construction Management, Survey
[2] Construction Management General Contractor

D.5.4 References

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U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). (n.d.). National Conservation Practice Standards. Retrieved from https://www.nrcs.usda.gov/Internet/ FSE_DOCUMENTS/stelprdb1076947.pdf.

Watershed Protection and Flood Prevention Act of 1954, Pub. L. No. 83-566, 68 Stat. 666.

D.6 Net Present Value of Eliminated Alternatives

This section presents the calculations used to estimate the net present value of the eliminated alternatives.

Design Life: PVC piping (33 years), steel piping (50 years), canal lining (33 years)

Discount Rate: 2.75 percent

Period of Analysis: 100 years

Table 27. Net Present Value of the Eliminated Alternatives.

Project Groups	Alternatives		
	PVC Piping	Steel Piping	Canal Lining
Capital Costs[1]			
1	$17,940,000	$21,908,000	$13,182,000
2	$82,949,000	$70,929,000	$28,166,000
3	$15,332,000	$23,425,000	N/A
Total:	**$116,221,000**	**$116,262,000**	**$41,348,000**
Net Present Value of Replacement Costs[2]			
1	$5,068,000	$4,144,000	$10,044,000
2	$28,555,000	$13,603,000	$21,113,000
3	$3,188,000	$3,743,000	N/A
Total:	**$36,811,000**	**$21,490,000**	**$31,157,000**
Annual Operation and Maintenance Costs			
1	$224,000	$224,000	$555,000
2	$381,000	$381,000	$908,000
3	$295,000	$295,000	N/A
Total:	**$900,000**	**$900,000**	**$1,463,000**
Total Percent Change in O&M:	-10%	-10%	46%
Total Net Present Value of O&M Costs			
1	$7,605,000	$7,605,000	$18,843,000
2	$12,935,000	$12,935,000	$30,828,000

Project Groups	Alternatives		
	PVC Piping	Steel Piping	Canal Lining
3	$10,016,000	$10,016,000	N/A
Total:	**$30,556,000**	**$30,556,000**	**$49,671,000**
Total Net Present Value of Project			
1	$30,613,000	$33,657,000	$42,069,000
2	$124,439,000	$97,467,000	$80,107,000
3	$28,536,000	$37,184,000	$0
Total:	**$183,588,000**	**$168,308,000**	**$122,176,000**

Note: Totals may not align with totals in Table 23, Table 24, and Table 25 due to rounding.
[1] The capital cost for Project Group 2 includes $735,000 for installation of the sedimentation basin.
[2] For PVC pipe, 33 percent of the pipe was replaced at 33 years and 67 percent replaced at 66 years. For steel pipe, 25 percent was replaced at 50 years, and 75 percent replaced at 75 years. For canal lining, 100 percent was replaced at both 33 years and 66 years. The sedimentation basin was replaced fully at 50 years.

Appendix E

Other Supporting Information

E.1 Intensity Threshold Table

This section presents the intensity threshold table used to quantify effects to resources of concern because of the proposed East Fork Irrigation District (EFID) Infrastructure Modernization Project.

Table E-1. Intensity Threshold Table for the East Fork Irrigation District Infrastructure Modernization Project.

Resource	Intensity Threshold			
	Negligible	**Minor**	**Moderate**	**Major**
Cultural Resources	No above or underground cultural resources are adversely affected.	Affects a cultural resource that does not have local, regional or state significance. The historic context of the affected site(s) is local. Not affect the contributing element of a property eligible for the National Register of Historic Places. Causes a slight change to a natural or physical ethnographic resource, if measurable and localized.	Affects a cultural resource with modest potential of local, regional or state significance. Changes a contributing element but would not diminish resource integrity or jeopardize National Register eligibility. Localized and measurable change to a natural or physical ethnographic resource.	Affects a cultural resource with high potential of national context. Diminishes the integrity of the resource to the extent that affects cannot be mitigated, would permanently impact the historic register eligibility of the resource, prevent a resource from meeting criteria for listing in a historic register, or reduces the ability of a cultural resource to convey its historic significance. Permanent severe change or exceptional benefit to a natural or physical ethnographic resource.
Fish and Aquatic Species	No discernable short- or long-term impacts to fish populations or aquatic habitat.	Changes in watershed conditions that may cause non-measurable degradation to aquatic habitat. Direct or indirect habitat changes that result only in non-measurable, short-term change in risk to ESA-listed or other fish populations.	Changes in watershed conditions that cause measurable degradation to aquatic habitat. Direct or indirect habitat changes that cause measurable, short- or long-term change in risk to ESA-listed or other fish populations.	Changes in watershed conditions that cause high impairment to aquatic habitat that affects population viability. The proposed action would likely jeopardize a species' continued existence or destroy or adversely affect a species' critical habitat.

Resource	Intensity Threshold			
	Negligible	**Minor**	**Moderate**	**Major**
Land Use	Existing land uses or ownership would continue as before. A short-term change or interruption to land use or access to existing land uses.	Land use changes that are consistent with existing ownership, easements, or right-of-way.	Land use changes that are inconsistent with existing ownership, easements, or right-of-way but are compatible to adjacent.	A new unauthorized land use or access that is not compatible with adjacent land use.
Public Safety	No increase in risk to human health and safety.	Any risks to public health and safety created by the project would be eliminated through mitigation.	Any risks to public health and safety created by the project would be eliminated through mitigation, but would require a short-term behavioral change by the public or present a temporary inconvenience.	Create a permanent and known health and safety risk.
Socioeconomics	No reduction in the yield of agricultural products or timber. Non-measurable change to income and/or employment levels.	Measurable, but short term, reduction to yield of agricultural products or timber. Temporary reduction to income and/or local employment levels.	Long term reduction in the yield of agricultural products or timber on the scale of individual farms. Short term reduction to income and/or local employment levels.	Long term reduction in the yield of agricultural products or timber on a district wide scale. Long term reduction to income and/or regional employment levels.
Vegetation	Project activities would not affect vegetation or it is limited to small areas.	Most effects would be localized and/or temporary. While individual plants could be affected, there would be no effects on a population scale. Any permanent effects would not be widespread nor affect sensitive species or populations.	A large proportion of one or more populations are affected but relatively localized and could be mitigated. Any effects to sensitive species could be mitigated.	Considerable effects on plant populations over large areas. Extensive mitigation required offsetting adverse effects to sensitive species, but success not assured.
Visual Resources	Project features are visually negligible or not visible.	The majority of project features do not attract attention to the landscape.	A majority of project features attract attention to the landscape.	Project features create a disruptive change and dominate the landscape.

Resource	Intensity Threshold			
	Negligible	Minor	Moderate	Major
		Short-term visual changes during project construction.		
Water Resources	Project activities would not disturb or alter water quantity, water quality, or groundwater quantity.	*Surface Water Quantity:* Temporary change in quantity away from the natural or target hydrograph. *Water Quality:* Short-term or non-measurable changes to water quality in waterbodies that is unlikely to result in excursions to water quality standards on the Oregon's 303(d) list. *Groundwater:* Long-term less than 10 percent change in depth to groundwater Change in depth to groundwater that does not result in any affects to groundwater users or their water rights.	*Surface Water Quantity:* Permanent change in water quantity that is measurable and that is counter to the natural or target hydrograph, that does not affect other water users or water rights. *Water Quality:* Permanent measurable changes to water quality in waterbodies that is unlikely to result in excursions to water quality standards on the Oregon's 303(d) list. *Groundwater:* Measurable changes in depth to groundwater that does not reduce the availability of water for water users.	*Surface Water Quantity:* Permanent change in water quantity that is measurable and that is counter to the natural or target hydrograph, that affects other water users and water rights. *Water Quality:* Permanent measurable changes to water quality in waterbodies that results in excursions to water quality standards on the Oregon's 303(d) list. *Groundwater:* Measurable changes in depth to groundwater that reduces the availability of water for water users.
Wetland, Floodplains, Riparian Zones	Does not alter wetlands or riparian areas or change the hydraulic capacity of floodplains.	Degradation of non-jurisdictional wetlands. Project does not increase the potential for flooding and damage to personal property.	Mitigated degradation of jurisdictional wetlands. Increase to the potential for flooding and damage to personal property that can be permitted and mitigated.	Permanent, non-mitigated degradation of jurisdictional wetlands. Increase to the potential for flooding and damage to personal property that cannot be mitigated.

Resource	Intensity Threshold			
	Negligible	**Minor**	**Moderate**	**Major**
Wildlife	No degradation to wildlife habitats or populations.	Degradation and recovery of wildlife populations and/or their habitats would be short-term.	Degradation and recovery of wildlife populations and/or their habitats would be long-term but would not affect the viability of any population. Habitat availability would continue to be adequate.	Long-term degradation to wildlife populations or habitats that would affect the viability of a population. Inadequate habitat availability.
Ecosystem Services	No degradation to ecosystem services.	Any degradation to ecosystem services would be temporary.	Any degradation to ecosystem services could be mitigated.	Any degradation to ecosystem services could not be mitigated.

Duration of Effects	
Temporary	Transitory effects which only occur over a period of days or months.
Short-term	Effects lasting 1-5 years.
Long-term	Effects lasting greater than 5 years.

E.2 Supporting Information for Land Use

Table E-2. Project Area Length Crossing Land Use Classes.

Land Use	Percent of the Project Area Length	Project Area Length Crossing each Land Use Class (miles)
Agriculture	48%	27
Non-cultivated lands[1]	38%	21
Developed Use[2]	14%	8
Total	**100%**	**56**

Source: USGS 2011
[1] Shrub/scrub, barren land, evergreen forest, woody wetlands.
[2] High, medium, low intensity development, developed open space.

Table E-3. Water Users by Acres Served within East Fork Irrigation District.[1]

Acres Served	Total Irrigated Acreage in EFID (ac)	Total Irrigated Acreage in EFID (%)	Patrons (number)	Patrons (%)
0-5 acres	929	10%	724	74%
6-10 acres	477	5%	58	6%
11+ acres	8,000	85%	191	20%
Total	**9,397**[1]	**100%**	**973**[1]	**100%**

Source: East Fork Irrigation District
[1] The data varies slightly from the values presented in the Plan-EA (9,607 acres irrigated by 990 patrons).

References

U.S. Geological Survey (USGS). (2011). National Land Cover Database (2011 Edition). U.S. Geological Survey, Sioux Falls, SD. Retrieved from https://www.mrlc.gov/data

E.3 Supporting Information for Fish and Aquatic Resources

This appendix section presents supporting information associated with Primary Constituent Elements for critical habitat of federally listed species.

Table E-4. Primary Constituent Elements for Lower Columbia River Chinook, Coho, and Steelhead.

Primary Constituent Element Number	Habitat Description and Characteristics
PCE 1	Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.
PCE 2	Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
PCE 3	Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
PCE 4	Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.
PCE 5	Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
PCE 6	Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Table E-5. Primary Constituent Elements for Bull Trout.

Primary Constituent Element Number	Habitat Description and Characteristics
PCE 1	Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
PCE 2	Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
PCE 3	An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
PCE 4	Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
PCE 5	Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
PCE 6	In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
PCE 7	A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
PCE 8	Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
PCE 9	Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

E.4 Supporting Information for Water Resources

This appendix section presents supporting data used to evaluate effects of the Preferred Alternative with respect to water resources.

Table E-6. ODFW Instream Water Rights for the East Fork Hood River, Hood River, and Neal Creek.

Source	From	To	Certificate	Priority Date	Instream Rates (cfs)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
East Fork Hood River	Below EFID diversion (approx. RM 6.6)	Above Middle Fork Hood River confluence	68457	11/3/1983	100	100	100	150	150	150	100	100	100	150	150	150
East Fork Hood River	Below EFID diversion (approx. RM 6.6)	Above West Fork Hood River confluence	Pending IS-88322	12/1/2016	210	210	210	210	210	210	150	150	175	175	180	180
Hood River	RM 4.0	Mouth at Columbia River	59679	11/3/1983	170	270	270	270	170	170	130	100	100	100	100	170
Hood River	RM 4.0	Mouth at Columbia River	76155	10/8/1998	-	-	-	-	250	250	250	250	250	250	-	-
Neal Creek	Mouth at Hood River	Mouth at Hood River	59681	11/3/1983	13	13	13	20	20	20	13	13	5	20	20	13

E.5 Allocation of Conserved Water Program

This appendix section presents information on the State of Oregon's Allocation of Conserved Water Program. Oregon Revised Statutes 537.455-500 authorize this program, which is managed by the Oregon Water Resources Department. Per OWRD (2017),

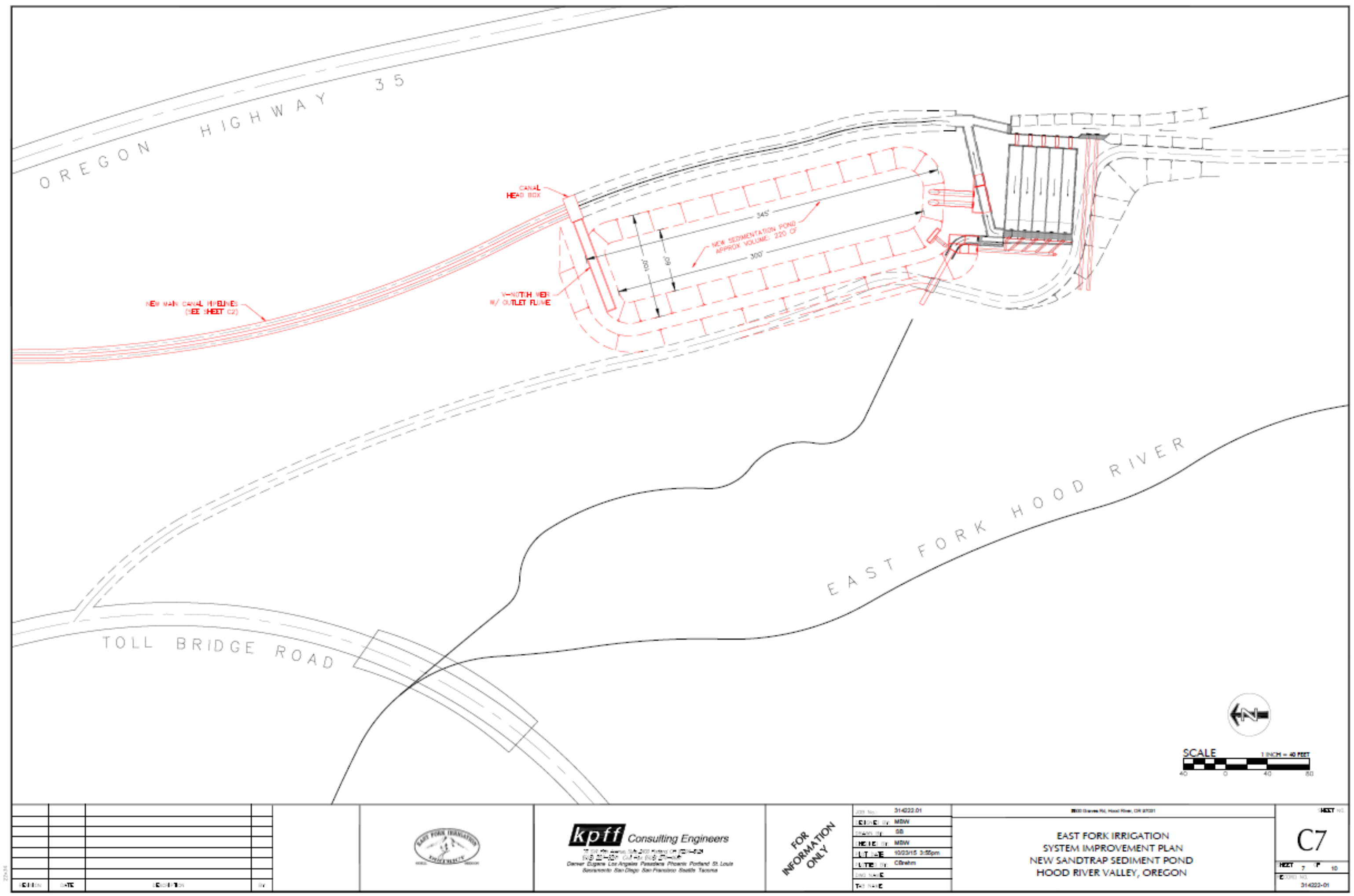
> The Allocation of Conserved Water Program allows a water user who conserves water to use a portion of the conserved water on additional lands, lease or sell the water, or dedicate the water to instream use. Use of this program is voluntary and provides benefits to both water right holders and instream values.
>
> The statutes authorizing the program were originally passed by the Legislative Assembly in 1987. The primary intent of the law is to promote the efficient use of water to satisfy current and future needs--both out-of-stream and instream. The statute defines conservation as "the reduction of the amount of water diverted to satisfy an existing beneficial use achieved either by improving the technology or method for diverting, transporting, applying or recovering the water or by implementing other approved conservation measures."
>
> In the absence of Department approval of an allocation of conserved water, water users who make the necessary investments to improve their water use efficiency are not allowed to use the conserved water to meet new needs; instead, any unused water remains in the stream where it is available for the next appropriator. In exchange for granting the user the right to "spread" a portion of the conserved water to new uses, the law requires allocation of a portion to the state for instream use.
>
> After mitigating the effects on any other water rights, the Water Resources Commission allocates 25 percent of the conserved water to the state (for an instream water right) and 75 percent to the applicant, unless more than 25 percent of the project costs come from federal or state non-reimbursable sources or the applicant proposes a higher allocation to the state. A new water right certificate is issued with the original priority date reflecting the reduced quantity of water being used with the improved technology. A certificate is issued for the state's instream water right, and, if requested, a certificate is issued for the applicant´s portion of the conserved water. The priority dates for the state's instream certificate and the applicant's portion of conserved water must be the same date and will be either the same date as the original water right or one-minute junior to the original right.

Section 2.3 of the draft Plan-EA describes the District's intention to allocate 75 percent of the water conserved through this project instream. Consistent with EFID's own Conserved Water Policy, adopted in 2007 and amended in 2014, the District has previously used the Allocation of Conserved Water Program (application nos. CW-86, CW-53, and CW-93) to restore a portion of the water conserved through three previous piping projects to the East Fork Hood River.

Reference

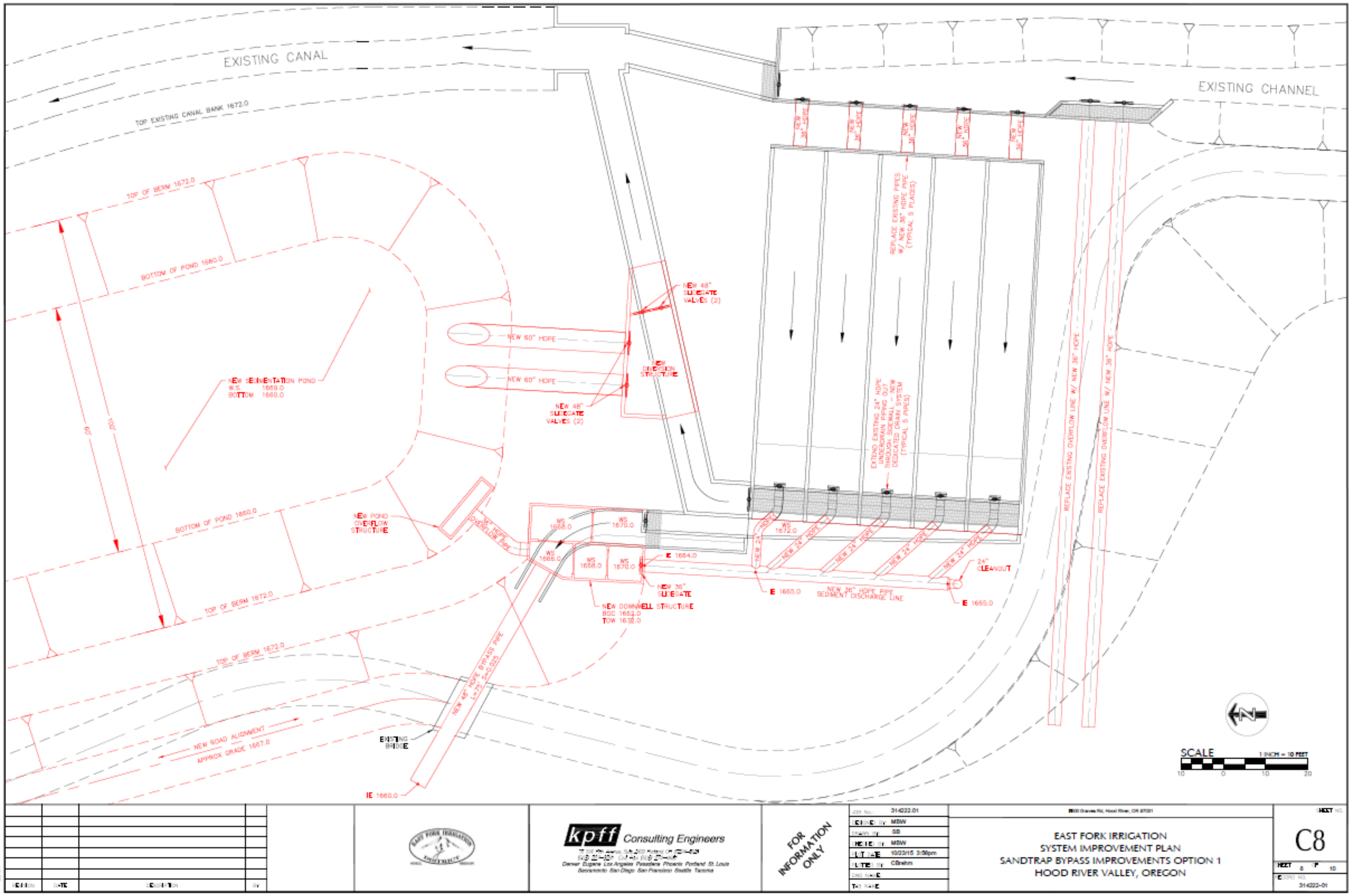
Oregon Water Resources Department (OWRD). (2017). Allocation of Conserved Water. Retrieved from http://www.oregon.gov/owrd/pages/mgmt_conserved_water.aspx

E.6 Proposed Sedimentation Basin



Source: Wharry 2016.

Figure E-1. Preliminary plan view of proposed sedimentation basin near East Fork Irrigation District's headworks.



Source: Wharry 2016.

Figure E-2. Preliminary drawing of proposed sedimentation basin.

E.7 Consultation Letters

Bonneville Power Administration

Department of Energy

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

RECEIVED
DEC 13 2018
USDA/NRCS
Oregon State Office

December 11, 2018

In reply refer to: EC-4

Ronald Alvarado, State Conservationist
Natural Resources Conservation Service
1201 NE Lloyd Blvd
Portland, OR 97232

RE: Formal Request to be a Cooperating Agency on the Watershed Plan-Environmental Assessment for the East Fork Irrigation District, Irrigation Modernization Project

Dear Mr. Alvarado:

Thank you for your October 5, 2018, letter requesting the Bonneville Power Administration's (BPA) participation as a cooperating agency on the Watershed Plan-Environmental Assessment (Plan-EA) that the Natural Resources Conservation Service (NRCS) is preparing pursuant to the National Environmental Policy Act (NEPA) to analyze the effects of NRCS' proposed East Fork Irrigation District Irrigation Modernization Project. Although it is unknown at this time whether BPA will have any role or decisions in the East Fork Irrigation Modernization, BPA agrees to participate as a cooperating agency on this Plan-EA.

As a cooperating agency, BPA expects to have a minor role in reviewing draft EA documents and may be able to provide special expertise on request. As such, BPA does not believe that a formal MOU or further role definition are necessary.

I have assigned BPA's cooperating agency responsibilities to Israel Duran, 503-230-3967 or induran@bpa.gov. Please contact Israel if you have any questions or concerns.

Sincerely,

Scott G. Armentrout
Executive Vice President for Environment, Fish and Wildlife

ecc:
Ronald Alvarado, State Conservationist, NRCS, ronald.alvarado@or.usda.gov
Tom Makowski, ASTC-Watershed Resources and Planning, NRCS, tom.makowski@or.usda.gov
Blayne Einechener, Biologist, CTWS, beineichner@hrecn.net

Oregon State Historic Preservation Office

USDA
United States Department of Agriculture
Natural Resources Conservation Service

2316 South Sixth Street, Suite C
Klamath Falls, OR 97601

Phone: (541) 887-3511
rachel.gebauer@or.usda.gov

Subject: East Fork Irrigation District Modernization Project, Hood River County

Date: January 7, 2019

To: SHPO Compliance

In compliance with the National Historic Preservation Act of 1966, Oregon State Revised Statutes (ORS 358.905-961 and ORS 97.740-760) and in accordance with our State PPA between Oregon SHPO and NRCS Oregon (Signed January 2018), the Natural Resources Conservation Service would like to initiate consultation with the Oregon State Historic Preservation Office for the following federally funded irrigation piping project. The NRCS proposes to provide technical and financial assistance to the East Fork Irrigation District through the Watershed Protection and Flood Prevention Program , Public Law 83-566 (PL566).

The East Fork Irrigation District (EFID) operates and maintains 17.9 miles of open canals and laterals and 64.8 miles of mostly unpressurized pipeline. EFID proposes to modernize its infrastructure by converting its open canals to buried, gravity-pressurized pipelines; replacing 43.5 miles of older pipelines with high-density polyethylene (HDPE) piping; and by adding a settling basin to manage glacial sand and silt in its water supply. The District plans to keep 21.3 miles of its existing pipeline, and to replace piping that is at least 10 years old or more. (Figures 1-5). The project will be divided into segments for the purpose of completing the work. The Eastside Canal is intended to be the first segment addressed by the District.
The EFID canals and laterals are located in Township 3N/ Range 11E/ Section 31; Township 2N/ Range 11E/ Sections 6, 7, 18; 19, 30, 31; Township 2N/ Range 10E/ Sections 12, 13, 21- 28, 33- 36; Township 1 N/ Range 10E/ Sections 1-4, 10,14, 15,22, 27,34; Township 1S/ Range 10E/ Sections 4,5.

In accordance with state and federal laws and under our State PPA between Oregon SHPO and NRCS Oregon (Signed January 2018), NRCS plans to identify the historic properties within the area of potential effect and to evaluate and assess any adverse effects. Recognizing that there may be segments of the canals and laterals that are determined to be historically significant cultural resources, we anticipate the potential need for avoidance or mitigation.

NRCS is consulting with the Confederated Tribes of the Warm Springs, Confederated Tribes and Bands of the Yakama Nation, and the Confederated Tribes of the Umatilla.

The following items are enclosed:

- EFID Index Map,
- EFID Sheets 1-5, detailed segments of EFID modernization project

Sincerely,

Rachel L S Gebauer

Rachel Smith Gebauer, M.A., RPA, Cultural Resources Specialist
rachel.gebauer@or.usda.gov

CC:
Tom Makowski, NRCS, ASTC Watershed Resources, Portland, OR
Carly Heron – NRCS, District Conservationist, Parkdale, OR
Kevin Conroy—NRCS, Basin Team Leader, Klamath Falls, OR
Kathy Ferge – NRCS Tribal Liaison, Portland, OR

Confederated Tribes of Warm Springs

United States Department of Agriculture

Natural Resources Conservation Service

2316 S. 6th St., Suite. C
Klamath Falls, OR 97601

January 7, 2019

Austin Green
Tribal Chairman
Confederated Tribes of Warm Springs
P.O. Box C
Warm Springs, OR 97761

Dear Mr. Green,

The purpose of this letter is to initiate consultation under the National Historic Preservation Act, within the homeland of the Confederated Tribes of the Warm Springs, for The NRCS proposes to provide technical and financial assistance to the East Fork Irrigation District through the Watershed Protection and Flood Prevention Program , Public Law 83-566 (PL566).

The East Fork Irrigation District (EFID) operates and maintains 17.9 miles of open canals and laterals and 64.8 miles of mostly unpressurized pipeline. EFID proposes to modernize its infrastructure by converting its open canals to buried, gravity-pressurized pipelines; replacing 43.5 miles of older pipelines with high-density polyethylene (HDPE) piping; and by adding a settling basin to manage glacial sand and silt in its water supply. The District plans to keep 21.3 miles of its existing pipeline, and to replace piping that is at least 10 years old or more. The project will be divided into segments for the purpose of completing the work. The Eastside Canal is intended to be the first segment addressed by the District.
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All of the project areas will be reviewed and surveyed for historic properties and reports will be submitted to the Oregon SHPO in compliance with the National Historic Preservation Act.

Attached are the proposed project area maps. Please understand this is a voluntary program; therefore, not all proposed projects are implemented. A copy of the completed reports will be made available to you for your review.

If there are any sites of religious or cultural significance to the CTWS in this vicinity, that you feel may be impacted by this project, please let us know so we can adequately address these concerns. Please let us know if you have any other questions or concerns.

Sincerely,

Rachel L.S. Gebauer
NRCS Basin Cultural Resources Specialist

CC:
Robert Brunoe, CTWS THPO, Warm Springs, OR
Brad Houslet, CTWS Manager, Natural Resource Planning, Warm Springs, OR
Mike McKay, CTWS Hydrologist, Warm Springs, OR
Christian Nauer, CTWS Cultural Resources, Warm Springs, OR
Tom Makowski, NRCS, ASTC Watershed Resources, Portland, OR
Carly Heron – NRCS, District Conservationist, Parkdale, OR
Kevin Conroy—NRCS, Basin Team Leader, Klamath Falls, OR
Kathy Ferge – NRCS Tribal Liaison, Portland, OR

Confederated Tribes of the Umatilla Indian Reservation

USDA

United States Department of Agriculture

Natural Resources Conservation Service

2316 S. 6th St.
Suite C
Klamath Falls, OR 97601
541-887-3511

January 7, 2019

Ms. Carey L. Miller
Tribal Historic Preservation Officer/Archaeologist
Confederated Tribes of the Umatilla Indian Reservation
Cultural Resources Protection Program
46411 Timíne Way
Pendleton, OR 97801

Dear Ms. Miller,

The purpose of this letter is to initiate consultation under the National Historic Preservation Act, within the homeland of the Confederated Tribes of the Umatilla Indian Reservation, for The NRCS proposes to provide technical and financial assistance to the East Fork Irrigation District through the Watershed Protection and Flood Prevention Program, Public Law 83-566 (PL566).

The East Fork Irrigation District (EFID) operates and maintains 17.9 miles of open canals and laterals and 64.8 miles of mostly unpressurized pipeline. EFID proposes to modernize its infrastructure by converting its open canals to buried, gravity-pressurized pipelines; replacing 43.5 miles of older pipelines with high-density polyethylene (HDPE) piping; and by adding a settling basin to manage glacial sand and silt in its water supply. The EFID plans to keep 21.3 miles of its existing pipeline, and to replace piping that is at least 10 years old or more. The project will be divided into segments for the purpose of completing the work. The Eastside Canal is intended to be the first segment addressed by the District.

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All of the project areas will be reviewed and surveyed for historic properties and reports will be submitted to the Oregon SHPO in compliance with the National Historic Preservation Act.

Attached are the proposed project area maps. Please understand this is a voluntary program; therefore, not all proposed projects are implemented. A copy of the completed reports will be made available to you for your review.

If there are any sites of religious or cultural significance to the CTUIR in this vicinity, that you feel may be impacted by this project, please let us know so we can adequately address these concerns. Please let us know if you have any other questions or concerns.

Sincerely,

Rachel LS Gebauer

Rachel L.S. Gebauer
NRCS Basin Cultural Resources Specialist

CC:
Tom Makowski, NRCS, ASTC Watershed Resources, Portland, OR
Carly Heron – NRCS, District Conservationist, Parkdale, OR
Kevin Conroy—NRCS, Basin Team Leader, Klamath Falls, OR
Kathy Ferge – NRCS Tribal Liaison, Portland, OR

Confederated Tribes and Band of the Yakama Nation

USDA

United States Department of Agriculture

Natural Resources Conservation Service

2316 S. 6th St.
Suite C
Klamath Falls, OR 97601
541-887-3511

January 7, 2019

V. Kate Valdez. THPO
Confederated Tribes and Band of the Yakama Nation
P.O. Box 151, 401 Fort Road
Toppenish, WA 98948

Dear Ms. Valdez,

The purpose of this letter is to initiate consultation under the National Historic Preservation Act, within the homeland of the Yakama Nation. The NRCS proposes to provide technical and financial assistance to the East Fork Irrigation District through the Watershed Protection and Flood Prevention Program, Public Law 83-566 (PL566).

The East Fork Irrigation District (EFID) operates and maintains 17.9 miles of open canals and laterals and 64.8 miles of mostly unpressurized pipeline. EFID proposes to modernize its infrastructure by converting its open canals to buried, gravity-pressurized pipelines; replacing 43.5 miles of older pipelines with high-density polyethylene (HDPE) piping; and by adding a settling basin to manage glacial sand and silt in its water supply. The EFID plans to keep 21.3 miles of its existing pipeline, and to replace piping that is at least 10 years old or more. The project will be divided into segments for the purpose of completing the work. The Eastside Canal is intended to be the first segment addressed by the District.
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All of the project areas will be reviewed and surveyed for historic properties and reports will be submitted to the Oregon SHPO in compliance with the National Historic Preservation Act.

Attached are the proposed project area maps. Please understand this is a voluntary program; therefore, not all proposed projects are implemented. A copy of the completed reports will be made available to you for your review.

If there are any sites of religious or cultural significance to the Yakama Nation in this vicinity, that you feel may be impacted by this project, please let us know so we can adequately address these concerns. Please let us know if you have any other questions or concerns.

Sincerely,

Rachel LS Gebauer

Rachel L.S. Gebauer
NRCS Basin Cultural Resources Specialist

CC:
Tom Makowski, NRCS, ASTC Watershed Resources, Portland, OR
Carly Heron – NRCS, District Conservationist, Parkdale, OR
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