Appendix A

Comments and Reponses

Table A-1. Topics and Associated Codes.

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

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

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

Appendix B

Project Maps

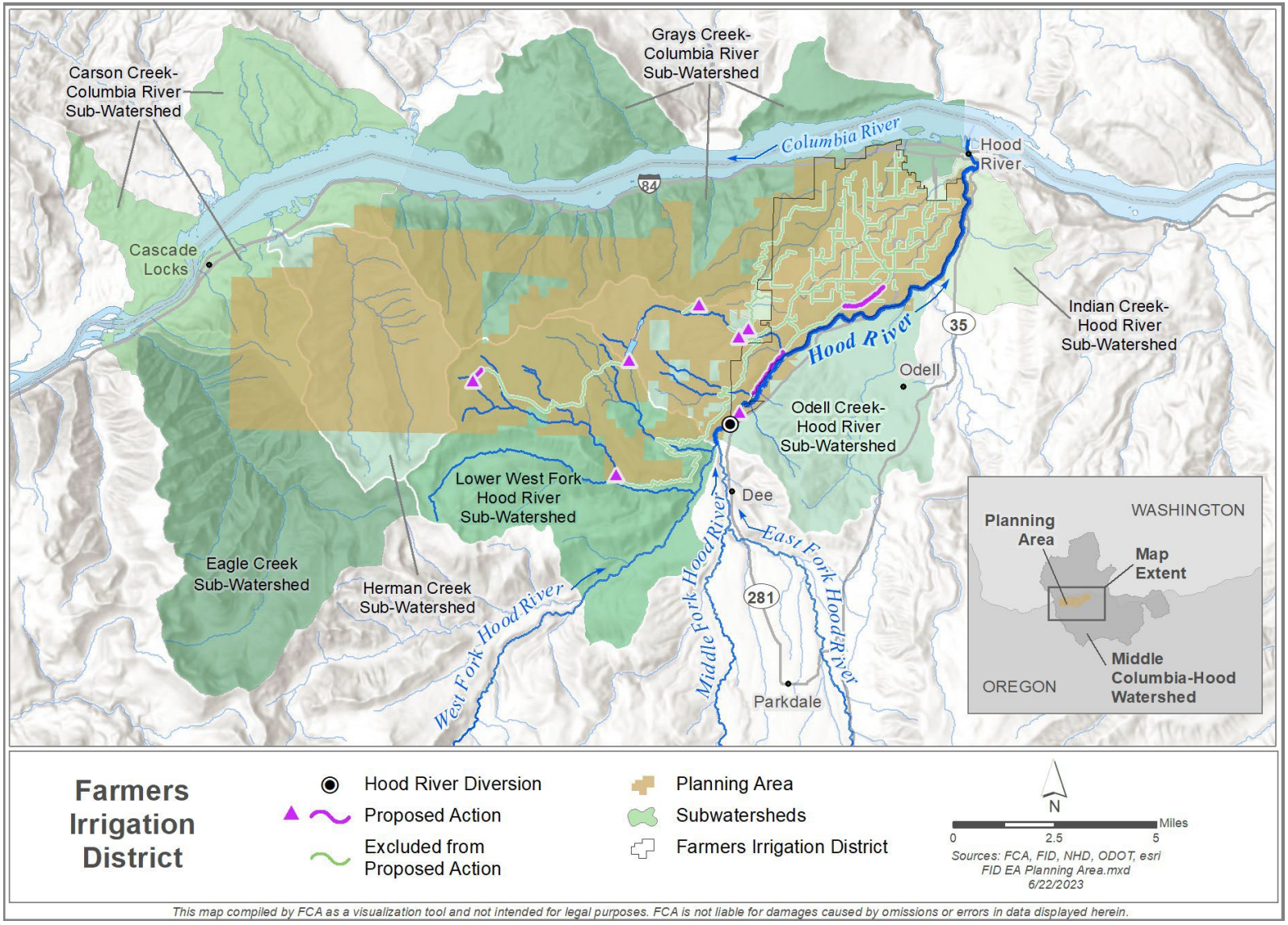


Figure B-1. The Farmers Irrigation District planning area.

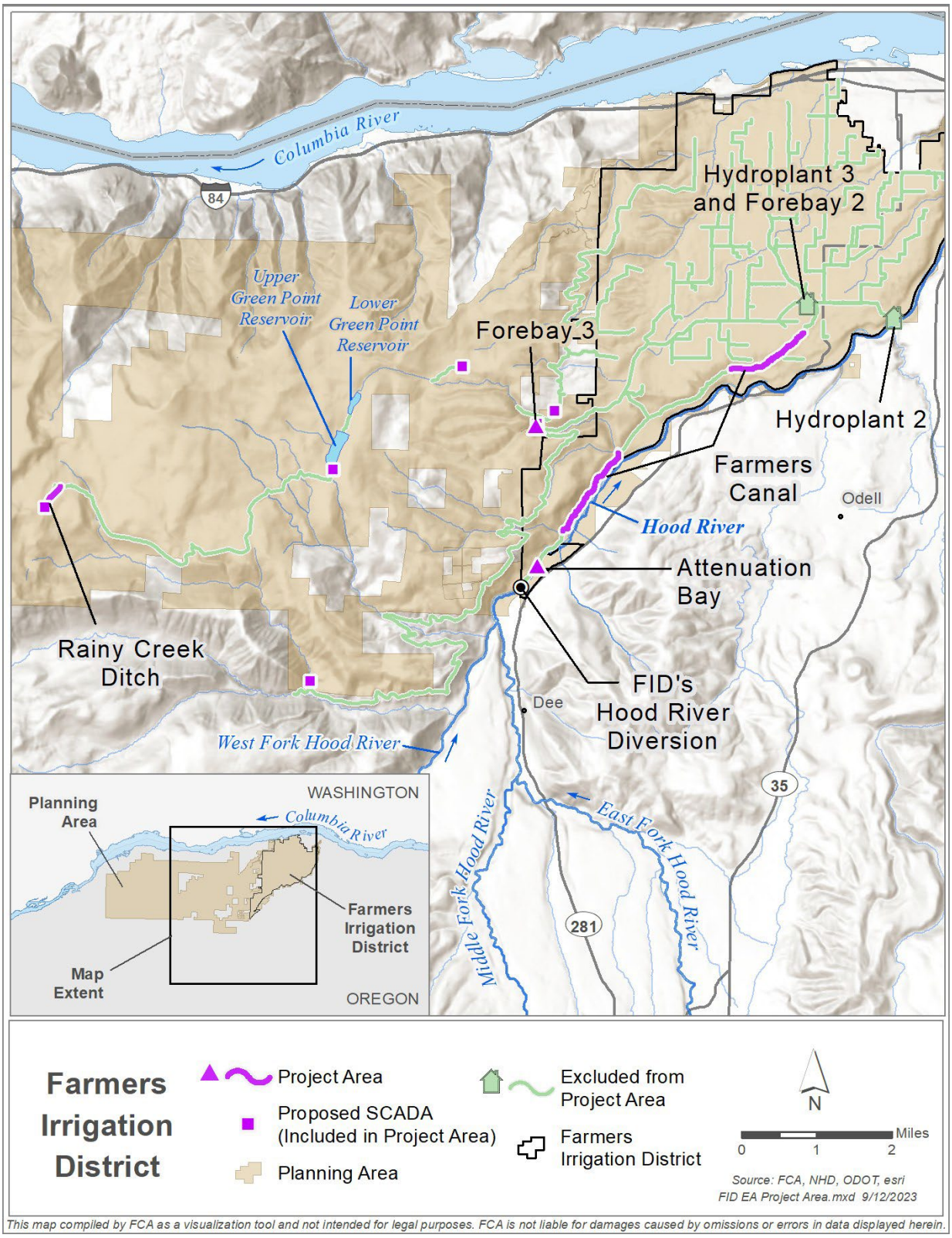


Figure B-2. Farmers Irrigation District Infrastructure Modernization project area.

Appendix C

Supporting Maps

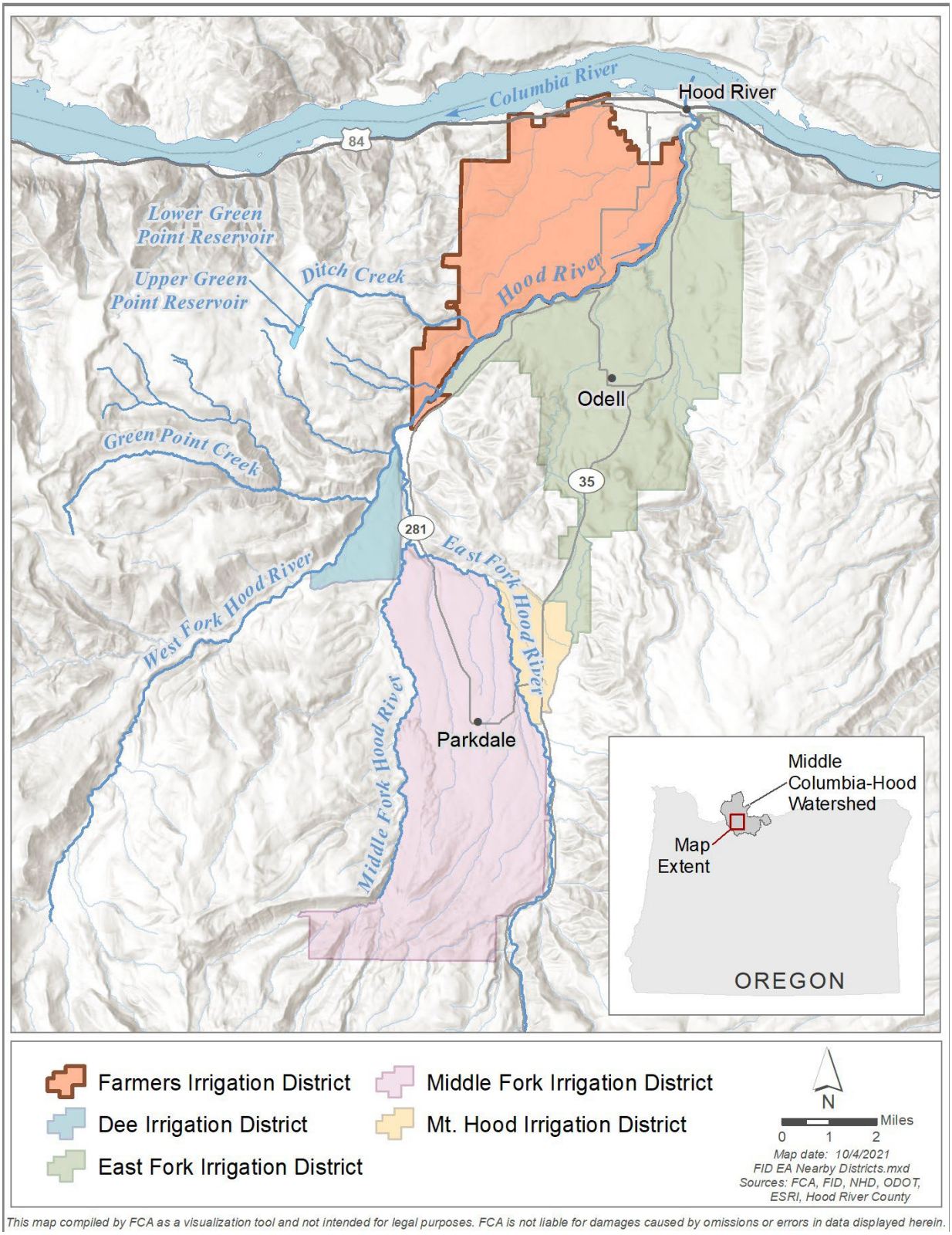


Figure C-1. Irrigation districts within the Hood River Basin.

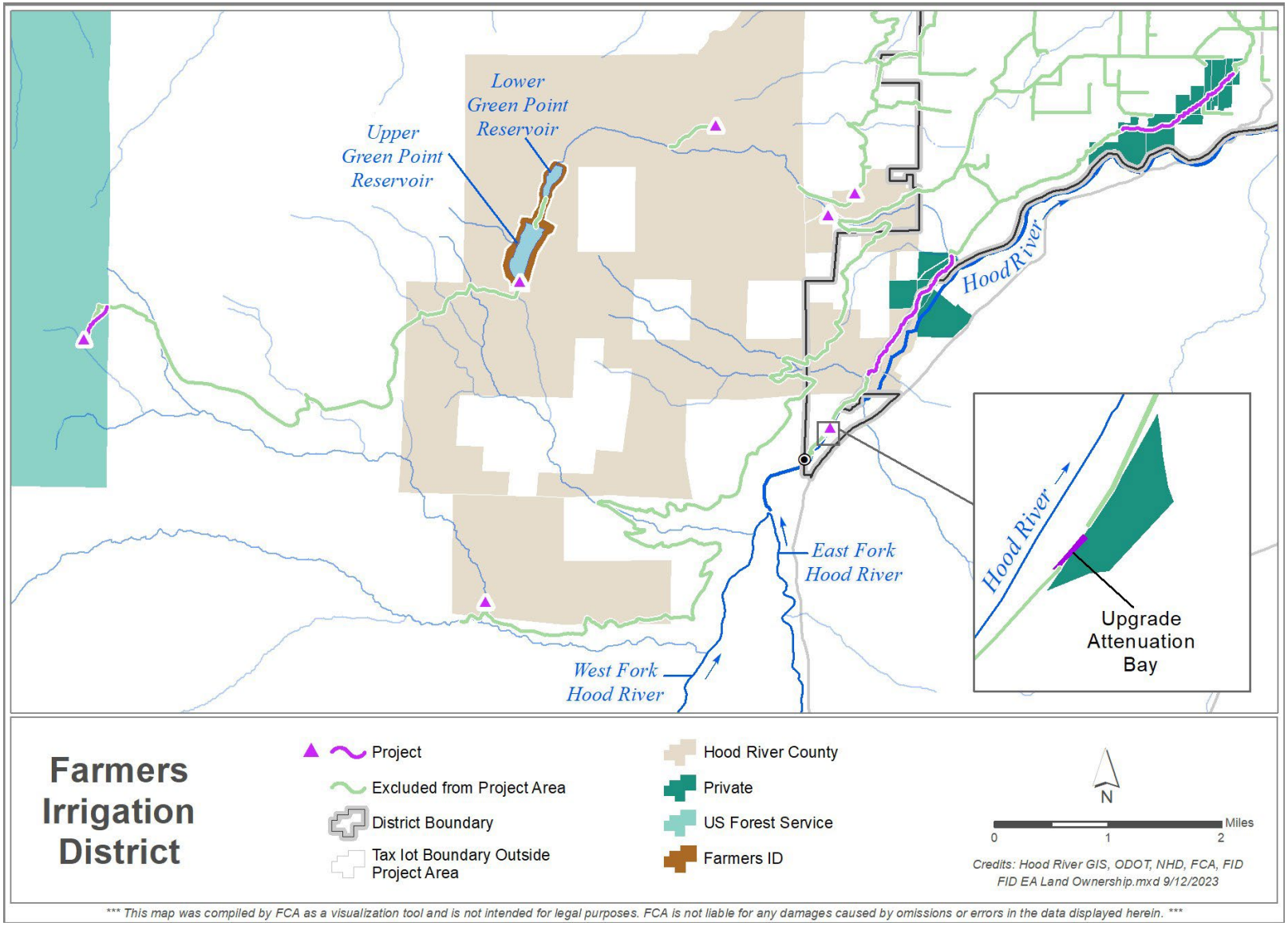


Figure C-2. Land ownership in planning area.

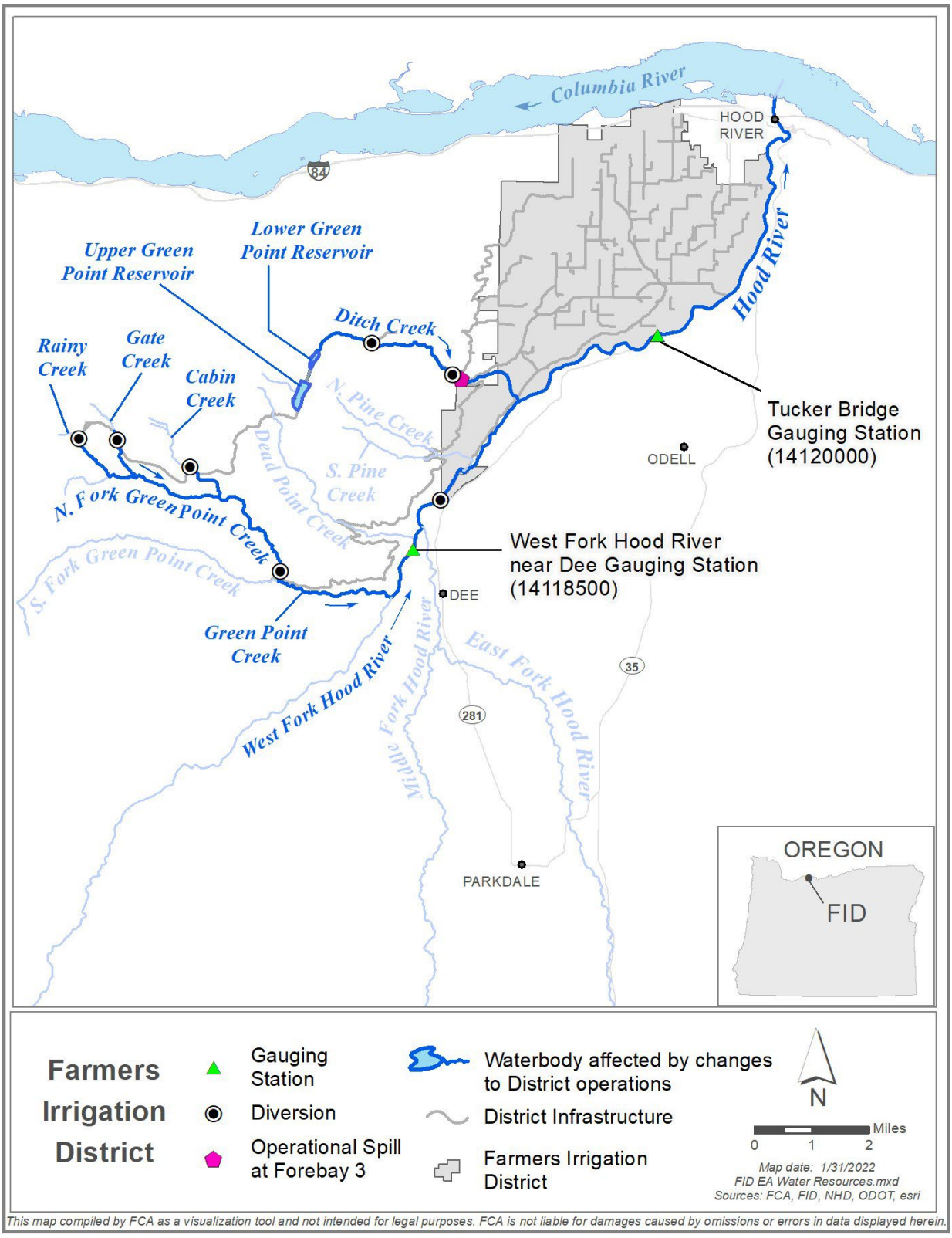
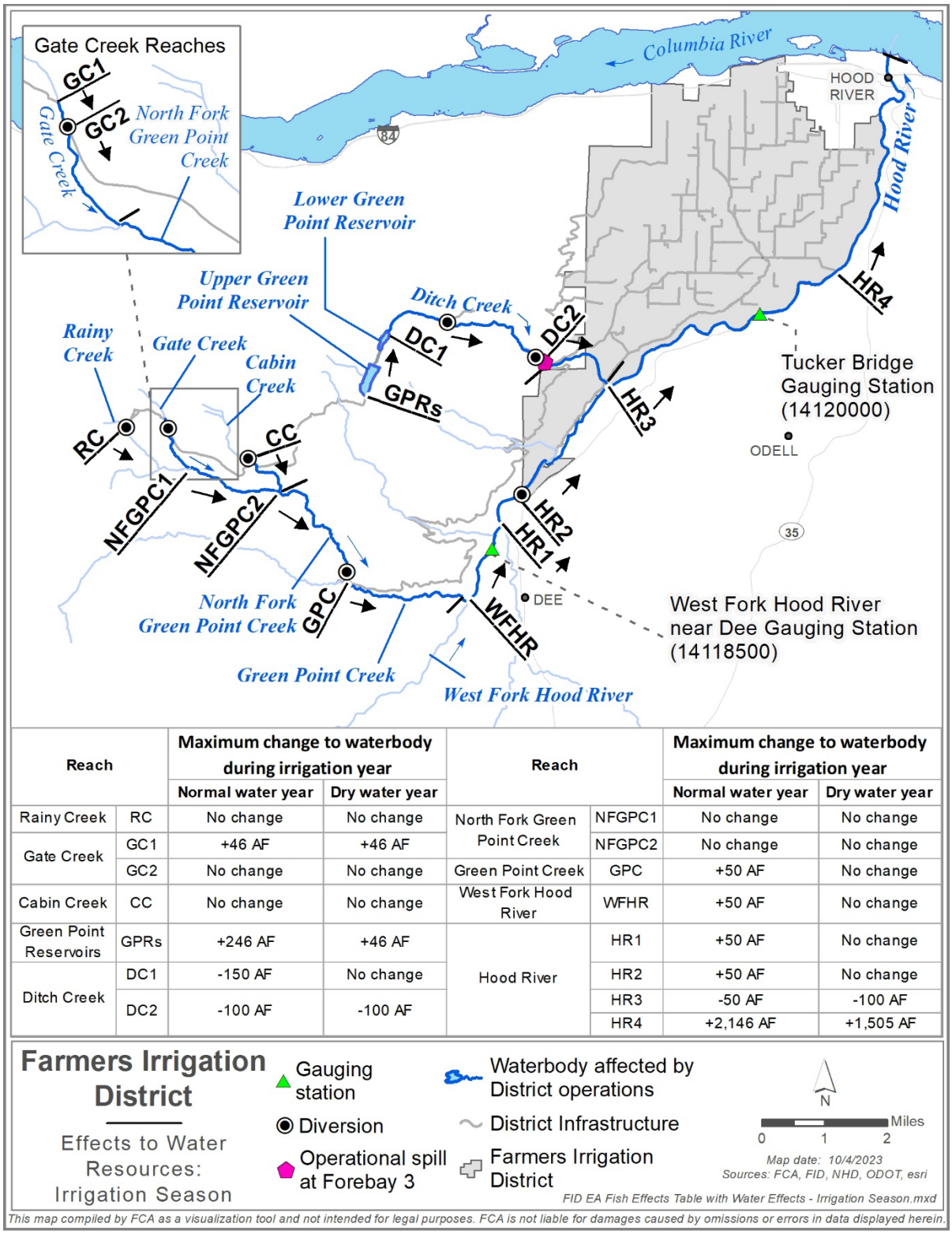
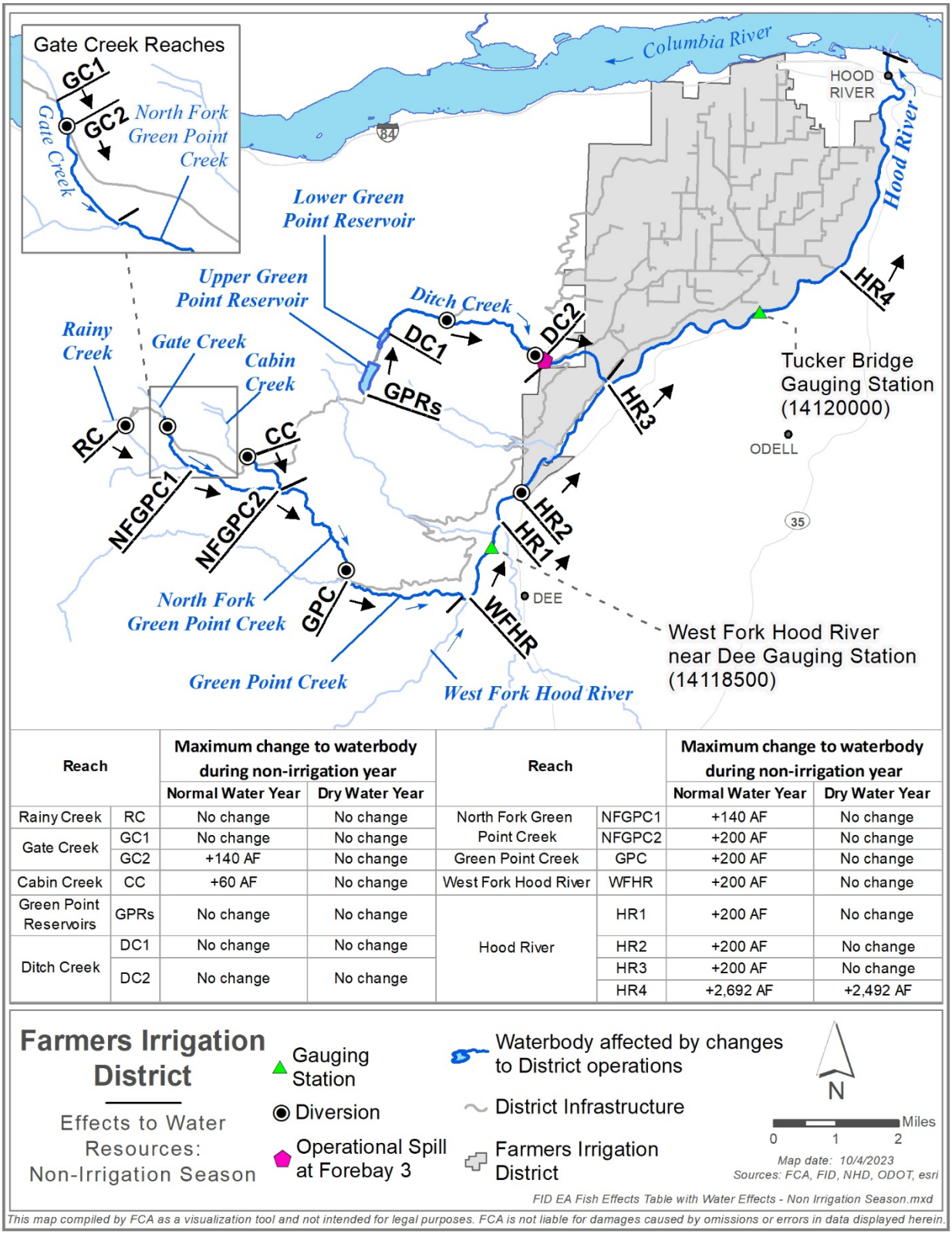


Figure C-3. Waterbodies and gauging stations associated with District operations.



Reach		Maximum change to waterbody during irrigation year		Reach		Maximum change to waterbody during irrigation year	
		Normal water year	Dry water year			Normal water year	Dry water year
Rainy Creek	RC	No change	No change	North Fork Green Point Creek	NFGPC1	No change	No change
Gate Creek	GC1	+46 AF	+46 AF		NFGPC2	No change	No change
	GC2	No change	No change	Green Point Creek	GPC	+50 AF	No change
Cabin Creek	CC	No change	No change	West Fork Hood River	WFHR	+50 AF	No change
Green Point Reservoirs	GPRs	+246 AF	+46 AF	Hood River	HR1	+50 AF	No change
Ditch Creek	DC1	-150 AF	No change		HR2	+50 AF	No change
	DC2	-100 AF	-100 AF		HR3	-50 AF	-100 AF
					HR4	+2,146 AF	+1,505 AF

Figure C-4. Summary of maximum volume change to waterbodies during the irrigation season per year as a result of the Modernization Alternative.



Reach		Maximum change to waterbody during non-irrigation year		Reach		Maximum change to waterbody during non-irrigation year	
		Normal Water Year	Dry Water Year			Normal Water Year	Dry Water Year
Rainy Creek	RC	No change	No change	North Fork Green Point Creek	NFGPC1	+140 AF	No change
Gate Creek	GC1	No change	No change		NFGPC2	+200 AF	No change
	GC2	+140 AF	No change	Green Point Creek	GPC	+200 AF	No change
Cabin Creek	CC	+60 AF	No change	West Fork Hood River	WFHR	+200 AF	No change
Green Point Reservoirs	GPRs	No change	No change	Hood River	HR1	+200 AF	No change
Ditch Creek	DC1	No change	No change		HR2	+200 AF	No change
	DC2	No change	No change		HR3	+200 AF	No change
					HR4	+2,692 AF	+2,492 AF

Figure C-5. Summary of maximum volume change to waterbodies during the non-irrigation season per year as a result of the Modernization Alternative.

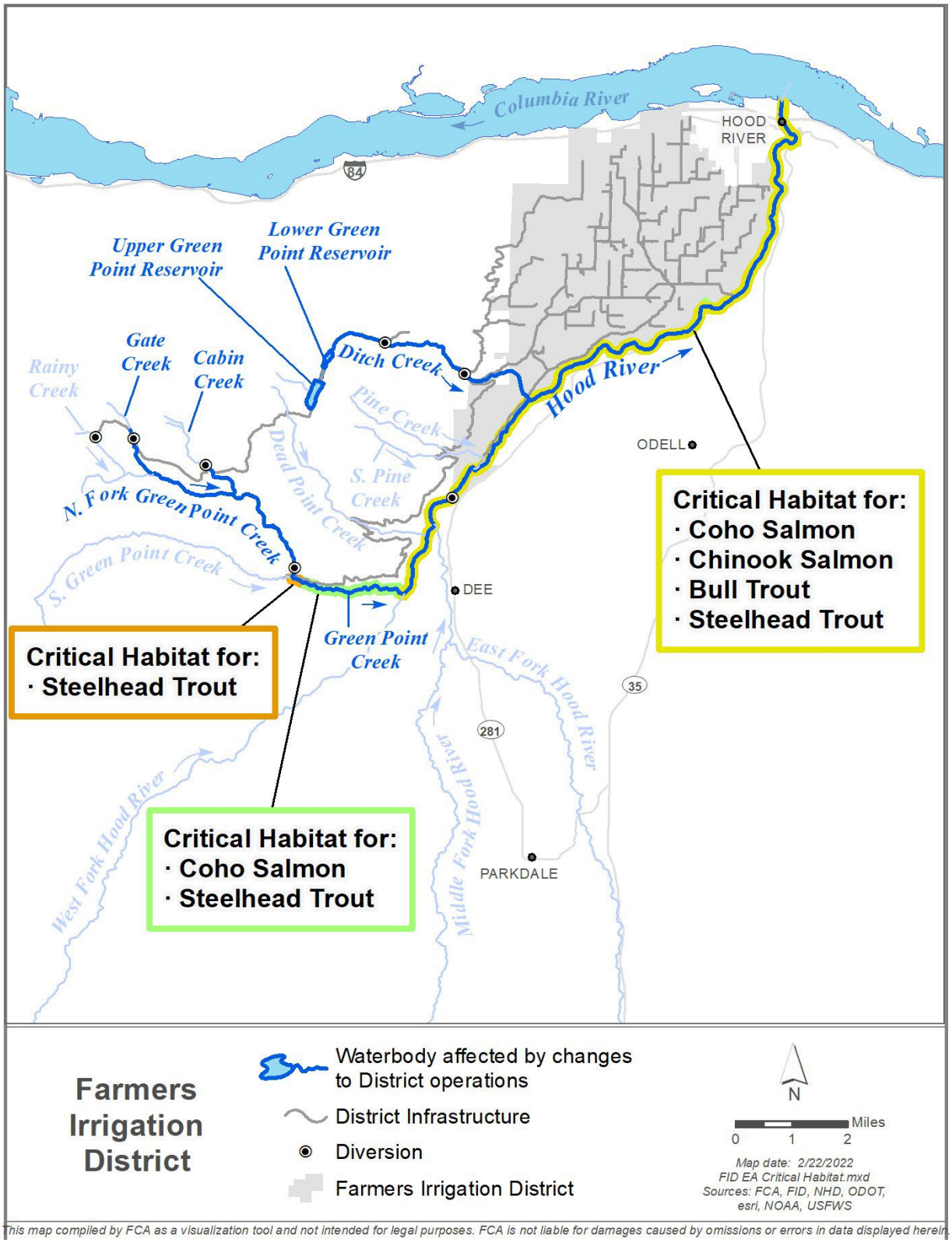


Figure C-6. Critical habitat designations for federally listed fish in the Hood River Basin.

Appendix D

Investigation and Analyses Report

D.1 National Economic Efficiency Analysis

Highland Economics LLC

Farmers Irrigation District

Barbara Wyse and Winston Oakley

9/28/2023

1. Introduction

1.1 Project Overview

The Farmers Irrigation District (FID or District) Infrastructure Modernization Project is an agricultural water conveyance efficiency project. The proposed action would pipe two open sections of the Farmers Canal, pipe the open Rainy Ditch, install Supervisory Control and Data Acquisition (SCADA) systems, upgrade the existing attenuation bay below FID's Hood River Diversion, and expand Forebay 3.

1.2 Project Location

The District is located near the City of Hood River in Hood River County, Oregon. The District is over 11,000 acres in size, of which 5,888 acres are irrigated lands. FID diverts natural flow from the Hood River and its tributaries, and stored water released from Upper and Lower Green Point reservoirs. The planning area is based on the irrigation problem area and is defined as the entire District, plus tax lots outside of the FID boundary that are within 50 feet of the proposed project.

1.3 Project Purpose and Need

The purpose of this project is agricultural water management through improved water delivery reliability and water conservation along District infrastructure. There is a need to improve water conservation and water conveyance in District-owned infrastructure and to improve operational efficiency to allow FID to more reliably deliver irrigation water to patrons, improve public safety and fish and wildlife habitat, and increase hydropower production.

1.4 Watershed Plan-EA Alternatives

1.4.1 No Action Alternative

Under the No Action Alternative, federal funding through P.L. 83-566 would not be available to implement the project. The District would continue to operate and maintain its existing system in its current condition. This alternative assumes that modernization of the District's system to meet the purpose and need of the project would not be reasonably certain to occur. For the purpose of this Plan-EA, the No Action Alternative is a near-term continuation of the standard operating procedures, which maximize the operational efficiency of the District with the current infrastructure.

The No Action Alternative would not meet the purpose and need of the project. There would be no reduction in water loss from seepage in District infrastructure and no improvement in water delivery reliability for patrons. Water delivery and operational inefficiencies would remain the same or could potentially worsen over time. Sediment in irrigation water deliveries would continue to reduce irrigation system efficiency and limit hydropower production. Low streamflow during the summer months would continue to limit the amount and quality of habitat for fish and wildlife. Since no water would be conserved, the No Action Alternative would not address the Federal Objective of protecting the environment.

1.4.2 Modernization Alternative

The Modernization Alternative is FID's desired alternative. Under this alternative, federal funding through P.L. 83-566 would be available. The District would perform the following actions (see Figure 5-1 in the Plan-EA):

- Convert the two remaining open sections of the Farmers Canal to a dual pipeline, 48 inches in diameter and rated to withstand pressures up to 9 pounds per square inch (psi) (2.65 miles[1] [14,003 feet])
- Expand the existing attenuation bay by approximately 1,000 cubic feet (0.02 acre-feet [AF]).
- Install SCADA equipment at 6 sites
- Expand Forebay 3 by approximately 2 AF
- Convert Rainy Ditch to a pipeline, 8 inches in diameter and rated to withstand 63 psi (0.36 miles [1,909 feet])

2. Economic Analysis Parameters

This National Economic Efficiency (NEE) analysis compares the economic benefits and costs of the Modernization Alternative to the benefits and costs of the No Action Alternative in order to estimate the net benefits of implementing the Modernization Alternative. All economic values are presented in 2023 dollars rounded to the nearest $1,000. Unless otherwise noted, all NEE values are presented in average annual values (following the approach described in the Natural Resources Conservation Service (NRCS) Water Resources Handbook for Economics) using the 2.5 percent planning rate for federal water projects for fiscal year 2023 (USDA Natural Resources Conservation Service, 2021). Under this method, all costs and benefits are evaluated at the 2023 price level for all applicable years in the study period, then converted to a present value over the entire analysis period using the 2.5-percent planning rate as the discount rate. Finally, each present value is amortized to average annual values over the evaluation period using the 2.5-percent rate.

2.1 Evaluation Unit

The proposed project consists of five project groups, which are the evaluation units for this analysis. While the project groups are described more fully in Section 1.4.2 above, they are listed here for quick reference:

1. Project Group (PG)1 Pipe Farmers Canal Piping
2. PG2 Modify Attenuation Bay
3. PG3 District-wide SCADA and Telemetry
4. PG4 Forebay 3 Expansion
5. PG5 Rainy Creek Ditch Piping

An important note for the incremental analysis is that the costs for constructing any given project group would not change if it were the only project group to be constructed.

[1] 2.61 miles of the Farmers Canal is open canal, and 0.04 miles is existing pipeline that would be upgraded.

2.2 Project Implementation and Analysis Timeline

District staff predict that, if PL 83-566 funds are made available, construction of the five project groups would likely be completed over approximately 5 years, with some overlap in construction timing between project groups. For each project group, this analysis assumes that full benefits would be realized the year after construction is completed (e.g., for PG1 Pipe Farmers Canal, which would complete construction in Year 0, full benefits would be realized in Year 1). This information is summarized in Table D-1 below.

2.3 Analysis Period

The analysis period is defined as 105 years, which includes 5 years of project construction/installation and 100 years of project life based on the expected life of buried pipe (during which time it is expected to bring significant project benefits). Accordingly, the study period extends from Year 0 (construction start) to Year 104 (last year of potential useful life for the project). The anticipated installation/construction timing, as well as the life of each project group, is summarized in Table D-1 below.

Table D-1. Construction Timeline and Project Life for the Modernization Alternative, Hood River Watershed, Oregon.

Works of Improvement	Construction Start Year	Construction End Year	Project Life Start Year	Project Life End Year
PG1 Pipe Farmers Canal	0	0	1	100
PG2 Modify Attenuation Bay	0	0	1	100
PG3 District-wide SCADA and Telemetry	1	1	2	101
PG4 Expand Forebay 3	2	2	3	102
PG5 Pipe Rainy Creek	3	4	5	104

Prepared September 2023

3. NEE Costs

This section describes the NEE costs of both the No Action Alternative and the Modernization Alternative. The costs and benefits were identified for each alternative. The No Action Alternative represents the most likely future condition without federal investment. The Modernization Alternative represents the most likely future condition with federal investment.

3.1 Costs of the No Action Alternative

Under the No Action Alternative, the District would continue existing operation, maintenance, repair, and replacement of the existing canal and pipeline system in its current condition.

3.2 Costs of the Modernization Alternative

The costs of the Modernization Alternative include the initial construction/installation costs of each project group, as well as other costs that are the direct result of project implementation that would

occur during the analysis period. These costs are referred to as "Other Direct Costs" and include costs of operations, maintenance, and replacement (OMR) for two project groups.[2] All costs are presented in 2023 dollars and converted to present value in the current year (and not the construction year), so no inflation of construction costs was included.

3.2.1 Project Installation Costs

Project installation costs include mobilization and staging of construction or installation equipment, delivery of construction materials to project areas, excavation of trenches and basins, fusing of pipe, removal of existing pipe in certain areas, placement of pipe, compaction of backfill that is native material and would not require the import of material from elsewhere, restoration and reseeding of the disturbed areas, and any costs associated with obtaining easements or land acquisitions. There are no expected installation costs associated with fish and wildlife mitigation or cultural mitigation. In the case of PG3 District-wide SCADA and Telemetry, the project installation costs include the equipment, installation (including providing power through solar panels or AC power), and setup of the system.

The total cost of installation/construction of the Modernization Alternative is estimated at $11,687,000 (Farmers Conservation Alliance, 2023). This includes the costs of construction; engineering, construction management, and survey costs (estimated at 10 percent of construction costs); contractor markup (estimated at 14 percent of construction costs); and contingency costs (estimated between 18 and 30 percent of the subtotal of other cost components). This also includes the costs for purchasing easements in three project groups: (1) $10,000 for an expanded easement in support of PG2 Modify Attenuation Bay, (2) $10,000 for PG3 District-wide SCADA and Telemetry, and (3) $10,000 for PG5 Pipe Rainy Creek (Perkins, 2022). FID would fully pay for the cost of these easements; PL 83-566 funds would not be used.

The total costs of the project include project administration costs for FID and NRCS (7 percent of the subtotal of previously mentioned cost components; 5 percent for FID, which will be covered by NRCS, and 2 percent for NRCS), and technical assistance from NRCS (estimated at 8 percent of the subtotal of previously mentioned cost components plus $20,000 per project group for cultural work). Permitting costs are estimated at 3 percent of construction costs. The costs of project installation are provided in Table D-2 and Table D-3 below (which correspond to NWPM 506.11 Economic Table 1 and NWPM 506.12 Economic Table 2, respectively). The average annualized cost of installation/construction of the Modernization Alternative is $318,000.

2 As noted above, only two project groups are expected to have OMR costs under the Modernization Alternative (Perkins, 2022).

Table D-2. Estimated Installation Cost, Hood River Watershed, Oregon, 2023 Dollars.[1]

Works of Improvement	Number				Estimated Costs (2023 dollars)[1]						Total
					Public Law 83-566 Funds			Other Funds			
	Unit	Federal land	Non-federal land	Total	Federal land NRCS[2]	Non-Federal land NRCS[2]	Total	Federal Land	Non-federal Land	Total	
PG1Pipe Farmers Canal	Miles	0.000	2.650	2.650	$0	$7,815,000	$7,815,000	$0	$2,374,000	$2,374,000	$10,189,000
PG2 Modify Attenuation Bay	Miles	0.000	0.080	0.080	$0	$498,000	$498,000	$0	$153,000	$153,000	$651,000
PG3 District-wide SCADA and Telemetry	Miles	0.004	0.013	0.017	$40,000	$131,000	$171,000	$19,000	$63,000	$82,000	$253,000
PG4 Expand Forebay 3	Miles	0.000	0.040	0.040	$0	$279,000	$279,000	$0	$105,000	$105,000	$384,000
PG 5Pipe Rainy Creek Ditch	Miles	0.360	0.000	0.360	$155,000	$0	$155,000	$55,000	$0	$55,000	$210,000
Total project	**Miles**	**0.364**	**2.783**	**3.147**	**$195,000**	**$8,723,000**	**$8,918,000**	**$74,000**	**$2,695,000**	**$2,769,000**	**$11,687,000**

1/ Price base: 2023 dollars Prepared September 2023

2/ Federal agency responsible for assisting in installation of works of improvement

Table D-3. Estimated Cost Distribution-Water Resource Project Measures, Hood River Watershed, Oregon, 2023 Dollars.[1]

Works of Improvement	Installation Cost – PL 83-566				Installation Cost – Other Funds					Total
	Construction	Engineering	Project Admin Subtotal [2]	Total Public Law 566	Construction	Engineering	Project Admin Subtotal [2]	Permitting	Total Other	
PG1 Pipe Farmers Canal	$6,414,000	$193,000	$1,208,000	$7,815,000	$2,138,000	$64,000	$0	$172,000	$2,374,000	$10,189,000
PG2 Modify Attenuation Bay	$403,000	$15,000	$80,000	$498,000	$134,000	$5,000	$0	$14,000	$153,000	$651,000
PG3 District-wide SCADA and Telemetry	$133,000	$5,000	$33,000	$171,000	$75,000	$2,000	$0	$5,000	$82,000	$253,000
PG4 Expand Forebay 3	$222,000	$9,000	$48,000	$279,000	$94,000	$3,000	$0	$8,000	$105,000	$384,000
PG5 Pipe Rainy Creek Ditch	$124,000	$4,000	$27,000	$155,000	$51,000	$1,000	$0	$3,000	$55,000	$210,000
Total project	**$7,296,000**	**$226,000**	**$1,396,000**	**$8,918,000**	**$2,492,000**	**$75,000**	**$0**	**$202,000**	**$2,769,000**	**$11,687,000**

1/ Price base: 2023 dollars. Prepared September 2023

2/ Includes project administration costs and technical assistance costs.

3.2.2 Other Direct Costs

Other Direct Costs are costs that result from the project but occur after installation/construction. For the Modernization Alternative, Other Direct Costs in the form of OMR are anticipated for three project groups: PG1 Pipe Farmers Canal, PG3 District-wide SCADA and Telemetry, and PG2 Modify Attenuation Bay.[3] In PG3 District-wide SCADA and Telemetry, the District estimates that operation and maintenance (O&M) of the SCADA and telemetry units will require approximately 5 hours of labor to maintain each of the six sites for a total of 30 hours per year. With a total labor cost of approximately $50 per hour (including wages and benefits), this results in an estimated annual O&M cost of $1,500 per year (Perkins, 2022).[4] PG1 Pipe Farmers Canal and PG2 Modify Attenuation Bay will not require annual O&M but will require replacement during the project life. PG3 District-wide SCADA and Telemetry would also have components that would require replacement prior to the end of the analysis period.

The District estimates the SCADA and telemetry equipment have a useful life of roughly 20 years, while the attenuation bay has a useful life of around 50 years, as do concrete structures necessary for PG1 Pipe Farmers Canal (Perkins, 2022). Accordingly, PG3 District-wide SCADA and Telemetry will require replacement in Years 22, 42, 62, and 82 (20 years after installation and every 20 years thereafter); and PG1 Pipe Farmers Canal and PG2 Modify Attenuation Bay will require replacements in Year 51 (50 years after construction). To estimate the costs of replacement, this analysis assumes the full cost of installation/construction for the respective project components will be required, including construction, engineering, contractor markup, and contingency costs.

Accounting for timing of costs, the average annual NEE cost of OMR under the Modernization Alternative is approximately $14,000, as shown in Table D-4 below.

[3] No OMR costs are expected for other project groups as FID expects that any OMR requirements for the other project groups, such as pipeline inspections, will be conducted as a part of already occurring site visits to manage diversions, and therefore will not result in expected costs related to travel or labor (Perkins, 2022). A 2018 analysis by NRCS Oregon comparing PVC and HDPE pipe for irrigation districts found that the expected life of HDPE pipe is longer than 100 years, and therefore no repairs are expected to be required over the expected 100-year life of the pipeline when considering the lifecycle cost of the pipe (USDA-NRCS Oregon PL-566 Proposed Projects Pipe Selection Justification, 7-27-2018). The analysis shows that HDPE pipe can withstand natural disasters/earthquakes, abrasion, water hammering, corrosion, UV, and is leak- and freeze-proof.

[4] FID expects that other potential costs of the SCADA system (such as software updates and hardware updates) would be minimal since those operations are handled by the District itself with minimal time requirement, and O&M requirements on similar systems have been low. The District would conduct inspections of the systems; however, these site inspections would be conducted as part of the normal site visits, so they would not require additional trips and are expected to require a negligible amount of additional labor (Perkins, 2022).

Table D-4. Other Direct Costs by Project Group, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Group	Increase in Average Annual O&M Costs	Average Annual Replacement Cost	Average Annual OMR Costs
PG1 Pipe Farmers Canal	$0	$1,000	$1,000
PG2 Modify Attenuation Bay	$0	$5,000	$5,000
PG3 District-wide SCADA and Telemetry	$2,000	$7,000	$9,000
PG4 Expand Forebay 3	$0	0	$0
PG5 Pipe Rainy Creek Ditch	$0	$0	$0
Total	**$2,000**	**$13,000**	**$15,000**

Note: Totals may not sum due to rounding. Prepared September 2023
1/ Price Base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

3.3 Costs of the Modernization Alternative over the No Action

Because no additional costs are anticipated under the No Action Alternative relative to current conditions, the NEE costs of the Modernization Alternative are equal to the estimated average annual installation/construction and OMR costs outlined above for each project group. In total across all project groups, the average annual project costs are $333,000. These costs are summarized in Table D-5 below, which corresponds to NWPM 506.18 Economic Table 4.

Table D-5. Estimated Average Annual NEE Costs, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Group	Project Outlays (Amortization of Installation Cost)	Project Outlays Operation, Maintenance, and Replacement Cost	Total Average Annual Costs
PG1 Pipe Farmers Canal	$278,000	$1,000	$279,000
PG2 Modify Attenuation Bay	$18,000	$5,000	$23,000
PG3 District-wide SCADA and Telemetry	$7,000	$9,000	$16,000
PG4 Expand Forebay 3	$10,000	$0	$10,000
PG5 Pipe Rainy Creek Ditch	$5,000	$0	$5,000
Total	**$318,000**	**$15,000**	**$333,000**

Note: Totals may not sum due to rounding. Prepared September 2023
1/ Price Base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

4. NEE Benefits

This section describes the benefits of the No Action Alternative and the Modernization Alternative. As with NEE costs, NEE benefits of the Modernization Alternative are the additional benefits of the Modernization Alternative compared to the No Action Alternative.

4.1 Benefits of the No Action Alternative

Because the District does not anticipate carrying out any project actions in the absence of PL 83-566 funding, the No Action Alternative has no economic benefits above those currently provided.

4.2 Benefits of the Modernization Alternative

The benefits of the Modernization Alternative include both on-site benefits (e.g., avoided District O&M costs and increased hydropower production value) and off-site benefits (such as reduced carbon emissions). The following subsections describe both of these types of benefits, some of which are quantified and included in the analysis (such as hydropower production) and others that are considered but not included (such as public safety). Of the Modernization Alternative benefits that are included and quantified in the analysis, the average annual values are summarized in Table D-6 below for each project group (which corresponds to NWPM 506.20 Economic Table 5a).

Table D-6. Estimated Average Annual Damage Reduction Benefits, Hood River Watershed, Oregon, 2023 Dollars.[1]

Item	Damage Reduction Benefit, Average Annual	
	Agricultural-Related	Nonagricultural-Related
PG1 Pipe Farmers Canal		
On-Site Damage Reduction Benefits		
Reduced O&M	$56,000	
Avoided Damage from Infrastructure Failure	$22,000	
Hydropower Revenue	$63,000	
On-site Subtotal	$141,000	
Off-Site Damage Reduction Benefits		
Avoided Carbon Emissions[2]		$33,000
Instream Flow Value		$172,000
Off-site Quantified Subtotal		$205,000
Total Quantified Benefits		**$346,000**

Item	Damage Reduction Benefit, Average Annual	
	Agricultural-Related	Nonagricultural-Related
PG2 Modify Attenuation Bay		
On-Site Damage Reduction Benefits		
Reduced O&M	$45,000	
Avoided Infrastructure Failure	$0	
Hydropower Revenue	$61,000	
On-site Subtotal	$106,000	
Off-Site Damage Reduction Benefits		
Avoided Carbon Emissions[2]		$32,000
Instream Flow Value		$0
Off-site Quantified Subtotal		$32,000
Total Quantified Benefits		**$138,000**
PG3 District-wide SCADA and Telemetry		
On-Site Damage Reduction Benefits		
Reduced O&M	$17,000	
Avoided Damage from Infrastructure Failure	$0	
Hydropower Revenue	$0	
On-site Subtotal	$17,000	
Off-Site Damage Reduction Benefits		
Avoided Carbon Emissions[2]		$0
Instream Flow Value		$3,000
Off-site Quantified Subtotal		$3,000
Total Quantified Benefits		**$20,000**

Item	Damage Reduction Benefit, Average Annual	
	Agricultural-Related	Nonagricultural-Related
PG4 Expand Forebay 3		
On-Site Damage Reduction Benefits		
Reduced O&M	$20,000	
Avoided Damage from Infrastructure Failure	$0	
Hydropower Revenue	$0	
On-site Subtotal	$20,000	
Off-Site Damage Reduction Benefits		
Avoided Carbon Emissions [2]		$0
Instream Flow Value		$0
Off-site Quantified Subtotal		$0
Total Quantified Benefits		**$20,000**
PG5 Pipe Rainy Creek Ditch		
On-Site Damage Reduction Benefits		
Reduced O&M	$2,000	
Avoided Damage from Infrastructure Failure	$0	
Hydropower Revenue	$0	
On-site Subtotal	$2,000	
Off-Site Damage Reduction Benefits		
Avoided Carbon Emissions[2]		$0
Instream Flow Value		$3,000
Off-site Quantified Subtotal		$3,000
Total Quantified Benefits		**$5,000**

Note: Totals may not sum due to rounding. Prepared September 2023
1/ Price Base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.
2/ This value represents the benefit of avoided carbon emissions as measured by the social cost of carbon. These benefits would also accrue to local residents, but the majority of the value would be experienced outside the proposed project area.

4.2.1 Benefits Considered and Included in Analysis

4.2.1.1 Operations and Maintenance Cost Savings

The Modernization Alternative would result in O&M cost savings for all project groups. These savings come from avoided vehicle costs, avoided equipment rental fees, and avoided labor hours that would no longer be needed to operate and maintain canals and other District infrastructure. The

total cost of staff labor to the District is approximately $50 per hour, while manager costs are roughly $70 per hour (Perkins, 2022). The cost of operating vehicles is estimated to be $0.55 per mile, and the blended rate to operate heavy equipment (dump truck and trailer, large excavator, small excavator, and large backhoe) is approximately $125 per hour (Perkins, 2022). The estimated annual savings (in terms of time, miles, and dollars) is shown Table D-7 below. In total, the project is expected to reduce District O&M costs by $140,000 per year.

Table D-7. Avoided District O&M Costs under the Modernization Alternative, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Group	Avoided Staff Labor Hours	Avoided Manager Labor Hours	Avoided Vehicle Driving Miles	Avoided Heavy Equipment Hours	Average Annual O&M Savings
PG1 Pipe Farmers Canal	900	40	2,000	60	$56,000
PG2 Modify Attenuation Bay	500	100	0	100	$45,000
PG3 District-wide SCADA and Telemetry	250	60	500	0	$17,000
PG4 Expand Forebay 3	350	25	4,000	0	$20,000
PG5 Pipe Rainy Creek Ditch	36	0	0	0	$2,000
Total	**2,036**	**225**	**6,500**	**160**	**$140,000**

Note: Totals may not sum due to rounding. Prepared September 2023
1/ Price Base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

4.2.1.2 Avoided Infrastructure Failure Damage

An irrigation canal can fail due to damage caused by a variety of factors, including landslides, burrowing rodents, and downed trees from windstorms (Perkins, 2022). When a canal fails and breaches, the District incurs a cost to repair the canal. Canal failures also have the potential to damage nearby property. Piping the proposed canal sections under the Modernization Alternative would eliminate the risk of canal breaching. The pipe has an expected life longer than the period of analysis; therefore, no repairs are expected to be required over the 100-year analysis period. This section describes the benefits of these avoided damages.

Based on historical occurrences, the FID District Manager estimates that failures on the Farmers Canal are likely to occur roughly every 25 years (Perkins, 2022). The costs to repair the canal can range from $100,000 to $500,000 per occurrence, with a most likely cost of $300,000 (Perkins, 2022). Damage to nearby property can range from $50,000 to $1 million, with a likely value of $250,000 per occurrence (Perkins, 2022). Given these parameters (a 4 percent chance of failure each year and a total of $550,000 in damages), the annual risk of canal failure is equal to approximately $22,000 in damages, for an average annual benefit under the Modernization Alternative of $22,000 (Table D-8).

Table D-8. Avoided District O&M Costs under the Modernization Alternative, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Group	Cost of Repairing the Canal Per Occurrence	Cost of Property Damage Per Occurrence	Average Annual Cost Savings
PG1 Pipe Farmers Canal	$300,000	$250,000	$22,000
PG2 Modify Attenuation Bay	$0	$0	$0
PG3 District-wide SCADA and Telemetry	$0	$0	$0
PG4 Expand Forebay 3	$0	$0	$0
PG5 Pipe Rainy Creek Ditch [2]	$0	$0	$0
Total	**$300,000**	**$250,000**	**$22,000**

Note: Totals may not sum due to rounding. Prepared September 2023

1/ Price Base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.
2/ In the No Action, FID expects no canal failure costs associated with PG5 Pipe Rainy Creek Ditch because it is very flat with relatively flat terrain surrounding it, which limits canal failure and the need for ditch repairs (Perkins, 2022). Therefore, piping that project group does not result in any effects on infrastructure failure costs.

4.2.1.3 Hydropower Production

Two project groups in the Modernization Alternative would result in higher hydropower at the District's Plant 2. The water savings produced by PG1 Pipe Farmers Canal would result in greater flows to the hydropower plant, which FID expects would increase power generation by 776,084 kilowatt-hours (kWh) in a normal water year and 612,963 kWh in a dry water year (Perkins, 2022).[5] Assuming that dry water years occur in 15 percent of years, the expected average annual increase in power production would be 751,369 kWh per year.[6] PG2 Modify Attenuation Bay would also improve hydropower production by reducing sedimentation problems in the pipeline and screen at Plant 2, thereby increasing flows in the Farmers Canal. The District estimates that the resulting increase in energy production would be 720,000 kWh annually (Perkins, 2022).

FID sells all the hydropower it generates to PacifiCorp through a power purchase agreement (PPA). The sales rate differs based on the time of day; on-peak generation sells at $0.09315 per kWh and off-peak sells for $0.0714 per kWh. The blended rate is approximately $0.08445 per kWh (Perkins, 2022). The District's current PPA expires at the end of 2025, after which it will likely negotiate another PPA with PacifiCorp. Because the negotiated rates in a future PPA are uncertain, this analysis uses the current blended rate of $0.08445 per kWh to estimate the benefits of additional power generation resulting from the project for the entire analysis period.

At $0.08445 per kWh, additional hydropower production of 1,471,369 kWh per year would generate approximately $124,000 annually in hydropower revenues to FID (as shown in Table D-9 below).

5 This includes 417,891.6 kWh every non-irrigation season, 195,071.7 kWh during the irrigation season in dry water years, and 358,192.8 kWh during the irrigation season in normal water years.

6 For a more detailed explanation of the frequency of dry and normal water years, see Section 4.2.1.5 Instream Flow Value.

Table D-9. Additional Hydropower Production and Revenues under the Modernization Alternative, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Group	Additional Hydropower Production (kWh/year)	Average Annual Hydropower Revenues
PG1 Pipe Farmers Canal	751,369	$63,000
PG2 Modify Attenuation Bay	720,000	$61,000
PG3 District-wide SCADA and Telemetry	0	$0
PG4 Expand Forebay 3	0	$0
PG5 Pipe Rainy Creek Ditch	0	$0
Total	**1,471,369**	**$124,000**

Note: Totals may not sum due to rounding. Prepared September 2023
1/ Price Base: 2023 dollars.

4.2.1.4 Carbon Emission Reductions

Increases in hydropower production resulting from the Modernization Alternative (described in the previous section) are expected to result in changes in carbon dioxide emissions from power generation. Specifically, additional hydropower is expected to displace power that would otherwise be supplied by fossil fuel generation. Every additional megawatt-hour (MWh) of hydropower is estimated to translate into an approximate reduction of 0.7525 metric tons (Mt) of carbon emissions.[7] Accordingly, the increased hydropower production under the Modernization Alternative (projected to be over 1,471 MWh) would result in an estimated reduction of 1,107 Mt of carbon each year.[8]

To value the potential decrease in carbon emissions, this analysis uses the social cost of carbon (SCC) per ton of carbon dioxide, which is the estimated incremental additional cost to society per unit of carbon emitted based on the expected damages associated with 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

[7] This assumes that marginal changes in energy demand are met with fossil fuel-based production , such that 100 percent of district hydro energy production results in reduced fossil fuel powered generation. This is reasonable since PacifiCorp's baseload power is almost entirely fossil fuel-based, and the hydropower generated under the Modernization Alternative is expected to displace PacifiCorp's baseload power (Perkins, 2022). Furthermore, this estimate assumes 0.7521 metric tons of carbon emitted from one MWh of fossil fuel powered electricity generation based on (1) the current proportion of fuel sources—oil, natural gas, and coal—for fossil fuel–powered electrical power generation in the West, and (2) the associated metric tons of CO_2 produced per MWh powered by each fossil fuel source, as reported by the Energy Information Administration.

[8] While some construction activities under the Modernization Alternative would increase carbon emissions through the use of vehicles and heavy machinery, the amount of emissions from these sources is relatively small and temporary. These emissions would also likely be offset by the annual vehicle emissions avoided when the need to inspect and maintain canals is reduced (as described in Section 4.2.1.1, Operations and Maintenance Cost Savings). For these reasons, we do not include vehicle emissions in the analysis of carbon.

values used by federal agencies have varied over the years. At first, federal agencies developed and applied their own estimates. Then, the Office of Management and Budget convened an Interagency Working Group (IWG) on the Social Costs of Greenhouse Gases, which in 2013 developed a set of SCC estimates that could be used across federal agencies (Interagency Working Group on Social Cost of Greenhouse Gases, 2013). In February 2021, the IWG updated its estimates of the SCC. It estimated that in the year 2020, at a 3-percent discount rate, the SCC value was $59 per Mt (Interagency Working Group on Social Cost of Greenhouse Gases, 2021).[9] We apply this value to the net change in carbon emissions each year throughout the project life to estimate the change in carbon emissions from the Modernization Alternative.

At an SCC value of $59 per Mt, the 1,107 Mt of annual avoided carbon emissions would have a value of roughly $65,000 (as shown in Table D-10 below).

Table D-10. Annual Average Reduction in Carbon Costs of Modernization Alternative, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Group	Additional Hydropower Under Project (kWh/year)	Annual Carbon Emissions Avoided (Mt/year)	Average Annual Net Benefit of Avoided Carbon Costs
PG1 Pipe Farmers Canal	751,369	565	$33,000
PG2 Modify Attenuation Bay	720,000	542	$32,000
PG3 District-wide SCADA and Telemetry	0	0	$0
PG4 Expand Forebay 3	0	0	$0
PG5 Pipe Rainy Creek Ditch	0	0	$0
Total	**1,471,369**	**1,107**	**$65,000**

Note: Totals may not sum due to rounding. Prepared September 2023
1/ Price Base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

4.2.1.5 Instream Flow Value

Implementing the Modernization Alternative would result in water savings by eliminating seepage through permeable canals and reducing operational spill due to imprecise control mechanisms. In total in a normal water year, the project would conserve approximately 2,292 AF. In a dry water year, the project would conserve approximately 1,964 AF. As described in the Plan-EA, the District plans to put most of the water conserved under the Modernization Alternative instream in most years.[10] However, as needed in dry years in the future, the District would use some of the conserved water to avoid agricultural water shortages. While the frequency and severity of dry years is expected to increase with climate change, it is uncertain how often the District would experience shortages and how often water would be used to avoid agricultural damages. Due to this uncertainty, this analysis values all water conserved under the Modernization Alternative at the estimated value of instream flow. It is likely that the value of conserved water to reduce agricultural damages would be

[9] This value has been adjusted for inflation to 2023 dollars using the GDP Implicit Price Deflator.
[10] See Section 6.8.2 in the Plan-EA for a full discussion of the District's plans to use the water conserved under the Modernization Alternative.

even higher than the value used in the analysis for instream flow augmentation (see Section 4.2.2.1). As such, the benefits of conserved water under the Modernization Alternative as presented in this analysis are likely conservative. The remainder of this section examines the value of additional instream flow.

The Hood River Watershed suffers from low summer streamflow, poor habitat quality, and high sediment loads (Hood River Watershed Group, 2021). These issues negatively impact resident aquatic species, some of which are listed as threatened or endangered, including salmon (steelhead, Chinook, and coho), bull trout, and Pacific lamprey (Hood River Watershed Group, 2021). The problems associated with diminished streamflows in the Hood River Watershed are expected to worsen in the future, as climate change is expected to further reduce summertime flows and increase sedimentation. According to a study by the U.S. Bureau of Reclamation, enhancing instream flow by conserving water in FID is one possible alternative to alleviate the habitat issues in the watershed (U.S. Bureau of Reclamation, 2015).

This section provides several types of information on the value of instream flow. First, the section presents available water market data for values paid by environmental or governmental groups to purchase water rights for instream flow. These values represent the cost of increasing instream flow and may significantly underestimate the full value of instream flow augmentation. While these values are in fact costs rather than a measurement of benefit, the amounts paid to enhance instream flow represent the minimum value to the funding entities of enhanced instream flow (benefits as perceived by funding entities are expected to at least equal costs, or funding would not be provided) and represent value only to funding entities and not all beneficiaries.

Data on water right transactions in the Hood River Basin were not available for this study. However, prices of water rights are 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 present market information on the value of water rights to irrigators in FID (since FID would be putting the water instream), as this indicates the potential cost of purchasing water rights from these irrigators to augment instream flows.

Taking into account the available data on the value of water transactions and the value of water to irrigators provided in the following discussion, we estimate that the economic benefit of instream flow augmentation would be at least $80 per AF per year. As stated above, the project's water savings in normal water years is expected to total 2,292 AF, while in dry years it is expected to be 1,918 AF. This analysis models the frequency of dry years at the rate droughts were observed in Oregon from 1991 to 2023: 15 percent (Oregon Water Resources Department, 2023). Using this rate and value of water cited ($80/AF), the weighted average expected value of enhanced instream flow is estimated to be approximately $179,000 per year once the project is complete under the Modernization Alternative (with an average annual value of $178,000 after taking into account project timing). 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 D-11), such as those that would benefit from the instream flows provided by the Modernization 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 for environmental water in the Western United States. Table D-12 shows the estimated average annual benefits of enhanced instream flow for the Modernization Alternative.

Table D-11. 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 2023 dollars	Restoration Location	Fish Enhancement	Survey Respondents
Bell, Huppert, & Johnson	2003	$24–$122 (2000$)	$40–$206	Coastal WA and OR	Annual WTP per household to increase local Coho salmon populations by 100 percent.	Households in Grays Harbor, WA; Willapa Bay, WA; Coos Bay, OR; Tillamook Bay, OR; Yaquina Bay, OR
Olsen, Richards, & Scott	1991	$43 (2006$)	$63	Columbia River Basin	Annual WTP per household to increase salmon and steelhead populations by 100 percent.	Pacific Northwest households that never fish
Loomis	1996	$59–$73 (1994$)	$110–$136	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–$250 (1998$)	$208–$437	Eastern WA and Columbia River; Western WA and Puget Sound	Annual WTP per household to increase migratory fish populations by 50 percent.	Households in WA state

Prepared September 2023

Sources: (Bell, Huppert, & Johnson, 2003); (Loomis, 1996); (Layton, Brown, & Plummer, 2001); (Olsen, Richards, & Scott, 1991) as cited in (Richardson & Loomis, 2009).
OR = Oregon; WA = Washington; WTP = willingness to pay

Table D-12. Estimated Instream Flow Value of the Modernization Alternative, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Group	Normal Water Year Additional Instream Flow (AF/Year)	Dry Water Year Additional Instream Flow (AF/Year)	Annual Benefit of Water Conservation Once Implementation Complete	Average Annual Benefits of Water Conservation
PG1 Pipe Farmers Canal	2,196	1,918	$172,000	$172,000
PG2 Modify Attenuation Bay	0	0	$0	$0
PG3 District-wide SCADA and Telemetry	50	0	$3,000	$3,000
PG4 Expand Forebay 3	0	0	$0	$0
PG5 Pipe Rainy Creek Ditch	46	46	$4,000	$3,000
Total	**2,292**	**1,964**	**$179,000**	**$178,000**

Note: Totals may not sum due to rounding. Prepared September 2023
1/ Price Base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

This value of $80 per AF per year is based on the following information (see Table D-13):

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 $1,792 per AF per year, with an average permanent sale transaction price of $245 per AF per year. Among the 51 permanent water right purchases with the sales price and volume recorded in a water transaction database published by the UC Santa Barbara Bren School, the permanent sales price value in 27 transactions (53 percent of transactions) was above $80 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. Specific to the Columbia Basin, in the Columbia Basin Water Transactions Program (established by the Bonneville Power Administration to purchase instream flows to meet commitments under both the Endangered Species Act and the Northwest Power Act), prices paid for water leases throughout the Columbia Basin from 2003 to 2016 varied from $2 to $177 per AF per year (WestWater Research Inc., 2016).[11]
2. *Value of water to irrigators in Hood River Basin*. Low-value crop irrigators are likely the first to sell water for environmental purposes, which makes the value of water to low-value crop irrigators 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). The 2020 Watershed Plan-Environmental Assessment for neighboring East Fork Irrigation District (EFID) found that the value of

[11] The original source did not provide details on the dollar year of the cited transactions, so we present them unadjusted for inflation.

water to hay growers was approximately $94 and ranged from $70 to $117 per AF per year (Farmers Conservation Alliance, 2020).[12] FID grows very few acres of hay, and most of the District supports high-value orchard crops (Perkins, 2022). For this reason, the value of water to FID irrigators is likely much higher than to hay growers in the Basin.

Table D-13. Value per AF per Year of Water (Market Prices and Value to Agriculture), Hood River Watershed, Oregon, 2019 Dollars.

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	$1,792	~$80	$245
Value of water to Hood River Basin hay and pasture irrigators (*Income Capitalization Approach*)	$70	$117	$94	

4.2.1.5.1 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. The values paid for this water are evidence of the *minimum* benefit of the purchased instream flows, as perceived and experienced by the funding entities. The values are indicative of a *minimum* perceived benefit because (barring very unusual circumstances) entities only pay for projects for which they believe the benefits will exceed costs. Furthermore, funding entities do not necessarily represent all individuals who value instream flow benefits. If unrepresented individuals valued the water saved in the projects and were willing to pay for the flow, the total value of the instream flow would be higher than the value paid by the funding entities. The value paid for instream flow would only equal the benefits received if all people who value the instream flow paid their maximum willingness to pay for instream flow restoration. 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 D-14. The costs range from $886,000 to $7.2 million per cubic feet per second (cfs) conserved, and an estimated $2,400 to $20,200 per AF conserved. Note that these are values per AF conserved in perpetuity, while the values above are values per AF per year; at a 2.5 percent discount rate over 100 years, the values per AF in Table D-14 equate to approximately $66 to $552 per AF per year.

[12] We adjusted the original values for inflation from 2019 dollars to 2023 dollars using the GDPIPD.

Table D-14. Cost and Water Savings of Piping Projects in the Hood River Basin, 2023 Dollars.[1]

Project	Year Complete	Water Saved (cfs)	Total Cost (2023$)[1]	Cost per Amount of Water Conserved ($/cfs)	Cost per Amount of Water Conserved ($/AF)
FID Lower District Pressurization Project	2009	7.5	$6,643,000	$886,000	$2,400
DID Piping Project	2013	3.0	$3,012,000	$1,004,000	$2,800
FID Green Point Pipeline Project	2016	1.5	$1,493,000	$995,000	$2,700
EFID Highline Canal Pipeline	2016	0.5	$976,000	$1,952,000	$5,400
MFID Glacier Ditch Pipeline Phase 3	2012	0.3	$710,000	$2,367,000	$6,500
EFID Central Lateral Piping	2008	2.1	$15,322,000	$7,296,000	$20,200

[1] Total costs were adjusted to 2023 dollars using the gross domestic product implicit price deflator (GDPIPD). Prepared September 2023

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.

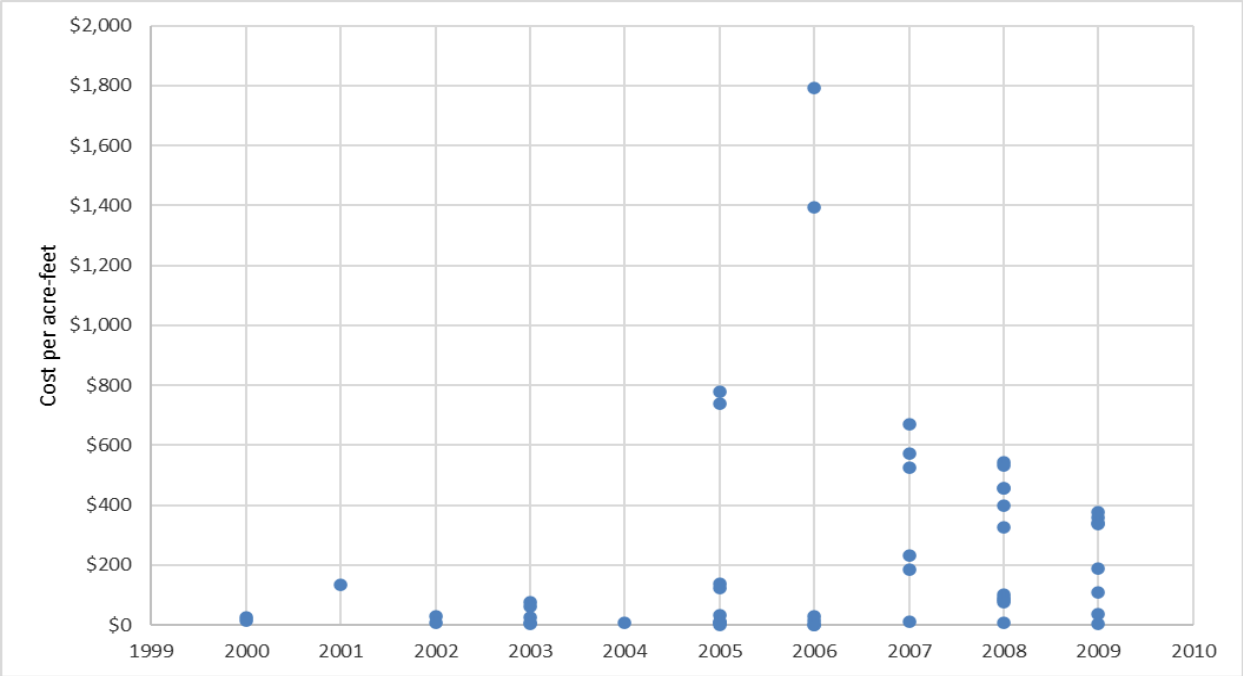
Water right leases and purchases for environmental purposes across the Western United States were analyzed in a 2003 paper (Loomis, Quattlebaum, Brown, & Alexander, 2003). During the period between 1995 and 1999, five water right purchases averaged $419 per AF in Oregon, while six water right leases averaged $197 per AF per year.[13] The paper also shows lease and purchase price by environmental use, including for riparian areas, wetlands, recreation, and instream flow. For instream flows in the Western United States, the average purchase price across 18 transactions per AF was $1,298, while across 35 lease transactions the annual price was $79 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). 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)

[13] Values were adjusted from 1999 dollars to 2023 dollars using the GDPIPD.

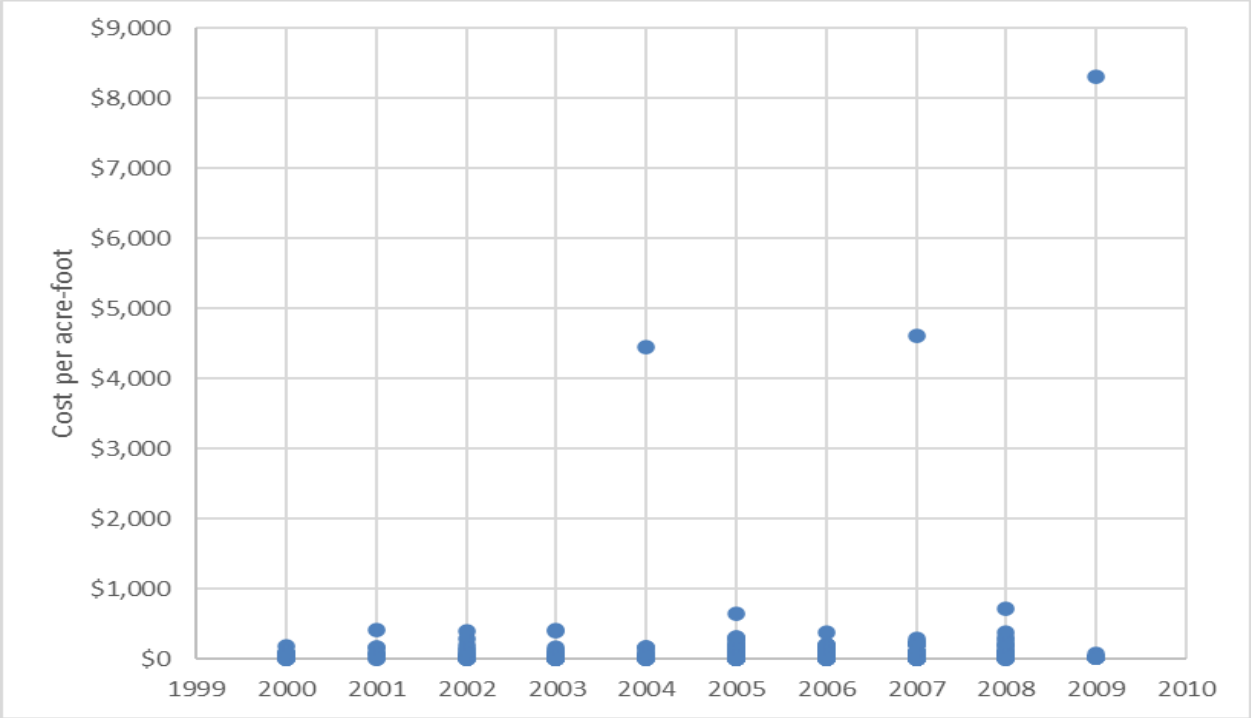
typically are less than $200 per year while one-year leases typically fall below $700 per AF per year (with several transactions showing prices rising over a $4,000 per AF per year). Among the 51 permanent water right purchases with the sales price and volume recorded in the database, the sales price value in 27 transactions (51 percent) was above $80 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 $21 per AF per year.

Another source of data on the prices paid for instream flow for environmental purposes comes from the Columbia Basin Water Transactions Program (CBWTP). Managed by the National Fish and Wildlife Foundation, the program's goal is to increase stream flows by acquiring water rights in the Columba River Watershed (which includes the Hood River Basin). From 2002 to 2016, the CBWTP funded 504 transactions (WestWater Research Inc., 2016). Prices for these transactions ranged from $0 (donated water rights) to nearly $180 per AF per year, with most transactions below $80 per AF per year (WestWater Research Inc., 2016). While the program's annual report does not show any transactions specific to the Hood River, we would expect water rights in the Hood River Basin to be at the higher end of the price range due to the predominance of high-value agriculture in the Hood River Basin.



Note: Purchase prices were adjusted to 2023 dollars using the GDPIPD and then amortized using a 2.5-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, 2023 dollars.



Note: Purchase prices were adjusted to 2023 dollars using the GDPIPD.

Figure D-2. One-year water leases for environmental purposes, price paid per acre-foot in the Western United States, 2023 dollars.

4.2.2 Benefits Considered but Not Included in Analysis

This section describes potential benefits of the Modernization Alternative that are not quantified in the analysis.

4.2.2.1 Agricultural Damage Reduction Benefits

Water conserved as a result of the Modernization Alternative has the potential to reduce future agricultural damage in FID. Currently, the District only experiences water shortages in extreme drought years. In these years (which currently occur in roughly one out of every 10 years), the District has rotated which patrons have been able to irrigate at any given time and reduced deliveries, but even in these years there have been sufficient water supplies for fruit growers to produce their normal yields (Perkins, 2022). Accordingly, under current conditions, enhanced water supplies are not necessary to avoid agricultural damages.

However, according to a 2015 Bureau of Reclamation study, climate change is expected to increase water shortages in the Hood River Basin in the future (U.S. Bureau of Reclamation, 2015). The hydrology and water demand models in the study indicate that water shortages in the District could be higher than 10 percent of current consumptive use. Under some projection scenarios, the Upper and Lower Green Point reservoirs (on which FID depends for supplying irrigation water) would not fill entirely, which could contribute to water shortages in the District. Under these conditions, it is possible that the water shortages could result in reduced yields for FID growers.

Because the vast majority of District acres are in high-value orchard crops (pears, cherries, and apples), the reduced yields could represent relatively large economic damages. In neighboring EFID,

which is similar to FID in having many acres of high-value orchard crops, an irrigation modernization project was projected to provide 1,322 AF per year, alleviating agricultural damages valued at $1,484 per AF (Farmers Conservation Alliance, 2020).[14] Given its similar crop mixture to EFID, the value of conserved water in FID to avoid agricultural water shortages would likely be similar (i.e., greater than the per AF value used in the analysis to represent the benefit of enhanced instream flow).

As described in the Plan-EA, the District plans to use some conserved water to alleviate agricultural damage in dry years. However, because of the uncertainty regarding the timing (i.e., what year the District may face shortages) and severity of the damages (what quantity of shortages the District may face), for the purposes of the economic analysis, all water conservation is assumed to provide instream flow benefits rather than be used to alleviate agricultural damages. As the value of conserved water to reduce agricultural damages in the District is expected to be higher than the value used to estimate instream flow benefit, the economic analysis of the benefits of conserved water is expected to be conservative.

4.2.2.2 Recreational Benefits

The Hood River system supports a variety of recreational activities, some of which may benefit from the Modernization Alternative. Recreational activities on the Hood River include whitewater rafting/kayaking and angling, both of which could benefit from increased instream flow resulting from the project. Additionally, PG3 District-wide SCADA and Telemetry, PG4 Expand Forebay 3, and PG5 Pipe Rainy Creek Ditch would result in more water stored in Upper Green Point Reservoir, which could enhance boating and fishing opportunities in the reservoir. According to a local boating guide, low streamflow currently limits the boating season on the Hood River, which extends from around late September to mid-June (Giordano, 2022). The Modernization Alternative (which would contribute about 6.9 cfs instream in a normal water year) may increase flows during part of the boating season. However, increases of roughly 100 to 200 cfs would be required to have a noticeable impact on boating recreation (Giordano, 2022). Given this, the Modernization Alternative is unlikely to result in meaningful changes in boating recreation.

Instream flow that increases fish populations could enhance fishing experiences by improving the opportunities to catch fish, which in turn could increase the economic benefits of angling on the Hood River. In this way, the Modernization Alternative could benefit fishing recreation. However, similar to its effect on boating recreation, the relatively small increase in instream flow under the Modernization Alternative may not result in substantive impacts to fishing recreation. For example, in the opinion of one local fishing guide, increases of at least 50 cfs would be needed to noticeably improve fishing conditions in the river (Sickles, 2022). As there is uncertainty regarding the magnitude of the impact of instream flows from the Modernization Alternative on fish populations (i.e., the number and species of fish whose populations would increase) and uncertainty in how any potential increases in fish populations would translate into enhanced angling experiences (e.g., an increase in number of fish caught), the benefits to fishing recreation are not quantified in this analysis.

[14] To calculate the value per AF, the original annual damage-reduction value of $1,676,000 in 2019 dollars was adjusted for inflation to 2023 dollars using the Implicit Price Deflator for Gross Domestic Product and divided by the amount of water alleviating the damages (1,322 AF per year).

4.2.2.3 Public Safety and Property Damage Avoided Costs

Open canals are a public safety hazard that would be avoided under the Modernization Alternative. Public safety may be threatened through injuries and drownings from people falling into the canal, or through canal failures (which could damage property and threaten lives downslope). Past incidents in the District (summarized in Table D-15) highlight some of the dangers of open canals in FID. The Modernization Alternative would pipe 14,003 feet of the Farmers Canal thus avoiding the hazards that have occurred in the past and are summarized in Table D-15 below.

Table D-15. Summary of FID Incidents Highlighting Open Canal Hazards.

Year(s)	Incident Description
2008, 2012, 2016	Rocks entered the conveyance system through an open canal and were transported into District pipelines. Once there, the rocks were very difficult and dangerous to remove as it required entering a pipeline to remove them.
2012	A severe ice storm caused hundreds of trees to fall along open sections of Lowline and Farmers Canal. Damaged canal walls forced the District to finish piping Lowline and to conduct large-scale tree removal and canal repair. No injuries resulted but could have.
2015	A waterline broke above an open section of the Farmers Canal and caused the steep hillside to fail, partially blocking the canal. District staff were able to open a spill gate and quickly dewater that section. If the dewater had not happened in time, the canal would have failed, which would have washed out orchards and homes below.
2018	A tractor lost control above an open section of Farmers Canal and dropped into the canal. The operator was able to jump to safety before the tractor went in the canal. It was a drop of several feet and likely could have seriously injured or killed the operator.
2021	Large-scale rockfall damaged half-buried pipe where a canal used to be. If it had been open canal, the canal would have been completely blocked and would have caused a large landslide as the section was steep. As it was, it caused small landslides that blocked roads. Cleanup and repair would have been extremely difficult if it had still been open canal.
2022	Ice accumulation in an open section of the Farmers Canal caused the canal to back up and overtop. The overflowing water eroded the canal bank in a stretch of canal where it is a near vertical drop to the Hood River. It took about 6 weeks to repair the canal, during which time the District ran the canal at a reduced volume for safety.
2022	A rodent tunnel in an open section of the Farmers Canal caused a leak above a house in late summer. The leak was fixed during FID's annual shutdown in October.

Source: (Perkins, 2022) Prepared September 2023

Safety incidents in the canals of neighboring irrigation districts also highlight the danger of open irrigation canals. Between 1983 and 1985, two drownings occurred in canals in EFID: one an adult male, the other a child (Buckley, 2019). As the population in Hood River County continues to grow and housing developments continue to push into rural areas near FID canals, there is increased likelihood of other public safety incidents associated with open canals.

While safety and property damage incidents resulting from FID's open canals are very possible, the extent and type of damage varies dramatically depending on the timing, location, and nature of the incident. Given the limited amount of available data on the previous incidents and the unknown likelihood of future incidents, the public safety benefit and property damage reduction benefit of the Modernization Alternative is not quantified in this analysis.

4.3 Benefits of the Modernization Alternative over the No Action

Because the No Action Alternative provides no benefit above current conditions, the NEE benefits of the Modernization Alternative over the No Action are equal to the NEE benefits of the Modernization Alterative. These are summarized above in Table D-6.

5 NEE Benefits Compared to Costs

Across all project groups, the Modernization Alternative would provide net average annual NEE benefits of roughly $139,000. The NEE costs and benefits are summarized in Table D-16 below (which corresponds to NWPM 506.21 Economic Table 6). For all project groups, the benefits exceed the costs, i.e., a benefit-cost ratio greater than one. Overall, in addition to the quantified benefits, by bolstering the reliability and efficiency of FID, the project would support the broader social and economic values provided by FID to the community and region. While these values are not expected to be jeopardized under the No Action Alternative, the project would increase the overall reliability of water necessary to sustain the rural way of life and the Hood River community identity rooted in historical agricultural land uses; it also would support the aesthetic and recreational values to locals and visitors provided by the orchards of the District and region.

Table D-16. Comparison of NEE Costs and Benefits of the Modernization Alternative, Hood River Watershed, Oregon, 2023 Dollars.[1]

Works of Improvement	Agriculture-Related			Non-Agricultural		Average Annual Benefits	Average Annual Cost [2]	Benefit-Cost Ratio
	Hydropower Revenue	Reduced O&M	Avoided Infrastructure Failure	Carbon Value	Water Conservation			
PG1 Pipe Farmers Canal	$63,000	$56,000	$22,000	$33,000	$172,000	$346,000	$279,000	1.2
PG2 Modify Attenuation Bay	$61,000	$45,000	$0	$32,000	$0	$138,000	$23,000	6.0
PG3 District-wide SCADA and Telemetry	$0	$17,000	$0	$0	$3,000	$20,000	$16,000	1.3
PG4 Expand Forebay 3	$0	$20,000	$0	$0	$0	$20,000	$10,000	2.0
PG5 Pipe Rainy Creek Ditch	$0	$2,000	$0	$0	$3,000	$5,000	$5,000	1.0
Total	**$124,000**	**$140,000**	**$22,000**	**$65,000**	**$178,000**	**$529,000**	**$333,000**	**1.6**

1/ Price base 2023 dollars. Prepared September 2023
2/ From Table D-5.

5.1 Incremental Analysis

The Modernization Alternative is evaluated using an incremental analysis, which identifies how total costs and benefits change as project groups are added (or removed). The design of each project group is independent of the number of project groups included and the order in which they are installed. Table D-17 presents the incremental costs and benefits of the Modernization Alternative.

Table D-17. Incremental Analysis of Annual NEE Costs and Benefits Under the Modernization Alternative, Hood River Watershed, Oregon, 2023 Dollars.[1]

Project Groups	Total Costs	Incremental Costs	Total Benefits	Incremental Benefits	Net Benefits
2	$23,000	–	$138,000	–	$115,000
2, 1	$302,000	$279,000	$484,000	$346,000	$182,000
2, 1, 4	$312,000	$10,000	$504,000	$20,000	$192,000
2, 1, 4, 3	$328,000	$16,000	$524,000	$20,000	$196,000
2, 1, 4, 3, 5	$333,000	$5,000	$529,000	$5,000	$196,000

1/ Price Based: 2023 dollars. Prepared September 2023

5.2 Preferred Alternative

The No Action Alternative would provide no benefits relative to current conditions. As the Modernization Alternative would provide net NEE benefits of $196,000, plus potential other unquantified values, the Modernization Alternative is the Preferred Alternative.

6 NEE References

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D.2 Alternatives Considered During Formulation

This 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 (PR&G). According to NEPA, "agencies shall rigorously explore and objectively evaluate all reasonable alternatives" (40 CFR 1502.14). According to the PR&G DM9500-013, 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 shown in Table D-18 and discussed below. Alternatives selected for further evaluation are discussed in the Plan-EA.

Table D-18. 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	
Piping Rainy Ditch in Existing Alignment	X	X		X	
Constructed Wetland				X	
Automation at Gate and Cabin creeks	X			X	
Reregulation Reservoirs	X				
Market-Based Approaches to Include Voluntary Duty Reduction			X		
Canal Lining	X	X		X	X
No Action (Future without Federal Investment			X		X
Modernization Alternative	X	X	X	X	X

D.2.1 Piping Rainy Ditch in Existing Alignment

Under this alternative, the District would pipe 0.3 miles of Rainy Ditch following the current ditch alignment. Presently, the ditch crosses under a U.S. Forest Service road, runs along the east side of the road, and then crosses back under the road and runs along the west side of the road in a wilderness area to where it joins another ditch. Since the section of Rainy Ditch on the west side of the road is in a wilderness area, piping this section would need to be completed by hand. In addition, additional permits would need to be obtained. As compared to the Modernization Alternative, which includes piping Rainy Ditch in a new alignment that is out of the wilderness area, piping Rainy Ditch in its existing alignment would result in a greater construction cost since the work would take significantly longer to construct by hand and incur greater permitting costs.

Piping Rainy Ditch in its existing alignment would meet the project's purpose and need. Piping would eliminate water that is currently lost to seepage in the ditch, and the saved water would be used to fulfill patrons' irrigation water rights.

Piping Rainy Ditch in its existing alignment was eliminated from further evaluation because it would be inefficient and more logistically complicated, as compared to the Modernization Alternative.

D.2.2 Constructed Wetland

A constructed wetland is a nonstructural alternative. Constructed wetlands are engineered systems that use vegetation, soil, and organisms to treat wastewater or stormwater, or remove pollutants. For this alternative, a constructed wetland would be built below the District's Hood River Diversion to remove sediment from water diverted by FID as it passes through the wetland.

The only suitable area that is available to build a constructed wetland is small because it is constrained geographically between the Hood River and a steep hillside. A wetland constructed in this location would quickly lose its function as it filled with sand.

A constructed wetland alternative would not meet the project's purpose and need. Since the wetland would be small it would not adequately remove sediment, District operation efficiency would not be improved, and sediment would continue to impact irrigation water conveyance.

A constructed wetland alternative was eliminated from further evaluation because it would not meet any of the project's purpose and need; would not be complete because the land to site the wetland is too small; would not be effective because it would fill quickly with sediment; and because it would not achieve the Federal Objective and Guiding Principles.

D.2.3 Automation at Gate and Cabin Creeks

Automation at Gate and Cabin creeks would include installing automated headgates at FID's diversions on Gate and Cabin creeks. This would allow the District to better manage diversions into the Stanley Smith pipeline. Due to the remote location and lack of existing power at FID's Gate and Cabin creek diversions, the headgates would require a solar array for power. However, due to dense trees, there is not enough sunlight at either location to power an array.

The alternative of automation at Gate and Cabin creeks would not meet the project's purpose and need since it would not function without power. It would therefore not improve water conservation, District operation efficiency, or water delivery reliability.

Automation at Gate and Cabin creeks was eliminated from further evaluation because it would not meet any of the project's purpose and need; it would not be complete or effective because it would not function without power; and because it would not achieve the Federal Objective and Guiding Principles.

D.2.4 Reregulation Reservoirs

A reregulation reservoir alternative would involve installing multiple reregulation reservoirs, also called bulges, throughout FID's system. These bulges would be used to store water and release it as needed to meet the needs of patrons while ensuring adequate water for hydropower generation. Bulges would be an alternative to expanding Forebay 3, which is included in the Modernization Alternative.

In order to construct bulges, FID would need to obtain property to locate them. Purchasing or condemning private land to site bulges, which could include land used for agriculture, may not be acceptable because it is inconsistent with public policy supporting and maintaining existing agricultural land use. Additionally, since FID's conveyance system is divided into different sections that receive water from various sources, bulges along a particular pipeline or canal would only affect a single portion of FID. In comparison, Forebay 3 is at a strategically better location because it serves multiple portions of FID.

As compared to expanding Forebay 3 in the Modernization Alternative, reregulation reservoirs would result in less water conservation and less improvements to water delivery since the reservoirs would benefit limited portions of FID. New bulges would require additional O&M costs for FID and would not meet the project's need to improve operational efficiency.

A reregulation reservoir alternative was eliminated from further evaluation because it would not be efficient and would likely not be acceptable.

D.2.5 Market-Based Approaches to include Voluntary Duty Reduction

For the purpose of this analysis, market-based approaches refer to patrons voluntarily accepting less than their full water delivery rate from the District, or to patrons temporarily or permanently moving water or water rights from their lands to the river. 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.

Market-based approaches such as voluntary duty reduction would not meet any of the project purposes. If water saved from duty reduction was put instream, it could meet the need of improving instream flow for fish and aquatic habitat, but this is not certain to occur because duty reduction would be voluntary, and any water saved would not necessarily be put instream by the patrons.

Incorporating market-based solutions into the proposed action without corresponding regulatory and policy changes, which would be required to provide the District with the authority to carry out the transfer of patron water instream, is not ripe for consideration as an alternative at this time. Without a change in the framework of current lawful authorities on the part of the District, incorporating market-based incentives into the proposed action is not within the District's ability or capacity to undertake, nor is it logistically or technically feasible.

For example, a reduction in duty by a patron could mean the District diverts less water, which would leave more water instream. Because the District is obligated to provide a certain amount of water to patrons to meet associated rights, this alternative would be voluntary and at the discretion of individual landowners. For this reason, there would be no certainty that water would be saved and that streamflow would be restored. Furthermore, FID lacks the statutory authority or responsibility to carry out, operate, and maintain voluntary duty reduction by its patrons, creating a logistically complex situation for FID to implement. Further, because the system has open canals, which are subject to certain operating inefficiencies, the District would still have to divert enough water, accounting for seepage, to ensure those deliveries. Therefore, carrying out this alternative would be logistically complex and technically infeasible.

A market-based incentives alternative including voluntary duty reduction was eliminated from further evaluation because it would not meet the project purpose; its effectiveness would be uncertain since reducing one's duty would be voluntary; the District lacks the ability to carry out patron duty reductions; it would not achieve the Federal Objective and Guiding Principles; and given current water delivery technology, it is technically infeasible by the District to accommodate.

D.3 Capital Costs

D.3.1 Canal Lining Alternative Costs

The capital cost of the Canal Lining Alternative (Table D-19) for 2.6 miles of the Farmers Canal and 0.36 miles of Rainy Ditch was estimated by using the following design and cost assumptions:

- Geomembrane liner to cover the sides and bottom of the canal at a cost of $0.79 per square foot using BTL 40 mil AquaArmor Double Scrim RPE Liner. Quote from Kevin Crew, Principal Engineer, of Black Rock Consulting based on a recent North Unit Irrigation District project (K. Crew, personal communication, November 29, 2021).
    - Geomembrane liner would extend 7 feet from the edge of the canal on either side and would be covered and weighted by fill material to anchor the liner.
- A layer of shotcrete (fine-aggregate concrete sprayed in place) to cover the geomembrane. Shotcrete thickness of 6 inches was recommended by Kevin Crew, Principal Engineer, of Black Rock Consulting based on experience (freeze-thaw cycles; K. Crew, personal communication, November 29, 2021). This assumption also conforms to NRCS engineering standards (NRCS 2017).
    - Shotcrete cost of $9.26 per square foot, assuming 6-inch depth. Based on a quote of $500 per cubic yard from Black Rock Consulting (K. Crew, personal communication, November 29, 2021).
- Installation costs of $100 per linear foot. This includes excavation of canal bottom, earth removal, canal reshaping to meet NRCS engineering standards (NRCS 2017), and installation of geomembrane liner and shotcrete.
- The cross-section dimensions for lining the canal were estimated for each corresponding pipe diameter size using transects on a digital elevation model from an irrigation district in Central Oregon.
- Since there would be no concern with overflow at the start of the canal lining, this alternative does not include an inlet structure or SCADA systems.
- Engineering/Survey was included at 2.25 percent and 10 percent was included for construction manager/general contractor, similar to the Modernization Alternative and estimated as a percentage of construction subtotal.
- Contingency was included at 30 percent, the same as the Modernization Alternative and estimated as a percentage of subtotal costs plus engineering/survey and construction manager/general contractor.

See Section 5.2.1 in the Plan-EA for further discussion of the Canal Lining Alternative and rationale for why it was eliminated from detailed study.

Table D-19. Canal Lining Alternative Costs.

Feature	Length (feet)	Unit	Cross-section width (feet)	Channel depth (feet)	Geomembrane	Shotcrete	Canal Reshaping and Installation	Subtotal[1]
Lining Farmers Canal	13,668	Feet	25.9	4.4	$441,171	$3,355,579	$1,400,297	$5,197,100
Lining Rainy Ditch	1,909	Feet	12.3	2.0	$36,651	$217,424	$190,935	$445,000
							Subtotal	**$5,642,100**
							Engineering / Survey (2.25%)	$126,900
							Construction Manager/General Contractor (10%)	$564,200
							Subtotal with Engineering, Survey, Construction Manager/General Contractor	**$6,333,200**
							Contingency (30%)	$1,900,000
							TOTAL	**$8,233,000**

Notes: Prepared September 2023

[1]Subtotals are rounded to the nearest $100.

D.3.2 Modernization Alternative/ Preferred Alternative Costs

This section presents capital costs for the Modernization Alternative (Table D-20), which is identified as the Preferred Alternative. Costs shown in Table D-20 differ from elsewhere in the Plan-EA because they do not include project administration costs.

Table D-20. Preferred Alternative Capital Costs.

Project Name	Item	Quantity	Units	Nominal Diameter	Pressure Rating (psi)	Construction Cost	Easement Cost	Engineering, Construction Management, Survey	Construction Manager/ General Contractor	Contingency Costs	Total Costs
Pipe Farmers Canal	Pipe	6,783	feet	48	9	$2,745,952	N/A	$274,595	$384,433	$1,021,494	$4,426,474
Pipe Farmers Canal	Pipe	7,220	feet	48	9	$2,922,771	N/A	$292,277	$409,188	$1,087,271	$4,711,507
Pipe Farmers Canal	Concrete Structures	42	cubic yards	N/A	N/A	$49,920	N/A	$4,992	$6,989	$18,570	$80,471
Modify Attenuation Bay	Sediment Management Infrastructure	1	each	N/A	N/A	$450,992	N/A	$45,099	N/A	$90,198	$586,289
SCADA at Rainy Ditch Diversion	Flow Meter	1	each	N/A	N/A	$10,950	$10,000	$1,095	N/A	$6,614	$28,659
SCADA at Stanley Smith Pipeline Outlet	Flow Meter	1	each	N/A	N/A	$10,950	N/A	$1,095	N/A	$3,614	$15,659
SCADA at Parkertown Pipeline	Flow meter, Solar Panel, and Radio Antenna	1	lump sum	N/A	N/A	$42,406	N/A	$4,241	N/A	$13,994	$60,641
SCADA at Highline Pipeline	Flow meter, Solar Panel, and Radio Antenna	1	lump sum	N/A	N/A	$42,406	N/A	$4,241	N/A	$13,994	$60,641
SCADA at Forebay 3	Flow Meters	3	lump sum	N/A	N/A	$32,850	N/A	$3,285	N/A	$10,841	$46,976
SCADA at NFGPC Diversion	Flow Meter	1	each	N/A	N/A	$10,950	N/A	$1,095	N/A	$3,614	$15,659
Expand Forebay 3	Forebay	1	each	N/A	N/A	$258,753	$10,000	$25,875	N/A	$51,751	$346,379
Pipe Rainy Ditch	Pipe	1,909	feet	8	63	$110,589	$10,000	$11,059	$15,482	$44,139	$191,269
					Total[1]	**$6,689,000**	**$30,000**	**$669,000**	**$816,000**	**$2,366,000**	**$10,571,000**

Notes: Prepared September 2023

N/A: Not applicable; project does not include piping or construction manager/general contractor costs would not be required for the project because the District would be overseeing the construction management.

[1] Totals rounded to nearest $1,000 and may not sum. Totals do not include project administration costs.

NFGPC = North Fork Green Point Creek; psi = pounds per square inch; SCADA = supervisory control and data acquisition

The following subsections D.3.2.1 through D.3.2.6 provide the design and costing methodologies used to estimate the capital costs for each of the five project groups.

D.3.2.1 PG1 Piping the Farmers Canal

Under Project Group 1, the District would convert 2.59 miles of the Farmers Canal to buried, dual 48-inch-diameter pipelines. The dual pipelines would be installed in the two separate sections of existing open canal. Piping was designed to meet the NRCS Conservation Practice Standard Code 430 for Irrigation Pipelines (NRCS Practice Standard 430). The pipe was sized to ensure that the full-pipe velocity would not exceed 5 feet per second, per NRCS Practice Standard 430, when conveying the maximum design flows of the Farmers Canal dual pipeline, and to ensure that the working pressure at any point would be 72 percent or below the pressure rating of the pipe. The pressure rating would also exceed any pressure surges that would be 150 percent of the working pressure.

To estimate the cost of the 48-inch piping for the Farmers Canal, various pressure pipes available in a variety of materials were evaluated. Piping materials that could be used for the Modernization Alternative include, but are not limited to, polyvinyl chloride (PVC), steel, high-density polyethylene (HDPE), bar-wrapped concrete cylinder, fiberglass, and ductile iron. Specifically, this Watershed Plan considered PVC, HDPE, and fiberglass reinforced pipe.

Krah profile-wall HDPE was selected for costing due to its superior design life and lower material costs based on the quotes that were obtained from vendors. At the time of project implementation, the specific piping material would be selected based on a number of considerations; the cost of the project would meet NEE requirements, meet construction requirements, be appropriate based on local conditions and risk factors, and result in minor or no changes to project effects described in Section 6 of the Plan-EA, as determined through the tiered decision framework approach outlined in Section 1.4. The NRCS State Conservationist and the Sponsoring Local Organization would possess the final discretion to select the appropriate piping material.

To connect the dual pipelines to the existing piped sections on the Farmers Canal, concrete structures or mechanical couplers would be installed at the inlets and outlets of the dual pipelines. In total, four concrete structures would be installed. One concrete structure would be installed at the inlet of the first area of proposed dual piping to connect to the outlet of the existing dual pipelines, and one concrete structure would be installed at the outlet of the proposed piping to connect to the inlet of the existing pipeline. For the second piping area, two concrete structures would be installed in the same manner as proposed for the first piping area. A box-type check and pipe inlet was selected using the Bureau of Reclamation's *Design of Small Canal Structures Manual* (1974). Based on the proposed diameters of the dual pipelines, 10 cubic yards of reinforced concrete would be needed for each concrete structure. Based on past irrigation modernization projects requiring similar improvements, reinforced concrete was costed at $1,200 per cubic yard. At the time of construction, mechanical couplers could be selected instead of concrete structures. Concrete structures were estimated to be more expensive and were, therefore, a more conservative estimate of the cost.

The proposed alignment for the dual pipelines would remain in the alignment of the existing Farmers Canal and would not have any road crossings.

D3.2.2 PG2 Modify Attenuation Bay

Under Project Group 2, the District would expand its existing fish screen attenuation bay by 0.02 AF (see Figure D-3). The modifications aim to enhance the functionality and efficiency of the attenuation bay in removing sediment. All proposed improvements for the attenuation bay would

conform to the following NRCS Practice Standards: NRCS Practice Standard 350 for Sediment Basins, NRCS Practice Standard 378 for Ponds, and NRCS Practice Standard 436 for Irrigation Reservoirs, where applicable.

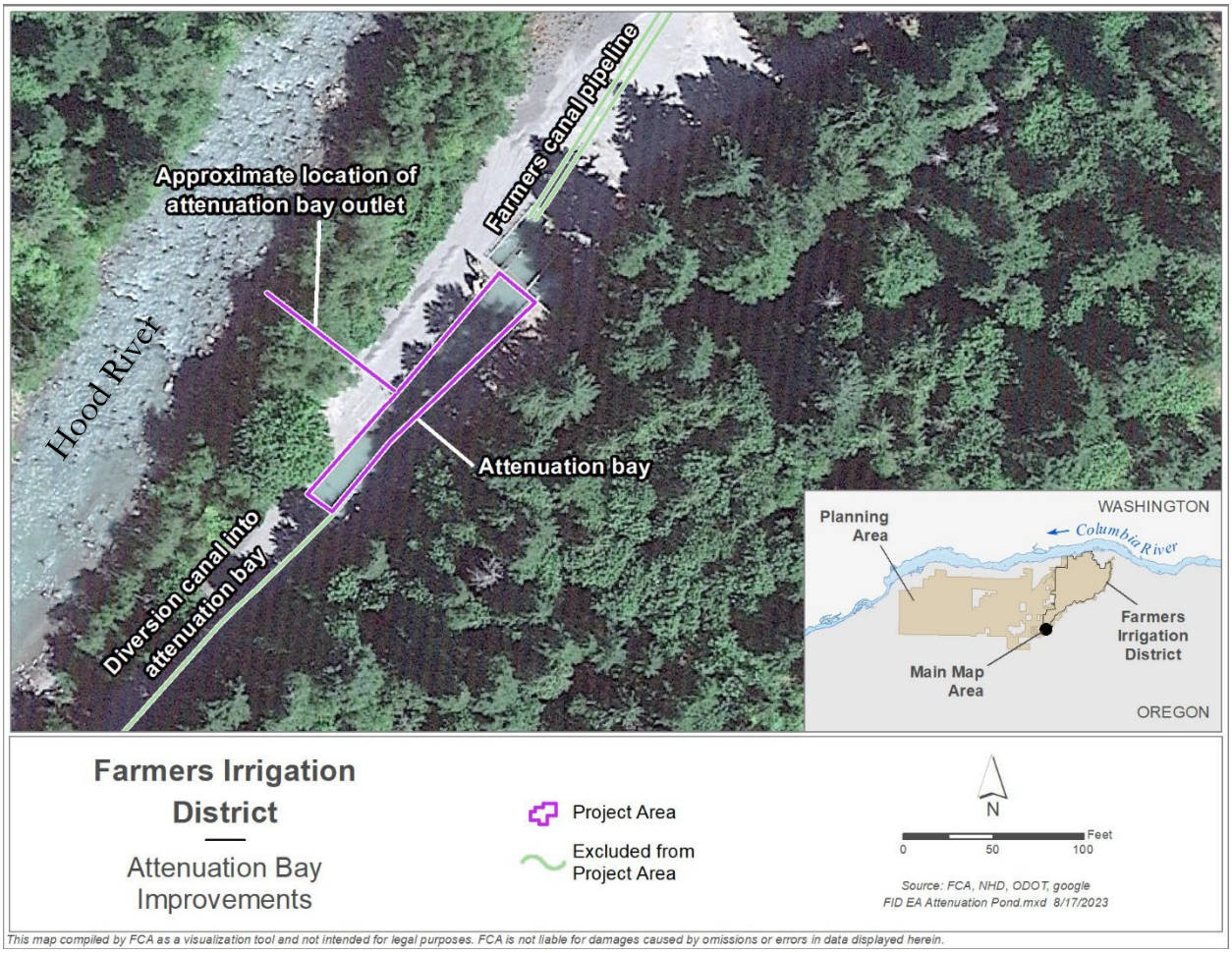


Figure D-3. Project area for the attenuation bay improvements.

The following construction activities would take place to modify the attenuation bay:

- Mobilization and demobilization activities would account for up to 5 percent of the total project cost, encompassing the logistics and setup required for the modification process. This would include site preparation, equipment transportation, and initial setup to ensure a smooth transition into the modification phase.
- Proper temporary erosion and sediment control measures would be established to mitigate the potential for erosion or sediment releases into the Hood River during construction. Additionally, project safety protocols would be implemented to safeguard workers and site integrity during construction of the attenuation bay modifications.
- The perimeter of the attenuation bay's concrete wall would be sawcut, and the existing concrete floor would be removed. This exposed area would be excavated, and a subgrade would be prepared so a sloped floor could be installed. The sloped floor would facilitate the settling of sediment to a low point in the system. No existing inlet or outlet structures from the attenuation bay would be modified.

- To ensure structural continuity and robustness, dowel and epoxy rebar would be strategically inserted into the existing concrete walls that would remain. This reinforcement would promote effective load distribution and prevent potential cracking or separation between old and new elements.
- Once the subgrade is prepped, new structural concrete, reinforced with high-quality rebar, would be poured for the new sloped floor.
- To route sediment more effectively from the new sloped floor, piping would be installed at the lowest point of the sloped floor and would route sediment from the attenuation bay back to the Hood River. The number of pipes that would be installed would be based on optimal redirection of sediment back to the Hood River.
- Adjustments to the entrance of the attenuation bay would be made to optimize the water inflow into the attenuation bay. This would involve reshaping and redesigning the forebay to maximize sediment settling and enhance the overall hydraulic performance of the system. As mentioned previously, the adjustments to the entrance of the attenuation bay would not modify any inlet or outlet structures associated with the attenuation bay.

D3.2.3 PG3 SCADA

Under Project Group 3, SCADA and telemetry equipment would be installed at six sites throughout the District (see Table D-21). At sites with existing SCADA infrastructure or sites where only a flow meter would be installed, no ground disturbance is expected during construction. At sites with no existing SCADA infrastructure, a ground disturbance of approximately 25 to 200 square feet would be expected during construction. See Table D-21 for more details on the equipment needed and ground disturbance at each SCADA site.

Table D-21. Proposed SCADA Installation Sites.

Site Name	Equipment to be Installed	Construction Disturbance (square feet)
Rainy Ditch Diversion	Flow meter	0
Stanley Smith Pipeline Outlet	Flow meter	0
Parkertown Pipeline	Flow meter, solar panel, radio antenna	100–200
Highline Pipeline[1]	Flow meter, solar panel, radio antenna	0
Forebay 3[1]	3 flow meters[2]	0
NFGPC Diversion[2]	Flow meter	0

[1]These sites have existing SCADA infrastructure. At Highline Pipeline, the existing SCADA infrastructure would be updated.

[2]Three flow meters would be installed at Forebay 3: Ditch Creek inflow, Lowline Pipeline inflow, and at the outflow to Penstock 3.

Costs were utilized from another project that included SCADA improvements. The costs for the other project were originally obtained in 2019, so the costs for this project were inflated from 2019 to 2023 dollars at a rate of 19 percent.

D3.2.4 PG4 Expand Forebay 3

Under Project Group 4, the District would expand Forebay 3 by adding 2 AF in water retention capability (see Figure D-4). As mentioned for Project Group 2, all proposed improvements for the expansion of Forebay 3 would conform to the following NRCS Practice Standards: NRCS Practice Standard 350 for Sediment Basins, NRCS Practice Standard 378 for Ponds, and NRCS Practice Standard 436 for Irrigation Reservoirs, where applicable.

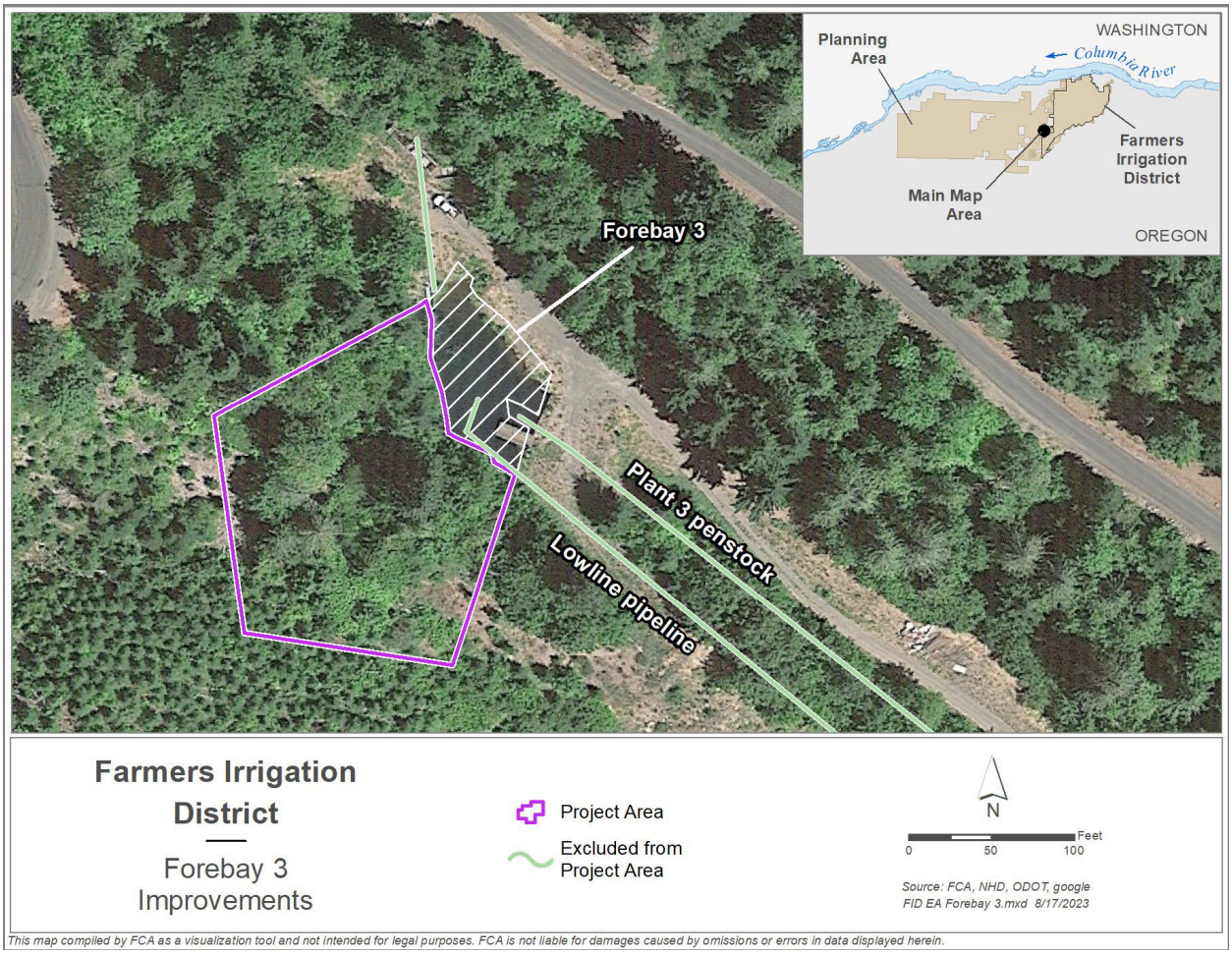


Figure D-4. Project area for Forebay 3 improvements.

The following construction activities would take place to expand Forebay 3:

- Mobilization and demobilization efforts would be required, and temporary erosion and sediment control measures would be implemented in a similar manner as proposed for Project Group 2.
- To facilitate the expansion, initial general log removal around the forebay area would be undertaken, ensuring a clear and unobstructed workspace. The area would be excavated to achieve the desired forebay dimensions, optimizing volume while maintaining structural integrity. The careful placement of excavated material and controlled fill operations would be executed in strict accordance with engineering standards to ensure stability and longevity.

- In tandem with excavation and fill, berm construction would be undertaken to create a robust containment structure that efficiently manages the increased capacity of the forebay. The design of these berms would integrate soil mechanics principles, enhancing their resilience against potential hydraulic forces and external pressures.
- Finally, the application of crushed rock surfacing would provide an essential protective layer, promoting surface drainage and erosion resistance. This surfacing material would be used for its durability, thereby contributing to the longevity of the expanded forebay while facilitating routine maintenance activities.

D3.2.5 PG5 Pipe Rainy Ditch

Under Project Group 5, the District would convert approximately 0.36 miles of Rainy Ditch to a buried 8-inch-diameter pipe. As mentioned for Project Group 1, piping was designed to meet NRCS Practice 430 requirements for velocity and pressure.

Piping material options were evaluated for Rainy Ditch in a similar manner as for the Farmers Canal pipeline. Solid-wall HDPE was selected for costing purposes due to its superior design life and lower material costs based on quotes that were received from vendors. As mentioned for Project Group 1, the pipe material ultimately selected at the time of construction may differ from what is proposed here, and the various factors mentioned previously would be considered.

Approximately 0.2 miles of the Rainy Ditch pipeline would follow a new alignment and would cross a U.S. Forest Service road. Costs to realign the conveyance and cross under the road are assumed to be 40 percent of the pipe material cost. For example, if the pipe material costs were $100, the realignment costs associated with the project would be $40.

D.3.3 Present Value of the Costs of the Preferred and Canal Lining Alternatives

This section presents the estimated present value of piping Rainy Ditch and the two open sections of the Farmers Canal, and it provides the net present value of installing canal lining along Rainy Ditch and the open sections of the Farmers Canal (see Table D-22). Annual O&M costs following piping and canal lining were estimated by Les Perkins, FID District Manager (L. Perkins, FID Manager, personal communication, April 18, 2022).

Discount Rate: 2.25 percent

Period of Analysis: 100 years

Table D-22. Present Value of the Preferred and Canal Lining Alternatives.

	Preferred Alternative (Pipe Rainy Ditch and two open sections of Farmers Canal)	**Canal Lining Alternative (Line Rainy Ditch and two open sections of Farmers Canal)**
Design Life (years)	100	100
Capital Costs	$9,409,000	$8,233,000
Present Value of Replacement Costs[1]	$26,000	$7,176,000
Annual O&M Costs	$2,200	$75,000
Present Value of O&M Costs	$87,000	$2,973,000
Present Value of Costs	**$9,522,000**	**$18,382,000**

Notes: Prepared September 2023

N/A = not applicable. Totals rounded to nearest $1,000.

[1] For canal lining, 100 percent was replaced at both 30 years and 60 years.

D.3.4 References

Reclamation. (1974). *Design of Small Canal Structures.* United States Bureau of Reclamation. Denver, Colorado.

U.S. Department of Agriculture Natural Resources Conservation Service. (2017). Conservation practice standard lined waterway or outlet code 468. Retrieved from: https://www.nrcs.usda.gov/sites/default/files/2022-09/Lined_Waterway_or_Outlet_468_CPS_9_2020.pdf

Appendix E

Other Supporting Information

E.1 Intensity Threshold Table

This section presents the intensity threshold table (Table E-1) used to quantify effects on resources of concern because of the proposed action.

Table E-1. Intensity Thresholds for the Farmers Irrigation District Infrastructure Modernization Project.

Negligible	Changes in the resource or resource-related values would be below or at the level of detection. If detected, the effects on the resource or environment would be considered slight with no perceptible impacts.
Minor	Changes in resource or resource-related values would be measurable but small. The effects on the resource or the environment would be localized.
Moderate	Changes in the resource or resource-related values would be measurable and apparent. The effects on the resource or the environment would be relatively local.
Major	Changes in resource or resource-related values would be measurable and substantial. The effects on the resource or the environment would be regional.
Impact Duration Definitions	
Temporary	Transitory effects, which only occur over a period of days or months
Short-term effect	Resource or resource-related values recover in less than 5 years
Long-term effect	Resource or resource-related values take more than 5 years to recover

E.2 Supporting Information for Cultural Resources

E.2.1 Summary of Cultural Resource Surveys Within the Project Area

Table E-23. Summary of Cultural Resource Surveys Within the Project Area.

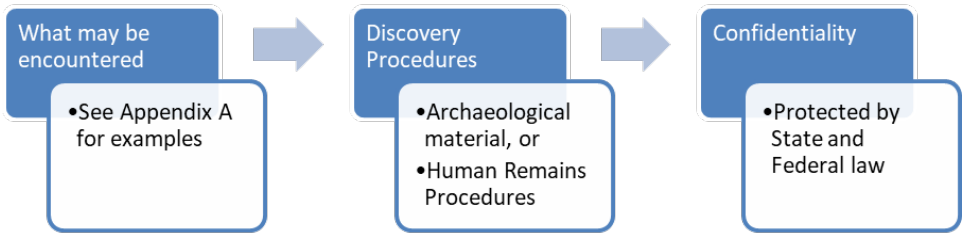
Project Area	Status of Cultural Resource Surveys
Farmers Canal	Planned for winter 2023
SCADA Locations 1. Rainy Ditch Diversion 2. Parkertown Pipeline 3. Stanley Smith Outlet 4. Forebay 3 (three sites) 5. Highline Pipeline 6. North Fork Green Point Creek Diversion	Planned for winter 2023
Rainy Ditch	Planned for winter 2023
Sediment Management Infrastructure	Planned for winter 2023
Forebay 3	Planned for winter 2023

E.2.2 Archaeological Inadvertent Discovery Plan

Archaeological Inadvertent Discovery Plan

PROJECT NAME: Farmers Irrigation District

How to use this document



Archaeology consists of the physical remains of the activities of people in the past. This inadvertent discovery plan should be followed should any archaeological sites, objects, or human remains be found. These are protected under federal and state laws, and their disturbance can result in criminal penalties.

This document pertains to the work of the Contractor, including any and all individuals, organizations, or companies associated with the FID Infrastructure Modernization Project.

What May be Encountered

Archaeology can be found during any ground-disturbing activity. If encountered, all excavation and work in the area MUST STOP. Archaeological objects vary and can include evidence or remnants of historic-era and precontact activities by humans. Archaeological objects can include but are not limited to:

- **Stone flakes, arrowheads, stone tools, bone or wooden tools, baskets, beads.**
- Historic building materials such as **nails; glass; metal** such as cans, barrel rings, and farm implements; **ceramics; bottles; marbles;** and **beads**.
- Layers of **discolored earth** resulting from hearth fire.
- Structural remains such as **foundations.**
- **Shell** middens.
- **Human skeletal remains** and/or **bone fragments** which may be whole or fragmented.

For photographic examples of artifacts, please see Appendix A. (Human remains not included.)

If there is an inadvertent discovery of any archaeological objects see procedures below.

If in doubt call it in.

Discovery Procedures: What to do if you find something

1. Stop ALL work in the vicinity of the find.
2. Secure and protect the area of inadvertent discovery with a 30-meter/100-foot buffer; work may continue outside of this buffer.
3. Notify the project manager and the agency official.
4. The project manager will need to contact a professional archaeologist to assess the find.
5. If the archaeologist determines the find is an archaeological site or object, contact the Oregon State Historic Preservation Office (SHPO). If it is determined to *not* be archaeological, continue work.

Human Remains Procedures

1. If it is believed the find may be human remains, stop ALL work.
2. Secure and protect the area of inadvertent discovery with a 30-meter/100-foot buffer; work may continue outside of this buffer with caution.
3. Cover remains from view and protect them from damage or exposure, restrict access, and leave in place until directed otherwise. **Do not take photographs. Do not speak to the media**.
4. Notify:
    - Project Manager

- Agency Official
- Oregon State Police **DO NOT CALL 9-1-1**
- SHPO
- Legislative Commission on Indian Services (LCIS)
- Appropriate Native American Tribes

5. If the site is determined not to be a crime scene by the Oregon State Police, do not move anything! The remains will continue to be *secured in place,* along with any associated funerary objects, and protected from weather, water runoff, and shielded from view.

6. Do not resume work in the buffered area until a plan is developed and carried out between the Oregon State Police, SHPO, LCIS, and appropriate Native American Tribes and you are directed that work may proceed.

Contact Information

- Project Manager, Les Perkins, (541) 490-4062
- NRCS Agency Official, Ron Alvarado: (503) 414-3201
- NRCS Archaeologist, Michael Petrozza: (503) 414-3212
- Oregon State Police, Lieutenant Craig Heuberger: (503) 731-3030
- Oregon State Historic Preservation Office
  - State Archaeologist, John Pouley: (503) 480-9164
  - Asst. State Archaeologist, Jamie French: (503) 979-7580
- LCIS, Elissa Bullion: (971) 707-1372
- Appropriate Tribes: Confederated Tribes of Warm Springs, Robert Brunoe: (541)-553-2026

Confidentiality

The Farmers Irrigation District and employees shall make their best efforts, in accordance with federal and state law, to ensure that its personnel and contractors keep the discovery confidential. The media, or any third-party member or members of the public, are not to be contacted or have information regarding the discovery, and any public or media inquiry is to be reported to NRCS. Prior to any release, the responsible agencies and tribes shall concur on the amount of information, if any, to be released to the public.

To protect fragile, vulnerable, or threatened sites, the National Historic Preservation Act, as amended (Section 304 [16 U.S.C. 470s-3]), and Oregon State law (ORS 192.501(11)) establishes that the location of archaeological sites, both on land and underwater, shall be confidential.

Appendix A

Visual Reference Guide to Encountering Archaeology

Figure 1. Stone flakes.

Figure 2. Stone tool fragments.

Figure 3. Cordage.

Figure 4. Shell midden.

Figure 5. Historic glass artifacts.

Figure 6. Historic metal artifacts.

Figure 7. Historic building foundations.

Figure 8. 18th-century ship.

E.3 Supporting Information for Land Use

Table E-3. Crops Grown in Farmers Irrigation District.

Crop	Total Estimated Acreage	Percentage Acreage
Apples	292	5%
Blueberries	50	1%
Cherries	458	8%
Grapes	66	1%
Pasture/ Hay/ Forage	300	5%
Pears	2,750	47%
Suburban/ Residential	1,662	28%
Golf Course	230	4%
Other	80	1%
Total	**5,888**	**100%**

Source: (FID 2020)

E.4 Supporting Information for Soil Resources

Table E-4. Project Area Length Crossing Farmland.

NRCS Farmland Class	Project Area (percentage)	Project Area (miles)
Farmland of statewide importance	35%	1.1
Not prime farmland	54%	1.7
No digital data available	12%	0.4
Total	**100%**	**3.1**

Source: (NRCS 2019)

E.5 Supporting Information for Vegetation Resources

Table E-5. General Vegetation Within the Project Area.

Vegetation Species	Scientific Name
Big leaf maple	*Acer macrophyllum*
Black cottonwood	*Populus balsamifera*
Douglas fir	*Pseudotsuga menziesii*
Douglas spirea	*Spiraea douglasii*
Grand fir	*Abies grandis*
Oregon grape	*Mahonia aquifolium*
Oregon white oak	*Quercus garryana*
Ponderosa pine	*Pinus ponderosa*
Red alder	*Alnus rubra*
Snowberry	*Symphoricarpos albus*
Vine maple	*Acer circinatum*
Western hemlock	*Tsuga heterophylla*
Western red cedar	*Thuja plicata*
Wild rose	*Rosa acicularis*
Willow	*Salix* spp.

Source: (L. Perkins, FID Manager, personal communication, November 4, 2021)

Table E-6. Common Noxious Weeds Occurring in the Project Area.

Vegetation Species	Scientific Name
Spotted knapweed	*Centaurea stoebe*
Diffuse knapweed	*Centaurea diffusa*
Meadow knapweed	*Centaurea debeauxii*
Reed canary grass	*Phalaris arundinacea*
Scotch broom	*Cytisus scoparius*
Himalayan blackberry	*Rubus armeniacus*
Russian thistle	*Kali tragus*

Source: (L. Perkins, FID Manager, personal communication, November 3, 2021)

E.6 Supporting Information for Water Resources

E.6.1 Water Rights Information

Table E-7. FID Water Rights.

Certificate/Permit	Beneficial Use(s)	Location of Use	Season of Use
48819	Storage for Supplemental Irrigation	Upper Green Point Reservoir – T2N; R9E; S22 Lower Green Point Reservoir – T2N; R9E; S22	October 1 to April 14
67266	Hydropower	Plant 2 – T2N; R10E; S11	Year-round
67267	Hydropower	Plant 3 – T2N; R10E; S10	Year-round
96113	Primary Irrigation Supplemental Irrigation	T2N; R10E; S3-4, 8-10, 15-17, 19-21, 30 T3N; R10E; S33	April 15 to October 1
95435	Supplemental Irrigation	T2N; R10E; S4, 10, 15-17, 20-21	April 15 through September 30
95429	Primary Irrigation	T2N; R10E; S1-4, 10-12, 14-16, 20-21 T3N; R10E; S26-27, 33-36	April 15 to October 1
75809	Hydropower	Plant 2 – T2N; R10E; S11 Plant 3 – T2N; R10E; S10	Year-round
95430	Primary Irrigation Supplemental Irrigation	T2N; R10E; S4-5, 8, 10, 15-18, 20	April 15 through September 30
95436	Supplemental Irrigation	T2N; R10E; S4-5, 8 T3N; R10E; S33	April 15 to October 31
81600	Primary Irrigation Supplemental Irrigation	T2N; R10E; S16	April 15 through September 30
95431	Primary Irrigation	T2N; R10E; S3-5, 8-10, 15-17, 19-21, 30 T3N; R10E; S33	April 15 to October 1

Certificate/Permit	Beneficial Use(s)	Location of Use	Season of Use
95433	Primary Irrigation Supplemental Irrigation	T2N; R10E; S3-5, 8-10, 15-18, 20-21 T3N; R10E; S33	April 15 to October 1
95434	Supplemental Irrigation	T2N; R10E; S3-4, 8-10, 15-17, 19-21, 30 T3N; R10E; S33	April 15 through September 30
93490	Spray Water	T2N; R10E; S1-3, 10-12, 14-16, 20-21 T3N; R10E; S33-35	February 15 to November 15
93491	Spray Water	T2N; R10E; S3-5, 8-10, 15-20, 33	February 15 to November 15
93492	Fertilization Temperature Control Frost Protection	T2N; R10E; S1-3, 10-12, 14-16, 20-21 T3N; R10E; S33-35	February 15 to November 15
93493	Primary Irrigation	T2N; R10E; S17	April 15 through September 30
R-15387	Storage for Supplemental Irrigation and Flow Augmentation	Upper Green Point Reservoir – T2N; R9E; S22	November 1 to April 14
S-55225	Supplemental Irrigation	T2N; R10E; S4-5, 8, 10, 15-18, 20 T3N; R10E; S33	April 15 to September 30

Source: FID 2020

E.6.2 Water Loss Field Assessment

FARMERS IRRIGATION DISTRICT

WATER LOSS ASSESSMENT

Prepared by
Farmers Conservation Alliance

November 2021

Submitted to Farmers Irrigation District

Version: Final

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1 Introduction

Farmers Conservation Alliance (FCA) completed a water loss assessment in Farmers Irrigation District (FID or the District) on June 15 and 16, 2021. The purpose of this assessment was to quantify water losses within the District's unlined ditches due to subsurface infiltration, evaporation, plant and tree transpiration, or a combination of such factors. Data from the discrete seepage assessment were then used to extrapolate season-long estimates of total water loss volumes. These losses could represent potential water savings with modernization efforts. FCA selected an assessment timeframe to coincide with the middle of the irrigation season to avoid the beginning of the irrigation season, which reportedly has initial seepage rates that are higher than the seasonal average. Matt Melchiorsen, FCA Hydrologist, selected discharge measurement locations prior to data collection with help from Les Perkins, District Manager, and Megan Saunders, Watershed Project Manager. They selected the locations to minimize variability resulting from stream inflows and/or to quantify known losing reaches. FID coordinated with District patrons to temporarily turn off irrigation during the data collection period. Turning off irrigation greatly increased the accuracy of the assessment by eliminating uncertainties related to directly quantifying canal withdrawals. Figure 1-1 identifies the reaches and transect locations in the District that were included in this assessment.

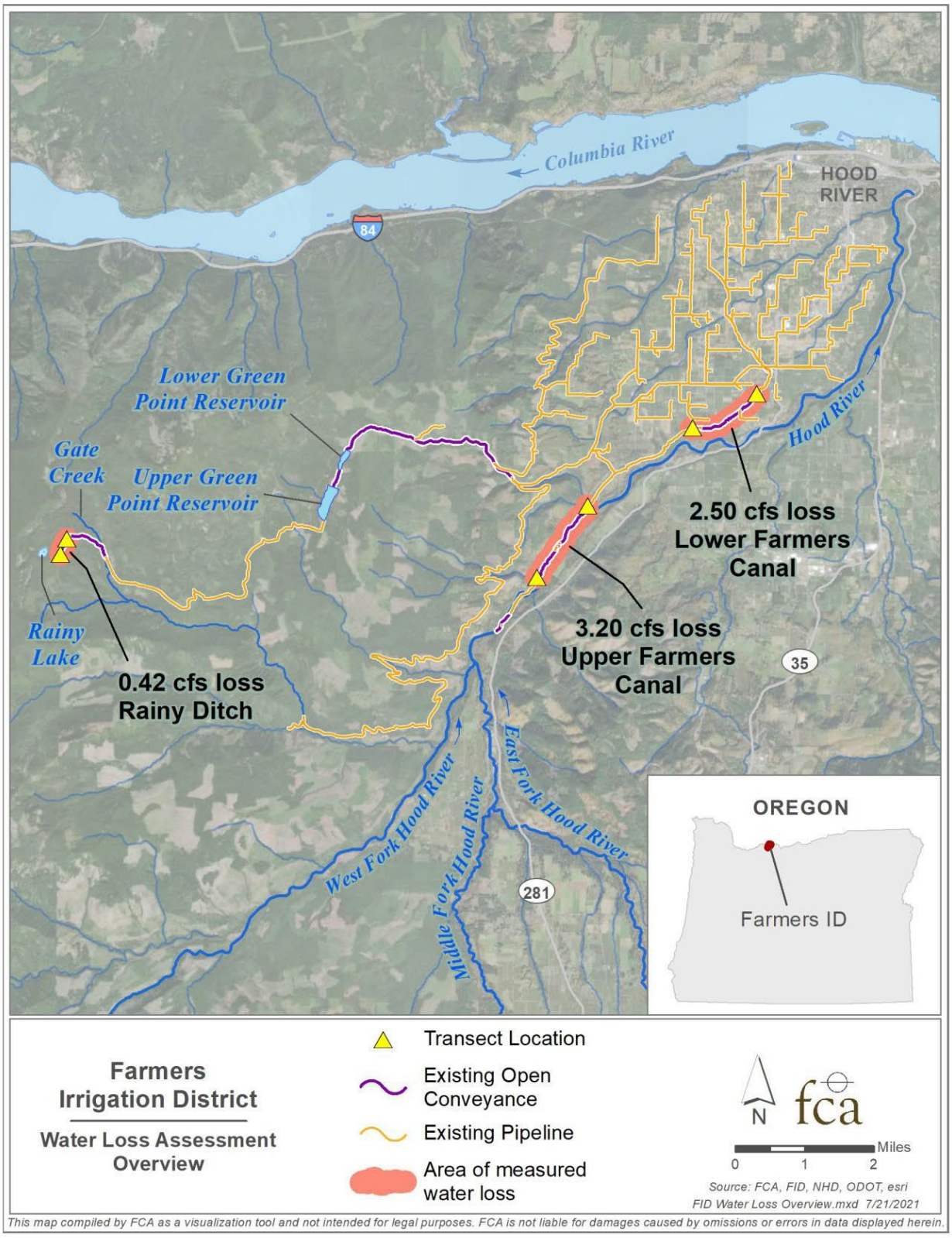

Figure 1-1. Seepage Sub-Reach Locations in Farmers Irrigation District.

2 Methodology

This section summarizes the methodologies used to conduct field measurements along with the analyses used to evaluate the measurements.

2.1 FIELD MEASUREMENTS

This section summarizes the field measurements that were conducted to assess seepage. Matt Melchiorsen led and oversaw the measurements; he has nearly fourteen years of experience as a hydrographer with the U.S. Geological Survey (USGS). Megan Saunders, FID Watershed Project Manager, assisted Matt in performing the measurements.

2.1.1 SEEPAGE

To measure losses associated with seepage, a total of two sub-reaches on the Farmers Canal and one sub-reach on the Rainy Ditch were measured and included in this assessment. The remainder of the District's conveyances were not included due to time constraints or the District's considering them to be less of a priority for modernization. Each sub-reach consisted of a measurement location (i.e., transect) at its upstream and downstream end.

Discharge measurements were performed in adherence to established USGS quality assurance protocols using SonTek Flow Tracker 2® Acoustic Doppler Velocimeters (ADVs) (Turnipseed and Sauer 2010). At each transect, the midsection method was used to estimate discharge. The midsection method was employed using standard methodologies. Under these methodologies, for a given discharge measurement, FCA aimed for a maximum of 5 percent of the total measured discharge in each measurement cell in the canal cross section (Buchannan 1969).

As an additional quality assurance measure, two measurements were made at each transect, either concurrently or sequentially, to verify that both measurements were within 5 percent of each other. Prior to each measurement, stage references were read when available. The stage (i.e., relative water surface elevation) was recorded before and after each measurement to ensure steady-state conditions. Photos and field notes associated with each transect can be found in Appendix A.

As mentioned earlier, seepage data from this assessment were used to extrapolate season-long estimates of potential water savings. The District provided FCA with daily values of flow from a gage located upstream from the two transects included in the study. For practical purposes, FCA's analysis centered around 'normal' irrigation season, and estimated losses using data between April 15 and September 30, 2020. Ratios were developed between the mean discharge as measured at the upper end of each transect, and the District provided data to scale the remainder of the daily values to the two study sub-reaches. Percent losses, as measured during the initial study, were then applied to the scaled daily values to estimate season long potential water savings. These volumes are presented below in Table 3-2.

2.2 ANALYSES

2.2.1 SEEPAGE

To estimate the loss or gain associated with each sub-reach and the corresponding discharge measurements, the following Equation 1 was used.

$$Q_{\Delta r,i} = Q_{upstream,i} + \sum_{j=1}^{n} Q_{inflow,j} - \sum_{k=1}^{m} Q_{diversion,k} - Q_{downstream,i}$$

Where:

$Q_{\Delta r,i}$ = Change in canal discharge (i.e., gain or loss) at sub-reach i

$Q_{upstream,i}$ = Average discharge at the upstream transect for sub-reach i

$Q_{downstream,i}$ = Average discharge at the downstream transect for sub-reach i

$Q_{inflow,j}$ = Inflow discharge at location j

$Q_{diversion,k}$ = Diversion discharge at location k

n = Total number of $Q_{inflow,j}$ between $Q_{upstream,i}$ and $Q_{downstream,i}$

m = Total number of $Q_{diversion,k}$ between $Q_{upstream,i}$ and $Q_{downstream,i}$

Equation 1

FCA estimated the uncertainty associated with these measurements using the USGS Discharge Measurement Quality Code (Turnipseed and Sauer 2010). Due to inherent uncertainties associated with using the midsection method for discharge measurements, accuracy ratings (in percent) were assigned to each measurement based on transect quality, velocity distributions, and overall site characteristics. The accuracy ratings are defined as follows:

- A discharge measurement with an "excellent" accuracy rating is within 2 percent of the actual flow.
- A discharge measurement with a "good" accuracy rating is within 5 percent of the actual flow.
- A discharge measurement with a "fair" accuracy rating is within 8 percent of the actual flow.
- A discharge measurement with a "poor" accuracy rating is 8 percent or greater than the actual flow.

Each measured discharge was multiplied by the assigned accuracy rating to present the measurement error in flow units (cfs). For a given sub-reach, the associated propagated uncertainty with the average discharge for either the upstream or downstream transects was calculated using Equation 2.

$$\delta Q_{upstream} \text{ or } \delta Q_{downstream} = \frac{\sqrt{(\delta Q_1)^2 + (\delta Q_2)^2}}{2}$$

Where:

$\delta Q_{upstream}$ *or* $\delta Q_{downstream}$ = Propagated uncertainty for $Q_{upstream,i}$ or $Q_{dowstream,i}$

δQ_1 = Assigned accuracy rating of the first measured discharge for $Q_{upstream,i}$ or $Q_{dowstream,i}$

δQ_2 = Assigned accuracy rating of the second measured discharge for $Q_{upstream,i}$ or $Q_{dowstream,i}$

Equation 2

Using the uncertainty estimated for each upstream or downstream transect of a given sub-reach, $\delta Q_{upstream}$ or $\delta Q_{downstream}$, the overall uncertainty associated with a sub-reach's loss was estimated using Equation 3.

$$\delta Q_{\Delta R,i} = \sqrt{(\delta Q_{upstream})^2 + (\delta Q_{downstream})^2}$$

$\delta Q_{\Delta R,i}$ = Propagated uncertainty for $Q_{\Delta R,i}$ at sub-reach i

$\delta Q_{upstream,i}$ = Propagated uncertainty for $Q_{upstream,i}$ at sub-reach i

$\delta Q_{downstream,i}$ = Propagated uncertainty for $Q_{downstream,i}$ at sub-reach i

Equation 3

3 Results

3.1 SYSTEM-WIDE LOSS SUMMARY

As discussed in Section 2, a total of three sub-reaches with a corresponding six measurement locations were used to estimate losses. Table 3-1 presents the estimated seepage losses for each section of canal and its sub-reaches as flow (cfs) and daily water volumes (acre-feet/day[af/day]).

Table 3-1. Farmers Irrigation District's Water Loss Summary.

Canal Name	Sub-Reach	Start Location ID	End Location ID	Measured Flow Loss (cfs)	Daily Volume Loss (af/day)
Upper Farmers Canal	FM.010	FM.010.0010	FM.010.0030	3.20	6.35
Lower Farmers Canal	FM.020	FM.020.0010	FM.020.0060	2.50	4.96
Rainy Ditch	RN.010	RN.010.0010	RN.010.0030	0.42	0.83
			Total:	**6.12**	**12.1**

Notes: cfs: cubic feet per second, af/day: acre-feet per day

Table 3-2. Farmers Irrigation District's Season-Long Loss Estimates.

Canal Name	Sub-Reach	Start Location ID	End Location ID	Average Flow Loss (cfs)	Total Volume Loss (af)
Upper Farmers Canal	FM.010	FM.010.0010	FM.010.0030	2.99	1,001
Lower Farmers Canal	FM.020	FM.020.0010	FM.020.0060	2.34	783
Rainy Ditch	RN.010	RN.010.0010	RN.010.0030	0.18	46.2
				Total:	**1,830**

Notes: cfs: cubic feet per second, af: acre-feet

3.2 SEEPAGE

This section presents the losses associated with each ditch that were measured as part of FCA's water loss assessment. Appendix B presents the discharge measurements and uncertainty calculations associated with each transect that were measured.

3.2.1 FARMERS CANAL LOSSES

The measured data collected on the Farmers Canal indicated total losses of 5.70 cfs, or approximately 11.3 af/day, as summarized in Table 3-3 and shown in Figure 3-1. The largest losses were measured in the Upper Farmers Canal, which begins below the outfall of the piped upper section and ends just above Ditch Creek and the intake to the next piped section at Reed Road. The channel along this sub-reach comprised primarily angular cobbles and gravels, set in what appeared to be a clay-loam soil. The lower sub-reach, which displayed lower loss amounts, was of similar composition, although it was concrete lined in several sections. In addition, there were several inflows to the lowers section of the canal, assumed to be return flows from irrigation occurring uphill.

Table 3-3. Farmers Irrigation District's Main Canal Measured Losses.

Sub-Reach	Description	Upstream Transect ID	Downstream Transect ID	Measured Flow Loss (cfs)	Sub-Reach Uncertainty (cfs)	Sub-Reach Loss (%)
FM.010	From 150 ft downstream of piped section outfall to 30 ft upstream of pipe intake near Ditch Creek	FM.010.0010	FM.010.0030	3.20	2.95	5.28%
FM.020	From 50 ft downstream of the City Inlet to just upstream from Draw 2 intake	FM.020.0010	FM.020.0060	2.50	2.86	4.30%
			Total:	**5.70**		

Notes: cfs: cubic feet per second

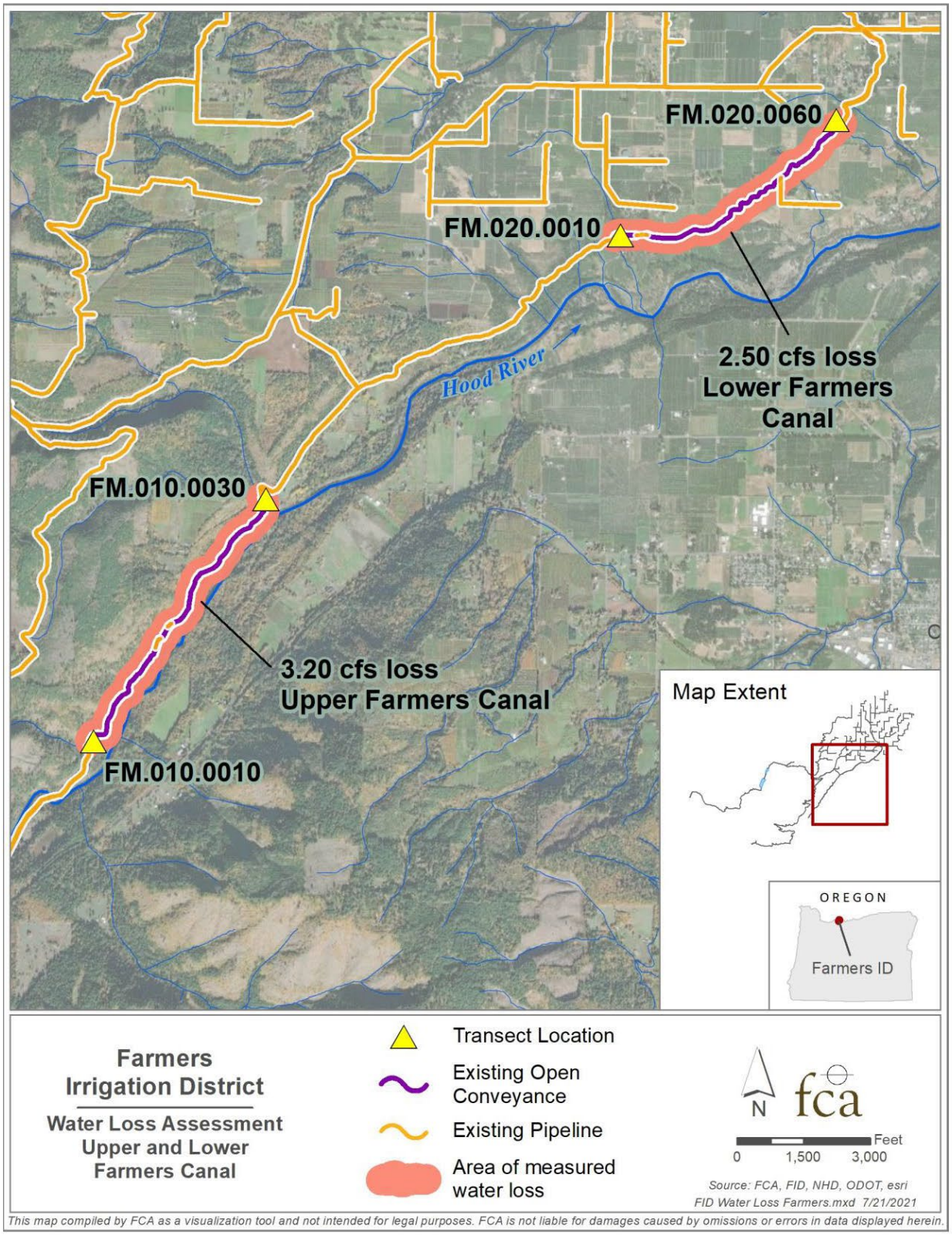

Figure 3-1. Measurement Locations on Upper and Lower Farmers Canal in Farmers Irrigation District.

3.2.2 RAINY DITCH LOSSES

The measured data collected on the Rainy Ditch indicated total losses of 0.42 cfs, or approximately 0.83 af/day, as summarized in Table 3-4 and shown in Figure 3-2. Ditch loss was discovered to be 100 percent. During data collection, the entire ditch was walked from the initial diversion point to where flow completely ceased. The channel along this sub-reach comprised primarily forest humus/organic material in a mineral soil, which appeared to be very well drained. It should be noted that earlier in the year, when full water rights can be captured at the diversion, results may differ. However, based on empirical observations of soil type and ditch composition, it is likely that this sub-reach of Rainy Ditch is still a losing conveyance at higher flows.

Table 3-4. Farmers Irrigation District's Rainy Ditch Measured Losses.

Sub-Reach	Description	Upstream Transect ID	Downstream Transect ID	Measured Flow Loss (cfs)	Sub-Reach Uncertainty (cfs)	Sub-Reach Loss (%)
RN.010	From just below the diversion off Rainy Creek to approximately 1/3 mile downstream	RN.010.0010	RN.010.0030	0.42	0.03	100%
			Total:	**0.42**		

Notes: cfs: cubic feet per second

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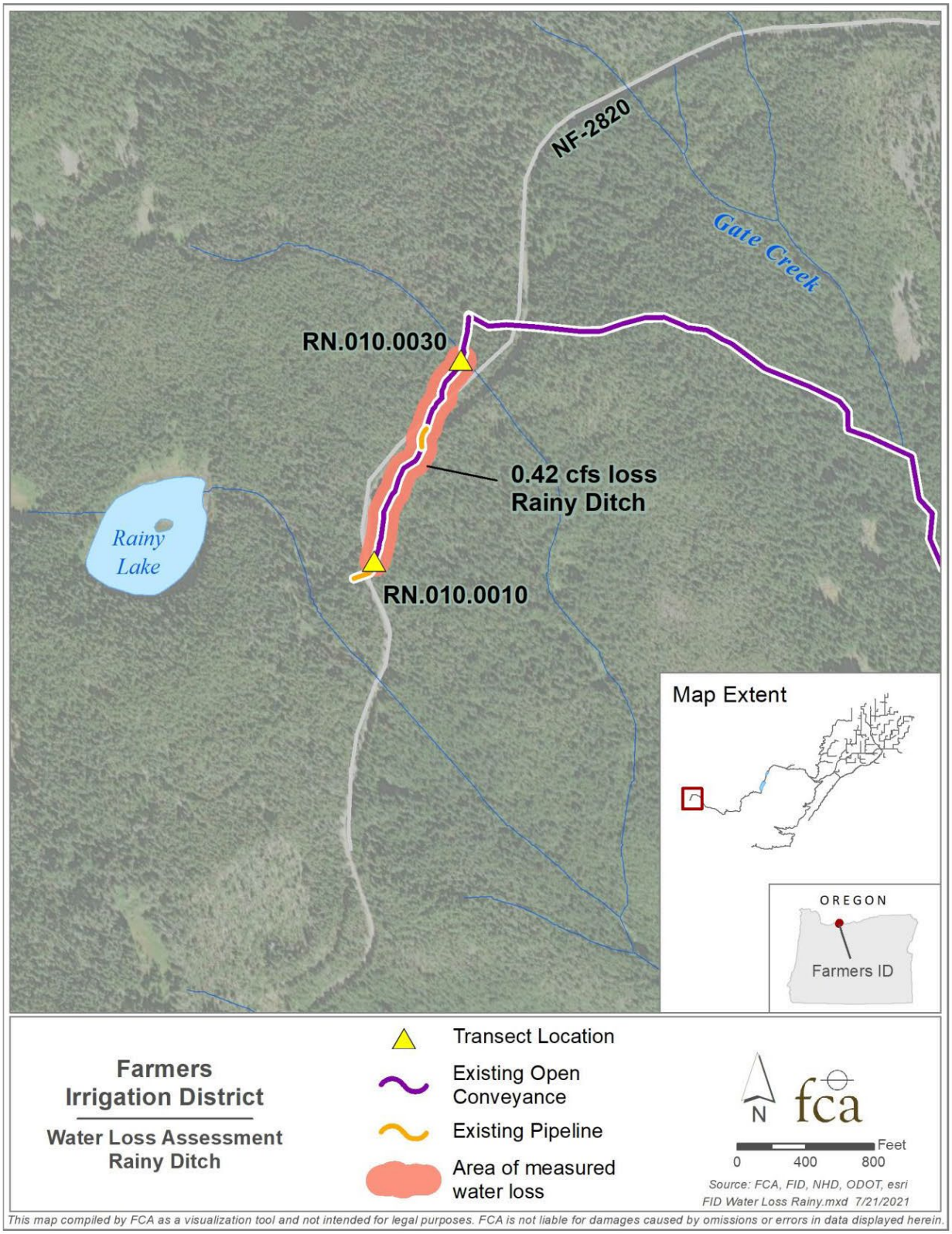

Figure 3-2. Measurement Locations on the Rainy Ditch in Farmers Irrigation District.

4 Discussion and Conclusions

Water loss measurements conducted by FCA in the Farmers Irrigation District on June 15 and 16, 2021 indicated seepage losses of 3.20 cfs in the Upper Farmers Canal, 2.50 cfs in Lower Farmers Canal, and 0.42 cfs in the Rainy Ditch. These values are supported by on-the-ground observations conducted during the field work. Saturated soils adjacent to both the Upper and Lower Farmers Canal, along with vegetation indicative of abundant moisture, were noted during data collection. The Rainy Ditch was primarily below surrounding land surface grade and did not exhibit evidence of seepage adjacent to the conveyance. However, visual evidence of continuous seepage was apparent as the ditch was followed downstream, eventually ending in a dry channel. These findings were also extrapolated between April 15 and September 30, using District flow data, to produce season-long loss estimates of potential water savings. This analysis resulted in an estimated 1,001 ac-ft of total seasonal loss in the Upper Farmers Canal sub-reach, 783 ac-ft in the Lower Farmers Canal sub-reach, and 46.2 ac-ft in the Rainy Ditch. Based on the results of this assessment, modernization of the earthen canals would likely result in water savings for the District.

Appendix A
Transect Summaries

A.1. FARMERS CANAL TRANSECT SUMMARIES

PHOTO 1. TRANSECT FM.010.0010 ON THE MAIN CANAL, JUNE 15, 2021

Location Description	Approximately 150 feet below the pipeline outfall into the unlined section of Upper Farmers Canal
Geographic Coordinates	45° 37' 24.56" N 121° 36' 54.28" W
Cross-Section Description	Firm, poorly sorted angular cobbles throughout; steady flows, swift centroid with good velocity distribution and smooth water surface
Stability Monitoring	A reference gage was monitored on the canal just upstream from the transect location, indicating steady-state flow during the concurrent measurements.
Reach Characteristics	The ditch downstream from the transect location comprised primarily angular cobbles and small boulders. Bank vegetation consisted of moderate grasses and established riparian vegetation. The location was selected in order to quantify baseline inflow to sub-reach 1 on the Upper Farmers Canal.
CMM#1 (cfs)	60.5
CMM#2 (cfs)	60.6
Mean Discharge (cfs)	60.6
Accuracy Rating	Measurements field rated good (+/- 5%); ISO generated uncertainty rated 2.7%

PHOTO 2. TRANSECT FM.010.0030 ON THE FARMERS CANAL, JUNE 15, 2021

Location Description	Approximately 30 feet upstream from the pipeline intake and 200 feet upstream from Ditch Creek
Geographic Coordinates	45° 38' 18.31" N 121° 36' 2.29" W
Cross-Section Description	Firm, poorly sorted angular gravel and cobbles, good depth and velocity distribution, with a smooth water surface
Stability Monitoring	A reference gage (OSS) was present on the canal just upstream from the transect location, reading 2.77 feet +/- .01 upon both arrival and departure, indicating steady-state flow during the concurrent measurements.
Reach Characteristics	The ditch both upstream and downstream from transect location comprised primarily cobbles and gravel. Bank vegetation consisted of light grasses and established riparian species. The location was selected in order to close out the loss assessment on sub-reach 1 on the Upper Farmers Canal.
CMM#1 (cfs)	58.1
CMM#2 (cfs)	56.7
Mean Discharge (cfs)	57.4
Accuracy Rating	Measurements field rated good (+/- 5%); ISO generated uncertainty rated 2.6%

PHOTO 3. TRANSECT FM.020.0010 ON THE LOWER FARMERS CANAL, JUNE 15, 2021

Location Description	On the Lower Farmers Canal, approximately 50 feet downstream from the City Inlet
Geographic Coordinates	45° 39' 17.12" N 121° 34' 11.30" W
Cross-Section Description	Firm, rectangular concrete with light gravel throughout, uniform depths and vertical banks; steady velocities, angles against the banks, smooth water surface
Stability Monitoring	A temporary reference gage (OSS) was set on the canal downstream from the transect location, reading 0.79 feet +/- .01 upon both arrival and departure, indicating steady-state flow during the concurrent measurements
Reach Characteristics	The ditch downstream from the transect location comprised primarily cobbles and gravels. Bank vegetation consisted of thick grasses and established conifer species. The location was selected in order to quantify baseline inflow to sub-reach 1 on the Lower Farmers Canal.
CMM#1 (cfs)	58.3
CMM#2 (cfs)	58.2
Mean Discharge (cfs)	58.2
Accuracy Rating	Measurement field rated good (+/- 5%); ISO generated uncertainty rated 2.8%

PHOTO 4. TRANSECT FM.020.0030 ON THE LOWER FARMERS CANAL, JUNE 15, 2021

Location Description	Approximately 25 feet below the Riverdale Road crossing
Geographic Coordinates	45° 39' 17.15" N 121° 34' 3.28" W
Cross-Section Description	Small diameter HDPE pipe contributing a minor amount of flow into the Lower Farmers Canal
Stability Monitoring	A reference gage (OSS) was not available at this location. Given the brief measurement, steady-state conditions can be assumed during the short stop for a volumetric determination of flow here.
Reach Characteristics	The ditch both upstream and downstream from transect location comprised primarily cobbles and gravels. Bank vegetation consisted of thick grasses and coniferous species. The location was selected in order to quantify this point inflow to the Lower Farmers Canal.
CMM#1 (cfs)	0.004
Mean Discharge (cfs)	0.004
Accuracy Rating	Measurement field rated good (+/- 8%)

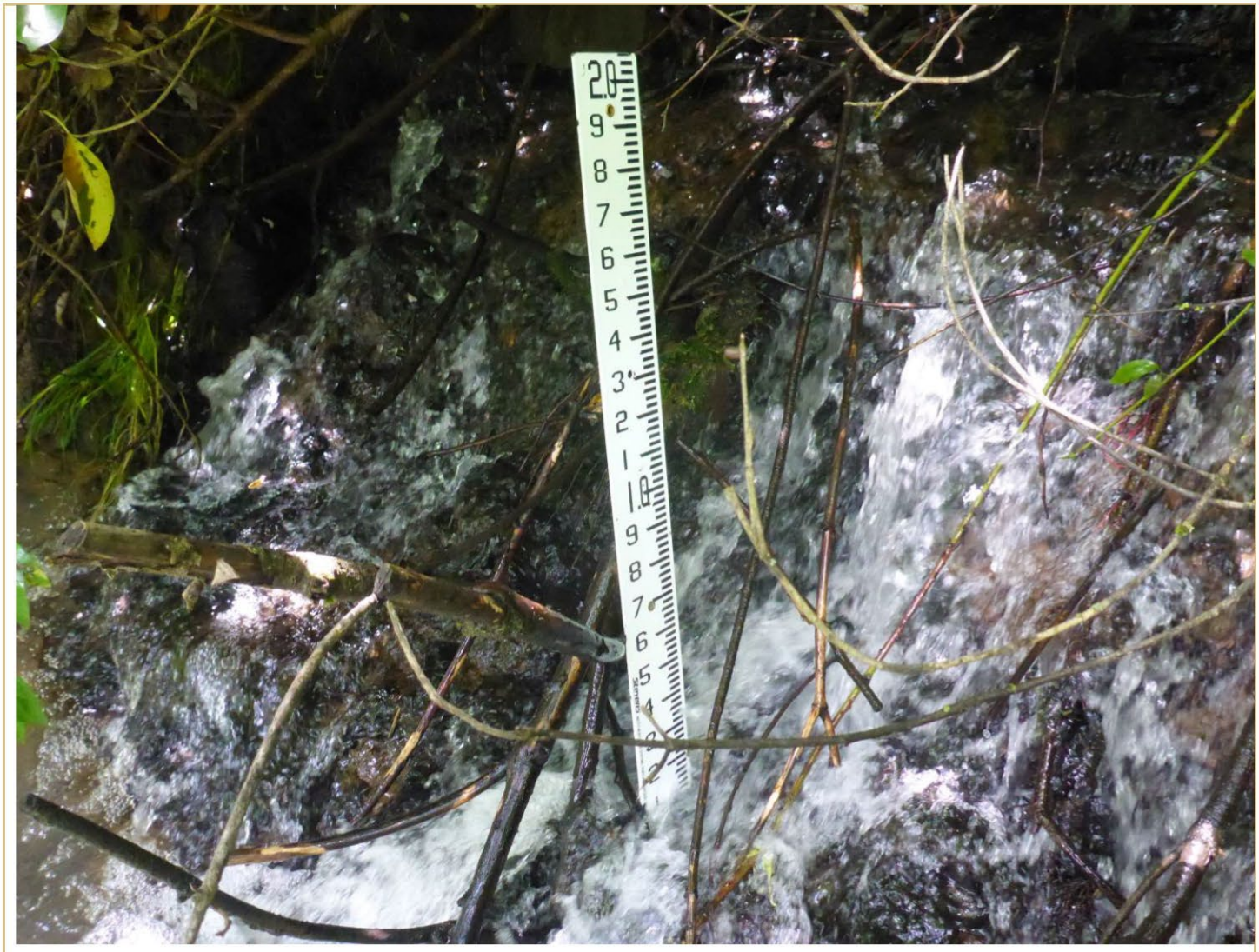

PHOTO 5. TRANSECT FM.020.0040 ON LOWER FARMERS CANAL, JUNE 15, 2021

Location Description	On the Main Canal, approximately 0.35 miles upstream from the Draw 2 intake
Geographic Coordinates	45° 39' 32.68" N 121° 33' 15.44" W
Cross-Section Description	Steep, shallow, braided inflows entering the Lower Farmers Canal from the left bank. Assumed to be return flows from uphill irrigation.
Stability Monitoring	Given the brief measurement, steady-state conditions can be assumed during the short stop for an estimated determination of flow here.
Reach Characteristics	Multiple small channels entering the canal from uphill against the right bank, with no way to accurately measure. This inflow was estimated visually to account for the contribution to overall canal discharge.
CMM#1 (cfs)	0.50
Mean Discharge (cfs)	0.50
Accuracy Rating	Measurement field rated poor (+/- 10%)

PHOTO 6. TRANSECT FM.020.0060 ON THE LOWER FARMERS CANAL, JUNE 15, 2021

Location Description	Approximately 60 feet upstream from the intake to Draw 2
Geographic Coordinates	45° 39' 42.28" N 121° 33' 1.48" W
Cross-Section Description	Firm, trapezoidal, concrete-lined section with light gravel throughout. Smooth water surface and good velocity distribution across channel.
Stability Monitoring	A temporary reference gage (OSS) was set prior to the concurrent measurements. Readings of 1.70 feet +/- .01 both before and after the measurements indicate steady-state flow conditions.
Reach Characteristics	The ditch both upstream and downstream from transect location comprised primarily cobbles and gravel. Bank vegetation consisted of thick grasses and established riparian tree species. Location was selected to close out the loss assessment on sub-reach 1 on the Lower Farmers Canal.
CMM#1 (cfs)	56.9
CMM#2 (cfs)	55.6
Mean Discharge (cfs)	56.2
Accuracy Rating	Measurements field rated good (+/- 5%); ISO generated uncertainty rated 2.7%

A.2. RAINY CANAL TRANSECT SUMMARIES

PHOTO 7. TRANSECT RN.010.0010 ON THE RAINY CANAL, JUNE 16, 2021

Location Description	Approximately 100 feet downstream from the diversion off Rainy Creek
Geographic Coordinates	45° 37' 35.37" N 121° 45' 26.29" W
Cross-Section Description	Firm organic matter/forest humus, shallow and narrow cross section, smooth water surface
Stability Monitoring	A reference gage (OSS) was available just upstream from the cross section. Readings of 0.24 feet +/- .01 both before and after the measurements indicate steady-state flow conditions.
Reach Characteristics	The ditch both upstream and downstream from transect location comprised primarily organic matter and forest soil. Bank vegetation consisted of sparse shrubs and established coniferous tree species. Location was selected to establish baseline inflow to the Rainy Ditch.
CMM#1 (cfs)	0.41
CMM#2 (cfs)	0.42
Mean Discharge (cfs)	0.42
Accuracy Rating	Measurements field rated poor (+/- 10%); ISO generated uncertainty rated 7.5%

PHOTO 8. TRANSECT RN.010.0030 ON THE RAINY CANAL, JUNE 16, 2021

Location Description	Approximately 0.25 miles downstream from the diversion off Rainy Creek
Geographic Coordinates	45° 37' 47.01" N 121° 45' 18.95" W
Cross-Section Description	Firm organic matter/forest humus, some sparse gravels, observation of zero flow
Stability Monitoring	A reference gage (OSS) was not available but given the dry channel no stability monitoring was required.
Reach Characteristics	The ditch both upstream and downstream from transect location comprised primarily organic matter and forest soil. Bank vegetation consisted of sparse shrubs and established coniferous tree species. Location was selected to identify where zero flow began below the diversion on the Rainy Ditch.
CMM#1 (cfs)	0.00
Mean Discharge (cfs)	0.00
Accuracy Rating	Measurements field rated excellent

Appendix B
District Measurement Data and Uncertainty Calculations

Table B-1. Discharge Measurement Data for the Upper Farmers Canal in Farmers Irrigation District, June 15, 2021.

Sub-Reach ID	Transect	Field Measurement Rating	Discharge (cfs)	Average Discharge (cfs)	Relative Uncertainty (%)	Absolute Uncertainty (cfs)	Uncertainty Paired Measurements (cfs)	Sub-Reach Loss (cfs)	Sub-Reach Uncertainty (cfs)	Sub-Reach Loss (%)
FM.010 (Upper Farmers Canal)	FM.010.0010	Good	60.5	60.6	5.0%	3.03	2.14	3.20	2.86	5.28%
		Good	60.6		5.0%	3.03				
	FM.010.0020	Good	58.1	57.4	5.0%	2.91	2.03			
		Good	56.7		5.0%	2.84				

Table B-2. Discharge Measurement Data for the Lower Farmers Canal in Farmers Irrigation District, June 15, 2021.

Sub-Reach ID	Transect	Field Measurement Rating	Discharge (cfs)	Average Discharge (cfs)	Relative Uncertainty (%)	Absolute Uncertainty (cfs)	Uncertainty Paired Measurements (cfs)	Sub-Reach Loss (cfs)	Sub-Reach Uncertainty (cfs)	Sub-Reach Loss (%)
FM.020 (Lower Farmers Canal)	FM.020.0010	Good	58.3	58.2	5.0%	2.92	2.06	2.50	2.86	4.30%
		Good	58.2		5.0%	2.91				
	FM.020.0060	Good	56.9	56.2	5.0%	2.85	1.99			
		Good	55.6		5.0%	2.78				

Table B-3. Discharge Measurement Data for the Rainy Canal in Farmers Irrigation District, June 16, 2021.

Sub-Reach ID	Transect	Field Measurement Rating	Discharge (cfs)	Average Discharge (cfs)	Relative Uncertainty (%)	Absolute Uncertainty (cfs)	Uncertainty Paired Measurements (cfs)	Sub-Reach Loss (cfs)	Sub-Reach Uncertainty (cfs)	Sub-Reach Loss (%)
RN.010 (Rainy Ditch)	RN.010.0010	Poor	0.41	0.42	10.0%	0.04	0.03	0.42	0.03	100%
		Poor	0.42		10.0%	0.04				
	RN.010.0030	Excellent	0.00	0.00	2.0%	0.00	0.00			
		Excellent	0.00		2.0%	0.00				

E.6.3 Water Loss Assumptions

To: Les Perkins, Farmers Irrigation District
From: Staff, Farmers Conservation Alliance
Date: September 12, 2023
Re: Water resources assumptions

Farmers Conservation Alliance (FCA) developed assumptions to inform the water resources analysis associated with the Farmers Irrigation District Infrastructure Modernization Project Plan-EA. The assumptions were used along with the measured water loss (see Appendix E.6.2) to calculate water loss for the project. These assumptions appear below.

Gauge Locations

- FID operates measurement points at three locations relevant to this project:
  - Fish Screen: Measures the flow rate in the Farmers Canal below the fish screen at the District's diversion on the Hood River. Data from this measurement point are not as accurate as data from the following two measurement points.
  - Deep Cut: Measures the flow rate in the Farmers Canal upstream of the upstream reach that would be modernized through this project.
  - Draw 2: Measures the flow rate in the Farmers Canal downstream of the downstream reach that would be modernized through this project.
- The flow rate at Deep Cut represents the flow rate entering reaches of the Farmers Canal that would be piped under this proposed project.

Diversion and Loss Rates

- FCA measured water losses on the Farmers Canal on June 15, 2021. On this date, FID was conveying 63.9 cfs in the canal above the measurement locations. FCA measured a total of 5.7 cfs of water loss on this date (FCA 2021a).
- FID has a maximum diversion rate of 73 cfs. Of that 73 cfs, FID typically diverts 40 cfs for irrigation. Depending on water availability, FID diverts up to an additional 33 cfs for hydropower production (L. Perkins, FID Manager, personal communication, June 13, 2023).
- FCA assumes that loss rates are proportional to canal flow rates. Following that assumption, the loss rate in the Farmers Canal would be 6.9 cfs at a canal flow rate of 73 cfs.
- When estimated conveyance rates exceed 73 cfs, a maximum rate of 73 cfs was assumed.

Water Savings

- Water savings on any given day will be proportional to FID's diversion rate. For example, if FID diverts 65.7 cfs (90 percent of 73 cfs), water savings will be 6.2 cfs (90 percent of 6.9 cfs).

- Water savings can be divided into agricultural water savings and hydropower water savings. For example, on a given day:
  - FID diverts 73 cfs, with 40 cfs (55 percent) for agricultural use and 33 cfs (45 percent) for hydropower use.
  - The proposed project would save 6.9 cfs, with 3.8 cfs (55 percent) saved from water diverted for agricultural use and 3.1 cfs (45 percent) saved from water diverted for hydropower use.

Potential Affects to Water Resources

- During normal years:
  - FID would restore 100 percent of the savings from water diverted for agricultural use instream the Hood River below Plant 2.
  - FID would restore 100 percent of the savings from water diverted for hydropower use instream the Hood River below Plant 2.
- During dry years:
  - FID would restore 75 percent of the savings from water diverted to agricultural use instream the Hood River below Plant 2. FID would retain 25 percent of the savings from water diverted for agricultural use.
  - FID would restore 100 percent of the savings from water diverted for hydropower use instream the Hood River below Plant 2.
- For the purposes of this project, FID will consider dry years to occur when the State issues a drought declaration for the region.

Periods of Analyses

- FID does not have a long-term, robust record of its diversions.
- The NEE analysis will use representative years selected from the period of record with diversion data available. FID has identified 2015 as a representative dry year and either 2019 or 2020 as representative normal years.
- USGS Gauge 13120000, Hood River at Tucker Bridge Near Hood River, Oregon, represents streamflow in the reach potentially affected by the project. The effects analysis uses a 30-year period of record for this reach. The effects analysis uses the 50 percent exceedance of daily average streamflow to represent normal years and the 80 percent exceedance of daily average streamflow to represent dry years.

Seasonality and Hydropower

- For the purposes of this analysis, FCA assumes the following pre-project diversion rates and seasons.

Table E-8. Pre-Project Diversion Rates and Seasons.

Months	Irrigation Rate	Hydropower Rate
October 1 to October 31	0 cfs	Up to 73 cfs (with approximately 1 week of shutdowns for maintenance)
November 1 to March 31	0 cfs	Up to 73 cfs (with approximately 1 week of shutdowns due to weather conditions)
April 1 to April 14	0 cfs	Up to 73 cfs
April 15 to September 30	40 cfs	Up to 33 cfs

- For the purposes of this analysis, there is no minimum rate for hydropower production. Any water conveyed in excess of 40 cfs during the irrigation season will go to hydropower.
- For the purposes of this analysis, any additional water available for hydropower would be used to generate additional hydropower (i.e., production is not limited by rate).
- For the purposes of considering potential effects, the effects analysis will assume that FID diverted the maximum rates identified in the table above except for during periods of shutdown.
- Following FID's Low Impact Hydrpower Institute agreement, FID does not divert for hydropower from August 16 through August 30 of each year.
- The District operates under a memorandum of agreement with the Oregon Department of Fish and Wildlife (ODFW) and the Oregon Department of Environmental Quality (ODEQ) related to Plant 2 hydropower operations to help maintain a minimum flow in the Hood River at Tucker Bridge (RM 6.0).
    - If the daily mean flow in the river drops below 250 cfs for 3 consecutive days, diversion into FID's Farmers Canal will not exceed 40 cfs until the flow in the river exceeds 250 cfs.
    - For the purposes of this analysis, FCA assumes that FID would not divert water for hydropower during August and September of dry years in order to comply with the memorandum of agreement.

E.7 Supporting Information for Fish and Aquatic Resources

Table E-9. Fish Species in Waterbodies Associated with District Operations.

Fish Species	Scientific Name	Origin
Bridgelip sucker	*Catastomus columbianus*	indigenous
Bull trout	*Salvelinus confluentus*	indigenous
Chinook salmon (spring and fall)	*Oncorhynchus tshawytscha*	indigenous
Brook trout	*Salvelinus fontinalis*	introduced
Brown trout	*Salmo trutta*	introduced
Chiselmouth	*Acrocheilus alutaceus*	indigenous
Coastal cutthroat trout	*Oncorhynchus clarkii*	indigenous
Coho salmon	*Oncorhynchus kisutch*	indigenous
Dace species	*Rhinichthys* spp.	indigenous
Largescale sucker	*Catostomus macrocheilus*	indigenous
Mountain whitefish	*Prosopium williamsoni*	indigenous
Pacific lamprey	*Lampetra tridentata*	indigenous
Rainbow trout	*Oncorhynchus mykiss irideus*	indigenous
Sculpin species	*Cottus* spp.	indigenous
Steelhead (summer and winter)	*Oncorhynchus mykiss*	indigenous
Three-spined stickleback	*Gasterosteus aculeatus*	indigenous

Source: Bonneville 1996; Hood River Watershed Group 2021; NOAA Fisheries 2021; USFWS 2021; Personal Communication, Jason Seales, ODFW, April 12, 2022
Note: Brown bullhead (*Ameiurus nebulosus*), northern pike minnow (*Ptychocheilus oregonensis*), and white sturgeon (*Acipenser transmontanus*) are three fish species that were identified in online databases as potentially existing in waterbodies associated with District operations. However, Jason Seales at ODFW provided technical assistance which indicated that these species did not exist in waterbodies associated with District operations (Personal communication, Jason Seales, ODFW, April 12, 2022). For this reason, we are not including brown bullhead, northern pike minnow, or white sturgeon in the above table.

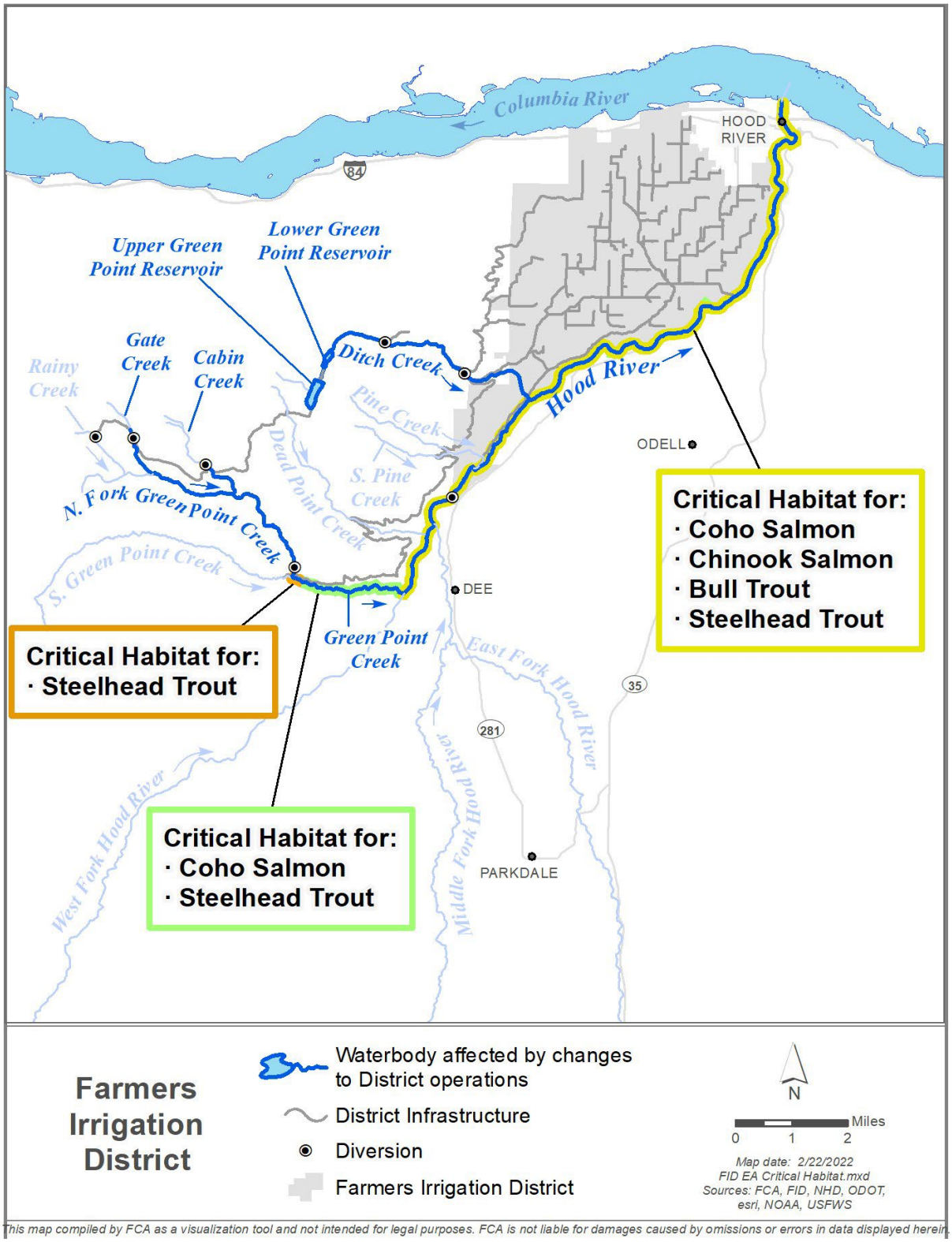

Figure E-1. Critical habitat designations for federally listed fish in the Hood River Basin.

E.8 Supporting Information for Wetlands and Riparian Areas Resources

The U.S. Army Corps of Engineers (USACE) administers Section 404 of the Clean Water Act (CWA) with the oversight of the U.S. Environmental Protection Agency (USEPA). This law regulates the placement of dredged or fill material in wetlands and other waters over which USACE has jurisdiction (or "jurisdictional wetlands").

Section 404 of the CWA defines wetlands as "those areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (USACE 1986).

The Oregon Department of State Lands (ODSL) implements the state's Removal-Fill Law (ORS 196.800-990), which regulates the removal or fill of material in wetlands or waterways. The law requires any person who plans to "remove or fill" material within "waters of the state" to obtain a permit from ODSL.

Per the Oregon Removal-Fill statute OAR 141-085-0515(9), an irrigation ditch is not jurisdictional under Oregon Removal-Fill permitting if it meets both of the following (ODSL 2013):

- The ditch is operated and maintained for the primary purpose of irrigation; and
- The ditch is dewatered[15] outside of the irrigation season except for isolated puddles in low areas.

On July 24, 2020, USACE and USEPA signed a memorandum providing a clear, consistent approach regarding the application of the exemptions from regulation under Section 404(f)(1)(C) of the CWA for the construction or maintenance of irrigation ditches and for the maintenance of drainage ditches. As defined in this memorandum, an "irrigation ditch" is a ditch that either conveys water to an ultimate irrigation use or place of use, or that moves and/or conveys irrigation water away from irrigated lands. Further, the construction and maintenance of irrigation ditches is considered an exempt activity under Section 404 of the CWA. However, the construction and maintenance of irrigation ditches[16] in jurisdictional wetlands or other waters of the U.S. may not meet this exemption.

Riparian areas are transition zones between waterbodies and adjacent upland areas and support hydrophytic vegetation that is dependent upon the hydrology of the waterbody. As defined by Section 404 of the CWA, riparian areas are "areas next to or substantially influenced by water. These riparian areas may include areas adjacent to rivers, lakes, or estuaries" (USEPA 2015). Riparian areas are typically associated with high water tables due to their close proximity to aquatic ecosystems; certain soil characteristics; and a range of vegetation that requires free water or conditions that are moister than normal (Oakley et al. 1985).

[15] "Dewatered" means that the source of the irrigation water is turned off or diverted from the irrigation ditch. A ditch that is dewatered outside of the irrigation season may be used for temporary flows associated with stormwater collection, stock water runs, or fire suppression.

[16] Irrigation ditches in the FID system are not drainage ditches; they do not intentionally accept water for any other use.

E.9 Supporting Information for Wildlife Resources

Table E-10. Wildlife Species Likely to Occur within the Project Area.[1]

Wildlife Species		Scientific Name
Mammals	Bat	*Vespertilionidae* spp.
	Black Bear	*Ursus americanus*
	Bobcat	*Lynx rufus*
	Cottontail rabbit	*Sylvilagus spp.*
	Coyote	*Canis latrans*
	Cougar (mountain lion)	*Puma concolor*
	Mule deer	*Odocoileus hemionus* spp.
	Raccoon	*Procyon lotor*
	Rocky mountain elk	*Cervus elaphus nelsoni*
	Skunk	*Mephitis mephitis*
	Western gray squirrel	*Sciurus griseus*
Birds	American crow	*Aphelocoma californica*
	California quail	*Callipepla californica*
	Dark-eyed junco	*Junco hyemalis*
	Northern flicker	*Colaptes auratus*
	Red-tailed hawk	*Buteo jamaicensis*
	Rufous hummingbird	*Selasphorus rufus*
	Turkey vulture	*Cathartes aura*
	Western scrub jay	*Aphelocoma californica*
Reptiles	Common garter snake	*Thamnophis sirtalis*
	Western rattlesnake	*Crotalus viridus*

Source: ODFW 2021; L. Perkins, FID Manager, personal communication, November 3, 2021
Notes:
[1] Partial list of wildlife species likely to occur in the project area; it is not exhaustive.

Table E-11. Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act Species Potentially Occurring within the Project Area.

MBTA/BGEPA Species[1]	Scientific Name
Bald eagle	*Haliaeetus leucocephalus*
Brewer's sparrow	*Spizella breweri*
California thrasher	*Toxostoma redivivum*
Cassin's finch	*Carpodacus cassinii*
Clarke's grebe	*Aechmophorus clarkii*
Evening grosbeak	*Coccothraustes vespertinus*
Golden eagle	*Aquila chrysaetos*
Great blue heron	*Ardea herodias fannini*
Lesser yellowlegs	*Tringa flavipes*
Lewis's woodpecker	*Melanerpes lewis*
Marbled godwit	*Limosa fedoa*
Olive-sided flycatcher	*Cantopus cooperi*
Rufous hummingbird	*Selasphorus rufus*
Sage thrasher	*Oreoscoptes montanus*
Semipalmated sandpiper	*Calidris pusilla*
Peregrine falcon	*Falco peregrinus*
Western screech-owl	*Megascops kennicottii kennicottii*
Willow flycatcher	*Empidonax traillii*

Source: USFWS 2021
Notes:
[1] Partial list of all migratory birds that potentially occur within the project area; this list is not exhaustive.

E.10 Supporting Information for Minimization, Avoidance, and Compensatory Mitigation Measures

Temporary Access

Prior to construction, the District would contact each landowner along the proposed route to discuss the project, and if applicable, approve an easement agreement at the site of the proposed project. Adjacent landowners would be provided with a construction schedule before construction begins. Construction limits would be clearly flagged to preserve existing vegetation and private property. Access to residences and farms would be maintained during construction. Construction would occur during the daytime to minimize disturbance to landowners or other individuals in the construction area vicinity.

Staging, Storage, and Stockpile

Mechanized equipment and vehicles would be selected, operated, and maintained in a manner that minimizes adverse effects on the environment. Construction staging areas would be selected and used to minimize effects on vegetation and avoid the removal of trees. Construction equipment and vehicles would be parked a minimum of 150 feet away from streams, wetlands, ditches, and other waterbodies at the end of each workday. Fueling and maintenance operations would be performed on a flat surface, away from moving equipment, and at least 150 feet away from any water source.

Roads and Traffic Control

Standard construction safety procedures and traffic control measures would be employed to reduce the risk of collisions between construction vehicles and other vehicles, pedestrians, or bicyclists while construction is ongoing. Lane closures on roadways would be avoided during peak travel periods where possible to reduce potential traffic delays from construction vehicles.

Erosion Control

Silt fencing, straw wattles, geotextile filters, straw bales, or other erosion control measures would be used to minimize soil erosion and prevent eroded soil from entering waterbodies during construction. Erosion control measures would be free of weeds and weed seeds. Drainage measures would be incorporated into the engineering design to minimize effects of piping canals on local flooding.

Spill Prevention, Control, and Countermeasure

Spill kits would be located at fuel storage areas, and the construction crew would have adequate absorbent materials and containment booms on hand to enable the rapid cleanup of any spill. Immediately upon learning of any fuel, oil, hazardous material including uncured concrete, or other regulated substance spill, or upon learning of conditions that would lead to an imminent spill, the person discovering the situation shall initiate actions to contain the fluid or eliminate the source of the spill and notify the spill coordinator or crew foreman immediately. If it is determined that a spill is beyond the scope of on-site equipment and personnel, an Environmental Emergency Response Contractor would be contacted immediately to contain or clean up the spill. Any spill into a waterbody or along the adjacent streambed would be reported immediately to Oregon Emergency Response Service at 1-800-452-0311 and the National Response Center at 1-800-424-8802. The spill coordinator would complete a spill report form for each release of a regulated substance, regardless of volume.

Invasive Species Control

The measures below would be followed to avoid the introduction of invasive plants and noxious weeds into project areas. Any gear to be used in or near water would be inspected for aquatic invasive species. Ground disturbances would be limited to those areas necessary to safely implement the Preferred Alternative.

Begin activities in areas uninfested with invasive plants or noxious weeds before operating in infested areas.

Use uninfested areas for staging, parking, and cleaning equipment. Avoid or minimize all types of travel through infested areas, and restrict necessary travel to those periods when the spread of seed or plant reproductive parts is least likely.

When it is necessary to conduct soil work in infested roadsides or ditches, schedule activity when seeds or propagules are least likely to be viable to be spread.

Monitor disturbed areas for at least three growing seasons following completion of activities. Provide follow-up treatments based on inspection results.

Inspect material sources at site of origin to ensure that they are free of invasive plant material before use and transport to the extent practicable. If possible, treat contaminated material before any use.

Revegetation

During excavation, any topsoil would be saved and replaced as the top layer after trenches are filled. Areas disturbed for access purposes or during construction would be regraded to their original contours. When necessary, compacted areas, such as access roads, staging, and stockpile areas, would be loosened to facilitate revegetation and improved infiltration. Disturbed areas would be planted with a native seed mix appropriate to the habitat. Revegetation practices would follow NRCS's *Oregon and Washington Guide for Conservation Seedings and Plantings* (NRCS 2000). Costs of revegetation are included in project installation cost estimates. Pruning and tree removal would occur entirely within the District's easements and would not exceed what is required for equipment clearance. At adjacent landowners' requests and during the non-irrigation season, the District would remove trees in the easement that did not survive.

Wildlife

Construction would occur outside of the primary nesting period for migratory birds of concern (April 15 through July 15) and raptors (April through July). For rare occasions where construction would occur during the primary nesting period, construction would occur outside the U.S. Fish and Wildlife Service (USFWS)-approved buffer distance of known nests. Should an active nest be found, construction would be paused and consultation with a local USFWS biologist would occur to determine the next steps.

In appropriate cases and under consultation with USFWS, ramps would be placed in open trenches during construction to avoid the potential for wildlife to become trapped overnight.

Cultural Resources

If archaeological resources were inadvertently discovered during construction, an inadvertent discovery plan would be followed. Construction would stop in the vicinity of the discovery, the area would be secured and protected, a professional archaeologist would assess the discovery,

consultation with SHPO and NRCS cultural resources staff would occur as appropriate, and the appropriate tribes would be notified. Continuation of construction would occur in accordance with applicable guidance and law.

Land Rights and Easements

Prior to construction, the District would communicate with landowners and obtain necessary easement agreements or land acquisitions.

For Rainy Ditch piping, Rainy Creek SCADA, and Forebay 3 expansion, following project installation, as-built surveys would be completed and attached to easements.

E.11 Supporting Information for Permits and Compliance

Local and County

Hood River County Planning: Under OAR 340-18, a Land Use Compatibility Statement would be submitted for County approval prior to construction. A Right-of-Way Permit may be required for work involving the Farmers Canal as it is located close to a County road; consultation with County planning officials would determine the need for a Right-of-Way Permit prior to construction.

Hood River County Floodplain Administrator: All work, except for construction of the expanded attenuation bay or sediment basin, would be outside of the 100-year floodplain. Consultation with the County floodplain administrator would determine appropriate permitting requirements for the expanded attenuation bay or sediment basin.

State

Department of Environmental Quality: The National Pollutant Discharge Elimination System program, implemented by ODEQ, would require a permit for construction activities including clearing, grading, excavation, and materials and equipment staging and stockpiling that would disturb one or more acres of land and have the potential to discharge into a public waterbody. The proposed project would meet these conditions, therefore prior to project construction, as appropriate, a permit would be applied for.

Department of State Lands: Prior to project implementation, consultation with ODSL would occur to perform wetland determinations for sites throughout the project area and determine exemption applicability to water conveyance infrastructure in the project area.

Oregon Fish Passage Law: Laws regarding fish passage are found in ORS 509.580 through ORS 509.910 and in OAR 635-412. Functioning fish screens are present at the District's irrigation diversions. Due to overflow from nearby ponds, there is a small population of resident trout and perch in the Farmers Canal. The District has performed fish salvage several times to ensure that fish populations are not entering the Farmers Canal from the Hood River. No additional consultation or permitting would be required because the District is in compliance with the Oregon Fish Passage Law and the Modernization Alternative would not affect the resident trout and perch in the Farmers Canal at a population level.

Federal

National Historic Preservation Act Section 106: Pursuant to 36 CFR Part 800 of the NHPA (1966, as amended in 2000), and the regulations of the Advisory Council on Historic Preservation implementing Section 106 of the NHPA (54 U.S.C. 306108), federal agencies must take into account the potential effect of an undertaking on "historic properties," which refer to cultural resources listed in, or eligible for listing in the National Register of Historic Places. Consultation with SHPO to fulfill Section 106 obligations would be completed for the project prior to implementation.

Clean Water Act:

Section 404: Under Section 404(f)(1)(C) of the CWA, discharges of dredged or fill material associated with construction or maintenance of irrigation ditches, or the maintenance (but not construction) of drainage ditches, are not prohibited by or otherwise subject to regulation under Section 404. Discharges of dredged or fill material associated with siphons, pumps, headgates, wingwalls, weirs, diversion structures, and such other facilities as are appurtenant to and functionally related to irrigation ditches are included in the exemption for irrigation ditches. Under 33 CFR 323.4(a)(1)(iii)(C)(1)(i), "[c]onstruction and maintenance of upland (dryland) facilities such as ditching and tiling, incidental to the planting, cultivating, protecting, or harvesting of crops, involve no discharge of dredged or fill material into waters of the U.S., and as such never require a Section 404 permit." The construction and maintenance of irrigation ditches and maintenance of drainage ditches may require the construction and/or maintenance of a farm road. Subsection 404(f)(1)(E) exemption for discharges of dredged or fill material associated with the construction or maintenance of farm roads applies where such related farm roads are constructed and maintained in accordance with BMPs. However, in 33 CFR 323.4(a)(6) and 40 CFR 232.3(c)(6), there must be assurance that flow and circulation patterns and chemical and biological characteristics of waters of the U.S. are not impaired, that the reach of the waters of the U.S. is not reduced, and that any adverse effect on the aquatic environment would be otherwise minimized. Prior to construction activities, coordination and consultation with USACE would occur and measures would be taken as required to identify and mitigate effects on potential jurisdictional wetlands and waters of the U.S.

Section 401: Section 401 of the CWA authorizes ODEQ to review proposed activities or facilities that require a federal permit and that may discharge into the waters of Oregon.

Farmland Protection Policy Act: The Farmland Protection Policy Act (7 U.S.C. 4201 *et seq.*) directs federal agencies to identify and quantify adverse impacts of federal programs to farmlands. The Act's purpose is to minimize the number of federal programs that contribute to the unnecessary and irreversible conversion of agricultural land to nonagricultural uses. A segment of the Farmers Canal piping would occur in an exclusive farm use zone (Hood River County 2021); however, all work would be done within existing easement agreements. The project would support agricultural production and the intention of the Act.

Endangered Species Act: The ESA establishes a national program for the conservation of threatened and endangered species and the preservation of the ecosystems on which they

depend. The ESA is administered by USFWS for wildlife and freshwater species, and by the National Marine Fisheries Service for marine and anadromous species. The ESA defines procedures for listing species, designating critical habitat for listed species, and preparing recovery plans. It also specifies prohibited actions and exceptions. Section 7 of the Act, called "Interagency Cooperation," is the mechanism by which federal agencies ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any listed species. Under Section 7, federal agencies must consult with USFWS when any action the agency carries out, funds, or authorizes (such as through a permit) *may affect* a listed endangered or threatened species.

Construction of the Modernization Alternative may result in a short-term increase in potential for sediment loading into project area waterways, which may temporarily affect water quality, affecting four ESA-listed fish species (Section 6.9.2.2 of the Plan-EA) and their critical habitat (70 Fed. Reg. 56211, 2005). Coordination with USFWS regarding ESA-listed fish species is ongoing, and informal Section 7 consultation under the ESA as amended would be initiated following the public review period.

Magnuson-Stevens Act: The Magnuson-Stevens Fishery Conservation and Management Act established requirements for including Essential Fish Habitat (EFH) descriptions in federal fishery management plans, and it requires federal agencies to consult with the National Marine Fisheries Service on activities that may adversely affect EFH (PL 104-297). EFH can include all streams, lakes, ponds, wetlands, and other viable waterbodies, and most of the habitat historically accessible to salmon necessary for spawning, breeding, feeding or growth to maturity. As the project would not adversely affect EFH, consultation under the Magnuson-Stevens Act is not required.

Safe Drinking Water Act: Since the project would have no direct or indirect discharge to groundwater, permitting under the Safe Drinking Water Act is not required.

Migratory Bird Treaty Act: The MBTA implements various treaties and conventions between the United States and other countries, including Canada, Japan, Mexico, and the former Soviet Union, for the protection of migratory birds (16 U.S.C. 703–712). Under the Act, taking, killing, or possessing migratory birds, or taking, destroying, or possessing their eggs or nests, is unlawful. The Act classifies most species of birds as migratory, except for upland and nonnative birds such as pheasant, chukar, gray partridge, house sparrow, European starling, and rock dove.

Bald and Golden Eagle Protection Act: The BGEPA prohibits the taking or possessing of and commerce in bald and golden eagles, with limited exceptions (16 U.S.C. 668–668d). The Act only covers intentional acts or acts in "wanton disregard" of the safety of bald or golden eagles. The project is not proximal to any known nesting sites; should nesting sites be discovered, requirements of the Protection Act would be implemented appropriately.

E.12 Guiding Principles

Guiding Principles (USDA 2017) The Guiding Principles identified in the PR&G are considered when developing and evaluating alternatives, as described below.	
Healthy and Resilient Ecosystems	A primary objective of the PR&G analysis is the identification of alternatives that protect and restore the functions of ecosystems. Alternatives should first avoid adverse impact. When environmental consequences occur, alternatives should minimize the impact and mitigate unavoidable damage. If damage occurs, mitigation to offset environmental damage must be included in the alternative's design and costs.
Sustainable Economic Development	Alternatives for resolving water resources problems should improve the economic well-being of the Nation for present and future generations. The PR&G analysis considers the effects of alternatives on both water availability and water quality to evaluate the sustainability of economic activity and ecosystem services. Water use or management factors that provide improved sustainability or reduced uncertainty should be identified in alternatives.
Floodplains	The PR&G seek to avoid unwise use of floodplains and flood prone areas. Alternatives should avoid investments that adversely affect floodplain function, such that the floodplain is no longer self-sustaining. If an alternative impacts floodplain function, then the alternative should describe efforts to minimize and mitigate the impact and the residual loss of floodplain function. The PR&G investment evaluation of alternatives must be consistent with Executive Order 11988 of May 24, 1977 (Floodplain Management), as modified by Executive Order 13690 of January 30, 2015 (Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input), and the Federal Flood Risk Management Standard, which require executive departments and agencies to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. The PR&G investment evaluation is informed by the processes to evaluate the impacts of Federal actions affecting floodplains consistent with Executive Order 11988, as amended.
Public Safety	An objective of the PR&G is to reduce risks to people, including life, injury, property, essential public services, and environmental threats concerning air and water quality. These risks to public health and safety must be evaluated and documented for all alternatives, including those using nonstructural approaches. The residual risks to public health and safety associated with each of the water investment alternatives should be described, quantified if possible, and documented.

Environmental Justice	An objective of the PR&G investment evaluation process is the fair treatment of all people including meaningful involvement in the public comment process. Any disproportionate impact to minority, Tribal, and low-income populations should be avoided. In implementing the PR&G, agencies should seek solutions that would eliminate or avoid disproportionate adverse effects on these communities. For watershed investments, particular attention should be focused to downstream areas. The study area may need to be reexamined to include the concerns of affected communities downstream of the immediate investment area. The PR&G process should document efforts to include the above-mentioned populations in the planning process. The PR&G process must be in compliance with Executive Order 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations). Applications of the PR&G process in USDA agencies must be in compliance with USDA DR 5600-002 (Environmental Justice).
Watershed Approach	A watershed approach must be used when completing a PR&G analysis. This approach recognizes that there may be upstream and downstream impacts of a water resources activity that may be outside of the applicable political or administrative boundaries. A watershed approach is not necessarily limited to analyzing impacts within a specific hydrologic unit. Rather, it is broad, systems-based framework that explicitly recognizes the interconnectedness within and among physical, ecological, economic, and social/cultural systems. A watershed approach enables examination of multiple objectives, facilitates the framing of water resources problems, incorporates a broad range of stakeholders, and allows for identification of interdependence of problems and potential solutions. In many instances, a specific hydrologic unit may be the appropriate scale to examine alternatives to address water resources problems and opportunities. In this case, the watershed would become the study area. In other cases, environmental, economic, or social conditions may merit a study area that is combination of various hydrologic units or other geographic groupings. Ideally, the area of analysis should represent a geographical area large enough to ensure plans address cause and effect relationships among affected resources, stakeholders, and investment options, both upstream and downstream of an investment site. The watershed approach also establishes the framework to examine cumulative effects and the interaction of a potential Federal investment with other water resources projects and programs. When considering the impact of Federal investments against some economic and ecological measures, the analysis may need to be expanded to include regional markets and habitat considerations beyond the initial study area (e.g., beyond the immediate hydrologic unit).

E.13 References

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