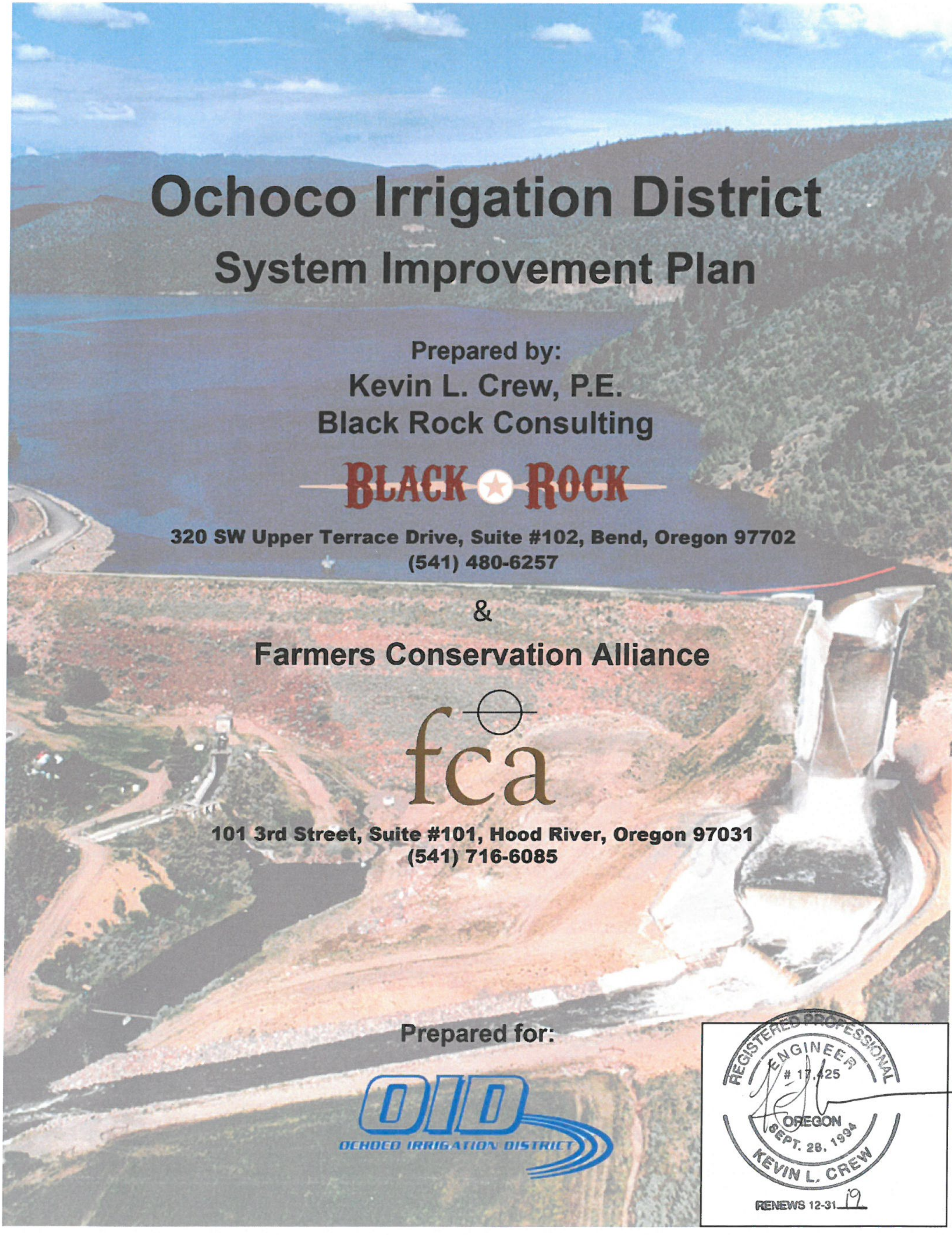


Ochoco Irrigation District

System Improvement Plan

Prepared by:

Kevin L. Crew, P.E.

Black Rock Consulting

BLACK ROCK

320 SW Upper Terrace Drive, Suite #102, Bend, Oregon 97702

(541) 480-6257

&

Farmers Conservation Alliance

fca

101 3rd Street, Suite #101, Hood River, Oregon 97031

(541) 716-6085

Prepared for:

OID

OCHOCO IRRIGATION DISTRICT

REGISTERED PROFESSIONAL ENGINEER

17,425

OREGON

SEPT. 28, 1994

KEVIN L. CREW

RENEWS 12-31-19

Table of Contents

Executive Summary

Farmers Conservation Alliance commissioned this System Improvement Plan with support from the Energy Trust of Oregon. The purpose of this System Improvement Plan (SIP) was to develop a well-considered evaluation of the District's primary and secondary canal systems, a mitigation plan for the seepage losses, and consideration of resulting pressurized deliveries, if any. System piping was the primary method proposed for such mitigation.

In January and February of 2017, meetings were held with District staff to confirm approach on the SIP. Data requests were fulfilled by the District. The District and Black Rock Consulting determined that a value of 7.5 GPM/Acre should be used for hydraulic modeling and pipe sizing purposes. The cost estimate resulting from the SIP should provide District flexibility and should provide grouped project seepage loss and cost of mitigation (through piping) information. The District wishes to continue evaluations of hydroelectric power potential at the Ochoco and Bowman Dams. The SIP should provide a reconnaissance-level impact assessment of the effects of the proposed McKay Creek project to add 650 acres to the District. Lastly, the model should include future acreage capacity in five areas.

The District's patrons are served by two primary diversions fed by two reservoirs. The current estimated acreage served from these sources and the District's canal system is approximately 18,480 acres and direct creek and river withdrawals another 1,190 acres. The primary canals and laterals were evaluated for seepage loss using state-of-the-art measurement equipment and it was found that approximately 53 CFS were being lost at the time of measurements. Of the 53 CFS, it was determined that approximately 41 CFS might be conserved if the system were completely piped (assuming peak flows of 7.5 GPM/Acre delivered within the piped system).

The District will continue to evaluate hydroelectric potential at Ochoco Dam (500 kW and 1,360,667 kWh) and Bowman Dam (currently 2.5 MW in a cooperative with the City and County). Fully piping the District system will accomplish low to moderate pressurization of the District resulting in the estimated reduction of 2,687,650 kWh in patron pumping costs each season. No pressure reducing valves were found to be necessary.

Concurrent with the proposed piping, new Crooked River Pump Stations are included, to address proposed system hydraulic requirements and to adequately serve irrigation capacities. The four pump stations will conserve an approximate 1,942,311 kWh annually.

For HDPE pricing, a pipe manufacturer/vendor was contacted to provide budgetary pipe cost information for pipe delivered to Central Oregon. For large diameter profile wall pipe, current construction bids were incorporated. This information was used to develop reconnaissance-level cost estimates to design and construct the entire piped system to all patron and private delivery points. The cost estimates were evaluated and broken into grouped cost elements. An At-A-Glance map and summary tables are provided in Section 1 indicating the summary results of this System Improvement Plan. The At-A-Glance table also includes the cost of implementing the new Crooked River Pump Stations and the cost of implementation of the Ochoco Dam Hydroelectric Power Project.

Section 1

At-A-Glance System Modernization Summary

Figure 1.1 At-A-Glance Ochoco Irrigation District System Improvement Plan

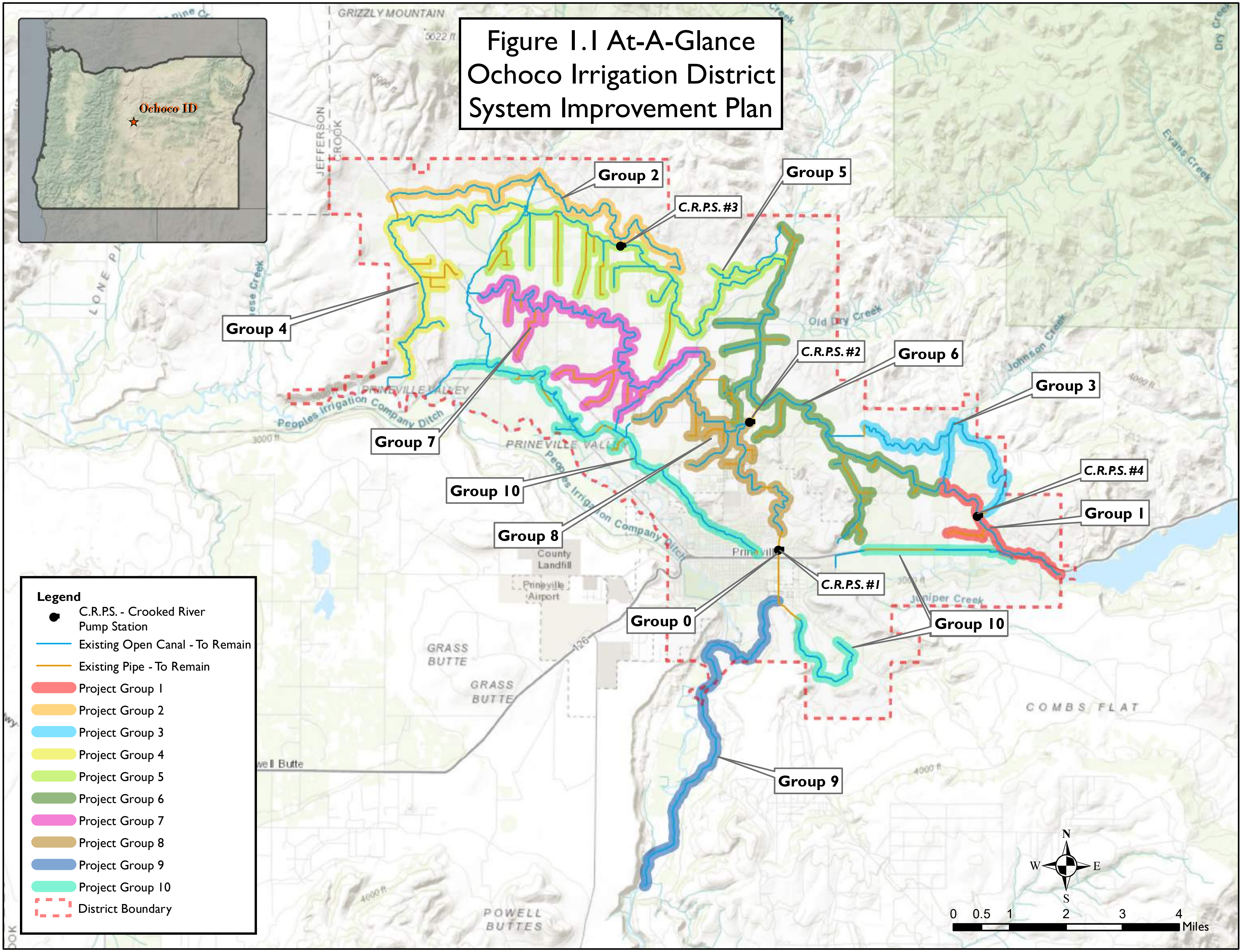


Table 1.1 At-A-Glance Main Canal and Lateral Piping

AT A GLANCE - MAIN CANAL AND LATERAL PIPING					
PROJECT GROUP	CANAL/LATERAL	EST. WATER CONSERVATION (CFS)	EST. ENERGY CONSERVATION (KWH/YR)	LENGTH PIPED (FT)	RECON-ESTIMATED COST
0	Crooked River Pump Station No. 1		642,950		$4,737,158
1	Ochoco Main Canal - Upper	1.1	90,615	15,322	$14,779,690
1	Lanius Lateral				
2	Grimes Flat East and West Laterals	3.8	280,163	43,165	$3,354,419
2	Crooked River Pump Station No. 3		306,239		$381,330
3	Johnson Creek Lateral	0.0	72,971	33,566	$1,899,966
3	Crooked River Pump Station No. 4		421,466		$323,354
4	Ochoco Main Canal - Tail	4.8	327,023	57,490	$18,910,266
4	459 Lateral				
4	451 Lateral				
4	449 Lateral				
5	Ochoco Main Canal - Lower Middle	2.9	762,589	82,723	$36,887,476
5	Lytle Creek Lateral				
5	W-Lateral				
5	407 Lateral				
5	401 Lateral				
5	393 Lateral				
5	391 Lateral				
5	389 Lateral				
5	381 Lateral				
5	375R Lateral				
5	369 Lateral				
5	West McKay Lateral				
6	Ochoco Main Canal - Upper Middle	4.8	531,580	87,864	$58,694,977
6	Cox Lateral				
6	321 Lateral				
6	Tunnel Lateral				
6	315 Lateral				
6	311 Lateral				
6	301 Lateral				
6	J-Lateral				
6	161 Lateral				
7	CR Distribution Canal - Tail	7.6	212,326	76,330	$17,127,118
7	825 Lateral				
7	819 Lateral				
7	817 Lateral				
7	815 Lateral				
7	799 Lateral				
7	785 and 785A Laterals				
7	779 Lateral				
7	777 Lateral				
8	CR Distribution Canal - Upper	6.2	168,999	53,551	$41,299,550
8	769 Lateral				
8	763 Lateral				
8	755 Lateral				
8	B-Lateral				
8	Crooked River Pump Station No. 2		571,656		$2,464,745
9	Crooked River Diversion Canal	9.3	16,757	39,610	$52,622,431
10	Combs Flat Lateral	0.6	224,628	79,414	$9,677,792
10	Breese Lateral				
10	Rye Grass Canal				
11	Prineville Reservoir Hydro Project				$2,008,600
	TOTAL=	**41.0**	**3,987,011**	**569,034**	**$265,168,874**

Section 2

Project Description and Overview

2.0 Authorization

Farmers Conservation Alliance commissioned this System Improvement Plan with support from the Energy Trust of Oregon and authorized its preparation on March 29, 2016 through a Consultant Services Agreement by and between the Farmers Conservation Alliance (FCA) and Black Rock Consulting (BRC).

2.1 Purpose

The Ochoco Irrigation District, with headquarters in the historic Prineville, Oregon operates water rights dating back as far as 1869 (just 4 years after the American Civil War ended). A majority of its water right priority dates range from 1869 to 1917 and one small industrial water right was also procured in 1986 from Ochoco Creek and Ochoco Reservoir. The District currently serves approximately 19,670 acres of irrigated lands located in the Prineville, Oregon area generally spanning from about 5 ½ miles east of Prineville at the Ochoco Reservoir to approximately 12 miles west of Prineville. Generally, the District boundary is approximately 6 miles in width, bounded by the Crooked River on the southwest, and serves approximately 606 delivery accounts. The District has a contractual relationship with the United States Bureau of Reclamation regarding ownership and operation of elements of the Ochoco Irrigation District system and associated reservoirs.

The District operates and maintains over 122 miles of main canal and laterals, including existing piped segments (excluding drains), 8 pumping plants, and operates the Ochoco Reservoir and the Prineville Reservoir. The District's service area is across sloping terrain with its three primary canals traversing the sloped terrain and each canal terraced below the next. The geology of the area is mixed. Seepage losses do exist in the system although they are not as pronounced as some of the other Central Oregon irrigation district systems; however, tailwater, runoff, and returning flows from the system are more pronounced within the Ochoco Irrigation District. Of the approximate 80,000 AF diverted annually, approximately 18,000 AF are lost to returning flows from the system.

The purpose of this System Improvement Plan (SIP) is to develop a well-considered evaluation of the District's primary and secondary canal systems, a mitigation plan for the seepage and returning flow losses, and consideration of resulting low-head deliveries. Consistent with its existing modernization program, well under way, system piping is to be the primary method proposed for such mitigation.

The plan will become a key element of the District's planning documents and is expected to become the basis for future phased construction of the District's conveyance system.

2.2 Scope of Services

Black Rock Consulting (hereinafter "BRC") was employed to provide the following services and deliverables in conjunction with this plan:

Kickoff Meeting -

> Prior to the kick-off meeting, BRC requested updated account delivery information related to all of the District's patrons.
>
> BRC met with District staff and management to confirm approach to the study. BRC developed a list of questions to review with District staff. At these meetings BRC requested documents for major system elements that affected system hydraulic modeling, requested a copy of the District Water Conservation Plan, and requested water diversion and water right information, and associated operational input from the District.
>
> BRC discussed seepage loss information with the District and discussed the concluded loss assessment program implemented by BRC within the District.
>
> Hydroelectric power potential and system pressurization was also discussed.

Review of Materials -

> BRC reviewed materials obtained from the District following the kick-off meetings to ensure that required materials for moving the study forward were obtained or readily supplemented during the study to develop the deliverables indicated below. Data gaps that were found during the meeting process were identified and resolved with District staff.

Coordination -

> BRC coordinated with the OID staff at various project milestones to confirm that the System Improvement Plan continued to be developed in accordance with the direction of OID.

Seepage Loss Study -

> BRC coordinated the development of a seepage loss study with OID staff. The seepage loss study identified a program of seepage loss measurements for the OID system to support loss assumptions to be used in the SIP and to assist with water conservation estimates and system implementation phasing development.

Review of Provided Flow Data -

BRC provided a thorough review of diversion data and on-farm delivery rates (per water right certificates) to insure a clear understanding of delivery approach. BRC coordinated with the District to insure rates used in system evaluation and modeling were as agreed to by the District.

OID SIP Base Map Development -

In conjunction with OID staff, BRC, OID, and FireWhat? developed an SIP primary and secondary canal and lateral system base map. The base map was populated with the OID primary and secondary canal system in its existing state.

OID SIP Improvement Map Development -

BRC (with OID input) developed a proposed primary and secondary system piping overlay on the base map. To the extent possible, existing mapping obtained as described above was used for this purpose. This map included an aerial underlay as available and as practical to manage file size.

OID SIP Hydraulic Model -

BRC confirmed approach regarding system piping with OID. Following the agreed approach discussed with OID and following delivery of basic system control and elevation information from FireWhat?, BRC then modeled the primary and secondary system elements (i.e. primary and secondary system canals and laterals) with EPANET hydraulic modeling software. Flow assumptions were based upon the rates agreed with OID staff. From iterations of model runs, BRC developed system elements including piping, pump stations, primary system valving points, as necessary, etc. Pipe materials and diameters were determined during this analysis.

OID SIP Phasing Approach -

In conjunction with the system model and upon review with OID, BRC developed a system improvement cost estimate that was broken down by phasing elements as agreed to by the District. Phasing elements were not considered to be the only approach possible, but serve as a starting point for phasing, cost, and funding considerations.

OID SIP Conservation Table -

BRC developed a table indicating water conservation estimates based upon historic diversions, desired delivery rates within a fully piped system, and also corroborated by the loss assessment program results.

Final SIP Mapping -

In conjunction with OID staff, BRC developed a final SIP map indicating primary and secondary canal system elements, indications of existing and proposed piping, key necessary pump stations, and other key system elements.

Reconnaissance-Level Cost Estimate -

BRC coordinated with reputable material vendors and engineering resources and developed reconnaissance-level cost estimating for the proposed piping system and pumping identified for the District.

SIP Reporting -

BRC compiled the results of the SIP study into this System Improvement Plan draft report for review and comment by OID. Comments received were incorporated as appropriate into the Final SIP Report. The report includes mapping and summarizes all findings for elements identified above.

2.3 Goals and Objectives – District Meeting(s)

As indicated in the scope, Black Rock Consulting met with District staff on January 18, 2017 and on February 1, 2017. Black Rock Consulting and District staff discussed key project parameters required to establish the approach for the SIP.

The meeting on January 18, 2017 was attended by:

Russell Rhoden, District Manager
Julie Vaughan, OID Office Administrative Staff
Kevin L. Crew, Principal, Black Rock Consulting

The subsequent meeting on February 1, 2017 was attended by Russell Rhoden and Kevin L. Crew.

Key agenda items addressed were as summarized below:

1) Data Needs: District Water Right Certificates, District's Water Management and Conservation Plan, District's Most Recent Irrigated Acre Accounting, Direct River Points of Delivery and Primary Diversions, Diversion Flow Rate Records

   These materials were either provided to Black Rock Consulting and discussed in some detail, or Black Rock Consulting was directed where to obtain these materials. Clarifications were provided by the District.

2) How will the new Federal legislation related to Bowman Dam affect diversions to the District?

It is not anticipated that the legislation will affect the normal diversion method or flow rates to District patrons at the Crooked River Diversion Canal.

3) What are the plans for piping and pressurization of the District?

The District has some segments of piping already in place. Certain segments of existing pipe may tolerate pressurization whereas others likely will not. With only a few noted exceptions, the entire system should be modeled and new proposed pipe and pump stations sized. The District will evaluate what pipes it may wish to preserve once it has the model results, including anticipated pressures, etc. and as it designs and implements its improvements.

Generally, the District plans to pipe a majority of its system, however, the prioritization and timing of piping will be an ongoing consideration by the District.

The District would like to continue to explore hydroelectric power potential at the Bowman Dam and at the Ochoco Reservoir Dam. It is anticipated that pressures within the piped system will not support significant hydroelectric power generation potential versus the benefit of pressurization to the Patrons and reduction in pumping costs.

Given the irrigation system complexity with pumping systems, surface water rights, and returning beneficial flows, the District recommends piping from the most topographically high elements of the system to the lower system elements. Given this approach, Grimes Flat East and West Laterals and the Ochoco Main Canal may first be considered for piping, then the Crooked River Distribution Canal, followed by the Crooked River Diversion Canal and lastly the Rye Grass Canal.

A project on McKay Creek has been considered by the District. Should this project proceed, it would add an additional 650 acres of irrigation demand on the system that should be supplied predominantly from the Crooked River Diversion and the subsequent canals and pumping systems necessary to deliver the water to the additional acreage.

4) What irrigation delivery flow rate should be used per acre in the District for system pipe sizing? Does the District anticipate any shift of acreage or flow rates within the District boundary and service areas?

   The model should use 7.5 GPM/Acre for normal delivery modeling at 5 FT/S velocities or less in system elements per NRCS guidelines. The modeling should also consider future demands in particular District areas:

   - *Johnson Creek Lateral – 100 acres,*
   - *Grimes Flat West Lateral – 50 acres,*
   - *Grimes Flat East Lateral – 50 acres,*
   - *the Gap area of the Ochoco Main Canal Tail – 50 acres,*
   - *Diversion Canal – 50 acres.*

Section 3

Existing System

3.0 Existing System Description

Please refer to Figure 3.0.1 regarding the existing District Delivery System that indicates the District service territory boundary, measurement points, and the primary canal system.

Under its certified water rights, the Ochoco Irrigation District stores water in the Ochoco Reservoir located on Ochoco Creek, and the Prineville Reservoir located on the Crooked River. Stored water in each of these reservoirs is delivered to the OID irrigation system during the irrigation season. Irrigation water from Ochoco Reservoir is released directly into the Ochoco Canal and Ochoco Creek (also serving the District's Breese Lateral). Irrigation water from the Prineville Reservoir is released into the Crooked River and then diverted into the Crooked River Diversion Canal about 5 miles south of Prineville. Other minor diversions occur on McKay, Lytle, and Johnson Creek.

The District is generally served from three primary canals that convey water from southeast to northwest. The primary upper canal is the Ochoco Main Canal. It is served from the Ochoco Reservoir at the southeast end and from the Relift Pump Station that supplies water to the Ochoco Main Canal from the Crooked River Distribution Canal. The Johnson Creek Lateral, Tunnel, McKay West, and Grimes Flat East and West Lateral systems are all pumped systems that source water from the Ochoco Main Canal. The primary middle canal is the Crooked River Distribution Canal. It is served from the Crooked River through the Crooked River Diversion Canal System after lifting occurs through the Barnes Butte Pump Station. The primary lower canal is the Rye Grass Canal. It is served from a diversion from Ochoco Creek that conveys water from a spill into Ochoco Creek from the Crooked River Diversion Canal System. The Breese Lateral is served from a diversion on Ochoco Creek that conveys water from the spill into Ochoco Creek from the Ochoco Reservoir. The Crooked River Diversion Canal also serves several direct diverters along its path between the diversion point from the Crooked River to Combs Flat Road. It also supplies the Combs Flat Pump Station and canal system and the Barnes Butte Pumping Plant (that lifts water to the Crooked River Distribution Canal).

The above primary delivery system serves approximately 18,480 acres of irrigated lands. The 1,190-acre difference between the total 19,670 acres currently served by the District and the 18,480 acres are the direct deliveries from the Crooked River and Ochoco Creek. These deliveries are not included in the scope of this SIP since they are typically monitored by the District but privately constructed and operated on-farm systems.

The sources of stored and diverted water is based upon the water right certificates that govern the District's storage and direct river diversion limitations as indicated in Section 3.1. For storage withdrawals, the District operates under its multi-party agreement for withdrawals from Prineville Reservoir and under its own rule-curve for withdrawals from Ochoco Reservoir. Once water is diverted into the Crooked River Diversion Canal, the water is measured as it passes through a fish screen and then enters into the District's canal conveyance system. For water discharged from the Ochoco Reservoir, measurements and telemetry exist for water entering the Ochoco Main Canal and the spill to Ochoco Creek.

As indicated on Figure 3.0.1 and as described above, the OID system generally supplies water to its patrons from the southeast to the northwest. The system is generally open-channel in its current state with predominantly unlined canals and laterals. Some piping has progressed on laterals in the District including pressure-rated piping and low-head concrete piping. In Combs Flat Road, the feeder pipe to the Barnes Butte Pump Station is pressure-rated concrete cylinder pipe. Existing pump discharges are all of pressure-rated pipe materials. Existing piping within the District is indicated on Figure 3.0.1. Retention of any of these pipes will be considered on a case-by-case basis by the District and during design for piping improvements. In all, the District operates and maintains over 122 miles of canal and piping in the system.

The Ochoco Irrigation District's system is topographically very gradual. For this reason, the original system was designed with the three primary delivery canals terraced through the delivery system. Additionally, pumping was required to adequately distribute irrigation water throughout the system. Although the irrigated lands vary in elevation from approximately 3120 feet above sea level to 2800 feet above sea level, most canals only slope at a rate of about 1-FT in 1,000-FT of longitudinal run. This challenge causes the piped system design to carefully consider the hydraulic grade line during peak flow rate events and minimum piped flow rates during low flow times early and late in the irrigation season.

Patron turnouts from the District's main canal and laterals are typically gate regulated and weir measured. The District regulates flows to each system lateral and patron turnout via its field staff.

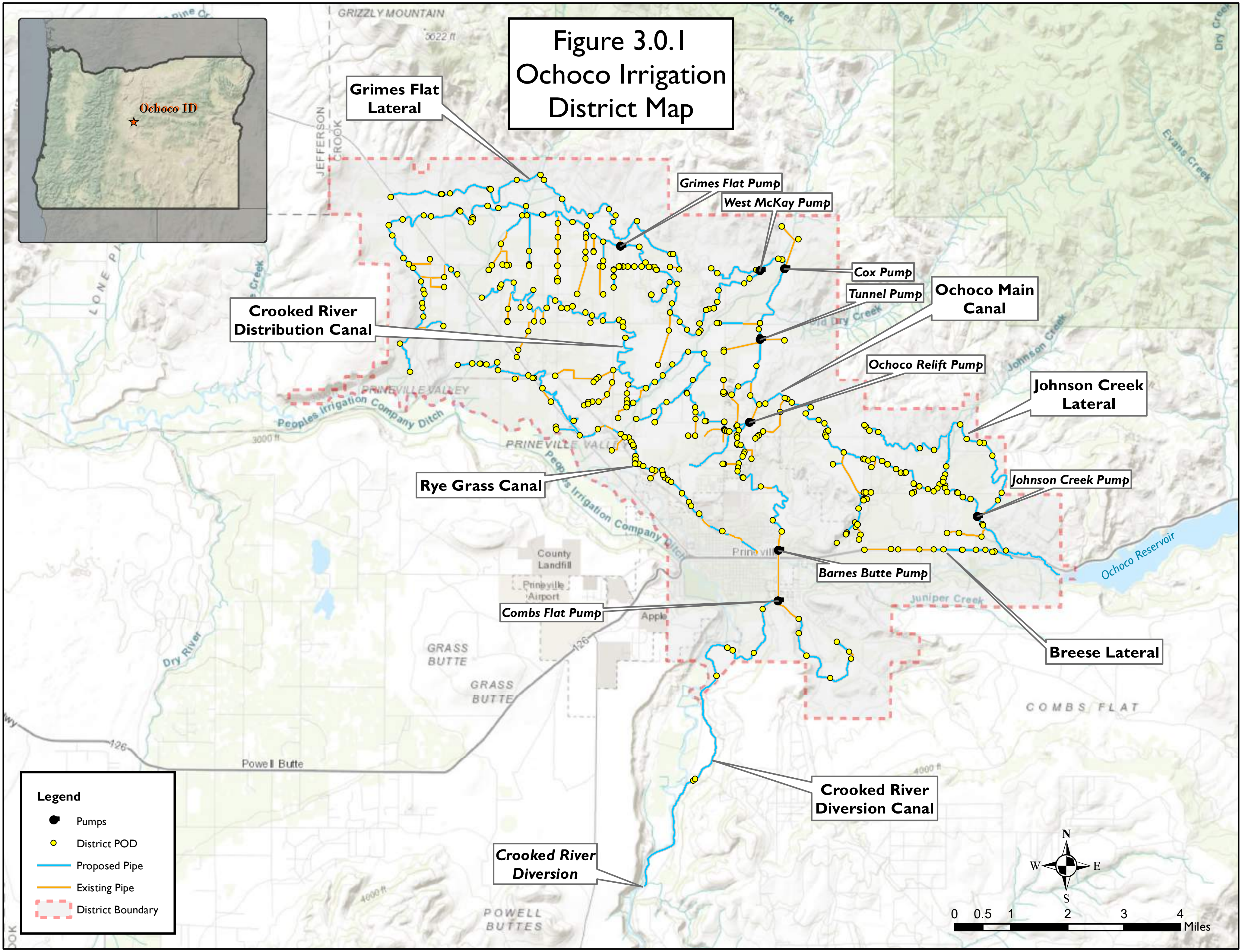


Figure 3.0.1 Ochoco Irrigation District Map

3.1 Water Supply and Certificates

The Ochoco Irrigation District sources water primarily from Ochoco Creek and the Crooked River. Impounded water in the Ochoco Reservoir is diverted directly into the Ochoco Canal headworks, and impounded water in Prineville Reservoir (at Bowman Dam) is released by the District into the Crooked River and conveyed to the District's Crooked River Diversion Canal. The District also operates under a certificate that allows for withdrawals from other waterways. Complete water right information is not included in this SIP but may be obtained from the Oregon Water Resources Department and viewed in the District's Water Management and Conservation Plan on file with the Oregon Water Resources Department. It should be noted that the District's water rights change from time to time with conservation activities, hydroelectric power development, transfers, and other water right activities. For the purposes of this SIP, the primary goal is to evaluate the modernization of the District's conveyance system; therefore, information regarding primary and secondary water delivery rate and duty are the primary consideration regarding the certificates summarized below.

Certificate 82246

Permit: 5426
Source: Ochoco, McKay, Dry, Lytle, and Johnson Creek, all waste and return water flowing in all unnamed waterways, and Ochoco Reservoir
Priority: March 13, 1916 from McKay Creek and August 10, 1917 from all other sources named herein
Use: Primary irrigation of 16614.3 acres and industrial use of 160.2 acres/equivalent
Rate: 209.7 CFS
Duty: 4 AC-FT/ACRE
Legal Season: February - December
Actual Season: April - October
Remarks: This is the primary right for most of the District

Certificate 82247

Permit: 25991
Source: Crooked River and Prineville Reservoir
Priority: April 8, 1914
Use: Primary irrigation of 3087.3 acres and supplemental irrigation of 12011.9 acres
Rate: 190 CFS
Duty: 4 AC-FT/ACRE
Legal Season: February - December
Actual Season: April - October
Remarks: This is the supplemental right for most of the District.

Certificate 82248

Permit: 49824
Source: Ochoco Creek and Reservoir
Priority: September 2, 1986
Use: Industrial use for the equivalent of 200 irrigated acres
Rate: 2.75 CFS
Duty: 4 AC-FT/ACRE
Legal Season: Year round
Actual Season: Year round
Remarks: This right makes use of 600 AC-FT of the water stored in Ochoco Reservoir.

Certificate 82249

Permit: N/A
Source: Crooked River, Ochoco Creek and Springs, and McKay Creek
Priority: Varies from 1869 to1916
Use: Supplemental irrigation of 4601.87 acres
Rate: 59.93 CFS
Duty: 4 AC-FT/ACRE
Legal Season: Year round
Actual Season: Year round
Remarks: This certificate combined many prior rights with varying priority dates into one supplemental certificate.

Certificate 55973

Permit: R-528
Source: Ochoco Creek
Priority: April 8, 1914
Use: Storage of 46,400 AC-FT for irrigation and 600 AC-FT for industrial use
Rate: N/A
Duty: N/A
Legal Season: Year Round
Actual Season: Year Round
Remarks: The reservoir lands and this water right are owned by OID.

Certificate 57612

Permit: R-2223
Source: Crooked River
Priority: April 8, 1914
Use: Storage of 155,000 AC-FT for irrigation
Rate: N/A
Duty: N/A

Legal Season: Year round
Actual Season: Year round
Remarks: The reservoir lands and water right are owned by the United States Bureau of Reclamation (BOR). OID operates the reservoir under contract with BOR. OID has contracted for 57,899 AC-FT of the storage space. The right to storage for the United States is secondary to the OID natural flow right.

For the purposes of this SIP, the most critical criteria for system modernization and pipe size estimation is the maximal flow rate anticipated in a fully piped system. Based upon discussions with the District and delivery history, it was determined that an on-farm delivery flow rate of 7.5 GPM/Acre would be appropriate for System Improvement Plan piped system sizing. This rate falls within the existing water rights for the District indicated above to serve the District's patrons and represents a flow rate that the District believes sufficient to support crop irrigation at peak irrigation season.

3.2 On-Farm Water Demand Analysis - Acreage and Duty

For the purposes of this SIP, and based upon District input as indicated above, a SIP design delivery flow rate to on-farm was established at the calculated on-farm rate of 7.5 GPM/Acre. At this rate, and based upon the Natural Resources Conservation Service criteria, 5 FT/S was used as a maximal velocity criterion for the proposed piping of the system. Given the relatively flat elevation profiles within most of the system elements, conceptual system sizing indicated that velocities well below the NRCS criteria were to be expected in much of the system.

3.3 System Loss Assessment

Black Rock Consulting worked with the District to coordinate a seepage loss study performed by Farmers Conservation Alliance staff under Black Rock Consulting/Kevin L. Crew, P.E and David C. Prull, P.E. direction. During the summer of 2016, the Seepage Loss Assessment Program (LAP), supported by Oregon State University and the Oregon Water Resources Department, was implemented in 7 of the 8 Central Oregon irrigation districts to inform the Districts of current system losses and to enhance SIP development for these Districts. The program included the use of newly purchased and calibrated Sontek Flowtracker II and Doppler-Boat technology, manual, and office and field training, all in accordance with the United States Geological Survey and United States Bureau of Reclamation "Discharge Measurements at Gauging Stations – Chapter 8 of Book 3, Section A, Techniques and Methods 3-A8". The program was managed by Oregon Registered Professional Engineers, Kevin L. Crew, P.E. and David C. Prull, P.E.

The primary purpose of the LAP was to perform a one-time measurement program in each District thus providing the District SIPs of approximate seepage losses in elements of each system. The measurements were performed at different times of the irrigation season within each District, therefore the percentage of peak flow varied by District as the LAP team entered, measured, and exited each District. The results were used to provide a strong indication of losses. The results were interpolated or extrapolated based upon the maximal expected loss within each District as indicated in the SIP below. The final loss information was used to identify losses associated by project phase or lateral depending upon each specific District SIP. In instances where grants are to be allocated in direct exchange for conserved irrigation water to be dedicated by revised water rights certificates to instream flow, the grantor may be compelled to confirm these seepage loss results by conducting a subsequent loss measurement program performed by the USGS and/or the Oregon Water Resources Department prior to project implementation.

For Ochoco Irrigation District, the LAP was implemented throughout the District's primary canal and system laterals. Tabular results for the LAP study within OID are included in Appendix A to this SIP. A tabulated summary version of the results is provided below in Table 3.3.1. It should be noted that this summary indicates a rolled-up version of the full LAP, given the complexities found in measuring the OID system. OID's system contains 8 pumping plants and a variety of returning flow points that resulted in significant analysis and the recommendation that additional confirming measurements occur during 2017, if possible.

Table 3.3.1 includes seepage loss estimates for the District as well as two primary tail loss areas that are within the District where flows leave the primary irrigation system and return to surface waters.

Table 3.3.1

OCHOCO IRRIGATION DISTRICT CONSERVATION ESTIMATE BY CANAL AND LATERAL				
CANAL/LATERAL	MEASURED (Y/N)	SEEPAGE LOSS MEASURED (CFS)	ADJUSTMENT FACTOR	ADJUSTED CONSERVATION ESTIMATE (CFS)
Ochoco Main Canal	YES	17.5	0.77	13.5
Grimes Flat East and West Laterals	YES	4.9	0.77	3.8
Crooked River Diversion Canal	YES	12.0	0.77	9.3
Crooked River Distribution Canal	YES	17.8	0.77	13.8
Breese Lateral	YES	0.8	0.77	0.6
Johnson Creek Lateral	YES	0.0	0.77	0.0
Lytle Creek Lateral	YES	0.0	0.77	0.0
Rye Grass Canal	YES	0.0	0.77	0.0
	TOTAL=	**53.0**		**41.0**
TAIL LOSS MEASURED		TAIL LOSS (CFS)		
Lytle Creek/Rye Grass Tail	YES	13.9		
Ochoco Canal Tail (Gap)	YES	5.3		
	TOTAL=	**19.2**		

The adjustment factor provided in Table 3.3.1 is the simple ratio of the estimated total piped conservation (fully piped system) at a delivery rate of 7.5 GPM/Acre, 41 CFS (see Table 3.3.2 below), versus the measured system loss of approximately 53 CFS. The tail loss was not considered in the conservation analysis as more measurement data is required in the District to more accurately determine the inputs, beneficial use of, and outputs of surface waters in OID. For the purposes of this SIP, however, apportioning of seepage losses was considered satisfactory for the development of conservation potential in the District, given the direct methodology employed for calculating total estimated potential conservation in the District.

Total piped system conservation estimates were developed. Delivery acreages as assessed for the OID system were used to estimate the fully piped system flow rates at the peak certificate rate (7.5 GPM/Acre). Flow diversion data for the District were evaluated to determine the peak diverted flow rate over the last seven years of operation (approximately 350 CFS peak from Ochoco Reservoir and the Crooked River Diversion including 20 CFS supply to the Breese Lateral and 4 CFS supply to the Rye Grass Canal). This peak was compared to the peak piped flow rate to estimate potential conservation based upon a completely piped hydraulic delivery system (including all laterals and private laterals down to the individual patron turnouts). The results of this total conservation estimate are tabulated in Table 3.3.2.

Table 3.3.2

OCHOCO IRRIGATION DISTRICT TOTAL PIPED CONSERVATION ESTIMATE			
Diverted Acreage	Maximum Diversion 2006-2016 (CFS)	Diversion Flow Rate at 7.5 GPM/Acre (CFS)	Estimated Cons. at 7.5 GPM/Acre (CFS)
18,480	**350**	**309**	**41**
Note: Acreage is for Current Main Canal Diversion and Not All Inclusive of District			

Section 4

System Improvement

4.0 System Improvement Approach

The primary purpose of this SIP was to identify water conservation, hydroelectric power and pumped power conservation possibilities for the District, and to develop a mitigation strategy for system water losses. Although some limited piping has already occurred in the District, there remains a significant canal system calling for mitigation through piping. Consistent with its Scope of Services and the subsequent goals and direction provided by the District, Black Rock Consulting performed a comprehensive hydraulic piping and pumping evaluation of the District.

There are two primary alternatives for the mitigation of seepage losses. The first is canal lining and the second is canal piping. Within each of these alternatives there are a variety of material choices. Canal lining involves the installation of an impervious system to cover the canal bottom and banks. Materials typically employed include geomembranes, rubber liners, shotcrete, or similar materials. Canal lining does not provide pressurization of the irrigation system and it also increases canal velocities, thus increasing hazard risk to people. Black Rock Consulting has performed 50-year life cycle evaluations of lining versus piping alternatives to the District and has not included these in this SIP. In summary, over a 50-year life cycle it was found that canal lining may be less expensive to implement in its first installation cycle, however, canal lining requires significant maintenance and replacement cycles that ultimately cause it to exceed the cost of piping over time. In addition, given the elevation differential across the District and the desire of the District to optimize pressurized deliveries to its patrons and reduce pumping electricity effects on the utility grid, piping was chosen as the District's preferred choice for canal water loss mitigation.

Black Rock Consulting commenced the process of hydraulic modeling for the Ochoco Irrigation District by receiving base EPANET (.INP) files from FireWhat? in electronic form. The files were generated by FireWhat? by including spatially (i.e. northing, easting, and elevation) correct patron turnout locations and patron delivery flow rates at each turnout. Updated acreage by patron were provided by the District for this purpose. EPANET modeling is discussed further in this SIP below. From the base files, Black Rock Consulting inserted the data into EPANET and then began the process of including existing piped elements of the District. The District was modeled based upon the District's current system approach with intakes from Ochoco Creek and the Crooked River, existing pumping systems, and incremental gravity pressurization of the system.

The system was evaluated as a completely closed system (i.e. fully piped and to its extremities). The completed model was calibrated, and pipes were sized based upon selected pipe manufacturer information and a peak velocity of 5 FT/S for proposed piping at 7.5 GPM/Acre throughout the system.

Once this process was completed, the system was evaluated for cost as further detailed below. Project "Groups" were developed based upon one approach to incremental system piping as provided in this SIP. This approach is subject to modification based upon funding availability, District operation, and preference over time.

4.1 Pipe and Valve Materials

Pipe material selections were made by Kevin L. Crew, P.E., based upon 29 years of experience with large diameter piping systems including 20 years of experience in Central Oregon. From the hydraulic model, both static and dynamic pressures were evaluated throughout the system to select appropriate pipe material options. For pipe up to 63-inches in diameter, high density polyethylene solid wall pipe was selected due to its outstanding abrasion resistance, longevity, and ability to be pulled into canal curve alignments. For pipe exceeding 63-inches in diameter, due to the low-head nature of the OID system, high density polyethylene profile wall pipe was assumed (capable to withstand operating pressures to 30 PSI). Costs for materials were obtained from large, reputable vendors that are active in bidding to Central Oregon projects.

While pressure reducing valves were not proposed in this SIP, they were evaluated in the event that any may be required for future use in parallel with hydroelectric power production or other energy dissipation needs that may arise. Valves for pressure reducing stations were technically assessed and narrowed down to plunger valves and Cla-Val valves. Both use internal energy dissipation within the valve to accomplish the needed pressure-sustaining function downstream of the valves. Cla-Val valves use a control tubing and a diaphragm/bonnet arrangement to adjust pressures within the pressure reducing apparatus. No power is necessary for the operation of a Cla-Val. Should pressure reducing valves be required in the future, Cla-Val E-90-01 pressure reducing valves should be considered.

4.2 Hydroelectric Power Potential, Pumping Mitigation, and Pressurization Approach

The District has hydroelectric power potential in two locations: Ochoco Dam and Bowman Dam. Potential at Bowman Dam, also the Crooked River irrigation supply to the Crooked River Diversion Canal, is being evaluated by the District in partnership with the City of Prineville and Crook County. Currently, the Bowman Dam Hydroelectric Power Project is being considered for a 2.5 MW project. Details of that project are under development; therefore, no further consideration is given in this System Improvement Plan. The Ochoco Dam Hydroelectric Power Project was evaluated by the District during the development of its System Optimization Review in 2012. A copy of the feasibility study is included in Appendix D of this System Improvement Plan. The study indicates that approximately 1,360,667 kWh of production may be realized on an annual average if the project were fully implemented. The financial return on the project was deemed marginal at the time of the study preparation and PacifiCorp Schedule 37 rates have been reduced since that time. It is anticipated, however, that if direct power sale or opportune wheeling arrangements could be achieved, the project may become financially viable and the District should continue to evaluate this potential resource.

Beyond the hydroelectric power potential indicated above, the hydraulic analysis for the District indicates that there is no appreciable hydroelectric power potential in the District and what pressurization exists may best be used for direct patron pumping offset benefit.

Pressurization of the system will occur as it is piped. The hydraulic model indicates that dynamic (i.e. pressures achieved during full flow operation of the system) will range from approximately 0 PSI to 37 PSI from gravity, however, discharge pressures at some pumps will exceed this pressure. In reality, system pressures will likely rise above this pressure range as hydraulic losses (i.e. pressure losses) will be less if the system is moving less water.

Based upon the following assumptions, private patron (on-farm) pumping mitigation was also evaluated:

- 3 AC-FT/Acre of water applied to grow grass or alfalfa/season
- 70% application efficiency
- 4.28 AC-FT/Acre required to flow from the sprinkler heads/season
- 70% pumping efficiency

Where partial pressurization was anticipated by the hydraulic model, a percent of pumping mitigated was assigned to the associated lateral or main canal. The overall District private pumping mitigation and associated patron kWh savings was estimated at 2,687,650 kWh/Year.

Table 4.2.1

ESTIMATED PUMPING POWER SAVINGS THROUGH PRESSURIZATION					
CANAL/LATERAL	IRRIGATED ACRES ASSOCIATED WITH SEGMENT	ESTIMATED % OF PUMPING MITIGATED	70% EFF. PUMPING PER ACRE AT 60 PSI GRASS HAY (kWh)	SAVINGS/AC (kWh)	TOTAL ESTIMATED PUMPING SAVINGS (kWh/YR)
Ochoco Main Canal - Upper	340.8	31%	867.3	265.9	90,615
Ochoco Main Canal - Upper Mid	4,457.1	14%	867.3	119.3	531,580
Ochoco Main Canal - Lower Mid	3,625.8	24%	867.3	210.3	762,589
Ochoco Main Canal - Tail	1,682.0	22%	867.3	194.4	327,023
Crooked River Dist. Canal Upper	1,674.0	12%	867.3	101.0	168,999
Crooked River Dist. Canal Tail	2,618.2	9%	867.3	81.1	212,326
Crooked River Diversion Canal	360.7	5%	867.3	46.5	16,757
Grimes Flat East/West Laterals	832.6	39%	867.3	336.5	280,163
Johnson Creek Lateral	580.5	14%	867.3	125.7	72,971
Breese Lateral	513.5	10%	867.3	90.8	46,609
Combs Flat Lateral	508.9	22%	867.3	190.1	96,733
Rye Grass Canal	1,271.7	7%	867.3	63.9	81,286
TOTAL=	**18,466**				**2,687,650**

The proposed piped system for the District will require pump stations to sustain its irrigation deliveries as contemplated in this System Improvement Plan. New primary pump stations will be necessary to convey irrigation water through the District's system. The District chose to focus on these primary pumping systems for inclusion in this Review. Four existing pump stations will be eliminated as these new pump stations are constructed to meet the proposed system hydraulic criteria, post piping. The Barnes Butte Pump Station, the Ochoco Relift Station, the Grimes Flat Station and the Johnson Creek Station will be eliminated. Crooked River Pump Stations 1, 2, 3, and 4 will be designed and constructed on the existing OID parcels to serve the requirements of the newly piped system. The new pump stations will reduce the District's pumping, and associated demand on the electrical grid, by approximately 1,942,311 kWh annually. District pump stations were evaluated separately in the Ochoco Irrigation District's *System Optimization Review*, dated December 2012. For the purposes of this System Improvement Plan, we used the estimated costs from pages 217-321 of the referenced *System Optimization Review* to estimate the cost to design and construct the new Crooked River Pump Stations 1, 2, 3, and 4. These costs were escalated by use of the United States Bureau of Reclamation Construction Cost Index (Pumping Plants) for 2012 versus 2018 as indicated in Table 4.2.2.

Table 4.2.2

New Pump Stations Integral to Modernization of Piping
Ochoco Irrigation District
Reconnaissance-Level Construction Cost Estimate 7/23/2018

Feature	Horsepower	SOR Est. 2012	USBR Index '12	USBR Index '18	Total Cost
Crooked River Pump Station No. 1	1,950	$4,261,000	349	388	$4,737,158
Crooked River Pump Station No. 2	1,500	$2,217,000	349	388	$2,464,745
Crooked River Pump Station No. 3	260	$343,000	349	388	$381,330
Crooked River Pump Station No. 4	375	$290,852	349	388	$323,354

Given the complexity of pump station design and associated construction, the costs included in Table 4.2.2 should be considered reconnaissance in nature and should be re-assessed during the preliminary and design phases of the implementation of the four pump stations.

4.3 Elevation Data

Elevation data for use in modeling was obtained through a LiDAR flight performed in November of 2016 by Quantum Spatial of Corvallis, Oregon. The data was post-processed to the requirements of FCA and Black Rock Consulting. Specifications for the data collection are provided in Table 4.3.1.

Table 4.3.1

LiDAR Collection Specifications	
Multi-Swath Pulse Density	≥ 8 pulses/m^2
Scan Angle	≤ 30^o (+/-15^o from Nadir)
Returns Collected Per Laser Pulse	Up to 4
Intensity Range	1-255
Swath Overlap	50% side-lap (100% overlap)
Maximum GPS Baseline	13 nautical miles

With the use of on-ground RTK and OPUS corrections, the data was provided in 0.5-FT contour interval format and was considered better than 1-FT accuracy vertically.

Units for the elevation information were reported and used in the following systems:

- Horizontal Projection: Oregon State Plane (ORSP) South Zone. International Feet
- Horizontal Datum: NAD83(2011)(Epoch2010.00)
- Vertical Datum: NAVD88 using Geoid12A

4.4 Future Delivery Flexibility

The District has requested system flexibility to ensure that, within reason, system changes, added and subtracted irrigated acreage, effects of climate change, effects of changes in cropping patterns, and similar system demands may be addressed in this SIP.

First, the system was modeled with demands at a higher-than-anticipated on-farm water right of 7.5 GPM/Acre. This, in and of itself, is conservative given that it is highly unlikely that every patron within the District will be irrigating at the same moment at this rate. The District's Water Management and Conservation Plan (2013), Section 1.7, indicates that the peak on-farm rate is estimated to be 291 CFS for the District. This rate translates to approximately 6.64 GPM/Acre based upon 19,670 acres. Using 7.5 GPM/Acre provides an approximate 13% buffer on the peak on-farm flow rate identified in the District's WMCP.

The second system flexibility that was included in the base modeling analysis was the addition of future acreage and associated demand to the following laterals:

- *Johnson Creek Lateral – 100 acres*
- *Grimes Flat West Lateral – 50 acres*
- *Grimes Flat East Lateral – 50 acres*
- *The Gap area of the Ochoco Main Canal Tail – 50 acres*
- *Diversion Canal – 50 acres*

With the exception of the Johnson Creek Lateral, the piping proposed by this SIP and base hydraulic model will accommodate these additional acreages that were assigned to the ends of each of the named laterals. For the Johnson Creek Lateral, only 10 acres of additional irrigation demand could be added without the development of system pressure issues. If the District finds that 100 acres of future flexibility is necessary for the Johnson Creek Lateral, the Johnson Creek Pumping Station and proposed piping should be further evaluated prior to implementation of that modernization project group.

The Ochoco Irrigation District system hydraulics was found to be very sensitive to additional demand and also to pipe sizing. Generally, pipes were sized to minimize friction losses and it was necessary to size many pipes such that velocities during peak flow were near 2 FT/S. Final design for the system elements should specifically address the effects of minimized system flow rates with measures such as increased cleanout frequency, air and vacuum relief for localized high points, blow-offs, and other measures to try to minimize operational issues if modeled system demands were increased to 9 GPM/Acre. At flow rates higher than 7.5 GPM/Acre, due to the very gradual system topography on most east-to-west canals, the model indicated that the fully piped system will realize low-pressure issues. Should the District believe that it will need capacity beyond the future acreages added to the laterals indicated above and with the entire system exceeding 7.5 GPM/Acre, the system should be further evaluated, modeled, and updated to accommodate such capacity prior to commencing system improvements.

4.5 Hydraulic Modeling

EPANET –

EPANET was used to model the District's proposed piped network. EPANET is a free-ware product that is maintained by the EPA. The Natural Resources Conservation Service technical offices in Oregon use EPANET exclusively for hydraulic modeling. For these reasons, EPANET was selected as the modeling software of choice for this SIP.

EPANET modeling capabilities go beyond steady-state hydraulic modeling. The software is capable of chemical transport analysis and varying flow modeling. A description of some of its capabilities follows:

EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves, and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated.

EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. It can be used for many different kinds of applications in distribution systems analysis. Sampling program design, hydraulic model calibration, chlorine residual analysis, and consumer exposure assessment are some examples. EPANET can help assess alternative management strategies for improving water quality throughout a system. These can include:

- altering source utilization within multiple source systems,
- altering pumping and tank filling/emptying schedules,
- use of satellite treatment, such as re-chlorination at storage tanks, and
- targeted pipe cleaning and replacement.

Running under Windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots.

Hydraulic Modeling Capabilities –

Full-featured and accurate hydraulic modeling is a prerequisite for doing effective water quality modeling. EPANET contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

- places no limit on the size of the network that can be analyzed,
- computes friction head loss using the Hazen-Williams, Darcy-Weisbach, or Chezy-Manning formulas,
- includes minor head losses for bends, fittings, etc.,
- models constant or variable speed pumps,
- computes pumping energy and cost,
- models various types of valves including shutoff, check, pressure regulating, and flow control valves,
- allows storage tanks to have any shape (i.e. diameter can vary with height),
- considers multiple demand categories at nodes, each with its own pattern of time variation,

- models pressure-dependent flow issuing from emitters (sprinkler heads), and
- can base system operation on both simple tank level or timer controls and on complex rule-based controls.

Velocity Criteria –

As stated above, the maximal velocity criterion was set at 5 FT/S for on-farm deliveries at 7.5 GPM/Acre.

Elevations –

As indicated above, elevation data was derived from a 2016 LiDAR flight.

Spatially Correct Layout –

Horizontal information for the various system elements and patron turnouts was collected through a field survey performed by District staff in 2016. Turnout locations were "snapped" to the canal centerline (perpendicular to the centerline) as determined through post-processing of the LiDAR data and locating canal and lateral centerlines. The "snapped" locations represented turnout node locations used during hydraulic modeling of the system and were represented in the model by Northing and Easting coordinates of the Oregon State Plane South Zone.

Pressure Reduction (Not Applicable to the Ochoco Irrigation District) –

Where applicable, pressure reducing stations and/or hydroelectric power plants were entered into the model as PRVs (pressure reducing valves). These valves are a programmed element in EPANET. The diameter of the valve and the downstream pressure set-point are entered to establish the downstream system pressure to be held by the PRV. PRVs were also used to emulate the pressure reduction through hydroelectric plant(s).

Pipe Diameter Selection –

Pipe diameter selections were derived iteratively in the hydraulic model with the first iteration being a rough estimate. The second iteration utilized actual pipe diameters for high density polyethylene pipe (HDPE) material at the appropriate dimension ratio and pressure rating for each model "link" (pipe). Generally, the third iteration adjusted all pipes in the system to a range of 2 FT/S to 5 FT/S at the peak system flow rates based upon 7.5 GPM/Acre.

Pipe Pressure Rating Selection –

> HDPE solid-wall pipes (PE4710 resin) were sized from HDPE pipe sizing tables for the expected static pressure for each pipe segment. For large diameter system elements, due to the low-head characteristics of these reaches, low-head profile wall HDPE pipe was assumed (30 PSI maximum operating pressure).

The model for the Ochoco Irrigation District is included in Appendix B of this SIP.

4.6 Cost Estimating by Lateral (and Main Canal)

Pipe Estimates –

> Pipe material estimates were provided by a reputable vendor that routinely supplies pipe materials to Central Oregon projects. Pipe material budgetary estimates are provided in Appendix C for reference.

Turnouts –

> For the purposes of this SIP, patron turnouts were assumed to be converted to pressurized delivery systems. A standard pressurized irrigation delivery turnout was assumed to include an appropriately sized tee from the mainline or lateral, a pressure relief valve, a gear-actuated plug valve (or gate or possibly butterfly valve in smaller turnout situations), a magnetic meter, a combination air and vacuum relief valve and associated hardware, and spool pipe segments. Based upon experience with similar installations at irrigation districts in Central Oregon, the cost of installation of a turnout was set at an estimated average cost of $8,000 per installation.

Construction –

> Contractor procurement may come in several forms in Oregon. Design-Bid-Build is a conventional process wherein the survey and design is developed first and then a traditional competitive bid is held to obtain the lowest-cost responsive and responsible bidding contractor. In this process, typically the design-engineering firm will serve as the inspection/construction management firm during the course of construction. Given the magnitude of the project phases, and for the purposes of this SIP, a Construction Manager General Contractor (CMGC) model was assumed. In this contractor procurement method, design would precede obtaining the contractor, however, the contractor would include construction management in its delivery of the constructed project. An estimated contractor fee structure of 12% - 18% of the project value was assumed for this construction delivery method depending upon the size of the lateral or main canal project being evaluated.

Engineering, Construction Management –

Engineering and Owner’s Representative/Inspection services typically range as high as 10% - 18% of construction value. For the purposes of this SIP, and assuming that project phases are constructed sequentially and annually, it was assumed that total fee of 6% - 18% for survey, engineering design, and inspection/owner’s representative services would be appropriate depending upon the scale of the particular lateral or main canal project. This was based upon the experience of Black Rock Consulting on similar projects deployed in Central Oregon.

Contingency –

The contingency percentage was carefully considered. The Association for the Advancement of Cost Engineering (AACE) is a nationally recognized organization that has developed an accepted system of contingency ranges based upon project specificity level “Class”. There are 5 project Classes starting from Class 5 with only conceptual project definition to Class 1 where a project has been completely developed and bid. This SIP was considered to fall within the Class 4 definition. The AACE Class 4 project specificity level (i.e. a project at 1% - 15% definition) carries an anticipated contingency range from -15% to -30% on the low end of the range to +20% to +50% on the high end of the range. We selected a contingency value of +30% that is in the middle of the positive contingency range provided by AACE. It should be noted that the phased cost estimate is based largely upon the cost of pipe materials. Budgetary pricing for high density polyethylene pipe was found to be very competitive at the time of development of this SIP. High density polyethylene solid-wall pipe is manufactured from an oil-based pelletized product. The pellet pricing is tied directly to the cost of oil at the time of pipe manufacture ordering. Given that oil prices have been reduced in the past two years and will likely rebound, it should be anticipated that pipe material pricing will increase significantly with time. The timing of such increases will be dependent upon oil pricing, the economic conditions at the time of order, and the demand for pipe at the time of order. For construction that is completed soon after the development of this SIP, the cost estimates should remain robust. For work lagging several years beyond the development of this SIP, the risk of cost change is greater. For this reason, it is recommended that every 2 years a cost evaluation be performed to update the phased construction cost estimates. As part of a cost update, it is recommended that new pipe pricing and construction installation pricing be obtained as HDPE pipe pricing can be subject to fluctuations abnormal to the market. For general construction cost inflation/deflation information, it is recommended that the Engineering News Record (ENR) Construction Cost Index or the RSMeans Construction Cost Index be evaluated, using July 2017 as the report date and current index value, and the future cost estimation date as the comparable index.

4.7 McKay Creek Project and its System Effects

A project to supply irrigation water to an additional 650 acres in the McKay Creek area is being evaluated by the District and other interested basin parties. The current conceived project includes the replacement of the Cox Pumping Station with a new and upsized pumping system and high-density polyethylene piping to serve the increased flows to the 650 acres proposed.

This SIP does not include details of the McKay project itself, which is currently in development. The additional system flow effects were evaluated to ensure that the proposed fully piped system could supply the additional 650 acres of irrigation demand. In the absence of OID modernization through piping as contemplated in this SIP, the additional McKay Creek Project flows are anticipated to affect system elements as outlined in Table 4.7.1.

Table 4.7.1

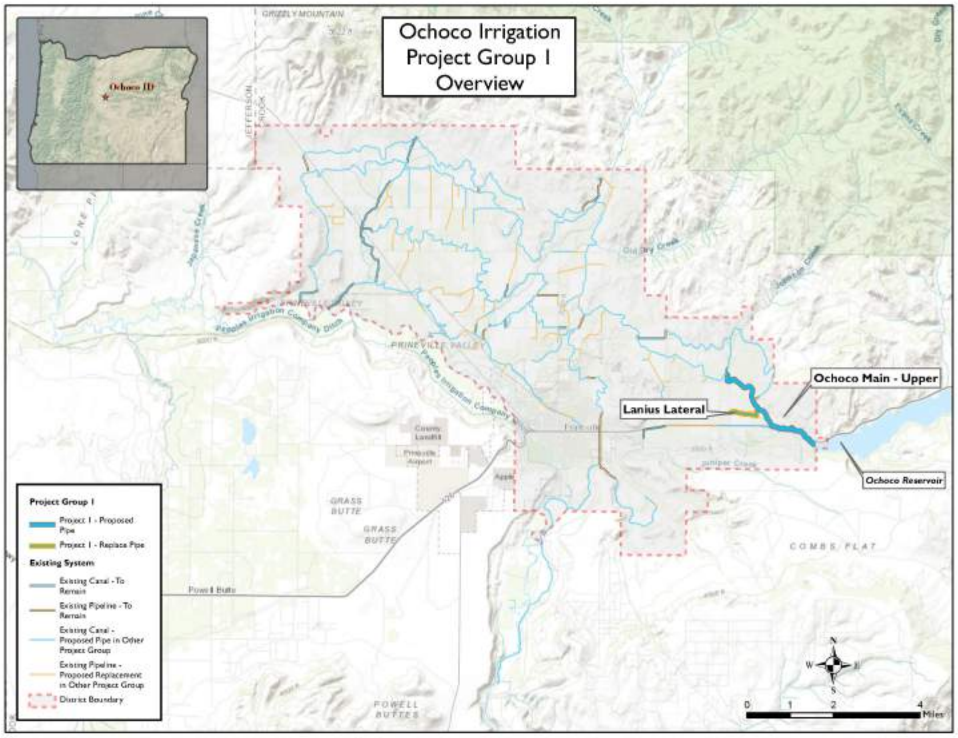
MCKAY SWITCH SYSTEM EFFECTS ANALYSIS ***Black Rock Consulting***	
AFFECTED SYSTEM ELEMENT:	**Quantity**
1. Crooked River Diversion Weir Raise	1
2. Crooked River Diversion Canal Bank Raise Plus Liner Height Inc.	1
3. CR Diversion Canal Drum Screen Area	1
4. CR Intake Overflow Culvert Raise	1
5. Ochoco Creek Weir/Spill Structure	1
6. Combs Flat 60" Pipe Upsize to 72"	1,029
7. Barnes Butte Pump Station/Dishcarge Pipe Upgrades (Per BOD)	1
8. Raise Banks Across Iron Horse 2-FT (2-Sides)	7,800
9. Raise Banks from Siphon to McKay Spill	26,900
10. Ochoco Relift Pump Station Upgrades	1
11. Ochoco Main Canal Bank Raise	16,060
12. Ochoco Siphon Size Increase	1

Should OID system modernization as contemplated under this SIP be performed in conjunction with the McKay Creek Project (known as the McKay Switch Project), it was found that the Crooked River Diversion Canal would require upsizing from 90-inches in diameter to 96-inches in diameter for approximately 2,242 linear feet. Additionally, the Barnes Butte and Ochoco Relift Pump Stations were evaluated as part of the McKay Switch Project analysis (outside of this SIP) and it was determined that both plants would require upsizing by approximately 350 hp, each.

The above information should be considered reconnaissance in nature and should be verified as the McKay Switch Project moves into final design phase and should the District choose to further evaluate the effects of the project on the balance of its systems.

Section 5

Ochoco Irrigation Improvements by Project Group



Project Group 1
Figure 5.0.1

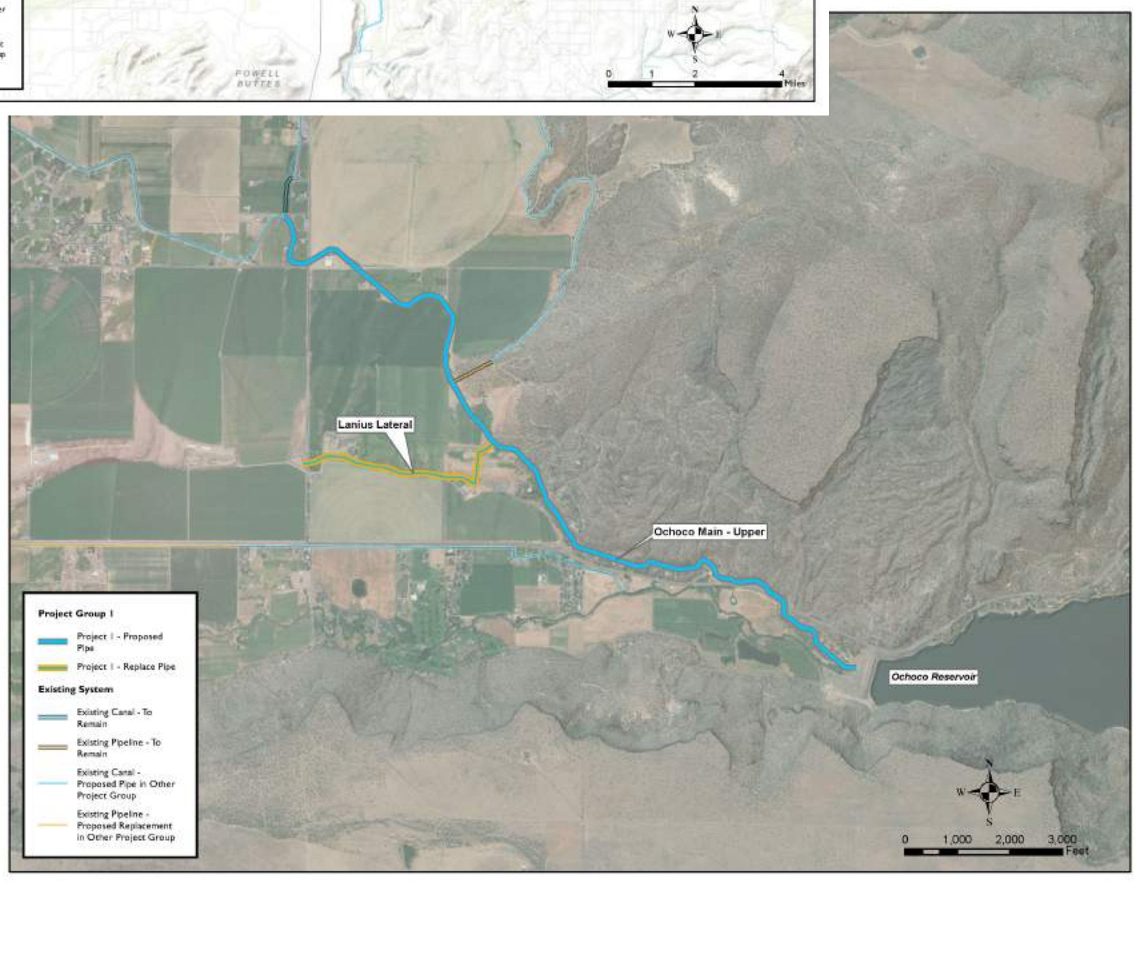


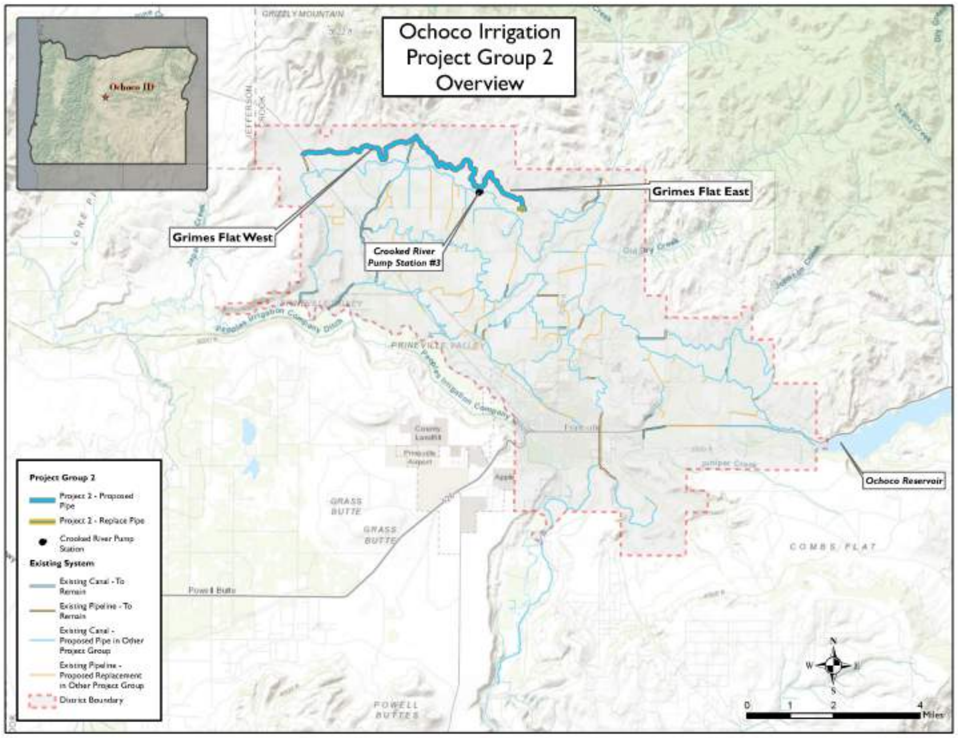
Table 5.0.1 Ochoco Main Canal – Upper Cost Estimate

Ochoco Main Canal - Upper						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	90	10,935	LF	$850	$9,294,980
TURNOUT			2	EA	$8,000	$16,000
	SUBTOTAL					$9,310,980
	ENGINEERING, CM, SURVEY			8%		$744,878
	CMGC			12%		$1,117,318
	CONTINGENCY			30%		$3,351,953
	TOTAL					**$14,525,128**

Table 5.0.2 Lanius Lateral Cost Estimate

Lanius Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	3,200	LF	$32	$102,415
PIPE	32.5	12	10	LF	$16	$161
PIPE	32.5	8	1,176	LF	$8	$9,407
TURNOUT			4	EA	$8,000	$32,000
	SUBTOTAL					$143,983
	ENGINEERING, CM, SURVEY			18%		$25,917
	CMGC			18%		$25,917
	CONTINGENCY			30%		$58,745
	TOTAL					**$254,562**

Project Group 2
Figure 5.1.1



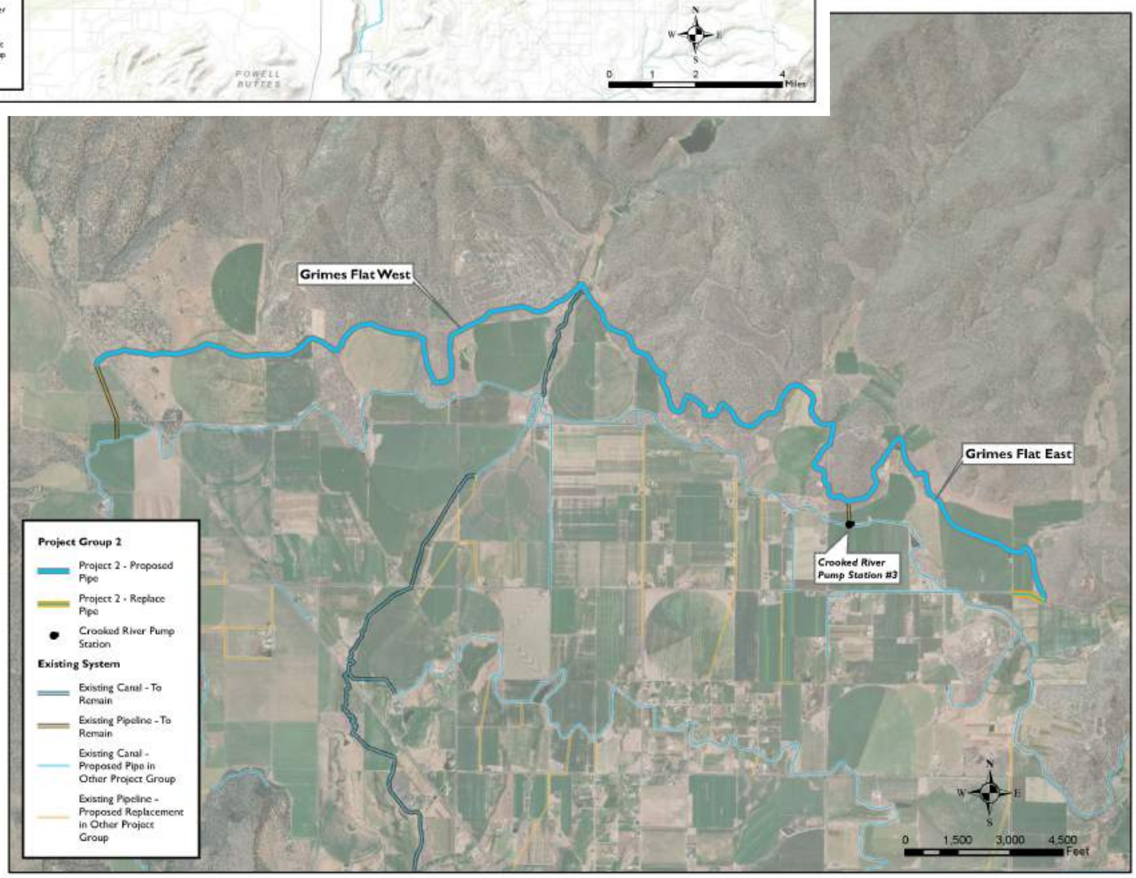


Table 5.1.1 Grimes Flat East Lateral Cost Estimate

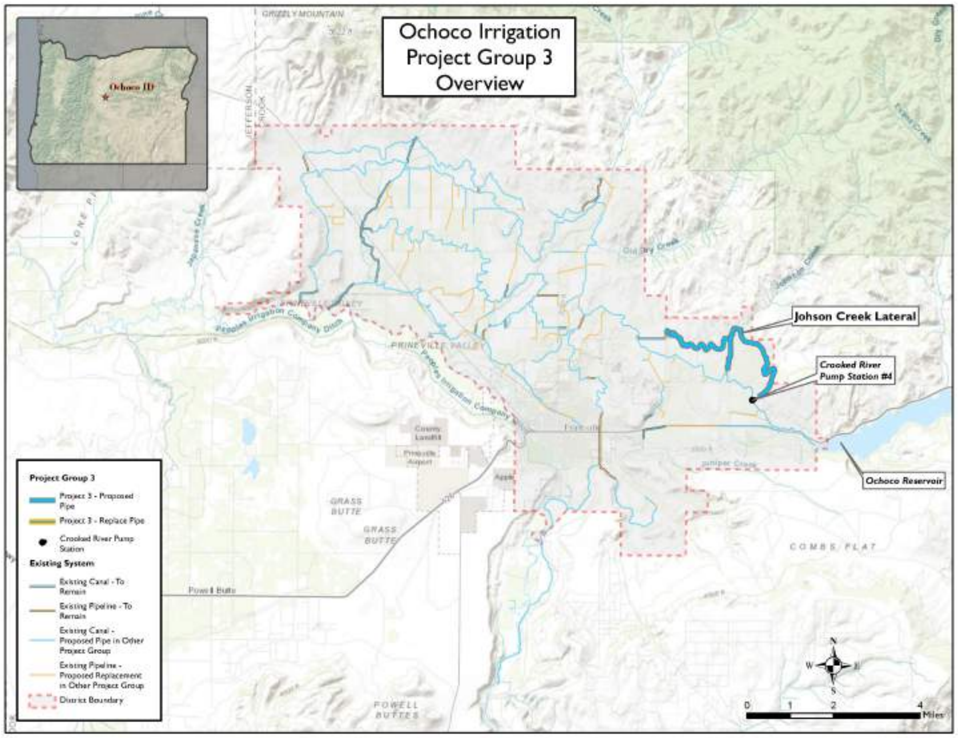
Grimes Flat East Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	2,832	LF	$32	$90,622
PIPE	32.5	12	5,118	LF	$16	$81,895
PIPE	32.5	8	1,847	LF	$8	$14,778
PIPE	32.5	4	944	LF	$3	$2,831
TURNOUT			5	EA	$8,000	$40,000
	SUBTOTAL					$230,126
	ENGINEERING, CM, SURVEY			18%		$41,423
	CMGC			18%		$41,423
	CONTINGENCY			30%		$93,891
	TOTAL					**$406,862**

Table 5.1.2 Grimes Flat West Lateral Cost Estimate

Grimes Flat West Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	26	4,098	LF	$64	$262,279
PIPE	32.5	24	18,130	LF	$54	$978,997
PIPE	32.5	20	5,070	LF	$40	$202,785
PIPE	32.5	18	163	LF	$32	$5,215
PIPE	32.5	16	4,964	LF	$32	$158,840
TURNOUT			17	EA	$8,000	$136,000
	SUBTOTAL					$1,744,117
	ENGINEERING, CM, SURVEY			15%		$261,617
	CMGC			15%		$261,617
	CONTINGENCY			30%		$680,205
	TOTAL					**$2,947,557**

Table 5.1.3 Crooked River Pump Station No. 3 Cost Estimate

Crooked River Pump Station No. 3					
Ochoco Irrigation District					
Reconnaissance-Level Construction Cost Estimate					7/23/2018
Feature	**Horsepower**	**SOR Est. 2012**	**USBR Index '12**	**USBR Index '18**	**Total Cost**
Crooked River Pump Station No. 3	260	$343,000	349	388	$381,330



Project Group 3
Figure 5.2.1

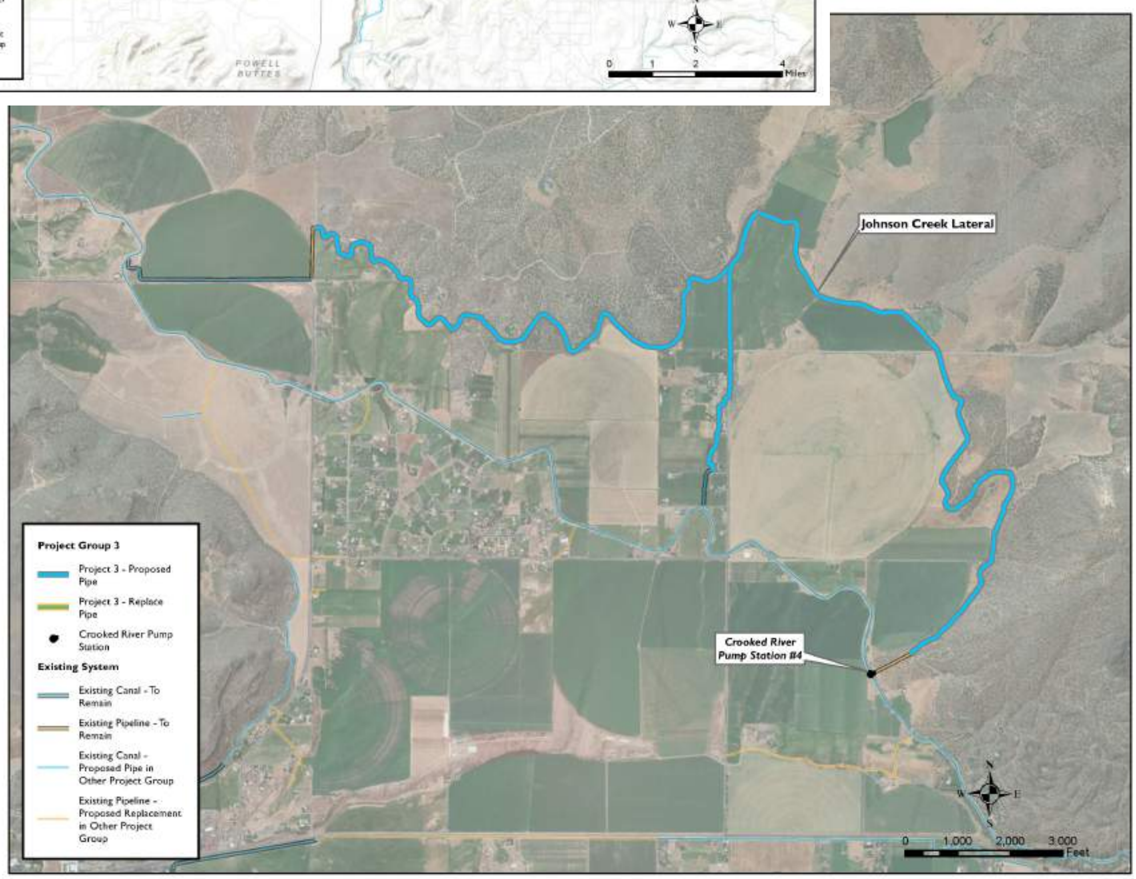
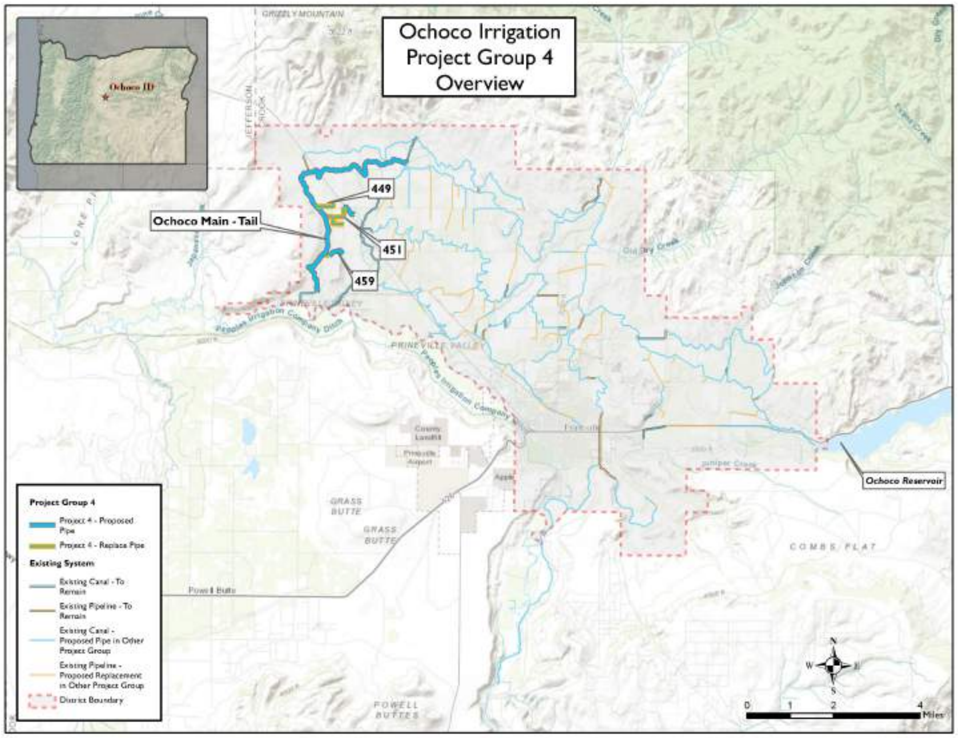


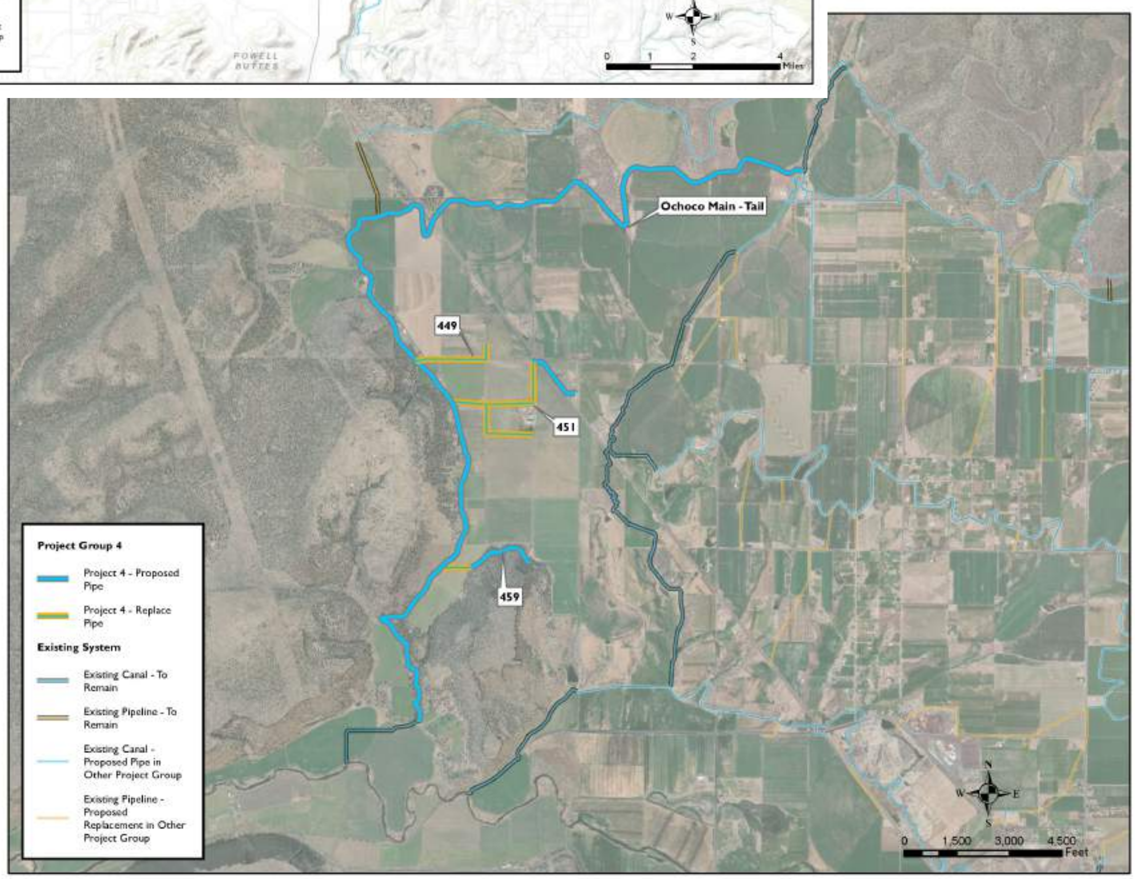
Table 5.2.1 Johnson Creek Lateral Cost Estimate

Johnson Creek Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	30	30	LF	$86	$2,597
PIPE	32.5	24	1,639	LF	$54	$88,493
PIPE	32.5	20	12,434	LF	$40	$497,368
PIPE	32.5	18	5,544	LF	$32	$177,396
PIPE	32.5	14	5,874	LF	$20	$117,478
PIPE	32.5	8	1,318	LF	$8	$10,541
PIPE	32.5	6	5,092	LF	$5	$25,459
PIPE	32.5	4	1,636	LF	$3	$4,907
TURNOUT			25	EA	$8,000	$200,000
	SUBTOTAL					$1,124,240
	ENGINEERING, CM, SURVEY			15%		$168,636
	CMGC			15%		$168,636
	CONTINGENCY			30%		$438,454
	TOTAL					**$1,899,966**

Table 5.2.2 Crooked River Pump Station No. 4 Cost Estimate

Crooked River Pump Station No. 4					
Ochoco Irrigation District					
Reconnaissance-Level Construction Cost Estimate					7/23/2018
Feature	**Horsepower**	**SOR Est. 2012**	**USBR Index '12**	**USBR Index '18**	**Total Cost**
Crooked River Pump Station No. 4	374	$290,852	349	388	$323,354





Project Group 4
Figure 5.3.1

Table 5.3.1 Ochoco Main Canal – Tail Cost Estimate

Ochoco Main Canal - Tail Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	72	3,621	LF	$684	$2,476,997
PIPE	32.5	66	4,182	LF	$628	$2,626,578
PIPE	32.5	63	2,569	LF	$600	$1,541,362
PIPE	32.5	54	7,393	LF	$356	$2,631,860
PIPE	32.5	48	2,189	LF	$212	$464,156
PIPE	32.5	42	3,066	LF	$164	$502,903
PIPE	32.5	36	4,087	LF	$126	$514,999
PIPE	32.5	34	1,533	LF	$110	$168,651
PIPE	32.5	32	1,144	LF	$94	$107,499
PIPE	32.5	30	3,277	LF	$86	$281,797
PIPE	32.5	28	1,540	LF	$76	$117,010
PIPE	32.5	20	506	LF	$40	$20,240
PIPE	32.5	18	2,102	LF	$32	$67,275
PIPE	32.5	16	2,538	LF	$32	$81,203
PIPE	32.5	10	2,670	LF	$12	$32,042
PIPE	32.5	6	3,252	LF	$5	$16,260
TURNOUT			28	EA	$8,000	$224,000
	SUBTOTAL					$11,874,831
	ENGINEERING, CM, SURVEY			8%		$949,986
	CMGC			12%		$1,424,980
	CONTINGENCY			30%		$4,274,939
	TOTAL					**$18,524,736**

Table 5.3.2 459 Lateral Cost Estimate

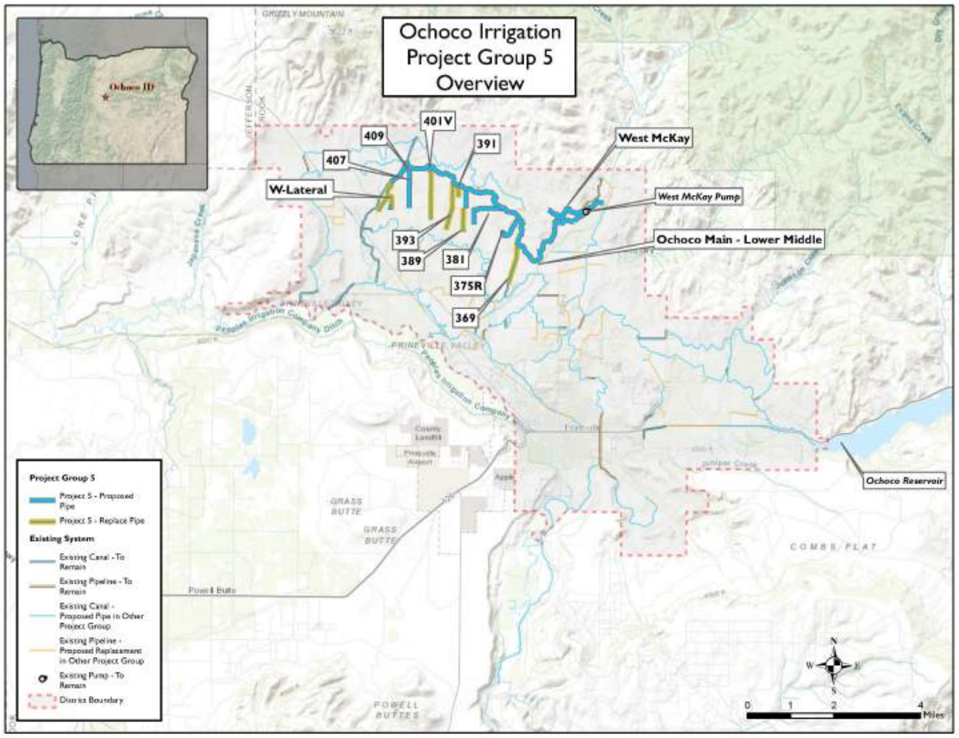
459 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	8	2,028	LF	$8	$16,221
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$24,221
	ENGINEERING, CM, SURVEY			18%		$4,360
	CMGC			18%		$4,360
	CONTINGENCY			30%		$9,882
	TOTAL					**$42,823**

Table 5.3.3 451 Lateral Cost Estimate

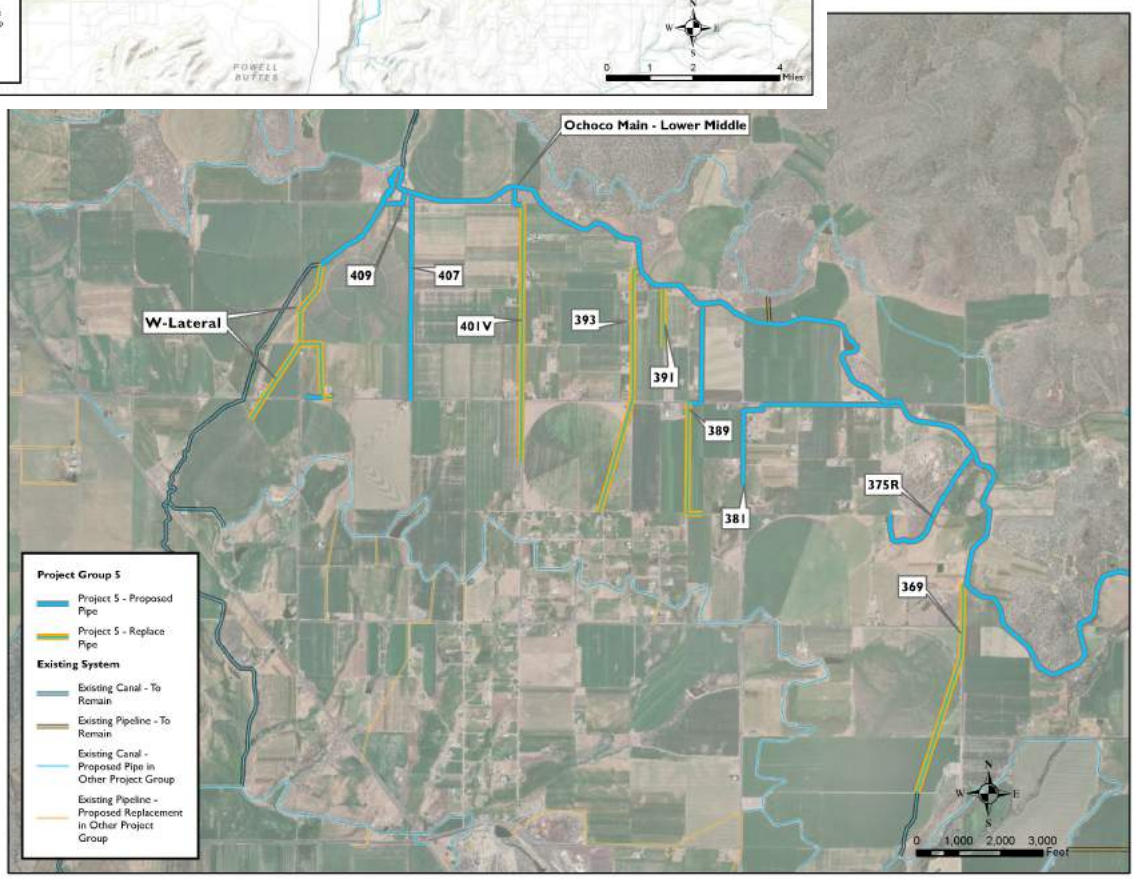
451 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	1,019	LF	$32	$32,621
PIPE	32.5	12	2,156	LF	$16	$34,496
PIPE	32.5	8	1,327	LF	$8	$10,619
PIPE	32.5	4	2,844	LF	$3	$8,531
TURNOUT			10	EA	$8,000	$80,000
	SUBTOTAL					$166,266
	ENGINEERING, CM, SURVEY			18%		$29,928
	CMGC			18%		$29,928
	CONTINGENCY			30%		$67,837
	TOTAL					**$293,959**

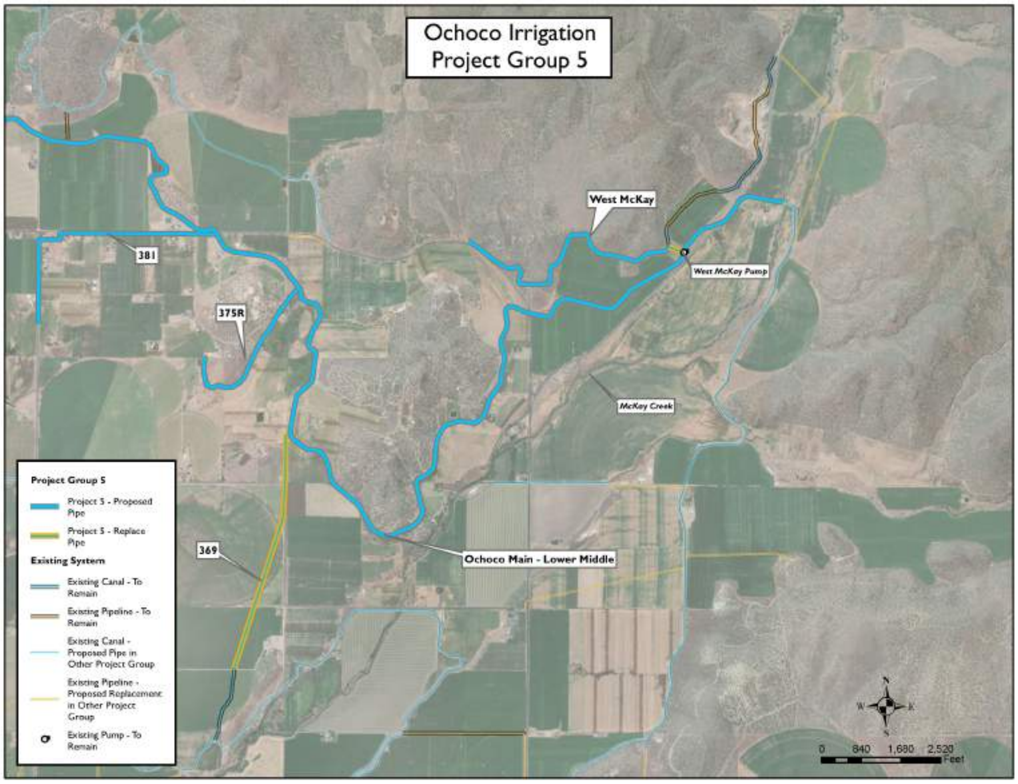
Table 5.3.4 449 Lateral Cost Estimate

449 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	8	2,447	LF	$8	$19,573
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$27,573
	ENGINEERING, CM, SURVEY			18%		$4,963
	CMGC			18%		$4,963
	CONTINGENCY			30%		$11,250
	TOTAL					**$48,749**



Project Group 5
Figure 5.4.1





Project Group 5
Figure 5.4.1 Cont.

Table 5.4.1 Ochoco Main Canal – Lower Middle Cost Estimate

Ochoco Main Canal - Lower Middle						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	84	22,076	LF	$800	$17,660,544
PIPE	32.5	78	5,262	LF	$741	$3,899,016
TURNOUT			21	EA	$8,000	$168,000
	SUBTOTAL					$21,727,560
	ENGINEERING, CM, SURVEY			8%		$1,738,205
	CMGC			12%		$2,607,307
	CONTINGENCY			30%		$7,821,922
	TOTAL					**$33,894,994**

Table 5.4.2 Lytle Creek Lateral Cost Estimate

Lytle Creek Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	18	3,468	LF	$32	$110,987
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$118,987
	ENGINEERING, CM, SURVEY			18%		$21,418
	CMGC			18%		$21,418
	CONTINGENCY			30%		$48,547
	TOTAL					**$210,369**

Table 5.4.3 W-Lateral Cost Estimate

W-Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	18	2,063	LF	$32	$66,016
PIPE	32.5	14	1,593	LF	$20	$31,868
PIPE	32.5	12	557	LF	$16	$8,918
PIPE	32.5	8	1,753	LF	$8	$14,023
PIPE	32.5	6	51	LF	$5	$253
PIPE	32.5	4	636	LF	$3	$1,907
TURNOUT			9	EA	$8,000	$72,000
	SUBTOTAL					$194,985
	ENGINEERING, CM, SURVEY			15%		$29,248
	CMGC			15%		$29,248
	CONTINGENCY			30%		$76,044
	TOTAL					**$329,525**

Table 5.4.4 407 Lateral Cost Estimate

407 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	3,573	LF	$32	$114,347
PIPE	32.5	12	1,360	LF	$16	$21,758
PIPE	32.5	8	3	LF	$8	$24
TURNOUT			4	EA	$8,000	$32,000
	SUBTOTAL					$168,129
	ENGINEERING, CM, SURVEY			18%		$30,263
	CMGC			18%		$30,263
	CONTINGENCY			30%		$68,597
	TOTAL					**$297,253**

Table 5.4.5 401 Lateral Cost Estimate

401 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	20	3,910	LF	$40	$156,389
PIPE	32.5	16	1,343	LF	$32	$42,987
PIPE	32.5	12	1,197	LF	$16	$19,151
PIPE	32.5	4	261	LF	$3	$783
TURNOUT			10	EA	$8,000	$80,000
	SUBTOTAL					$299,310
	ENGINEERING, CM, SURVEY			18%		$53,876
	CMGC			18%		$53,876
	CONTINGENCY			30%		$122,118
	TOTAL					**$529,180**

Table 5.4.6 393 Lateral Cost Estimate

393 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	14	648	LF	$20	$12,956
PIPE	32.5	12	1,972	LF	$16	$31,554
PIPE	32.5	10	3,435	LF	$12	$41,225
TURNOUT			7	EA	$8,000	$56,000
	SUBTOTAL					$141,735
	ENGINEERING, CM, SURVEY			18%		$25,512
	CMGC			18%		$25,512
	CONTINGENCY			30%		$57,828
	TOTAL					**$250,587**

Table 5.4.7 391 Lateral Cost Estimate

391 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	8	1,456	LF	$8	$11,651
TURNOUT			5	EA	$8,000	$40,000
	SUBTOTAL					$51,651
	ENGINEERING, CM, SURVEY			18%		$9,297
	CMGC			18%		$9,297
	CONTINGENCY			30%		$21,074
	TOTAL					**$91,319**

Table 5.4.8 389 Lateral Cost Estimate

389 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	14	2,366	LF	$20	$47,321
PIPE	32.5	12	302	LF	$16	$4,837
PIPE	32.5	6	2,986	LF	$5	$14,929
TURNOUT			6	EA	$8,000	$48,000
	SUBTOTAL					$115,086
	ENGINEERING, CM, SURVEY			18%		$20,716
	CMGC			18%		$20,716
	CONTINGENCY			30%		$46,955
	TOTAL					**$203,473**

Table 5.4.9 381 Lateral Cost Estimate

381 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	10	1,175	LF	$12	$14,099
PIPE	32.5	8	2,881	LF	$8	$23,050
PIPE	32.5	6	1,636	LF	$5	$8,181
PIPE	32.5	4	3	LF	$3	$9
TURNOUT			14	EA	$8,000	$112,000
	SUBTOTAL					$157,338
	ENGINEERING, CM, SURVEY			18%		$28,321
	CMGC			18%		$28,321
	CONTINGENCY			30%		$64,194
	TOTAL					**$278,173**

Table 5.4.10 375R Lateral Cost Estimate

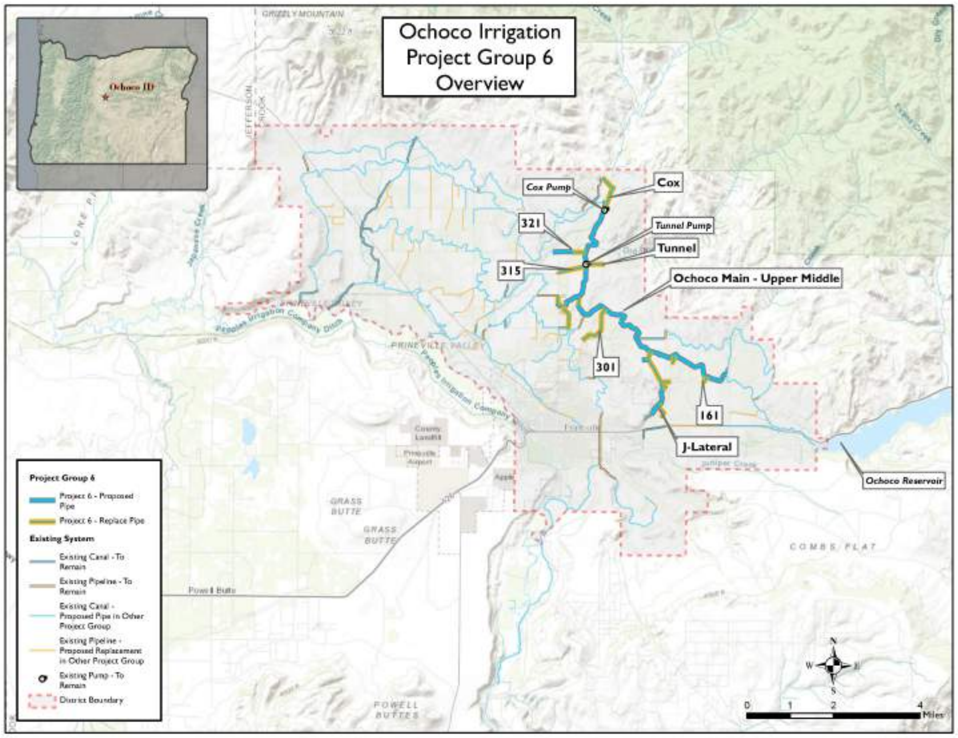
375R Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	3,727	LF	$32	$119,254
PIPE	32.5	10	18	LF	$12	$218
TURNOUT			7	EA	$8,000	$56,000
	SUBTOTAL					$175,473
	ENGINEERING, CM, SURVEY			18%		$31,585
	CMGC			18%		$31,585
	CONTINGENCY			30%		$71,593
	TOTAL					**$310,236**

Table 5.4.11 369 Lateral Cost Estimate

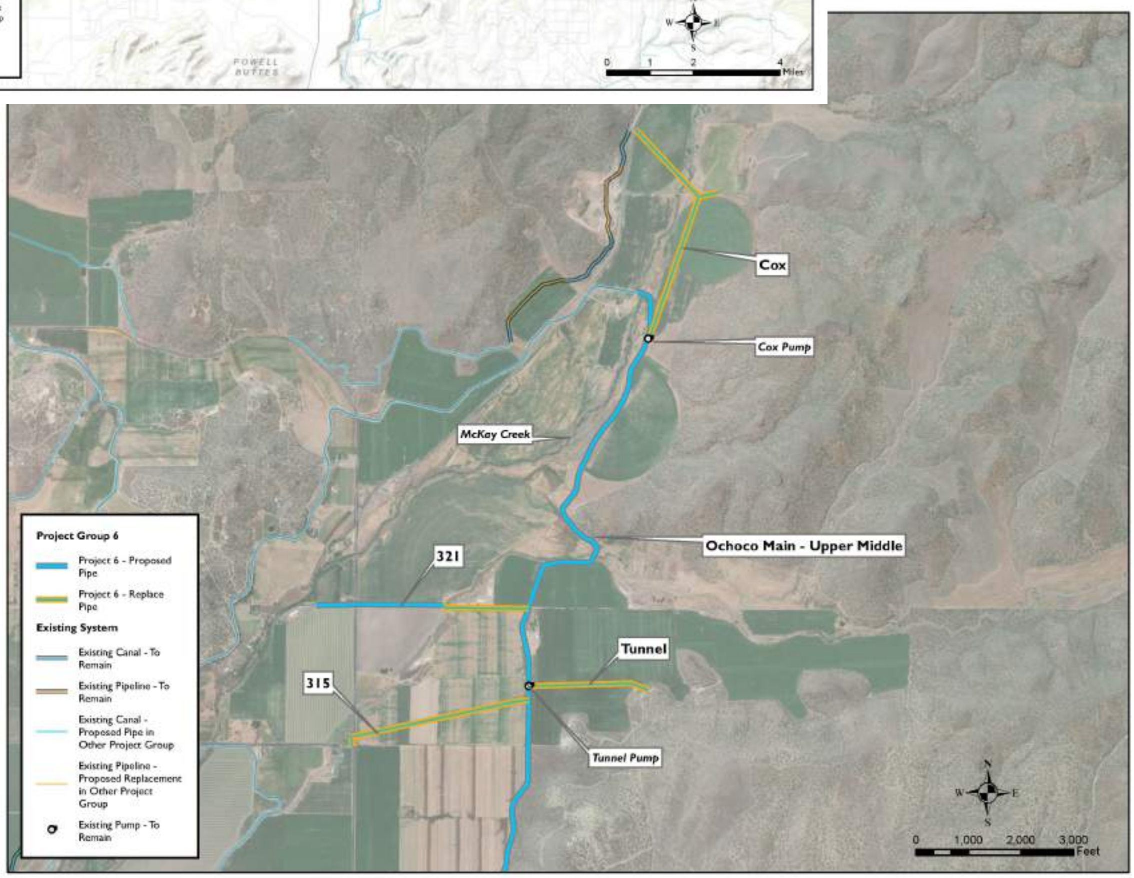
369 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	24	72	LF	$54	$3,862
PIPE	32.5	20	1,741	LF	$40	$69,638
PIPE	32.5	16	3,379	LF	$32	$108,127
TURNOUT			3	EA	$8,000	$24,000
	SUBTOTAL					$205,626
	ENGINEERING, CM, SURVEY			18%		$37,013
	CMGC			18%		$37,013
	CONTINGENCY			30%		$83,895
	TOTAL					**$363,547**

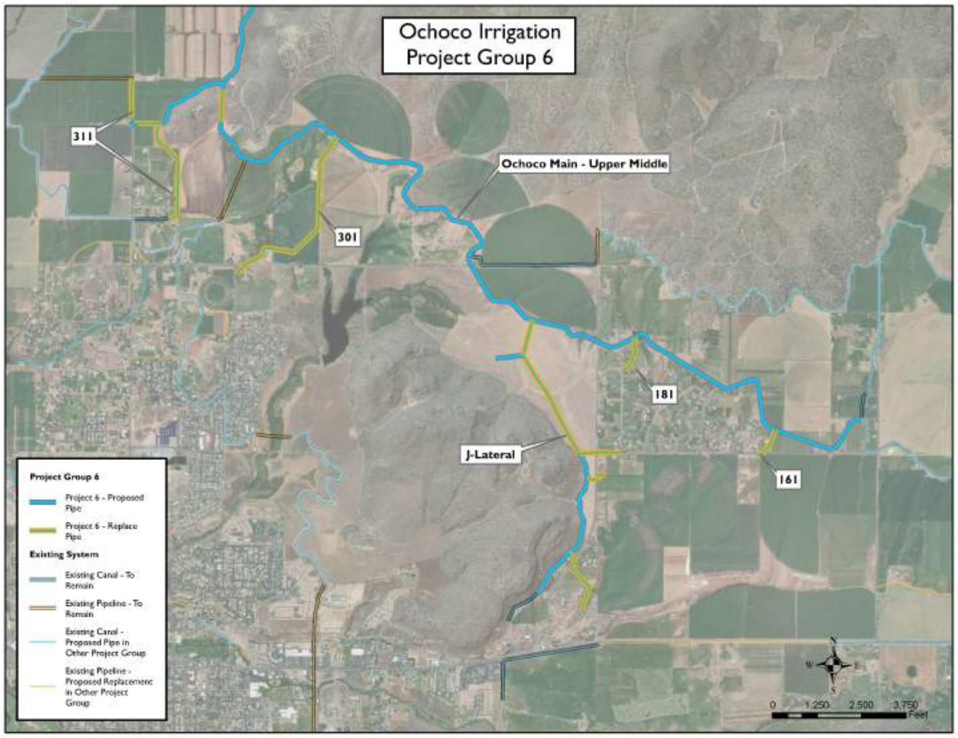
Table 5.4.12 West McKay Lateral Cost Estimate

West McKay Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	6	5,819	LF	$5	$29,096
TURNOUT			3	EA	$8,000	$24,000
	SUBTOTAL					$53,096
	ENGINEERING, CM, SURVEY			18%		$9,557
	CMGC			18%		$9,557
	CONTINGENCY			30%		$21,663
	TOTAL					**$93,874**



Project Group 6
Figure 5.5.1





Project Group 6
Figure 5.5.1 Cont.

Table 5.5.1 Ochoco Main Canal – Upper Middle Cost Estimate

Ochoco Main Canal - Upper Middle Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	90	11,325	LF	$850	$9,626,634
PIPE	32.5	84	20,302	LF	$800	$16,241,591
PIPE	32.5	78	4,317	LF	$741	$3,198,767
PIPE	32.5	72	9,757	LF	$684	$6,673,865
TURNOUT			83	EA	$8,000	$664,000
	SUBTOTAL					$36,404,857
	ENGINEERING, CM, SURVEY			8%		$2,912,389
	CMGC			12%		$4,368,583
	CONTINGENCY			30%		$13,105,748
	TOTAL					**$56,791,576**

Table 5.5.2 Cox Lateral Cost Estimate

Cox Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	8	2,880	LF	$8	$23,037
PIPE	32.5	4	2,119	LF	$3	$6,357
TURNOUT			2	EA	$8,000	$16,000
	SUBTOTAL					$45,394
	ENGINEERING, CM, SURVEY			18%		$8,171
	CMGC			18%		$8,171
	CONTINGENCY			30%		$18,521
	TOTAL					**$80,257**

Table 5.5.3 321 Lateral Cost Estimate

321 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	10	3,885	LF	$12	$46,617
PIPE	32.5	8	175	LF	$8	$1,403
TURNOUT			3	EA	$8,000	$24,000
	SUBTOTAL					$72,020
	ENGINEERING, CM, SURVEY			18%		$12,964
	CMGC			18%		$12,964
	CONTINGENCY			30%		$29,384
	TOTAL					**$127,332**

Table 5.5.4 Tunnel Lateral Cost Estimate

Tunnel Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	21	12	2,061	LF	$24	$49,462
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$57,462
	ENGINEERING, CM, SURVEY			18%		$10,343
	CMGC			18%		$10,343
	CONTINGENCY			30%		$23,444
	TOTAL					**$101,592**

Table 5.5.5 315 Lateral Cost Estimate

315 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	6	3,622	LF	$5	$18,108
TURNOUT			2	EA	$8,000	$16,000
	SUBTOTAL					$34,108
	ENGINEERING, CM, SURVEY			18%		$6,139
	CMGC			18%		$6,139
	CONTINGENCY			30%		$13,916
	TOTAL					**$60,303**

Table 5.5.6 311 Lateral Cost Estimate

311 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	20	2,264	LF	$40	$90,575
PIPE	32.5	16	759	LF	$32	$24,283
PIPE	32.5	10	1,451	LF	$12	$17,411
PIPE	32.5	8	123	LF	$8	$984
PIPE	32.5	4	2,990	LF	$3	$8,970
TURNOUT			10	EA	$8,000	$80,000
	SUBTOTAL					$222,223
	ENGINEERING, CM, SURVEY			18%		$40,000
	CMGC			18%		$40,000
	CONTINGENCY			30%		$90,667
	TOTAL					**$392,891**

Table 5.5.7 301 Lateral Cost Estimate

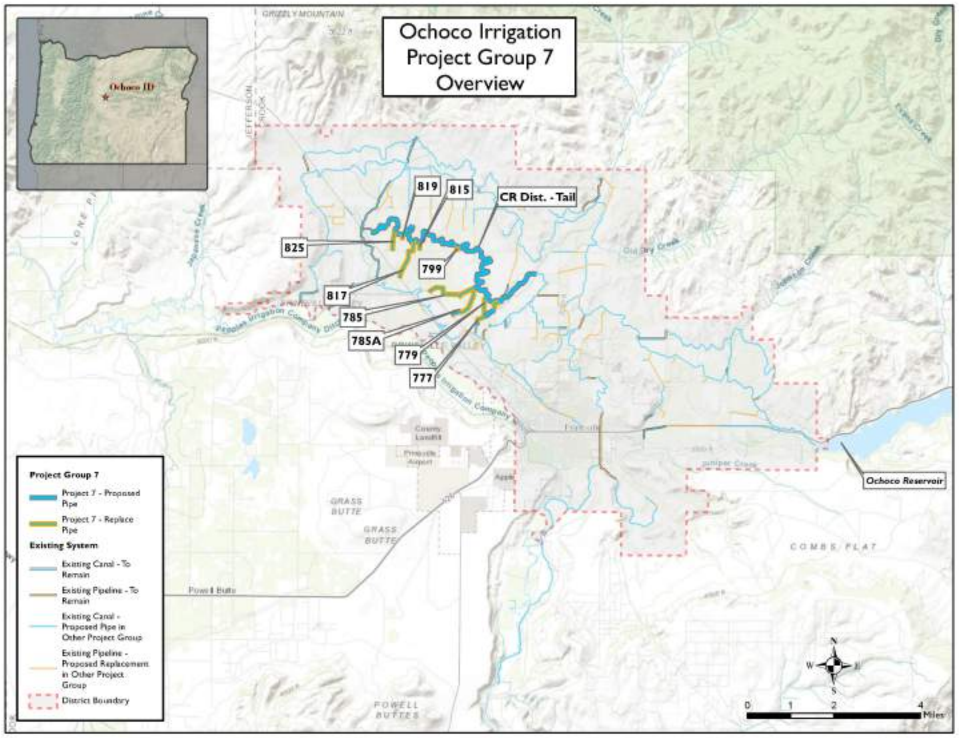
301 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	73	LF	$32	$2,349
PIPE	32.5	12	1,417	LF	$16	$22,669
PIPE	32.5	10	3,610	LF	$12	$43,326
PIPE	32.5	8	470	LF	$8	$3,761
TURNOUT			6	EA	$8,000	$48,000
	SUBTOTAL					$120,105
	ENGINEERING, CM, SURVEY			18%		$21,619
	CMGC			18%		$21,619
	CONTINGENCY			30%		$49,003
	TOTAL					**$212,345**

Table 5.5.8 J-Lateral Cost Estimate

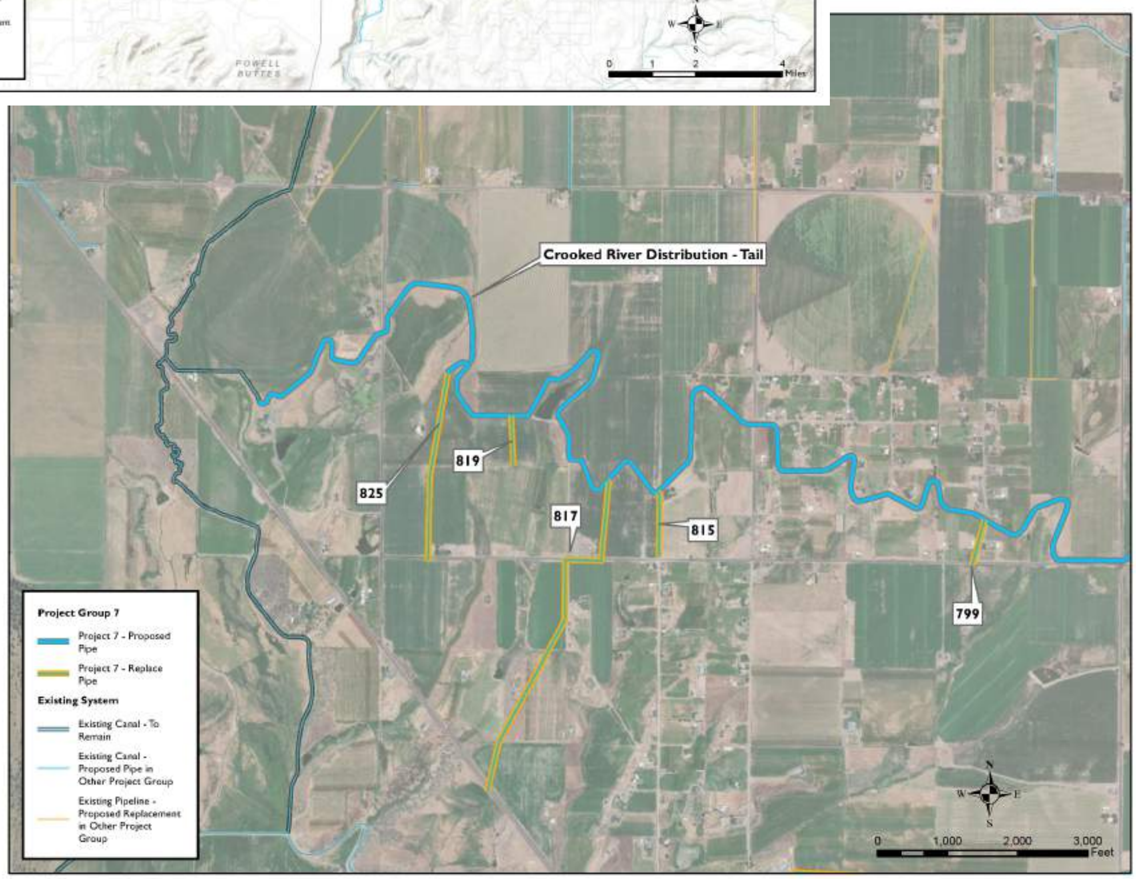
J-Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	1,025	LF	$32	$32,796
PIPE	32.5	14	3,202	LF	$20	$64,043
PIPE	32.5	12	1,551	LF	$16	$24,823
PIPE	32.5	10	2,313	LF	$12	$27,754
TURNOUT			6	EA	$8,000	$48,000
	SUBTOTAL					$197,416
	ENGINEERING, CM, SURVEY			18%		$35,535
	CMGC			18%		$35,535
	CONTINGENCY			30%		$80,546
	TOTAL					**$349,032**

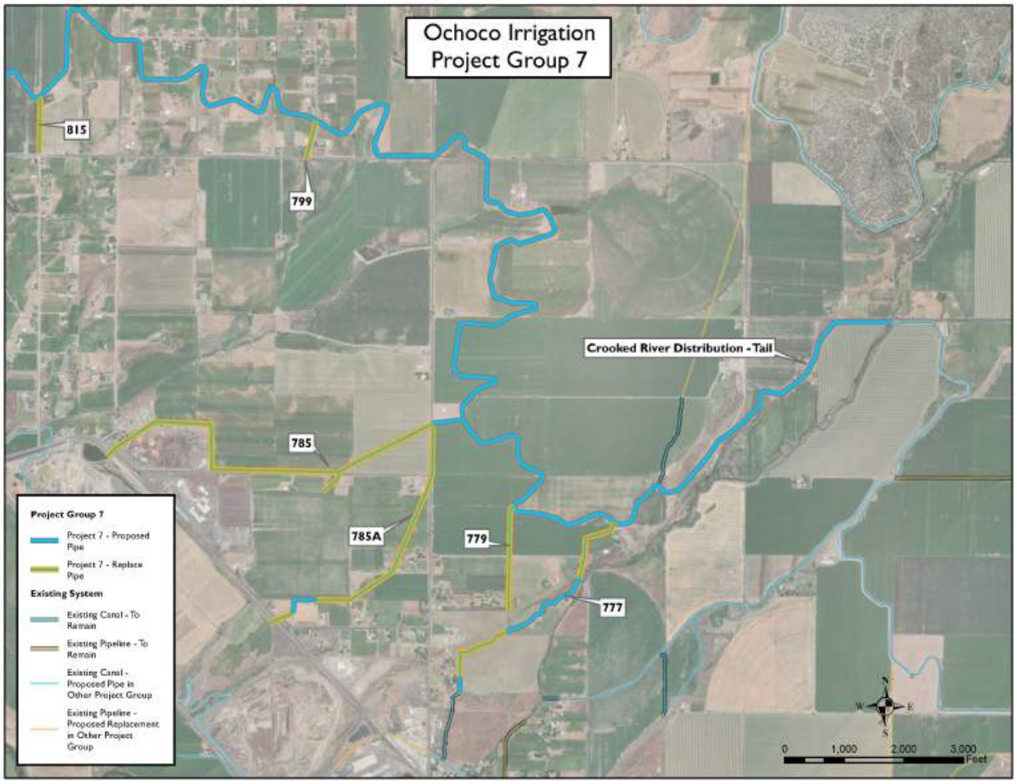
Table 5.5.9 161 Lateral Cost Estimate

161 Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	24	879	LF	$54	$47,462
PIPE	32.5	4	3	LF	$3	$8
TURNOUT			4	EA	$8,000	$32,000
	SUBTOTAL					$79,470
	ENGINEERING, CM, SURVEY			18%		$14,305
	CMGC			18%		$14,305
	CONTINGENCY			30%		$32,424
	TOTAL					**$140,504**



Project Group 7
Figure 5.6.1





Project Group 7
Figure 5.6.1 Cont.

Table 5.6.1 Crooked River Distribution Canal – Tail Cost Estimate

Crooked River Distribution Canal - Tail						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	63	7,344	LF	$600	$4,406,544
PIPE	32.5	54	4,608	LF	$356	$1,640,571
PIPE	32.5	48	8,692	LF	$212	$1,842,610
PIPE	32.5	42	4,466	LF	$164	$732,435
PIPE	32.5	36	3,109	LF	$126	$391,753
PIPE	32.5	34	2,308	LF	$110	$253,918
PIPE	32.5	32	1,915	LF	$94	$180,049
PIPE	32.5	30	1,576	LF	$86	$135,574
PIPE	32.5	28	811	LF	$76	$61,639
PIPE	32.5	26	1,865	LF	$64	$119,354
PIPE	32.5	24	1,690	LF	$54	$91,244
PIPE	32.5	20	1,397	LF	$40	$55,871
PIPE	32.5	14	902	LF	$20	$18,036
PIPE	32.5	12	1,492	LF	$16	$23,869
PIPE	32.5	8	349	LF	$8	$2,790
PIPE	32.5	6	2,675	LF	$5	$13,373
TURNOUT			28	EA	$8,000	$224,000
	SUBTOTAL					$10,193,629
	ENGINEERING, CM, SURVEY			8%		$815,490
	CMGC			12%		$1,223,235
	CONTINGENCY			30%		$3,669,706
	TOTAL					**$15,902,061**

Table 5.6.2 825 Lateral Cost Estimate

825 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	14	2,963	LF	$20	$59,255
PIPE	32.5	8	90	LF	$8	$720
PIPE	32.5	4	7	LF	$5	$33
TURNOUT			5	EA	$8,000	$40,000
	SUBTOTAL					$100,008
	ENGINEERING, CM, SURVEY			18%		$18,002
	CMGC			18%		$18,002
	CONTINGENCY			30%		$40,803
	TOTAL					**$176,815**

Table 5.6.3 819 Lateral Cost Estimate

819 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	8	715	LF	$8	$5,720
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$13,720
	ENGINEERING, CM, SURVEY			18%		$2,470
	CMGC			18%		$2,470
	CONTINGENCY			30%		$5,598
	TOTAL					**$24,257**

Table 5.6.4 817 Lateral Cost Estimate

817 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	12	3,334	LF	$16	$53,347
PIPE	32.5	8	1,394	LF	$8	$11,153
PIPE	32.5	6	2,188	LF	$5	$10,940
TURNOUT			5	EA	$8,000	$40,000
	SUBTOTAL					$115,441
	ENGINEERING, CM, SURVEY			18%		$20,779
	CMGC			18%		$20,779
	CONTINGENCY			30%		$47,100
	TOTAL					**$204,099**

Table 5.6.5 815 Lateral Cost Estimate

815 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	8	933	LF	$8	$7,464
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$15,464
	ENGINEERING, CM, SURVEY			18%		$2,784
	CMGC			18%		$2,784
	CONTINGENCY			30%		$6,309
	TOTAL					**$27,340**

Table 5.6.6 799 Lateral Cost Estimate

799 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	10	672	LF	$12	$8,064
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$16,064
	ENGINEERING, CM, SURVEY			18%		$2,892
	CMGC			18%		$2,892
	CONTINGENCY			30%		$6,554
	TOTAL					**$28,401**

Table 5.6.7 785 Lateral Cost Estimate

785 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	24	511	LF	$54	$27,618
PIPE	32.5	20	11	LF	$40	$430
PIPE	32.5	10	1,545	LF	$12	$18,536
PIPE	32.5	4	5,468	LF	$3	$16,405
TURNOUT			7	EA	$8,000	$56,000
	SUBTOTAL					$118,989
	ENGINEERING, CM, SURVEY			18%		$21,418
	CMGC			18%		$21,418
	CONTINGENCY			30%		$48,548
	TOTAL					**$210,373**

Table 5.6.8 785A Lateral Cost Estimate

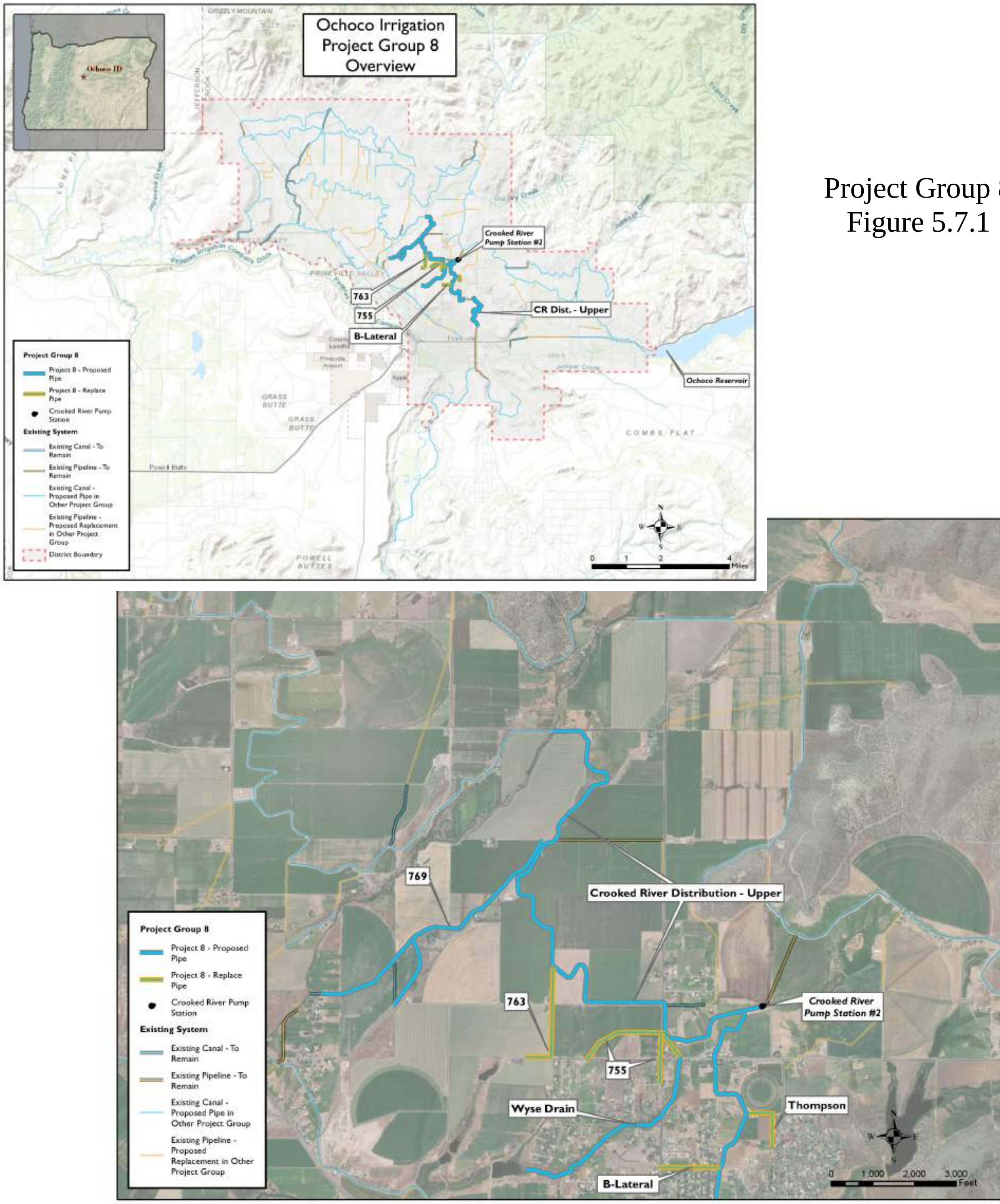
785A Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	16	3,446	LF	$32	$110,275
PIPE	32.5	14	573	LF	$20	$11,450
PIPE	32.5	10	1,041	LF	$12	$12,491
TURNOUT			8	EA	$8,000	$64,000
	SUBTOTAL					$198,216
	ENGINEERING, CM, SURVEY			18%		$35,679
	CMGC			18%		$35,679
	CONTINGENCY			30%		$80,872
	TOTAL					**$350,446**

Table 5.6.9 779 Lateral Cost Estimate

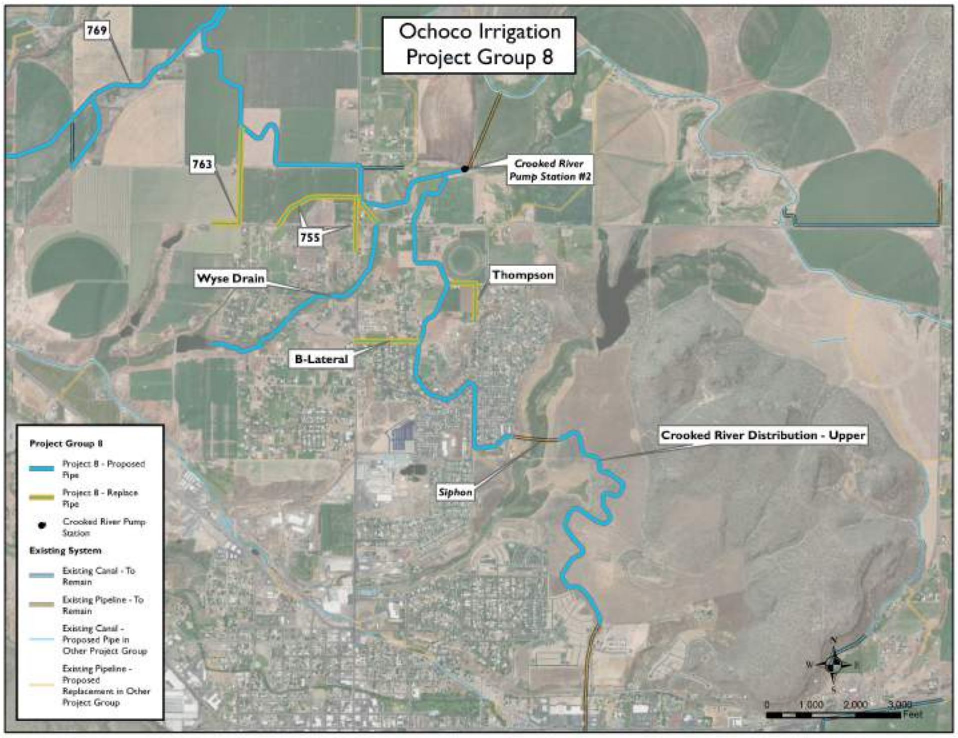
779 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	6	856	LF	$5	$4,281
PIPE	32.5	4	919	LF	$3	$2,757
TURNOUT			3	EA	$8,000	$24,000
	SUBTOTAL					$31,039
	ENGINEERING, CM, SURVEY			18%		$5,587
	CMGC			18%		$5,587
	CONTINGENCY			30%		$12,664
	TOTAL					**$54,876**

Table 5.6.10 777 Lateral Cost Estimate

777 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	8	2,914	LF	$8	$23,310
PIPE	32.5	4	1,551	LF	$3	$4,653
TURNOUT			7	EA	$8,000	$56,000
	SUBTOTAL					$83,964
	ENGINEERING, CM, SURVEY			18%		$15,113
	CMGC			18%		$15,113
	CONTINGENCY			30%		$34,257
	TOTAL					**$148,448**



Project Group 8
Figure 5.7.1



Project Group 8
Figure 5.7.1 Cont.

Table 5.7.1 Crooked River Distribution Canal – Upper Cost Estimate

Crooked River Distribution Canal - Upper						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	78	20,626	LF	$741	$15,284,019
PIPE	32.5	72	1,477	LF	$684	$1,010,005
PIPE	32.5	66	11,376	LF	$628	$7,143,843
PIPE	32.5	63	3,642	LF	$600	$2,185,455.24
TURNOUT			52	EA	$8,000	$416,000
	SUBTOTAL					$26,039,323
	ENGINEERING, CM, SURVEY				8%	$2,083,146
	CMGC				12%	$3,124,719
	CONTINGENCY				30%	$9,374,156
	TOTAL					**$40,621,344**

Table 5.7.2 769 Lateral Cost Estimate

769 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	18	4,073	LF	$32	$130,324
PIPE	32.5	16	845	LF	$32	$27,030
PIPE	32.5	14	1,899	LF	$20	$37,970
PIPE	32.5	10	3	LF	$12	$39
PIPE	32.5	4	1,940	LF	$3	$5,820
TURNOUT			8	EA	$8,000	$64,000
	SUBTOTAL					$265,184
	ENGINEERING, CM, SURVEY			18%		$47,733
	CMGC			18%		$47,733
	CONTINGENCY			30%		$108,195
	TOTAL					**$468,845**

Table 5.7.3 763 Lateral Cost Estimate

763 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	12	2,817	LF	$16	$45,066
TURNOUT			4	EA	$8,000	$32,000
	SUBTOTAL					$77,066
	ENGINEERING, CM, SURVEY			18%		$13,872
	CMGC			18%		$13,872
	CONTINGENCY			30%		$31,443
	TOTAL					**$136,253**

Table 5.7.4 755 Lateral Cost Estimate

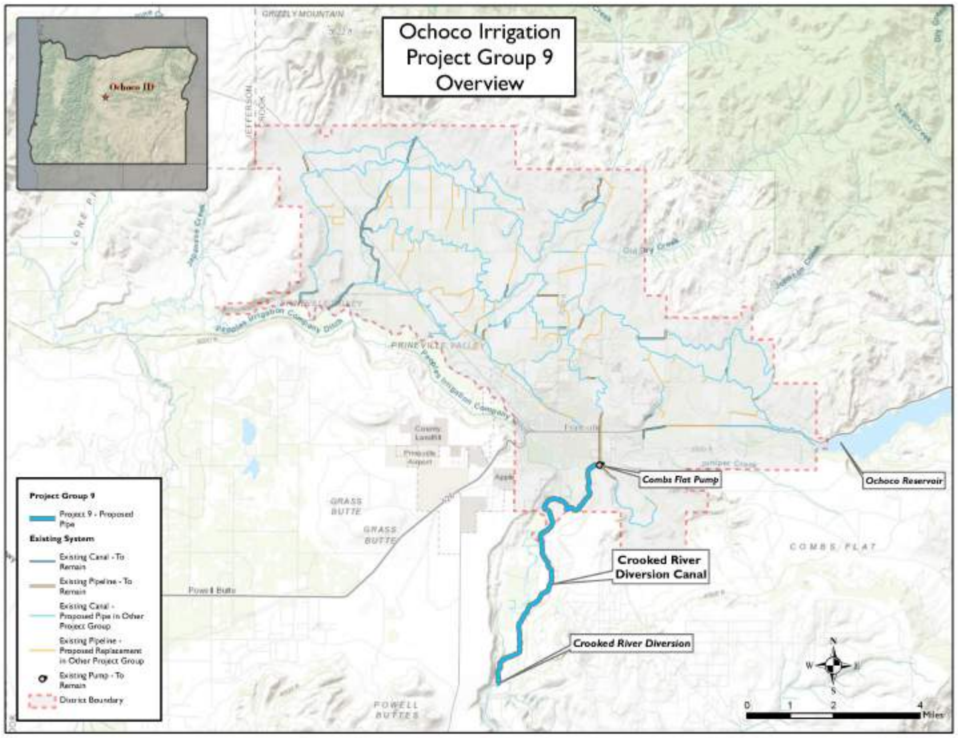
755 Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	4	3,379	LF	$3	$10,138
TURNOUT			1	EA	$8,000	$8,000
	SUBTOTAL					$18,138
	ENGINEERING, CM, SURVEY			18%		$3,265
	CMGC			18%		$3,265
	CONTINGENCY			30%		$7,400
	TOTAL					**$32,068**

Table 5.7.5 B-Lateral Cost Estimate

B-Lateral						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	6	1,394	LF	$5	$6,970
PIPE	32.5	4	81	LF	$3	$243
TURNOUT			2	EA	$8,000	$16,000
	SUBTOTAL					$23,213
	ENGINEERING, CM, SURVEY			18%		$4,178
	CMGC			18%		$4,178
	CONTINGENCY			30%		$9,471
	TOTAL					**$41,041**

Table 5.7.6 Crooked River Pump Station No. 2 Cost Estimate

Crooked River Pump Station No. 2					
Ochoco Irrigation District					
Reconnaissance-Level Construction Cost Estimate					7/23/2018
Feature	**Horsepower**	**SOR Est. 2012**	**USBR Index '12**	**USBR Index '18**	**Total Cost**
Crooked River Pump Station No. 2	1,500	$2,217,000	349	388	$2,464,745



Project Group 9
Figure 5.8.1

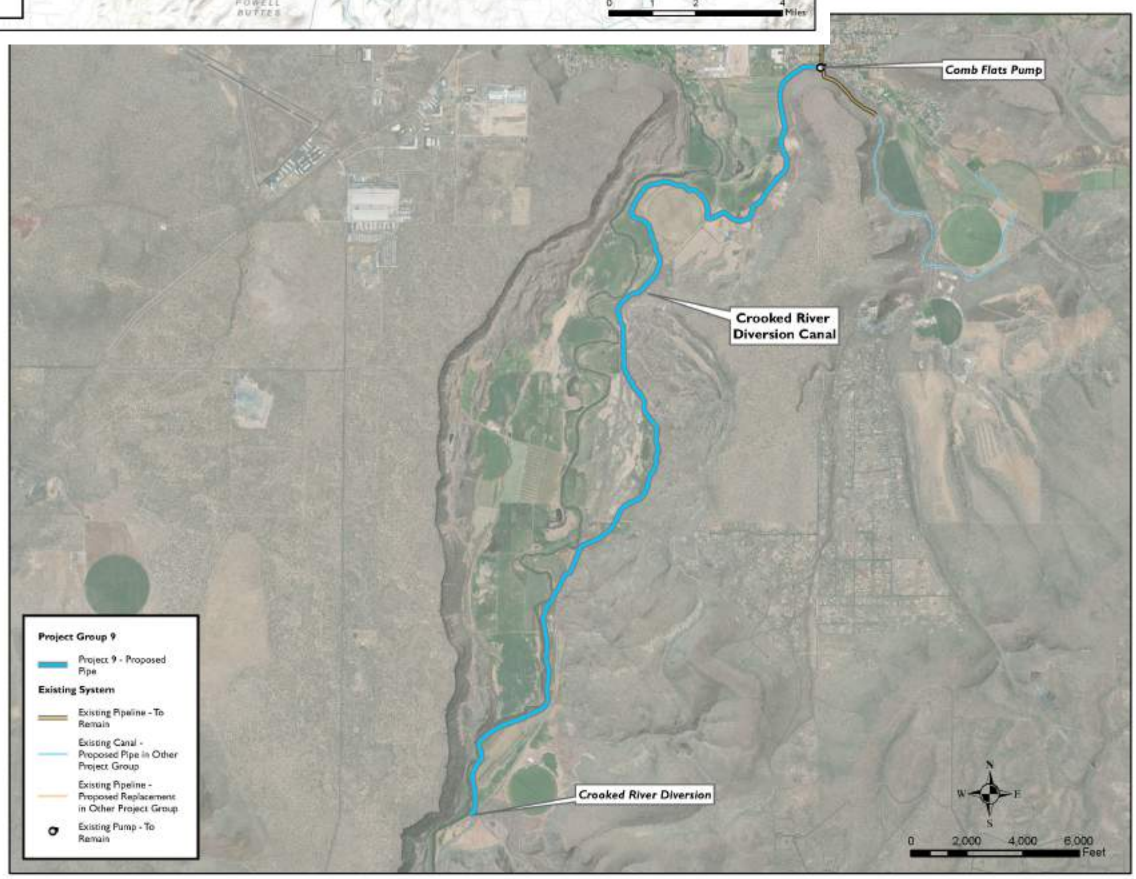
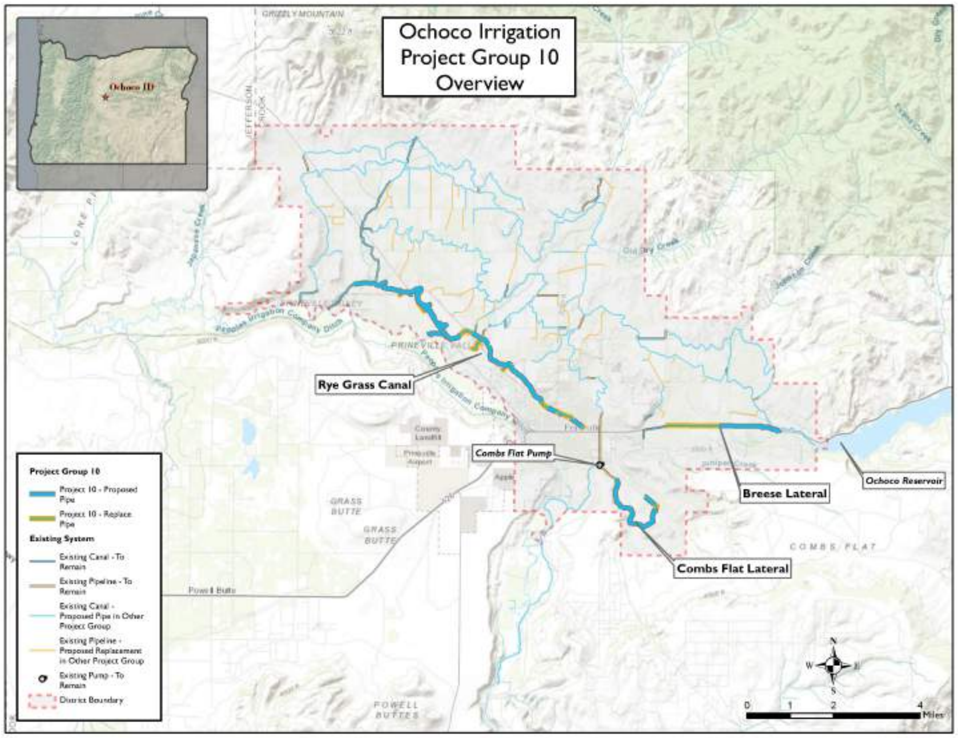
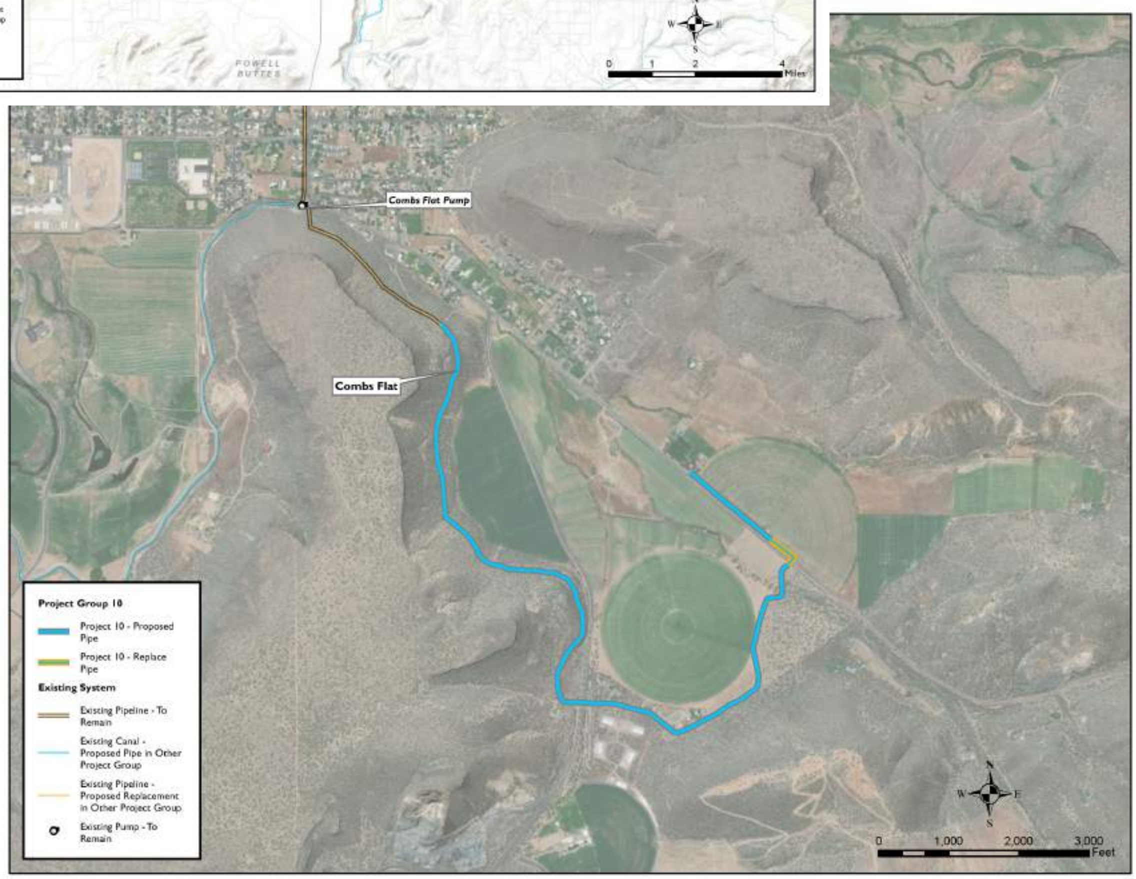


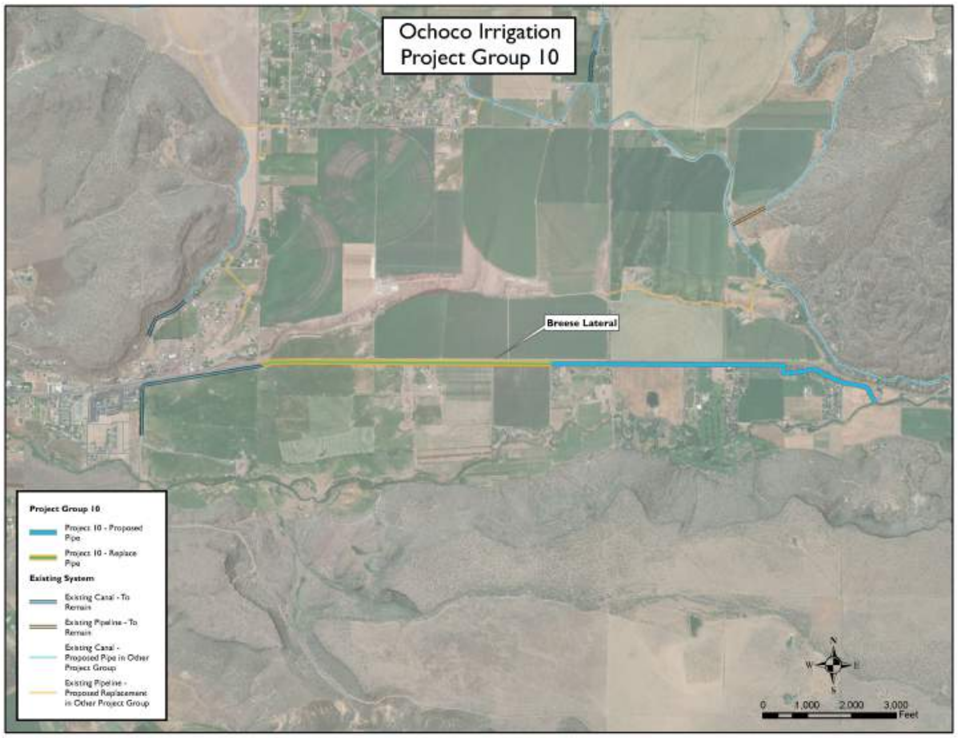
Table 5.8.1 Crooked River Diversion Canal Cost Estimate

Crooked River Diversion Canal						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	Weholite	90	39,610	LF	$850	$33,668,328
TURNOUT			8	EA	$8,000	$64,000
	SUBTOTAL					$33,732,328
	ENGINEERING, CM, SURVEY			8%		$2,698,586
	CMGC			12%		$4,047,879
	CONTINGENCY			30%		$12,143,638
	TOTAL					**$52,622,431**

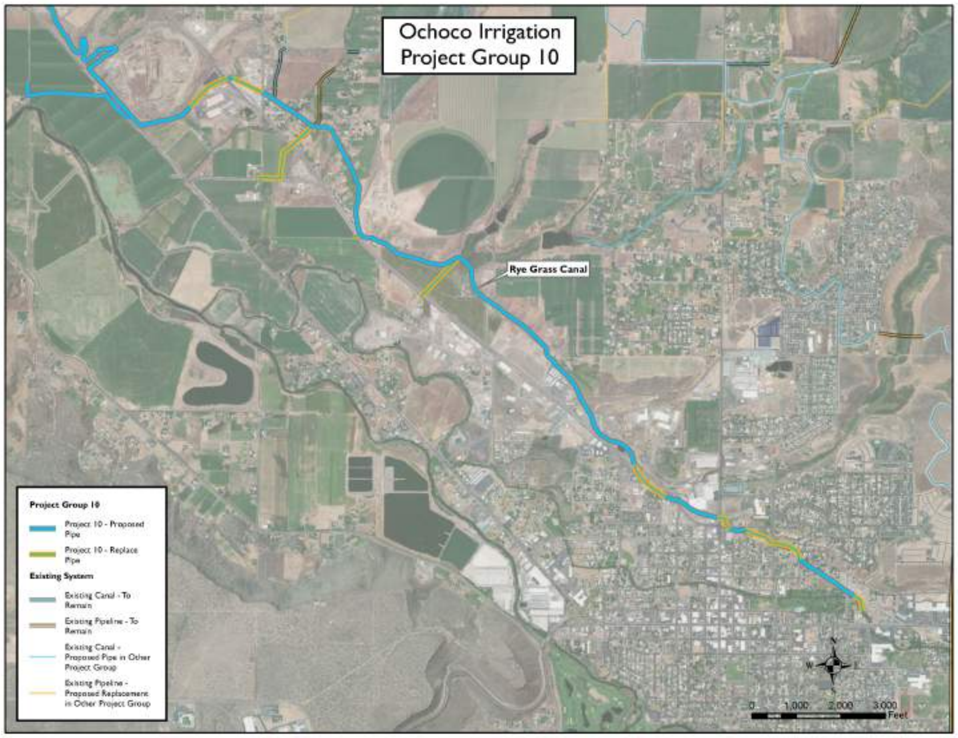


Project Group 10
Figure 5.9.1





Project Group 10
Figure 5.9.1 Cont.



Project Group 10
Figure 5.9.1 Cont.

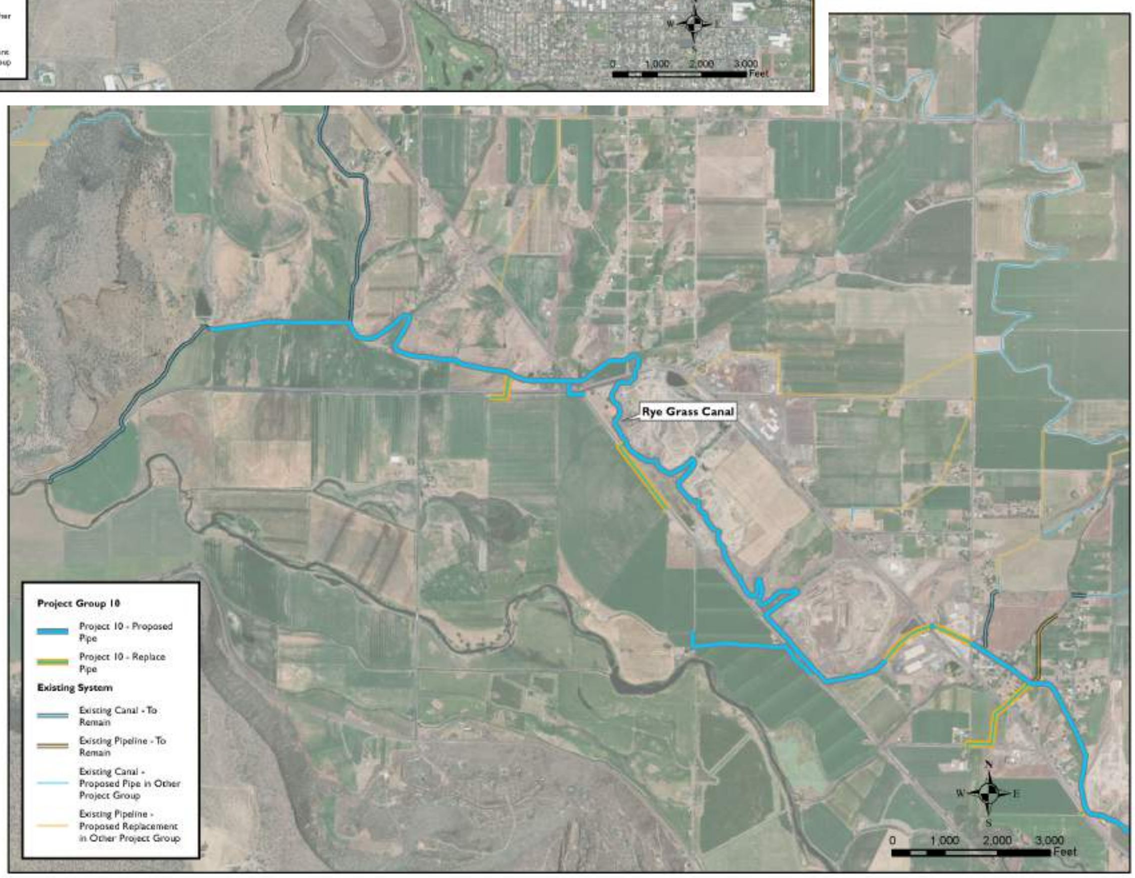


Table 5.9.1 Combs Flat Lateral Cost Estimate

Combs Flat Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	18	1,456	LF	$32	$46,576
PIPE	32.5	16	6,634	LF	$32	$212,283
PIPE	32.5	12	3,535	LF	$16	$56,555
PIPE	32.5	10	877	LF	$12	$10,529
PIPE	32.5	4	1,505	LF	$3	$4,516
TURNOUT			10	EA	$8,000	$80,000
	SUBTOTAL					$410,460
	ENGINEERING, CM, SURVEY			18%		$73,883
	CMGC			18%		$73,883
	CONTINGENCY			30%		$167,468
	TOTAL					**$725,693**

Table 5.9.2 Breese Lateral Cost Estimate

Breese Lateral Ochoco Irrigation District Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	24	2,209	LF	$54	$119,292
PIPE	32.5	20	7,025	LF	$40	$280,987
PIPE	32.5	16	1,982	LF	$32	$63,433
PIPE	32.5	12	680	LF	$16	$10,876
PIPE	32.5	10	2,504	LF	$12	$30,050
TURNOUT			12	EA	$8,000	$96,000
	SUBTOTAL					$600,638
	ENGINEERING, CM, SURVEY			15%		$90,096
	CMGC			15%		$90,096
	CONTINGENCY			30%		$234,249
	TOTAL					**$1,015,078**

Table 5.9.3 Rye Grass Canal Cost Estimate

Rye Grass Canal						
Ochoco Irrigation District						
Reconnaissance-Level Construction Cost Estimate						3/15/2017
Feature	**DR or PR**	**Dia. (In)**	**Length (ft)**	**Unit**	**$/Unit**	**Total Cost**
PIPE	32.5	42	8,869	LF	$164	$1,454,518
PIPE	32.5	36	13,011	LF	$126	$1,639,344
PIPE	32.5	34	1,555	LF	$110	$171,067
PIPE	32.5	30	8,861	LF	$86	$762,047
PIPE	32.5	26	3,571	LF	$64	$228,565
PIPE	32.5	24	214	LF	$54	$11,555
PIPE	32.5	20	2,938	LF	$40	$117,500
PIPE	32.5	18	1,034	LF	$32	$33,083
PIPE	32.5	16	1,882	LF	$32	$60,239
PIPE	32.5	12	1,755	LF	$16	$28,074
PIPE	32.5	10	47	LF	$12	$559
PIPE	32.5	8	3,357	LF	$8	$26,858
PIPE	32.5	6	3,342	LF	$5	$16,712
PIPE	32.5	4	571	LF	$3	$1,712
TURNOUT			67	EA	$8,000	$536,000
	SUBTOTAL					$5,087,834
	ENGINEERING, CM, SURVEY			8%		$407,027
	CMGC			12%		$610,540
	CONTINGENCY			30%		$1,831,620
	TOTAL					**$7,937,021**

5.10 **Project Group 11 Ochoco Dam Hydroelectric Power Project**: See Appendix D

APPENDIX A
TABULATED SEEPAGE LOSS DATA

Final
08-22-2017 (KLC)

OCHCO IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS

(green)	= Spill Loss; flow to Crooked River, Ochoco Crk, McKay Crk, Lytle Crk
(yellow)	= Not Measured or Estimated
(red)	= Return Flow
(purple)	= Turn-outs to Laterals and Sublaterals

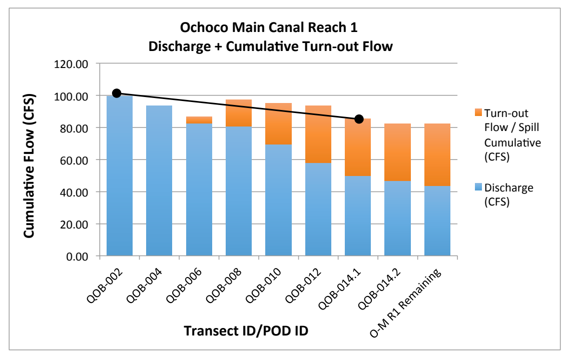
Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
Ochoco Main Canal Reach 1 (ADCP Boat Measurements)				ADCP Measurements
QOB-002	**99.39**		0.00	OWRD Measurement 07-27-17
OID 1		0.00		No measurement recorded, assumed OFF
OID 2		0.00		No measurement recorded, assumed OFF
OM1		0.00		No measurement recorded, assumed OFF
OID 3		0.00		No measurement recorded, assumed OFF
QOB-004	**93.39**		0.00	OWRD Measurement 07-27-17
Lanius #3		-1.50		Headgate
Lanius #5		-0.60		Headgate
Lanius #6		-1.70		Headgate
#130		-0.20		Pump in ditch
#131		0.00		No measurement recorded, assumed OFF
QOB-006	**82.64**		4.00	ADCP Boat Measurement 8-8-16
Johnson Creek Pump Sta.		-12.54		8-8-16, est. flow Johnson Crk Pump Station
QOB-008	**80.63**		16.54	ADCP Boat Measurement 8-8-16
#136		0.00		No measurement recorded, assumed OFF
#139		-2.80		Headgate
#141		0.00		No measurement recorded, assumed OFF
#144		0.00		No measurement recorded, assumed OFF
#145		0.00		No measurement recorded, assumed OFF
#146		0.00		No measurement recorded, assumed OFF
#146a		0.00		No measurement recorded, assumed OFF
Johnson Creek return		2.50		Johnson Creek return flow to Main Canal
#147		-0.25		Sump-piped thru canal road
#153		-3.00		Headgate
#157		0.00		No measurement recorded, assumed OFF
#158		0.00		No measurement recorded, assumed OFF
#160		0.00		No measurement recorded, assumed OFF
#161		-4.50		Headgate
#161-C		-0.35		Headgate (piped lateral)
#163		-0.10		Pump in canal
#165		-0.50		Headgate
QOB-010	**69.48**		25.54	ADCP Boat Measurement 8-8-16
#166		-1.40		Pump in canal
#167		-0.50		Headgate
#169		-0.25		Headgate
#172		-0.40		Pump in canal
#173		-0.50		Headgate
#175		-0.20		Headgate
#177		-0.45		Headgate
#179		0.00		No measurement recorded, assumed OFF
#181		-1.20		Headgate (piped lateral)
#182		0.00		No measurement recorded, assumed OFF
#183		-0.35		
#184		0.00		No measurement recorded, assumed OFF
#185		0.00		No measurement recorded, assumed OFF
Headgate Left Bank		0.00		No measurement recorded, assumed OFF
#188		0.00		No measurement recorded, assumed OFF
#191-J		-3.00		Headgate - J Lateral
J-1		-0.10		Headgate - J Lateral
J-2		-0.35		Headgate - J Lateral
J-4		-0.75		Headgate - J Lateral
J-5		-0.50		Headgate - J Lateral
QOB-012	**58.09**		35.49	ADCP Boat Measurement 8-8-16
Johnson Crk Canal return (QWO-14)		4.48		Johnson Crk Canal return flow to Main Canal
#197		-1.00		Headgate
#204		-1.50		Pump in ditch
#208		-2.00		Pump in ditch
QOB-014.1	**49.96**		35.51	ADCP Boat Measurement 8-8-16
QOB-014.2	**46.73**		35.51	ADCP Boat Measurement 8-9-16
#301		-3.00		Estimated
O-M R1 Remaining	43.73		38.51	Calc. value QOB-014 minus Turnout #301
Ochoco Main Canal Reach 2 (ADCP Boat Measurements)				ADCP Measurements
Re-lift Pump Station		92.27		Calculated inflow from Re-lifts 8-9-16
#307		0.00		Pump, no measure recorded, assumed OFF
#311 QWO-016		-4.41		Weir Measurement #311 Lat
#313		-2.50		Estimated & counted hand lines & pivot

Ochoco Main Reach 1

Over-all Ochoco Irrigation District Discharge Measurements

Overall System Intake to the Study Reaches	=	690.20		
Overall System Spill from Study Reaches	=	-31.38		
Overall System Turnouts + Flow Remaining	=	-605.80		
Overall System Seepage Loss in Study Reaches	=	53.02	=	7.68%

QOB-002 and QOB-004 Replaced BY OWRD Measurements
Taken July 27, 2017 (Readings Were 114 CFS at Head End
and 108 CFS at the End of Liner for a Difference of 6 CFS)
6 CFS was Added to the 93.93 CFS Reading at QOB-004
Per the OWRD Staff Measurements Taken



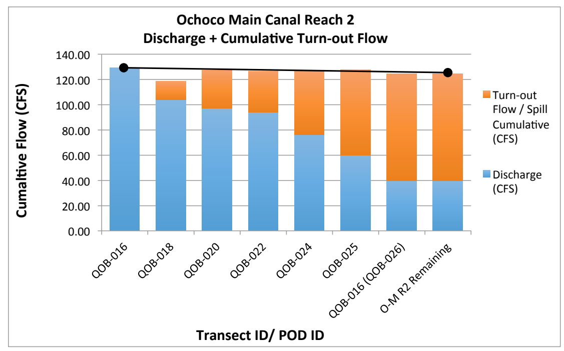
Ochoco Main Reach 1 Intake to the Study Reach	=	99.39		
Ochoco Main Reach 1 Spill from Study Reach	=	0.00		
Ochoco Main Reach 1 Turnouts + Flow Remaining	=	-85.47		
Ochoco Main Reach 1 Seepage Loss in Study Reach	=	13.92	=	14.01%

OCHCO IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS

Final
08-22-2017 (KLC)

Ochoco Main Reach 2

Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
QOB-016	**129.09**		0.00	ADCP Boat Measurement 8-9-16
#315		-0.73		Measured
#316		0.00		No measurement recorded, assumed OFF
#317		-3.20		Counted amount
318-TP		-5.00		Tunnel Pump, estimated flow
#318		-1.00		Brad Santucci Pump, counted amount
#319		0.00		No measurement recorded, assumed OFF
#321		-1.88		Measured
#324 (Shelly Pump)		-1.00		Estimated amount- Pump in ditch
#326		-2.00		Estimated Pivot amount used
#327		0.00		No measurement recorded, assumed OFF
#329		0.00		No measurement recorded, assumed OFF
#331		0.00		No measurement recorded, assumed OFF
#335		0.00		No measurement recorded, assumed OFF
#33?		0.00		No measurement recorded, assumed OFF
QOB-018	**103.70**		14.81	ADCP Boat Measurement 8-9-16
Cox Pump Station		0.00		8-9-16, no measure recorded, assumed OFF
Jones Dam Spill		***-8.82***		8.82 CFS measured spill to Mckay Crk (Loss)
Jones Pump		-1.15		Counted amount
#341		0.00		No measurement recorded, assumed OFF
#342 W. McKay Pump Sta.		-3.00		Estimated pump discharge
#345		-1.50		Estimated pivot amount
#347 (Reid Pump)		-2.50		Counted / estimated amount
W. McKay Pump tail water		1.50		Estimate return flow Mckay West to Main
QOB-020	**97.03**		30.28	ADCP Boat Measurement 8-9-16
#351		0.00		No measurement recorded, assumed OFF
#352		-0.25		Counted amount
#353		0.00		No measurement recorded, assumed OFF
#355		0.00		No measurement recorded, assumed OFF
#356		0.00		No measurement recorded, assumed OFF
#359		-0.10		Counted amount
#361		0.00		No measurement recorded, assumed OFF
#363		0.00		No measurement recorded, assumed OFF
#365		-0.40		Counted amount
#367		-0.75		Estimated counted amount
#361A		-0.70		Estimated pivot amount
QOB-022	**94.12**		32.48	ADCP Boat Measurement 8-9-16
#369 Sec. 13		-5.20		Measured amount
#369 Murphy		-2.62		Measured amount
#369 Melinda		-1.00		Estimated amount
#371		-1.00		Measured amount
#373		0.00		No measurement recorded, assumed OFF
#374		0.00		No measurement recorded, assumed OFF
#375		-2.06		Measured amount, weir measurement
#377		0.00		No measurement recorded, assumed OFF
#381		-2.52		Measured amount
#382		0.00		No measurement recorded, assumed OFF
#384		-2.50		Estimated amount
#385		-2.62		Measured amount
Grimes Flat East Return Flow		2.00		Estimate Grimes Flat East spill back to Main
QOB-024	**76.30**		50.00	ADCP Boat Measurement 8-9-16
Grimes Flat Pump Station		-18.00		Part to Grimes Flat E., part to Grimes Flat W.
QOB-025	**59.74**		68.00	ADCP Boat Measurement 8-9-16
#389		-5.30		Measured amount
#391		-0.40		Counted amount
#393		-1.23		Measured amount
#392		0.00		No measurement recorded, assumed OFF
#397		0.00		No measurement recorded, assumed OFF
#401		-6.69		Measured amount
#403		-1.10		Counted amount
#406		-2.00		Estimated Pivot (2) big guns amount
QOB-016 (QOB-026)	**39.76**		84.72	ADCP 8-9-16, just above 407 headgate
O-M R2 Remaining	**39.76**		84.72	
Ochoco Main Reach 3				ADCP and Wading Measurements
QOB-016 (QOB-026)	**39.76**		0.00	ADCP 8-9-16, just above 407 headgate
#407		-2.50		Measured amount
#409		-3.63		Measured amount
Lytle Creek Dam		-8.85		8-17-16, turn-out to Lytle Creek, measured
413 and waste				
QWO-038	**23.38**		14.98	8-17-16, undercut L & R banks, rated "Good"
#419		0.00		No measurement recorded, assumed OFF
#421		0.00		No measurement recorded, assumed OFF
#423		0.00		No measurement recorded, assumed OFF



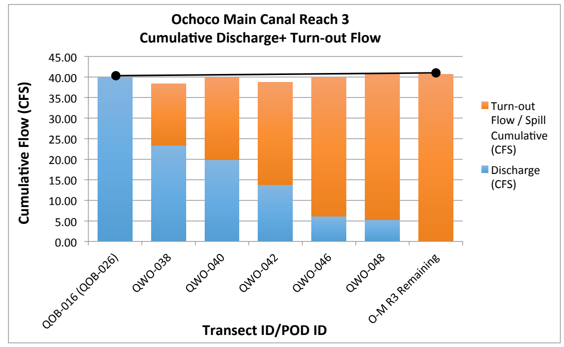
Ochoco Main Reach 2 Intake to the Study Reach	=	129.09		
Ochoco Main Reach 2 Spill from Study Reach	=	-8.82		
Ochoco Main Reach 2 Turnouts + Flow Remaining	=	-115.66		
Ochoco Main Reach 2 Seepage Loss in Study Reach	=	4.61	=	3.57%

OCHCO IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS

Final
08-22-2017 (KLC)

Ochoco Main Canal Reach 3

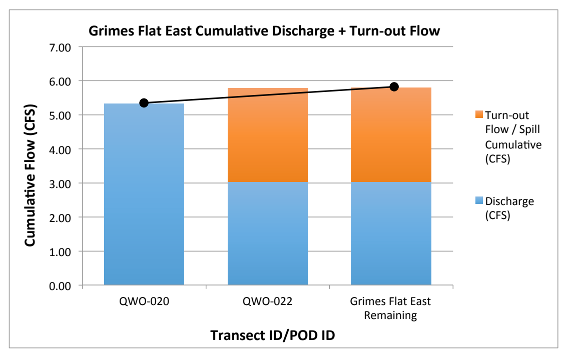
Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
#426		0.00		No measurement recorded, assumed OFF
#425		-2.00		Estimated amount
#428		0.00		No measurement recorded, assumed OFF
#429		-3.00		Estimated amount
QWO-040	**19.82**		19.98	8-17-16, measurement rated as "Good"
#434		0.00		No measurement recorded, assumed OFF
#435		-2.00		Estimated amount
#436		-2.00		Estimated amount
#444		-1.00		Counted amount
Grimes Flat W. Return Flow		2.53		G.F. West return to Main, QWO-034, 8-18-16
#442		0.00		No measurement recorded, assumed OFF
#445		0.00		No measurement recorded, assumed OFF
#447		-1.50		Estimated amount
#448		0.00		No measurement recorded, assumed OFF
#449		0.00		No measurement recorded, assumed OFF
#450		-1.00		Estimated amount
QWO-042	**13.74**		24.95	8-17-16, measurement rated "Good"
#451-X		-2.00		Estimated amount
#451-A (Y)		-2.00		Estimated amount
#452		-0.20		Counted amount
#454		-0.25		Counted amount
#455		0.00		No measurement recorded, assumed OFF
#456		0.00		No measurement recorded, assumed OFF
#457		-0.40		Counted amount
#458		-0.20		Counted amount
#459-Y		-3.84		Measured amount
QWO-046	**6.13**		33.84	8-17-16, measurement rated "Fair"
#461		0.00		No measurement recorded, assumed OFF
Telemetry	4.73			Per Staff Gauge
#463		-1.50		Estimated amount
QWO-048	**5.32**		35.34	8-17-16, measurement rated "Good"
Spill to Crooked River		***-5.32***		5.32 CFS spill to Crooked River (Loss)
O-M R3 Remaining	**0.00**		40.66	



Ochoco Main Reach 3 Intake to the Study Reach = 39.76
Ochoco Main Reach 3 Spill from Study Reach = -5.32
Ochoco Main Reach 3 Turnouts + Flow Remaining = -35.34
Ochoco Main Reach 3 Seepage Loss in Study Reach = -0.90 = -2.26%

Grimes Flat East

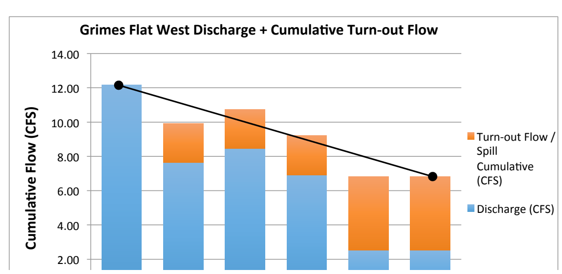
Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
Grimes Flat East				Flow Tracker II Measurements
QWO-020	**5.33**		0.00	8-18-16, measurement rated "Fair"
E-2		-0.93		Measured amount
E-4		-0.33		Measured amount
E-5		-1.50		Estimated amount
QWO-022	**3.03**		2.76	8-18-16, measurement rated "Good"
QWO-024	-			No measurement, trans at piped section
Grimes Flat East Remaining	**3.03**		2.76	Return flow to O-M btwn QOB-022 and 024



Grimes Flat East Intake to the Study Reach = 5.33
Grimes Flat East Spill from Study Reach = 0.00
Grimes Flat East Turnouts + Flow Remaining = -5.79
Grimes Flat East Seepage Loss in Study Reach = -0.46 = -8.67%

Grimes Flat West

Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
Grimes Flat West				Flow Tracker II Measurements
QWO-026	**12.17**		0.00	8-18-16, measurement rated "Good"
W-1		-0.75		Estimated amount
W-2		0.00		No measurement recorded, assumed OFF
W-3		-0.40		Counted amount
W-5		-1.00		Counted amount
W-5-A		-0.15		Counted amount
W-6		0.00		No measurement recorded, assumed OFF
W-6A		0.00		No measurement recorded, assumed OFF
QWO-028	**7.62**		2.30	8-18-16, measurement rated "Good"
Spill to Lytle Creek		***0.00***		8-18-16, O CFS spill to Lytle Crk estimate (Loss)
QWO-030	**8.44**		2.30	8-18-16, measurement rated "Good"
W-7		0.00		No measurement recorded, assumed OFF
W-8A		0.00		No measurement recorded, assumed OFF
W-8		0.00		No measurement recorded, assumed OFF



Final
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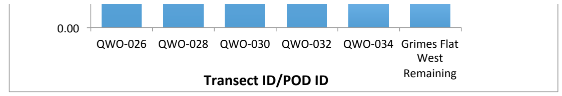
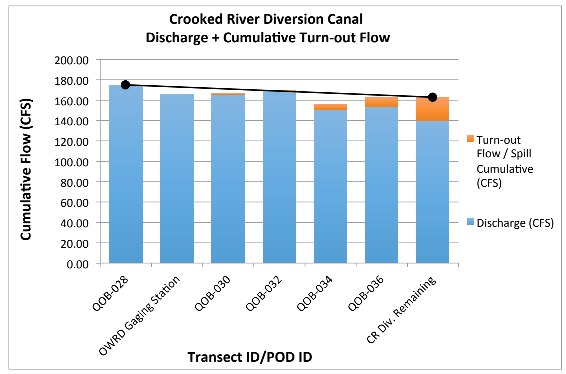
OCHCO IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS

Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
QWO-032	**6.90**		2.30	8-18-16, measurement rated "Fair"
W-9		0.00		No measurement recorded, assumed OFF
W-10		0.00		No measurement recorded, assumed OFF
W-11		-0.50		Estimated amount
W-12		-1.50		Estimated amount
W-13		0.00		No measurement recorded, assumed OFF
QWO-034	**2.53**		4.30	8-18-16, measurement rated "Poor"
W-14		0.00		No measurement recorded, assumed OFF
Grimes Flat West Remaining	**2.53**		4.30	Return flow to O-M btwn QWO-040 and 042
Crooked River Diversion (ADCP Boat Measurements)				ADCP measurements
QOB-028	**174.39**		0.00	ADCP Boat Measurement 8-4-16
D-1, D-2 Quail Valley		-1.00		Two Quail Valley Pumps
OWRD Gaging Station	**166.00**			Gaging station record 8-4-16
QOB-030	**165.75**		1.00	ADCP Boat Measurement 8-4-16
D-3		0.00		No measurement recorded, assumed OFF
Pump		0.00		No measurement recorded, assumed OFF
Head gate		0.00		No measurement recorded, assumed OFF
QOB-032	**169.13**		1.00	ADCP Boat Measurement 8-4-16
D-9		-1.00		Ulapalakua-Flood
D-12		-1.50		Ulapalakua-Pump
D-13		-1.00		Ulapalakua-Flood
D-15		-1.00		Prineville Property-Flood
QOB-034	**150.74**		5.50	ADCP Boat Measurement 8-4-16
D-15 B		-1.00		Prineville Property
D-21		-2.00		Prinville Property- Pump
QOB-036	**153.87**		8.50	ADCP Boat Measurement 8-4-16
Combs Flat Pump Station		-3.62		8-17-16 Combs Flat Pumps (QWO-002)
Ochoco Creek Wasteway		***-10.00***		10 CFS spill to Ochoco Creek (Loss)
CR Div. Remaining	**140.25**		22.12	= QOB-36 minus Combs Flat turn-out flow
Distribution Canal Reach 1 (ADCP Boat Measurements)				ADCP measurements
Main Pumping Plant	**140.25**		0.00	Lift from C.R. Diversion, calculated flow
#706		-0.70		
QOB-038	**137.91**		0.70	ADCP Boat Measurement 8-10-16
#711		0.00		Recorded value
#717		-2.04		Measured amount Highland, Buckaroo
#720		0.00		Recorded value
#724		0.00		Recorded value
#724 A		0.00		Recorded value
#724 A		0.00		Recorded value
#724 A		0.00		Recorded value
#725 B Lat		-1.10		
#726		0.00		Recorded value, haying, assumed OFF
#728		0.00		Recorded value
#729		-0.10		Thompson Group
#730		-0.25		Estimated
QOB-040	**117.89**		4.19	ADCP Boat Measurement 8-10-16
Return Flow from #301 & #302		3.00		Tail water return from Turnout #301 & #303
D-C R1 Remaining	**120.89**		1.19	
Distribution Canal Reach 2 (ADCP Boat Measurements)				ADCP measurements
Re-lift Pump Station		-98.00		Lift from Dist Canal, calculated flow, 8-10-16
QOB-042	**41.32**		0.00	ADCP Boat Measurement 8-10-16
#751		-0.05		Estimated amount
#753		-1.30		West Hills Subdivision
#755		-1.50		Houston Pump, estimated flow
#760		-1.25		Estimated amount
#762		-0.75		Estimated amount
#763		-2.75		Estimated amount
#768		-1.25		Estimated amount
#769		-1.64		Measured amount
#311 drain		0.50		Tailwater into Main (Dist.) Canal (record value)
#315 drain		0.50		Tailwater into Main (Dist.) Canal (record value)
QOB-044	**34.79**		9.49	ADCP Boat Measurement 8-10-16
Spill to McKay Creek		***-4.14***		4.14 CFS spill to McKay Crk, recorded value (Loss)
QOB-046	**30.37**		13.63	ADCP Boat Measurement 8-10-16
D-C R2 Remaining	**30.37**		13.63	

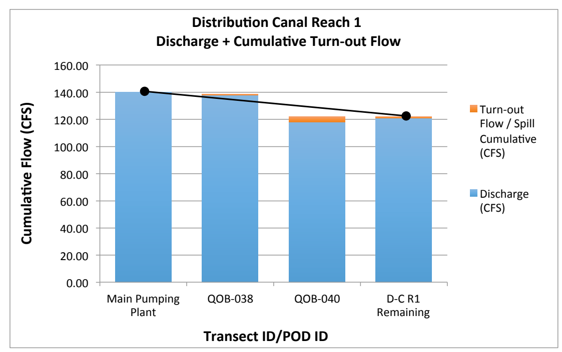
Gr... / Crooked River Diversion Canal / Distribution Canal Reach 1 / Distribution Canal Reach 2



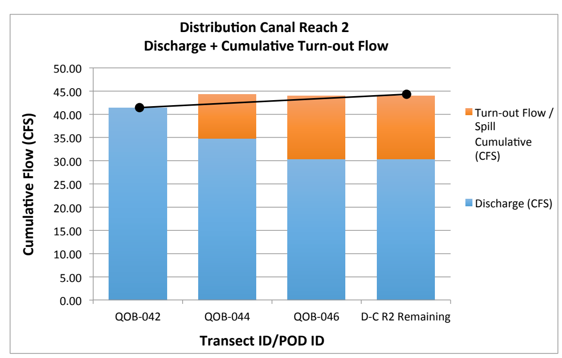
Grimes Flat West Intake to the Study Reach	=	12.17		
Grimes Flat West Spill from Study Reach	=	0.00		
Grimes Flat West Turnouts + Flow Remaining	=	-6.83		
Grimes Flat West Seepage Loss in Study Reach	=	5.35	=	43.92%



Crooked River Diversion Intake to the Study Reach	=	174.39		
Crooked River Diversion Spill from Study Reach	=	-10.00		
Crooked River Diversion Turnouts + Flow Remaining	=	-152.37		
Crooked River Div. Seepage Loss in Study Reach	=	12.03	=	6.90%



Dist. Canal Reach 1 Intake to the Study Reach	=	140.25		
Dist. Canal Reach 1 Spill from Study Reach	=	0.00		
Dist. Canal Reach 1 Turnouts + Flow Remaining	=	-122.08		
Dist. Canal Reach 1 Seepage Loss in Study Reach	=	18.17	=	12.95%



Dist. Canal Reach 2 Intake to the Study Reach	=	41.32		
Dist. Canal Reach 2 Spill from Study Reach	=	-4.14		
Dist. Canal Reach 2 Turnouts + Flow Remaining	=	-39.86		
Dist. Canal Reach 2 Seepage Loss in Study Reach	=	-2.68	=	-6.49%

Final
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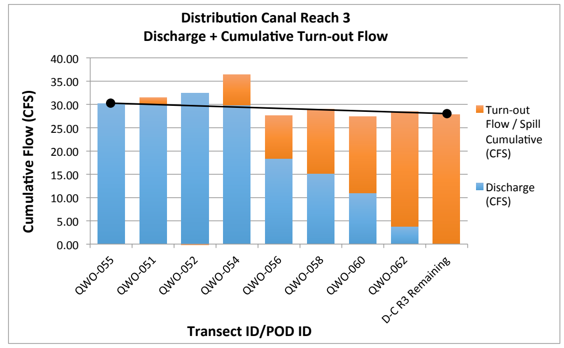
OCHCO IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS

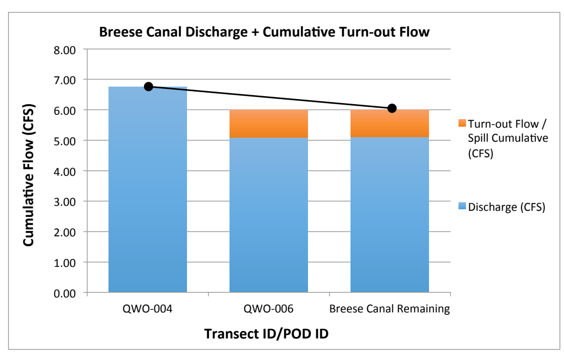
Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
Distribution Canal Reach 3 (Wading Measurements)				Flow Tracker II Measurements
QWO-055	**30.15**		0.00	8-16-16, measurement rated "Fair"
#773				
#774		-1.50		Counted 120 sprinklers
QWO-051	**29.95**		1.50	8-16-16, added transect, rated "Fair"
Drain Water		2.00		Unidentified inflow
QWO-052	**32.45**		-0.50	8-16-16, measurement rated "Poor"
#777 lateral		-1.25		measured rectangular weir
Canal Check	23.72			Rectangular weir, 36" wide, 22.5" depth
#785		-5.77		Measured 48" rectangular weir
QWO-054	**29.86**		6.52	8-16-16, measurement rated "Fair"
#789		-0.80		Estimated, no way to measure
#792		-0.70		Estimated, no way to measure
#795		-1.25		Estimated, no way to measure
QWO-056	**18.37**		9.27	8-16-16, measurement rated "Fair"
#797		-1.50		Recorded value, est., no way to measure
#799		-1.25		Recorded value, est., no way to measure
#800		0.00		No measurement recorded, assumed OFF
#801		-0.70		Recorded value, est., no way to measure
#811		-0.55		Recorded value, est., no way to measure
#813		-0.55		Recorded value, est., no way to measure
QWO-058	**15.16**		13.82	8-16-16, measurement rated "Fair"
#815		-1.25		Recorded value, est., no way to measure
#817		-1.38		Measured
Canal Check	10.92			Rectangular weir 3' width, 13.25" depth
QWO-060	**10.94**		16.45	8-16-16, measurement rated "Fair"
#819		-2.05		Measured
Canal Check	8.87			Rectangular weir 36" width, 11.5" depth
#821		-1.50		Recorded value, est., no way to measure
#823		-1.01		Rectangular weir 36" width, 2.625" depth
Canal Check	4.38			Rectangular weir 60" width, 5" depth
#825		-2.50		Recorded value, est., no way to measure
Return 407		0.75		Recorded value, est., no way to measure
#826		-0.72		Rectangular weir 18" width, 3.375" depth
Canal Check	2.75			Rectangular weir 48" width, 4.25" depth
#828		-0.25		Recorded value, est., no way to measure
Canal Check	2.80			Rectangular weir 36" width, 5.25" depth
#829		-1.00		Recorded value, est., no way to measure
QWO-062	**3.74**		24.73	8-16-16, measurement rated "Poor"
Tailwater to Lytle Creek		***-3.10***		3.10 CFS spill to Lytle Crk, recorded value, (Loss)
D-C R3 Remaining	**0.00**		27.83	
Breese Canal				Flow Tracker II Measurements
QWO-004	**6.75**		0.00	8-17-16, measurement rated "Fair"
#3		-0.15		Recorded value, est., no way to measure
#4		-0.25		Recorded value, est., no way to measure
#5		0.00		No measurement recoreded, assumed OFF
#6		-0.25		Recorded value, est., no way to measure
#7		-0.25		Recorded value, est., no way to measure
#8		0.00		No measurement recoreded, assumed OFF
QWO-006	**5.10**		0.90	8-17-16, measurement rated "Fair"
Breese Canal Remaining	**5.10**		0.90	Remaining flow enter Breeze piped section serves #9, #10, #11, #12, and #13 before tailwater return to Crooked River

Distribution Canal Reach 3



Dist. Canal Reach 3 Intake to the Study Reach	=	30.15		
Dist. Canal Reach 3 Spill from Study Reach	=	-3.10		
Dist. Canal Reach 3 Turnouts and Flow Remaining	=	-24.73		
Dist. Canal Reach 3 Seepage Loss in Study Reach	=	2.32	=	7.69%

Breese Canal



Breese Canal Intake to the Study Reach	=	6.75		
Breese Canal Spill from Study Reach	=	0.00		
Breese Canal Turnouts and Flow Remaining	=	-6.00		
Breese Canal Seepage Loss in Study Reach	=	0.75	=	11.06%

Final
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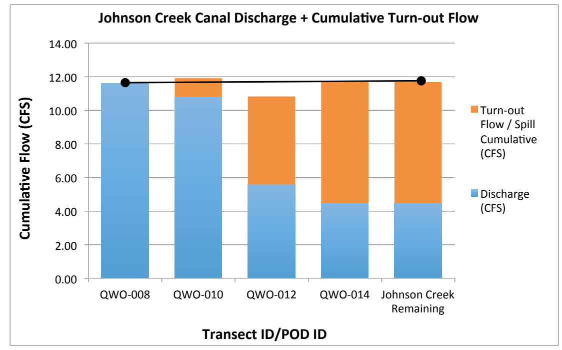
OCHCO IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS

Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
Johnson Creek Canal				Flow Tracker II Measurements
QWO-008	**11.60**		0.00	8-17-16, measurement rated "Good"
JC-1		-1.10		Estimated, no measurement device
JC-3		0.00		No measurement recorded, assumed OFF
JC-13		0.00		No measurement recorded, assumed OFF
JC-14		0.00		No measurement recorded, assumed OFF
JC-15		0.00		No measurement recorded, assumed OFF
#451-A		0.00		No measurement recorded, assumed OFF
QWO-010	**10.81**		1.10	8-17-16, measurement, rated "Good"
JC-17A		-1.00		Pump in ditch, no measurement device
JC-Deliv (Johnson Crk)		-2.50		Johnson Creek return to Main Canal
JC-17B		-0.30		Pump in ditch, est., no measure device
JC-19		-0.25		Pump in ditch, est., no measure device
JC -21		-0.10		No measurement device, esitmate flow
QWO-012	**5.58**		5.25	8-17-16, measurment rated "Excellent"
JC-23		-1.70		No measurement device, estimate flow
JC-25		0.00		No measurement recorded, assumed OFF
JC-27		0.00		No measurement recorded, assumed OFF
JC-29		0.00		No measurement recorded, assumed OFF
JC-31		-0.25		No measurement device, estimate flow
QWO-014	**4.48**		7.20	8-17-16, measurement rated "Good"
Johnson Creek Remaining	**4.48**		7.20	Johnson Crk Canal return to Main Canal

Johnson Creek Canal



Johnson Creek Canal Intake to the Study Reach	=	11.60		
Johnson Creek Canal Spill from Study Reach	=	0.00		
Johnson Creek Canal Turnouts and Flow Remaining	=	-11.68		
Johnson Creek Canal Seepage Loss in Study Reach	=	-0.08	=	-0.68%

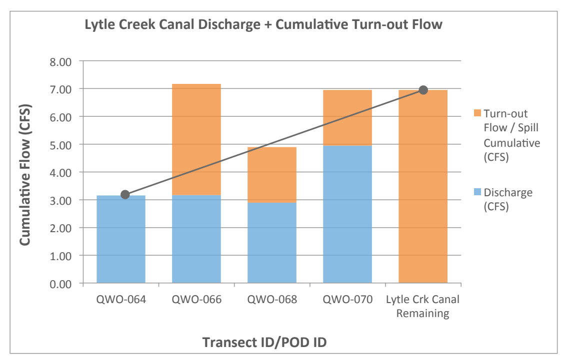
Data Not Included in Loss Assessment Summary *				
* Data insufficient, inadequate, or unceratin to provide useful interpretation				
McKay West Canal				Flow Tracker II Measurements
McKay Pump Station	3.00		0.00	Estimated pump discharge
QWO-018	**2.13**		0.00	8-18-16, measurement rated "Good"
Return Flow to Main Canal		-1.50		1.5 CFS estimated return flow to Main Canal
McKay West flow remaining	**0.00**		1.50	

McKay West Canal

McKay West Canal Intake to the Study Reach	=	3.00		
McKay West Canal Spill from Study Reach	=	0.00		
McKay West Canal Turnouts + Flow Remaining	=	-1.50		
McKay West Canal Seepage Loss in Study Reach	=	1.50	=	50.00%

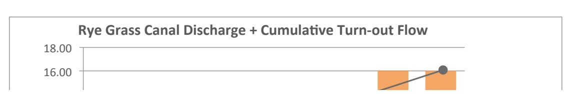
Data Not Included in Loss Assessment Summary *				
* Data insufficient, inadequate, or unceratin to provide useful interpretation				
Lytle Creek Canal				Flow Tracker II Measurements
Grimes Flat W. spill to Lytle Crk	0.00			8-18-16, Inflow from Grimes Flat West
QWO-029	0.00	(minor flow)		Over-grown veg, no access, electric fence
Ochoco Main spill to Lytle Crk	8.85			8-17-16, Inflow flow from Ochoco Main
QWO-064	**3.15**		0.00	8-18-16, measurement rated as "Good"
W lateral		-4.00		8-18-16, estimated amount
QWO-066	**3.17**		4.00	8-18-16, measurement rated as "Fair"
Tail From Woodward Pond		2.00		Return flow from Woodward Pond
From Distribution Canal		?		Inflow from Distribution Canal
QWO-068	**2.89**		2.00	8-18-16, measurement rated "Good"
QWO-070	**4.95**		2.00	8-18-16, measurement rated "Fair"
Spill to Lytle Creek Tail		*-4.95*		4.95 CFS spill to Lytle Creek Tail (Loss)
Lytle Crk Canal Remaining	**0.00**		6.95	

Lytle Creek Canal



Lytle Creek Canal Intake to the Study Reach	=	3.15		
Lytle Creek Canal Spill from Study Reach	=	-4.95		
Lytle Creek Canal Turnouts + Flow Remaining	=	-2.00		
Lytle Creek Canal Seepage Loss in Study Reach	=	-3.80	=	-120.52%

Data Not Included in Loss Assessment Summary *				
* Data insufficient, inadequate, or unceratin to provide useful interpretation				
Rye Grass Canal				Flow Tracker II Measurements
QWO-092	**6.79**		0.00	8-16-16, rated "Fair," 50 Yds south NE Juniper St

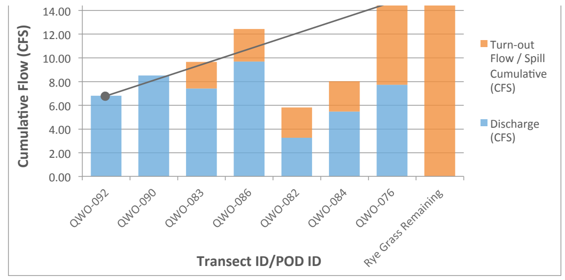


OCHCO IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS

Final
08-22-2017 (KLC)

Rye Grass Canal

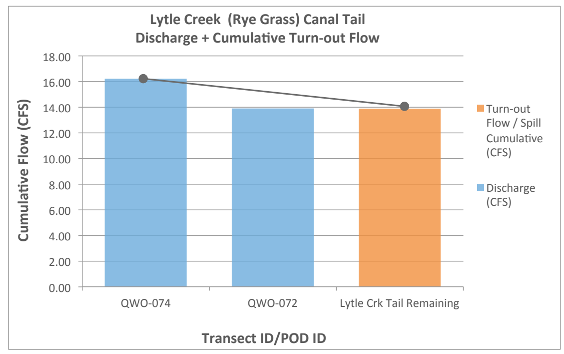
Transect No. POD #ID	Discharge (CFS)	Turn-out Flow / Spill Rate (CFS)	Turn-out Flow / Spill Cumulative (CFS)	Comments
QWO-090	**8.51**		0.00	8-16-16, measurement rated "Poor"
RG-10		-0.25		No way to measure
RG-17		-1.00		No way to measure
RG-19		-1.00		No way to measure
QWO-083	**7.41**		2.25	8-16-16, measurement rated "Fair"
RG-35		-0.20		No way to measure
RG-25		-0.30		No way to measure
QWO-086	**9.68**		2.75	8-16-16, rated "Fair," 75 yds above McKay Crk x-i
777 return		0.20		Return flow
QWO-082	**3.26**		2.55	8-16-16, measurement rated "Excellent"
RG5-51				
QWO-084	**5.47**		2.55	8-16-16, measurement rated "Fair"
#5-47		-2.00		No way to measure
RG-71		-2.00		No way to measure
RG-61		-1.00		No way to measure
RG-59-A		-0.75		No way to measure
QWO-076	**7.73**		8.30	8-16-16, measurement rated "Fair"
Spill to Lytle Creek Tail		***-7.73***		7.73 CFS spill to Lytle Creek Tail (Loss)
Rye Grass Remaining	**0.00**		16.03	



Rye Grass Canal Intake to the Study Reach	=	6.79		
Rye Grass Canal Spill from Study Reach	=	-7.73		
Rye Grass Canal Turnouts + Flow Remaining	=	-8.30		
Rye Grass Canal Seepage Loss in Study Reach	=	-9.24	=	-135.95%

Lytle Creek (Rye Grass) Canal Tail

Data Not Included in Loss Assessment Summary *				
* Data insufficient, inadequate, or unceratin to provide useful interpretation				
Lytle Creek (Rye Grass) Canal Tail				
QWO-074	**16.22**		0.00	8-16-16, measurement rated "Poor"
QWO-072	**13.90**		0.00	8-16-16, measurement rated "Poor"
Spill to Crooked River		***-13.90***		13.90 CFS spill to Crooked River (Loss)
Lytle Crk Tail Remaining	0.00		13.90	



Lytle Crk (Rye Grass) Tail Intake to the Study Reach	=	16.22		
Lytle Crk (Rye Grass) Tail Spill from Study Reach	=	-13.90		
Lytle Crk (Rye Grass) Tail Turnouts + Flow Remaining	=	0.00		
Lytle Crk (Rye Grass) Tail Seepage Loss in Study Reach	=	2.32	=	14.33%

Combs Flat

Data Not Included in Loss Assessment Summary *				
* Data insufficient, inadequate, or unceratin to provide useful interpretation				
Combs Flat Canal				Flow Tracker II Measurements
QWO-002	**3.62**			8-17-16, measurement rated "Good"

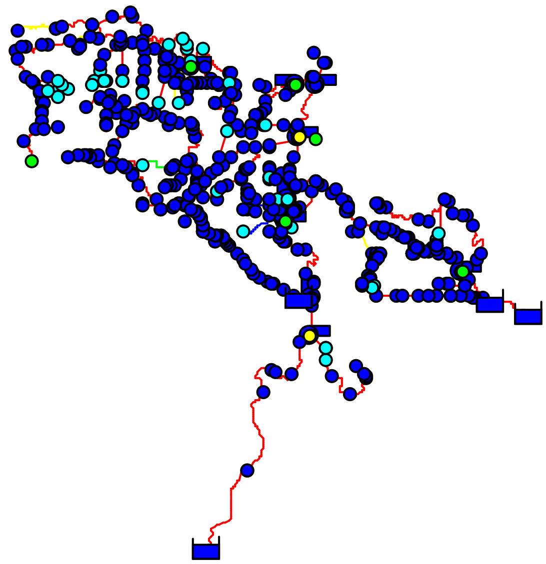
APPENDIX B
EPANET HYDRAULIC MODEL

Ochoco Irrigation District System Model

Pressure
25.00
50.00

Velocity
0.01
0.10
1.00
2.00
fps

Day 1, 1:



Ochoco Irrigation District System Model

Network Table - Nodes

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 123	3048.46	27.75	3052.54	1.77
Junc 130	3045.67	27.00	3051.76	2.64
Junc 131	3046.12	399.75	3051.79	2.46
Junc 136	3044.85	123.00	3051.22	2.76
Junc 139	3045.68	399.75	3051.06	2.33
Junc 141	3046.01	71.25	3050.96	2.14
Junc 142	3045.79	2321.25	3050.94	2.23
Junc 145	3045.52	97.50	3050.77	2.28
Junc 146	3046.38	9.75	3050.65	1.85
Junc 147	3045.21	73.50	3050.47	2.28
Junc 152	3045.27	45.00	3050.54	2.28
Junc 153	3045.13	1833.00	3050.40	2.28
Junc 158	3045.31	552.75	3050.32	2.17
Junc 160	3044.75	111.00	3050.20	2.36
Junc 163	3043.26	13.50	3050.12	2.97
Junc 166	3042.53	349.50	3049.83	3.16
Junc 167	3043.19	277.50	3049.81	2.87
Junc 172	3043.29	104.25	3049.67	2.76
Junc 175	3042.93	474.00	3049.53	2.86
Junc 177	3043.05	34.50	3049.52	2.81
Junc 179	3043.11	28.50	3049.44	2.74
Junc 182	3043.05	7.50	3049.27	2.70
Junc 183	3043.24	164.25	3049.21	2.59
Junc 184	3043.04	71.25	3049.16	2.65
Junc 185	3042.83	438.00	3049.14	2.73

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 188	3042.42	646.50	3048.75	2.74
Junc 191	3043.15	952.50	3044.90	0.76
Junc 194	3041.84	123.75	3048.35	2.82
Junc 195	3041.63	6.75	3048.30	2.89
Junc 196	3041.49	6.75	3048.33	2.96
Junc 197	3040.65	375.00	3048.21	3.28
Junc 198	3040.87	783.00	3048.16	3.16
Junc 200	3040.87	712.50	3047.96	3.07
Junc 201	3040.87	92.25	3047.82	3.01
Junc 203	3039.87	130.50	3047.47	3.29
Junc 204	3040.03	615.00	3047.30	3.15
Junc 207	3039.95	12.00	3046.90	3.01
Junc 208	3040.16	857.25	3046.79	2.87
Junc 302	3039.51	148.50	3046.25	2.92
Junc 303	3039.33	342.75	3046.35	3.04
Junc 307	3038.75	492.00	3045.94	3.12
Junc 313	3036.60	1325.25	3045.10	3.68
Junc 315	2994.11	269.25	3021.76	11.98
Junc 317	3036.45	684.00	3044.27	3.39
Junc 318	3036.36	736.50	3044.25	3.42
Junc 319	3036.82	597.75	3044.05	3.13
Junc 321	2968.94	531.75	3033.77	28.09
Junc 324	3036.52	1305.00	3043.89	3.19
Junc 326	3036.15	213.00	3043.89	3.35
Junc 341	3033.97	25.50	3041.89	3.43
Junc 345	3032.93	825.00	3041.07	3.53

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 347	3032.61	666.00	3040.92	3.60
Junc 351	3032.11	75.00	3040.23	3.52
Junc 352	3031.86	70.50	3039.98	3.52
Junc 353	3031.80	81.00	3039.84	3.48
Junc 355	3031.40	243.00	3039.72	3.61
Junc 361	3031.49	30.00	3039.21	3.34
Junc 365	3030.50	858.00	3038.87	3.63
Junc 367	3030.43	235.50	3038.67	3.57
Junc 371	3030.45	150.75	3038.26	3.39
Junc 374	3030.46	472.50	3037.92	3.23
Junc 382	3030.08	4.50	3037.45	3.20
Junc 384	3030.06	858.00	3037.25	3.12
Junc 385	3028.53	789.75	3036.86	3.61
Junc 392	3026.84	15.00	3035.78	3.87
Junc 397	3026.63	306.00	3035.44	3.82
Junc 403	3025.81	888.00	3034.70	3.85
Junc 406	3025.82	798.00	3034.68	3.84
Junc 413	3025.46	331.50	3034.14	3.76
Junc 419	3023.64	22.50	3033.45	4.25
Junc 421	3021.79	288.75	3033.17	4.93
Junc 423	3021.12	99.00	3032.62	4.98
Junc 425	3020.27	1562.25	3032.34	5.23
Junc 426	3021.01	35.25	3032.55	5.00
Junc 428	3019.07	3.00	3031.89	5.56
Junc 429	3019.01	1806.00	3031.84	5.56
Junc 435	3018.08	1272.75	3030.61	5.43

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 436	3016.77	993.75	3030.14	5.79
Junc 442	3014.05	563.25	3027.47	5.81
Junc 444	3015.40	141.00	3028.45	5.65
Junc 445	3013.17	859.50	3026.64	5.84
Junc 448	3011.08	184.50	3024.81	5.95
Junc 449	2955.21	528.00	3011.95	24.59
Junc 450	3012.34	350.25	3023.86	4.99
Junc 451	2944.18	594.75	3008.85	28.02
Junc 452	2987.93	92.25	3022.74	15.08
Junc 454	2984.25	74.25	3021.61	16.19
Junc 455	2983.39	69.00	3021.09	16.34
Junc 456	2981.34	81.00	3020.02	16.76
Junc 457	2982.29	78.75	3019.16	15.98
Junc 458	2978.37	66.75	3017.64	17.01
Junc 461	2961.83	638.25	3004.21	18.36
Junc 463	2827.66	225.75	2991.94	71.18
Junc 705	2956.78	2285.25	2965.66	3.85
Junc 706	2957.39	73.50	2966.58	3.98
Junc 711	2953.40	30.00	2961.32	3.43
Junc 717	2951.73	780.00	2959.43	3.34
Junc 720	2951.85	82.50	2959.38	3.26
Junc 724	2950.99	21.00	2958.91	3.43
Junc 726	2951.07	39.00	2958.51	3.22
Junc 728	2950.05	85.50	2958.05	3.47
Junc 729	2990	82.50	3068.38	33.96
Junc 730	2950.38	30.75	2957.90	3.26

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 731	2950.59	33.75	2957.79	3.12
Junc 735	2950.35	28.50	2957.30	3.01
Junc 736	2949.93	12.75	2957.11	3.11
Junc 738	2950.47	33.75	2956.75	2.72
Junc 739	2950.45	33.00	2956.67	2.70
Junc 742	2950.41	231.75	2956.20	2.51
Junc 744	2949.83	16.50	2955.20	2.33
Junc 746	2949.76	32.25	2955.17	2.34
Junc 748	2949.52	40.50	2954.88	2.32
Junc 750	2949.41	13.50	2954.83	2.35
Junc 751	2950.73	3.00	2954.77	1.75
Junc 753	2949.41	1426.50	2954.74	2.31
Junc 755	2949.43	174.75	2954.72	2.29
Junc 756	2948.80	44.25	2954.54	2.49
Junc 758	2948.88	6.00	2954.54	2.45
Junc 760	2948.02	527.25	2954.05	2.61
Junc 762	2948.08	527.25	2954.09	2.60
Junc 765	2947.30	244.50	2953.48	2.68
Junc 767	2946.76	583.50	2953.08	2.74
Junc 768	2946.73	275.25	2953.06	2.74
Junc 771	2944.92	237.00	2951.78	2.97
Junc 773	2941.67	645.00	2951.36	4.20
Junc 774	2942.89	555.00	2950.82	3.44
Junc 775	2940.39	8.25	2950.49	4.37
Junc 781	2937.13	863.25	2949.14	5.20
Junc 785	2936.80	574.50	2947.62	4.69

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 789	2933.21	540.00	2945.41	5.29
Junc 792	2932.86	526.50	2944.19	4.91
Junc 795	2932.57	1076.25	2944.01	4.96
Junc 796	2931.93	1047.75	2943.73	5.11
Junc 797	2932.11	1466.25	2942.70	4.59
Junc 798	2932.05	24.00	2943.72	5.06
Junc 799	2937.74	583.50	2940.38	1.14
Junc 800	2931.10	550.50	2941.73	4.61
Junc 801	2929.34	386.25	2941.23	5.15
Junc 804	2928.78	188.25	2939.75	4.75
Junc 806	2928.98	16.50	2939.73	4.66
Junc 807	2928.27	860.25	2939.29	4.78
Junc 809	2927.60	27.00	2938.93	4.91
Junc 811	2927.51	267.75	2938.21	4.64
Junc 813	2926.23	251.25	2936.73	4.55
Junc 815	2921.60	476.25	2932.41	4.68
Junc 819	2924.55	292.50	2934.74	4.41
Junc 821	2924.34	1275.00	2932.99	3.75
Junc 823	2921.15	402.75	2929.73	3.72
Junc 826	2922.05	232.50	2928.80	2.92
Junc 828	2918.61	66.75	2925.99	3.20
Junc 829	2916.26	207.75	2917.33	0.46
Junc 146-1	3046.38	29.25	3050.68	1.86
Junc 161-C-1	3039.65	3517.50	3049.07	4.08
Junc 161-C-2	3045.10	18.75	3049.32	1.83
Junc 161-C-3	3039.65	10.50	3049.05	4.07

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 161-C-4	3040.87	129.00	3049.04	3.54
Junc 161-C-5	3040.77	18.00	3049.07	3.60
Junc 165-D	3043.50	300.00	3050.11	2.86
Junc 169-E	3043.52	13.50	3049.75	2.70
Junc 181-G	3041.38	820.50	3045.13	1.62
Junc 191-J	3042.45	463.50	3048.75	2.73
Junc 301M	3040.29	702.00	3046.48	2.68
Junc 301M-1	3006.21	775.50	3038.50	13.99
Junc 301M-2	3002.17	86.25	3027.36	10.91
Junc 301M-3	3002.85	163.50	3025.69	9.90
Junc 301-M-5	2998.81	205.50	3024.71	11.22
Junc 301-M-6	3000.26	339.00	3024.09	10.33
Junc 311N-1	3035.22	326.25	3043.29	3.50
Junc 311N-2	3034.90	735.00	3041.58	2.89
Junc 311N-3	2980.89	127.50	3040.48	25.82
Junc 311N-4	2979.44	547.50	3039.82	26.16
Junc 311N-5	2981.53	3.75	3039.35	25.05
Junc 311N-6	2980.85	689.25	3033.44	22.79
Junc 311N-7	2980.76	287.25	3033.45	22.83
Junc 315-O	2995.35	28.50	3022.67	11.84
Junc 318TP	3123.74	1026.00	3253.85	56.38
Junc 321P	2970.50	97.50	3034.67	27.80
Junc 340-CP-1	3039.33	925.50	3145.07	45.82
Junc 340CP-2	3088.62	180.75	3125.11	15.81
Junc 340-CP-3	3070.89	336.00	3117.36	20.13
Junc 342WM-1	3081.73	128.25	3178.72	42.02

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 342WM-2	3072.28	28.50	3122.19	21.62
Junc 342WM-3	3071.33	376.50	3114.93	18.89
Junc 356-1	3031.66	27.75	3039.67	3.47
Junc 356-2	3031.68	50.25	3039.67	3.46
Junc 359-1	3031.37	15.00	3039.35	3.46
Junc 359-2	3031.39	20.25	3039.35	3.45
Junc 361A	3031.56	300.00	3039.15	3.29
Junc 369Q-1	3025.99	537.75	3038.31	5.34
Junc 369Q-2	2975.87	1124.25	3034.25	25.29
Junc 369Q-SEC-13	2968.76	2064.00	3023.80	23.85
Junc 375R-1	3030.58	32.25	3036.96	2.77
Junc 375R-2	3030.58	57.00	3036.96	2.77
Junc 375R-3	3028.02	36.75	3035.18	3.10
Junc 375R-4	3022.89	65.25	3031.04	3.53
Junc 375R-5	3023.58	140.25	3031.04	3.23
Junc 375R-6	3024.07	567.75	3031.02	3.01
Junc 375R-7	3023.05	754.50	3030.96	3.43
Junc 377-1	3030.04	39.75	3037.53	3.25
Junc 377-2	3030.04	38.25	3037.53	3.25
Junc 377-3	3030.19	56.25	3037.53	3.18
Junc 381-10	2974.83	17.25	3017.75	18.60
Junc 381-12	2968.23	69.00	3010.46	18.30
Junc 381-13	2968.04	59.25	3010.40	18.35
Junc 381-14	2958.49	142.50	3005.03	20.17
Junc 381-15	2958.55	133.50	3005.06	20.15
Junc 381-2	3027.13	35.25	3035.02	3.42

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 381-3	3027.19	35.25	3034.99	3.38
Junc 381-4	3006.31	133.50	3032.46	11.33
Junc 381-5	2995.09	138.75	3027.11	13.88
Junc 381-6	2990.72	32.25	3023.93	14.39
Junc 381-7	2984.49	32.25	3022.04	16.27
Junc 381-8	2983.82	8.25	3020.80	16.02
Junc 381-9	2981.54	19.50	3020.37	16.83
Junc 381S-1	3028.24	68.25	3035.20	3.02
Junc 389-1	3026.98	353.25	3035.92	3.87
Junc 389-2	3027.44	53.25	3035.93	3.68
Junc 389-3	2994.69	66.00	3032.21	16.26
Junc 389-4	2985.41	14.25	3031.24	19.86
Junc 389-5	2985.30	910.50	3030.37	19.53
Junc 389-6	2952.86	186.00	3022.49	30.17
Junc 391-1	3027.42	17.25	3035.98	3.71
Junc 391-2	3008.04	118.50	3028.46	8.85
Junc 391-3	3006.55	78.75	3028.22	9.39
Junc 391-4	3005.79	327.75	3028.19	9.70
Junc 391-5	3006.39	34.50	3028.21	9.45
Junc 393-1	3026.46	30.00	3034.83	3.63
Junc 393-2	3021.40	108.75	3033.72	5.34
Junc 393-3	3021.40	391.50	3033.72	5.34
Junc 393-4	3003.04	135.00	3030.40	11.86
Junc 393-5	2993.70	33.00	3029.54	15.53
Junc 393-6	3002.96	140.25	3030.39	11.89
Junc 393-7	2955.05	697.50	3019.66	27.99

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 401-V-1	3012.67	177.75	3031.34	8.09
Junc 401V-2	2995.68	252.75	3027.91	13.97
Junc 401V-3	2996.42	595.50	3027.92	13.65
Junc 401V-4	2980.19	577.50	3025.92	19.81
Junc 401V-5	2980.36	213.75	3025.92	19.74
Junc 401V-6	2966.49	33.00	3022.87	24.43
Junc 401V-7	2966.19	528.00	3022.86	24.56
Junc 401V-8	2951.98	1145.25	3018.85	28.97
Junc 401V-9	2946.48	42.00	3018.56	31.23
Junc 407-1	2975.11	1203.75	3021.03	19.90
Junc 407-2	2960.14	236.25	3017.55	24.88
Junc 407-3	2958.77	278.25	3017.30	25.36
Junc 407-4	2959.01	572.25	3017.28	25.25
Junc 409-1	3013.54	279.00	3029.80	7.04
Junc 409-2	3021.89	28.50	3032.15	4.44
Junc 449-1	3010.00	27.00	3024.27	6.18
Junc 450X-3	2923.95	15.00	2994.58	30.60
Junc 451-X-1	2928.22	1248.00	3012.41	36.48
Junc 451X-2	2931.98	98.25	2994.71	27.18
Junc 459Y	2957.41	596.25	2999.70	18.32
Junc 724A	2951.39	27.00	2958.72	3.18
Junc 725-1	2947.23	120.00	2950.42	1.38
Junc 725-2	2948.51	165.00	2949.29	0.34
Junc 737-A	2950.91	11.25	2957.06	2.66
Junc 737-B	2950.06	63.00	2957.04	3.03
Junc 741-1	2950.87	53.25	2956.61	2.49

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 741-2	2949.36	18.75	2954.82	2.37
Junc 763-1	2948.95	76.50	2953.48	1.96
Junc 763-2	2947.90	30.00	2951.80	1.69
Junc 763-3	2938.94	71.25	2947.63	3.76
Junc 763-4	2939.32	979.50	2946.15	2.96
Junc 769-1	2934.75	7.50	2952.59	7.73
Junc 769-2	2900.20	9.75	2945.60	19.67
Junc 769-3_IND	2885.30	439.50	2938.93	23.24
Junc 769-4	2885.40	942.00	2938.91	23.19
Junc 769-5	2883.93	723.00	2943.75	25.92
Junc 769-6	2876.44	137.25	2924.71	20.91
Junc 775A	2938.89	809.25	2950.24	4.92
Junc 777-1	2940.25	33.75	2949.80	4.14
Junc 777-2	2891.04	83.25	2940.52	21.44
Junc 777-3	2889.76	276.00	2938.00	20.90
Junc 777-4	2877.69	135.00	2923.23	19.73
Junc 779-1	2922.79	113.25	2945.11	9.67
Junc 779-2	2920.26	63.00	2939.15	8.18
Junc 779-3	2915.93	78.00	2937.97	9.55
Junc 781-11	2975.19	17.25	3017.34	18.26
Junc 785-1	2931.04	504.00	2943.89	5.57
Junc 785-2	2930.75	65.25	2941.31	4.58
Junc 785-3	2881.40	7.50	2941.62	26.09
Junc 785-4	2929.17	57.00	2940.63	4.97
Junc 785A-1	2928.53	252.00	2944.83	7.06
Junc 785A-2	2925.47	30.75	2942.63	7.44

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc 785A-3	2925.70	155.25	2940.76	6.53
Junc 785A-4	2925.97	205.50	2940.75	6.41
Junc 785A-5	2910.26	469.50	2939.60	12.71
Junc 785A-6	2905.75	9.00	2938.41	14.15
Junc 785A-7	2903.25	34.50	2937.91	15.02
Junc 785A-8	2901.19	642.00	2936.85	15.45
Junc 817-1	2921.62	169.50	2932.02	4.51
Junc 817-2	2915.35	195.75	2928.73	5.80
Junc 817-3	2915.16	200.25	2928.72	5.88
Junc 817-4	2901.37	265.50	2917.71	7.08
Junc 817-5	2897.94	297.75	2913.18	6.60
Junc 825-1	2924.21	432.75	2926.22	0.87
Junc 825-2	2913.52	262.50	2925.18	5.05
Junc 825-3	2912.25	360.00	2924.77	5.43
Junc 825-4	2912.59	141.75	2924.70	5.25
Junc 826-2	2918.81	503.25	2926.51	3.34
Junc BREESE	2968.51	24.00	2981.47	5.62
Junc BREESE-10	2947.38	630.00	2965.17	7.71
Junc BREESE-11	2932.46	915.75	2953.24	9.00
Junc BREESE-3	2988.87	22.50	2995.28	2.78
Junc BREESE-4	2988.75	59.25	2995.00	2.71
Junc BREESE-5	2983.96	41.25	2992.29	3.61
Junc BREESE-6	2981.87	58.50	2989.46	3.29
Junc BREESE-7-1	2976.28	197.25	2985.68	4.07
Junc BREESE-7-2	2974.75	276.00	2985.55	4.68
Junc BREESE-9-1	2966.68	866.25	2976.34	4.19

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc BREESE-9-2	2967.39	10.50	2979.42	5.21
Junc BREESE-9-3	2954.72	750.00	2968.88	6.14
Junc CD-5	2857.41	285.00	2864.28	2.98
Junc Cemetery	2871.27	208.50	2877.64	2.76
Junc CF-1	3034.77	450.00	3097.41	27.14
Junc CF-2	3031.24	174.75	3092.73	26.64
Junc CF-3	3029.37	387.00	3080.63	22.21
Junc CF-4	3026.05	617.25	3064.43	16.63
Junc CF-5	3023.54	687.75	3041.52	7.79
Junc CF-6	3019.70	971.25	3036.54	7.30
Junc CF-6A	2996.87	35.25	3035.35	16.67
Junc COMBS_FLAT_PUMP	2920.56	0.00	3099.66	77.60
Junc COOK_DAM	2866.56	30.75	2867.47	0.40
Junc COOK_DAM_SPILL	2862.92	0.00	2867.51	1.99
Junc D-10	2896.65	464.25	2904.83	3.54
Junc D-12	2894.92	682.50	2902.81	3.42
Junc D-13	2894.51	120.00	2902.57	3.49
Junc D-19	2894.18	81.75	2901.34	3.10
Junc D-21	2893.09	1195.50	2899.52	2.78
Junc D-3	2899.44	80.25	2909.57	4.39
Junc D-4	2899.17	81.00	2909.68	4.55
Junc GFE-2	3100.22	422.25	3160.93	26.31
Junc GFE-4	3097.03	146.25	3149.01	22.52
Junc GFE-5	3097.38	413.25	3148.53	22.16
Junc GFE-6	3093.33	362.25	3141.81	21.01
Junc GFE-7	3060.14	81.00	3138.32	33.88

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc GFW-10	3085.34	379.50	3135.63	21.79
Junc GFW-11	3084.96	57.00	3135.55	21.92
Junc GF-W-1-1	3100.25	467.25	3162.03	26.77
Junc GFW-12	3085.98	435.00	3135.46	21.44
Junc GFW-14	3082.25	1075.50	3130.88	21.07
Junc GFW-2	3099.83	449.25	3161.22	26.60
Junc GFW-3	3099.83	153.00	3160.24	26.18
Junc GFW-5	3095.32	153.00	3150.86	24.06
Junc GFW-5A	3098.32	23.25	3156.74	25.31
Junc GFW-6	3093.82	173.25	3147.74	23.36
Junc GFW-6A	3093.38	18.00	3147.12	23.28
Junc GFW-7	3091.17	662.25	3144.31	23.02
Junc GFW-8	3088.19	598.50	3140.73	22.77
Junc GFW-8A	3088.25	37.50	3140.80	22.77
Junc GFW-8B	3088.25	45.00	3140.80	22.77
Junc GFW-9	3086.65	92.25	3136.31	21.52
Junc GRIMES_FLAT_RETURN_03	3014.25	0.00	3028.11	6.01
Junc HG-161-C	3044.69	0.00	3050.17	2.38
Junc HG-177	2939.03	0.00	2949.97	4.74
Junc HG-181-G	3043.14	0.00	3049.31	2.67
Junc HG-301	3040.24	0.00	3046.75	2.82
Junc HG-311	3037.31	0.00	3045.61	3.60
Junc HG-315	3035.87	0.00	3044.40	3.70
Junc HG-318	3036.53	0.00	3044.32	3.38
Junc HG-321	3036.45	0.00	3043.90	3.23
Junc HG-369	3030.07	0.00	3038.40	3.61

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc HG-375R	3030.43	0.00	3037.80	3.20
Junc HG-381	3030.10	0.00	3037.45	3.18
Junc HG-389	3027.90	0.00	3036.20	3.60
Junc HG-391	3027.49	0.00	3036.02	3.70
Junc HG-393	3027.09	0.00	3035.89	3.81
Junc HG-401V	3025.99	0.00	3035.04	3.92
Junc HG-407	3025.56	0.00	3034.42	3.84
Junc HG-409	3025.51	0.00	3034.37	3.84
Junc HG-449	3010.18	0.00	3024.26	6.10
Junc HG-451X	2987.95	0.00	3023.20	15.27
Junc HG-459	2977.58	0.00	3015.63	16.49
Junc HG-763	2947.40	0.00	2953.59	2.68
Junc HG-769	2946.31	0.00	2952.78	2.80
Junc HG-779	2937.00	0.00	2949.14	5.26
Junc HG-785	2936.84	0.00	2948.06	4.86
Junc HG-799	2930.39	0.00	2941.76	4.93
Junc HG-815	2926.26	0.00	2936.22	4.31
Junc HG-817	2924.95	0.00	2935.34	4.50
Junc HG-823	2924.59	0.00	2931.87	3.15
Junc HG-825	2921.52	0.00	2930.22	3.77
Junc HG-B-LAT	2951.11	0.00	2958.52	3.21
Junc HG-BREESE	2995.57	0.00	2997.83	0.98
Junc HG-COX_PUMP	3034.23	0.00	3042.21	3.46
Junc HG-CROOKED_RIVER_FEED	2911.93	0.00	2914.80	1.24
Junc HG-J-1	3039.84	0.00	3044.03	1.82
Junc HG-J-2	3039.24	0.00	3043.25	1.74

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc HG-J-4_J-5	3037.61	0.00	3041.54	1.70
Junc HG-JOHNSON_CREEK	3045.26	0.00	3051.59	2.74
Junc HG-LANIUS	3046.51	0.00	3051.88	2.33
Junc HG-OCHOCO_MAIN_CANAL	3052.27	0.00	3053.93	0.72
Junc HG-OCHOCO_RELIFT_PUMP	2950.99	0.00	2955.41	1.91
Junc HG-RG-19	2864.87	0.00	2871.29	2.78
Junc HG-RG-25	2864.10	0.00	2869.31	2.26
Junc HG-RG-55	2850.99	0.00	2857.51	2.83
Junc HG-RG-5-51	2858.97	0.00	2864.72	2.49
Junc HG-RG-57	2847.33	0.00	2854.13	2.95
Junc HG-RG-59A	2844.98	0.00	2852.32	3.18
Junc HG-THOMPSON-PIPE	2951.49	0.00	2957.68	2.68
Junc HG-W	2978.86	0.00	3027.06	20.88
Junc J-1-1	3011.43	14.25	3041.90	13.20
Junc J-1-2	3011.27	6.00	3041.89	13.27
Junc J-1-3	3005.51	15.00	3041.55	15.62
Junc J-1-4	3010.58	14.25	3041.85	13.55
Junc J-1-5	3000.65	7.50	3041.13	17.54
Junc J-1-6	3000.65	30.00	3041.13	17.54
Junc J-2-1	3019.79	92.25	3041.77	9.52
Junc J-2-2	3019.26	46.50	3041.80	9.77
Junc J-2-3	3020.91	21.75	3040.55	8.51
Junc J-2-4	3014.00	42.75	3039.54	11.07
Junc J-2-5	3009.76	67.50	3039.25	12.78
Junc J-3	3038.97	22.50	3042.59	1.57
Junc J-4-1	3040.38	9.75	3041.49	0.48

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc J-4-2	3012.43	21.00	3039.96	11.93
Junc J-4-3	3012.57	11.25	3039.97	11.87
Junc J-4-4	3013.55	16.50	3040.01	11.47
Junc J-4-5	3012.43	30.00	3039.96	11.93
Junc J-4-6	3012.93	13.50	3039.99	11.73
Junc J-4-7	3007.60	117.00	3035.59	12.13
Junc J-4-8	2954.96	7.50	3032.93	33.78
Junc J-4-9	2945.64	60.75	3031.95	37.40
Junc J-5-1	3037.10	13.50	3041.30	1.82
Junc J-5-2	3038.71	7.50	3041.29	1.12
Junc J-5-3	3037.48	6.00	3041.29	1.65
Junc J-5-4	3038.54	12.75	3041.35	1.22
Junc JC1	3165.24	412.50	3202.62	16.20
Junc JC-1	3063.17	133.50	3126.64	27.50
Junc JC13	3159.81	198.75	3181.18	9.26
Junc JC14	3157.14	7.50	3177.19	8.69
Junc JC15	3156.99	282.00	3176.09	8.27
Junc JC16	3155.98	381.00	3173.03	7.39
Junc JC17	3154.24	428.25	3169.97	6.81
Junc JC-19	3149.41	231.00	3162.50	5.67
Junc JC-2_JC-3	3052.99	66.75	3125.39	31.37
Junc JC-21	3149.42	40.50	3162.47	5.65
Junc JC-23	3147.30	840.75	3159.79	5.41
Junc JC-25	3139.59	663.75	3150.67	4.80
Junc JC-27	3137.15	69.00	3147.74	4.59
Junc JC-29	3136.78	94.50	3144.12	3.18

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc JC3	3164.87	195.00	3199.72	15.10
Junc JC-31	3134.61	174.75	3140.52	2.56
Junc JC-4	3050.2	67.5	3050.39	0.08
Junc JC-5	3050.	0	3050.40	0.17
Junc JC-6	3071.94	66.75	3146.45	32.28
Junc JOHNSON_CREEK	3046.14	0.00	3050.59	1.93
Junc JOHNSON_CREEK_DIV	3153.56	0.00	3169.10	6.73
Junc JOHNSON_CREEK_PUMP	3051.0	0.00	3051.57	0.25
Junc JONES_DAM	3034.72	232.50	3041.97	3.14
Junc Lanius/Lower4	2992.22	615.00	3043.87	22.38
Junc Lanius_Lanius2	2994.58	394.50	3048.69	23.45
Junc Lanius-Upper-3	2992.25	462.00	3043.90	22.38
Junc Lanius-Upper-5-Lower-6	2989.66	630.00	3035.66	19.93
Junc LYTLE_CREEK	3093.84	0.00	3147.07	23.07
Junc LYTLE_CREEK_JCT	3024.97	0.00	3034.15	3.98
Junc MAIN_PUMPING_PLANT	2890.69	0.00	2973.99	36.09
Junc NODE-00	2981.14	0.00	3040.47	25.71
Junc NODE-01	3044.70	0.00	3046.64	0.84
Junc NODE-02	2937.92	0.00	2947.61	4.20
Junc NODE-03	2929.93	0.00	2941.84	5.16
Junc NODE-04	2876.09	0.00	2879.63	1.54
Junc NODE-05	2956.78	0.00	2966.60	4.26
Junc NODE-09	2921.31	0.00	2929.47	3.54
Junc NODE-10	3032.49	0.00	3097.33	28.10
Junc NODE-11	3022.97	0.00	3039.56	7.19
Junc NODE-12	3018.43	0.00	3036.53	7.84

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc NODE-13	2954.80	0.00	2961.97	3.11
Junc NODE-14	2953.39	0.00	2961.32	3.44
Junc NODE-15	3042.54	0.00	3048.75	2.69
Junc NODE-16	3165.22	0.00	3205.34	17.38
Junc NODE-17	3040.65	0.00	3048.22	3.28
Junc NODE-18	3037.52	0.00	3045.65	3.52
Junc NODE-19	3038.65	0.00	3045.89	3.13
Junc NODE-20	3036.54	0.00	3042.03	2.38
Junc NODE-21	2966.79	0.00	3041.58	32.41
Junc NODE-22	2992.69	0.00	3039.95	20.48
Junc NODE-23	2869.90	0.00	2878.84	3.87
Junc NODE-24	2868.21	0.00	2878.06	4.27
Junc NODE-25	2867.36	0.00	2876.99	4.17
Junc NODE-26	2867.75	0.00	2876.46	3.77
Junc NODE-27	2863.02	0.00	2866.39	1.46
Junc NODE-28	2863.58	0.00	2866.34	1.20
Junc NODE-29	2865.52	0.00	2866.80	0.55
Junc NODE-30	2863.09	0.00	2866.93	1.67
Junc NODE-31	2860.08	0.00	2865.77	2.47
Junc NODE-32	2834.04	0.00	2844.31	4.45
Junc NODE-34	3018.67	0.00	3033.37	6.37
Junc NODE-35	2939.60	0.00	3000.70	26.47
Junc NODE-36	2960.29	0.00	3012.48	22.61
Junc NODE-37	3076.69	0.00	3131.15	23.60
Junc NODE-38	2954.99	0.00	3014.32	25.71
Junc NODE-39	2965.38	0.00	3023.09	25.01

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc NODE-40	2952.07	0.00	3020.35	29.59
Junc NODE-41	2954.75	0.00	2954.72	-0.01
Junc NODE-42	2954.05	0.00	2954.72	0.29
Junc NODE-43	2955.0	0.00	2954.72	-0.12
Junc NODE-44	2935.35	0.00	2954.74	8.40
Junc NODE-45	2892.20	0.00	2954.74	27.10
Junc NODE-46	2892.15	0.00	2944.26	22.58
Junc NODE-47	2879.33	0.00	2925.81	20.14
Junc NODE-48	2889.44	0.00	2937.95	21.02
Junc NODE-50	2883.86	0.00	2943.76	25.95
Junc NODE-51	2890.48	0.00	2944.27	23.31
Junc NODE-52	2868.94	0.00	2877.87	3.87
Junc OCHOCO_CREEK_SIPHON	2892.30	0.00	2898.85	2.84
Junc OCHOCO_CREEK_SPILL	2890.78	4490	2892.65	0.81
Junc OCHOCO_RELIFT_PUMP	2950.61	0.00	3050.24	43.17
Junc OCHOCO_RELIFT_RETURN	3039.22	0.00	3046.22	3.03
Junc PUMP_GRIMES_FLAT	3028.34	0.00	3036.52	3.54
Junc PUMP_GRIMES_FLAT_RETURN	3102.82	0.00	3165.34	27.09
Junc RG-10-1	2868.33	64.50	2874.33	2.60
Junc RG-10-2	2868.23	225.75	2875.42	3.11
Junc RG-11	2865.03	172.50	2872.84	3.38
Junc RG-12	2865.22	300.75	2872.85	3.30
Junc RG-13-1	2864.94	18.75	2872.52	3.28
Junc RG-13-2	2865.07	84.75	2872.14	3.07
Junc RG-15-1	2864.92	18.75	2871.75	2.96
Junc RG-15-2	2864.88	7.50	2871.95	3.06

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc RG-17	2864.86	97.50	2871.55	2.90
Junc RG-19	2856.16	215.25	2866.99	4.69
Junc RG-21	2864.94	15.00	2870.90	2.58
Junc RG-22	2864.44	30.00	2870.64	2.69
Junc RG-23-1	2865.44	10.50	2869.53	1.77
Junc RG-23-2	2864.83	82.50	2869.90	2.20
Junc RG-25-1	2865.27	600.00	2869.08	1.65
Junc RG-25-2	2861.95	189.00	2868.52	2.85
Junc RG-25-3	2861.87	387.00	2868.46	2.86
Junc RG-25-4	2863.62	11.25	2868.87	2.28
Junc RG-35-1_3_4	2862.93	72.00	2868.08	2.23
Junc RG-35-2	2862.71	12.00	2867.74	2.18
Junc RG-35-5	2863.13	6.75	2868.21	2.20
Junc RG-35-6	2864.25	60.75	2868.33	1.77
Junc RG-35-7	2863.14	4.50	2868.04	2.12
Junc RG-35-8	2864.28	6.00	2868.00	1.61
Junc RG-35-9	2862.91	21.75	2867.51	1.99
Junc RG-37	2867.0	3.00	2867.27	0.12
Junc RG-43_IND	2865.68	108.75	2865.97	0.13
Junc RG-4A_IND	2866.19	108.75	2876.17	4.32
Junc RG-5	2865.87	3.00	2875.62	4.23
Junc RG-52	2856.61	123.00	2863.24	2.87
Junc RG-5-47	2834.52	249.00	2850.96	7.12
Junc RG-55	2830.35	1248.00	2851.44	9.14
Junc RG-5-51-1	2836.01	270.00	2852.33	7.07
Junc RG-5-51-2	2849.86	741.75	2864.32	6.27

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc RG-55A	2851.06	65.25	2857.52	2.80
Junc RG-57-1	2844.65	120.00	2849.37	2.05
Junc RG-57-2	2844.17	27.00	2849.30	2.22
Junc RG-59	2846.99	1125.00	2853.85	2.97
Junc RG-59A	2834.78	140.25	2851.12	7.08
Junc RG-61	2838.35	361.50	2849.37	4.78
Junc RG-63	2837.12	341.25	2847.47	4.48
Junc RG-65	2835.51	61.88	2844.51	3.90
Junc RG-69	2835.61	1005.00	2843.11	3.25
Junc RG-71	2834.39	273.75	2842.97	3.72
Junc RG-73	2832.55	254.25	2840.23	3.33
Junc RG-75	2828.78	117.00	2836.50	3.35
Junc RG-76-1	2828.79	75.00	2836.49	3.34
Junc RG-DIVERSION	2872.64	0.00	2879.86	3.13
Junc SPILL-01	2946.32	0.00	2952.70	2.77
Junc SPILL-03	2948.86	0.00	2954.54	2.46
Junc SPILL-04	2940.10	0.00	2950.20	4.38
Junc W-1	2973.82	225.00	3024.27	21.86
Junc W-2	2946.13	165.75	3011.12	28.16
Junc W-3	2944.68	114.00	3011.49	28.95
Junc W-4	2952.83	639.75	3017.91	28.20
Junc W-5	2941.22	836.25	3016.89	32.79
Junc W-6	2953.43	252.00	3014.08	26.28
Junc W-7	2947.68	18.00	3017.00	30.04
Junc WEST_MCKAY_PUMP	3032.69	0.00	3041.35	3.75
Junc WEST_MCKAY_PUMP_RETURN	3081.23	0.00	3178.72	42.24

Ochoco Irrigation District System Model

Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc BBPump	2890.69	0	2891.41	0.31
Junc JCPUMPDISCHARGE	3051.72	0	3207.55	67.52
Junc TUNNELPUMPDISCHARGE	3036.5	0	3260.24	96.95
Junc GrimesPumpDischarge	3028.34	0	3167.18	60.16
Junc WMPUMPDISCHARGE	3032.69	0	3180.45	64.03
Junc OchocoReliftSuction	2950.6	0	2955.00	1.91
Junc OchocoReliftDischarge	2950.61	0	3052.85	44.30
Junc 1	2895	0	3100.03	88.84
Junc THOMPSON_DISCHARGE	2951.49	0	3077.55	54.62
Resvr OchocoRes	3054.0	#N/A	3054.00	0.00
Resvr OchocoCreekBreese	2998.0	#N/A	2998.00	0.00
Resvr OchocoCreekRyegrass	2880	#N/A	2880.00	0.00
Resvr CrookedRiverHeadworks	2915.0	#N/A	2915.00	0.00

APPENDIX C
PIPE BUDGET ESTIMATES FROM VENDORS

From: **Theetge, Mark A** <Mark.Theetge@hdsupply.com>
Date: Thu, Sep 15, 2016 at 8:55 AM
Subject: RE: Swalley Pipe Lengths
To: Kevin Crew <blackrockci@gmail.com>

Great to hear! I have attached basic pricing that I may end up refining for my own interest and share that later. The cost that I have used is based on actual footage which could include partial loads. The freight cost I have included is for the furthest distance which would be Kingman AZ. I have also included cost for a tech and equipment to weld the material. I used current project pricing levels and a conservative mark up about 12%. All of this could change with the market so for basic estimation only!!

If it was my district I might want to include cost for fusion equipment purchase in the cost of the project. For material 24" and down or possibly 18" and down based on the cooperation of other districts. Given Marc has a 36" machine and since there is not a whole lot of larger pipe it would make sense to rent possibly. Just a thought?

Thanks,

Mark A. Theetge

Fusible Plastics Specialist

HD Supply WaterWorks

M 503 341 3614

F 855 222-0361

	Proposed DR32.5		Proposed DR26		Proposed DR21	
54in	0.00		0.00		0.00	
48in	2,094.13	$105.50	0.00		0.00	
42in	4,559.92	$81.92	0.00		0.00	
36in	6,708.70	$62.89	0.00		0.00	
34in	1,932.25	$54.73	0.00		0.00	
32in	830.58	$4,703	0.00		0.00	
30in	2,558.88	$42.15	0.00		0.00	
28in	3,085.71	$37.05	1,664.91	$44.98	0.00	
26in	0.00	$0.00	2,745.63	$39.95	0.00	
24in	5,727.49	$26.86	2,533.51	$32.98	0.00	
22in	0.00	$0.00	0.00		0.00	
20in	6,350.76	$19.45	1,282.68	$24.15	0.00	
18in	5,644.83	$15.41	347.84	$23.97	319.85	$28.14
16in	2,295.26	$15.27	1,926.59	$15.61	3,038.68	$22.13
14in	9,163.29	$9.48	1,119.91	$12.78	1,565.95	$13.77
12in	8,351.11	$7.81	4,588.71	$9.56	2,437.56	$11.35
10in	9,020.98	$5.82	2,197.32	$7.23	2,380.32	$8.75
8in	13,531.69	$3.93	4,736.81	$4.68	525.96	$10.16

APPENDIX D
FEASIBILITY STUDY

REGISTERED PROFESSIONAL ENGINEER
17,425
OREGON
SEPT. 28, 1994
KEVIN L. CREW

EXPIRES: 31 DECEMBER, 2011

May 2011

Ochoco Irrigation District

Ochoco Canal Hydropower Feasibility Study

BLACK ROCK CONSULTING
Kevin L. Crew, P.E.
20380 Halfway Road Suite #1
Bend, Oregon 97701
541.480.6257
blackrockci@gmail.com

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EXECUTIVE SUMMARY

This Feasibility Study for Hydroelectric Power Generation at the Ochoco Main Canal Site was authorized by OID in January, 2011. The Study will be funded in part by the United States Bureau of Reclamation System Optimization Review (SOR) grant and in part by the District.

Based on 2007-2010 flow data gathered from the District/USBR Hydromet site, feasibility-level head-loss estimates and associated net-heads were developed for Francis-type turbine unit and Natel Energy Machine alternatives. Such heads ranged from approximately 34-FT to 68-FT over the 2007-2010 period of record.

PacifiCorp is the local power interconnect utility, and it is anticipated that the interconnect pole will be located adjacent to Highway 26 approximately 460-FT from the proposed powerhouse site. Current Schedule 37 blended rates were used to estimate power revenue from the project turbine and machine alternatives.

The site is considered medium-head and therefore Francis and Natel Energy options were explored. Chinese Francis and Natel appeared to be the most cost –effective alternatives for the site and each were compared against the other based upon potential revenue generation as well as potential project cost. The Natel Energy SLH-50 will pass up to approximately 150 CFS at a modulated constant 23-FT of net head, whereas the Francis turbine will pass up to approximately 160 CFS. For limited periods, it will be necessary to bypass additional flows that exceed the 160 CFS. The cost of site installation is expected to be lower for the Natel technology as the machine may be placed anywhere along the hydraulic column whereas the Francis turbine must be located deeper at the tailrace area, increasing its comparative design and installation cost.

Funding programs were discussed along with potential funders known in the basin. Feasibility-level cost estimates were prepared for both hydroelectric power types. For the Francis, the estimate with a 500 kW Chinese Turbine/Generator was $2,008,600 and for the 233 kW Natel Energy Machine was $1,621,620.

Expected revenue estimates were developed for the two alternatives and compared to the costs in a benefit-cost analysis. No options resulted in a positive benefit/cost ratio greater than 1.0, therefore indicating an unviable project given the assumptions.

It was noted that the project is very sensitive to potential funding programs such as the re-authorization of the Oregon Business Energy Tax Credit and out of state REC programs; therefore these should be watched carefully.

The apparent best project would be a Chinese Francis turbine with a benefit/cost ratio of 0.87 (given that grant funding and ETO funding were obtained).

BACKGROUND

The intent of this Feasibility Report is to evaluate and present the technical, financial, and permitting feasibility of a potential hydroelectric power generation site on the Ochoco Irrigation District's (OID) Ochoco Main Canal at its headworks in Prineville, Oregon.

The potential hydro site is generally located as indicated in Figure 1.

Black Rock Consulting (BRC) of Bend, Oregon was authorized by OID in January, 2011 to commence work on this Study that will be funded in part by the United States Bureau of Reclamation's the System Optimization Review Grant and in part by OID itself.

The primary objectives of this Feasibility Study and associated data development were as follows:

1) Review any available historical project information provided by OID.
2) Establish project limits based upon canal and future piping project specifics (elevation differential, existing houses or structures in vicinity, location of existing utility facilities, etc.).
3) Review and interpret feasibility-level gross head information for the proposed hydro site given Ochoco Reservoir telemetry data and as-built information for the Ochoco Canal headworks.
4) Develop an aerial site plan (from existing aerial sources) for the site.
5) Research and verify probable annual average flow rates (minimum/average/peak) at the site. Data to be gathered from OID SCADA and the USBR Hydromet systems.
6) Develop turbine/machine water supply strategies depending upon the technology evaluated and estimate potential head losses associated with these strategies.
7) Evaluate project head-loss for the site and develop probable elevation head range at the turbine or machine for the site.
8) Size a feasibility level turbine or machine and generator for the site. Explore alternative procurements both internationally and low head machine technology.
9) Request equipment cost estimates from reputable manufacturers.
10) Develop a feasibility level cost estimate for the site.
11) Develop feasibility level energy production estimates for the site.
12) Develop revenue expectations given estimated rates.
13) Develop a benefit/cost comparison for the site.
14) Prepare a feasibility report compiling the above information and providing recommendations for the site.

GENERAL PROJECT LOCATION

The proposed project site is located within the easterly extent of the OID boundary, approximately 6-miles east of Main Street in Prineville along Highway 26. The site is located near the OID Ochoco Reservoir immediately downstream of the Ochoco Dam exitworks and immediately upstream of the Oregon Water Resources Department's canal flow measurement telemetry station. The Ochoco canal supplies the District with over 130 CFS of irrigation water during the peak season and also is designed to return flows to Ochoco Creek at its headworks. With the exception of proposed power pole alignments, the proposed project falls completely within the fee title land ownership of OID. The site is located adjacent to the existing Ochoco Reservoir discharge structure and gate-house at approximate latitude/Longitude N44°17'55.62" W120°43'36.01".

As may be seen in Figures 1, the site is located on OID property, well insulated from development other than the District's own ditch rider residence located on the same parcel.

HISTORICAL INFORMATION AND DATA REVIEW

The Ochoco Irrigation District was established in 1917 and is a quasi-municipal corporation of the state of Oregon.

The District's system consists of three main canals: the Ochoco Main Canal, which runs east to west on the high side of the District, the Crooked River Distribution Canal which runs through the middle of the District, and Rye-Grass Canal which runs through the lower portion of the District. The District provides water to approximately 20,000 acres of farmland in and around the Prineville area.

The District owns, operates and maintains the Ochoco Dam and Reservoir. The reservoir provides 44,000 acre-feet of storage and feeds the Ochoco Main Canal. In addition the District is under contract to operate and maintain the Bowman Dam on Prineville Reservoir. This reservoir provides 150,000 acre-feet of storage, feeds the Crooked River and the Crooked River Diversion Canal as well.

Over the last 10 years, the Ochoco Irrigation District has implemented programs to modernize many of its facilities including conservation projects involving lining and piping of portions of its system, implementation of compliant automated fish screening facilities at its Crooked River Diversion, implementation of SCADA/Telemetry flow-measurement systems, installation of public and employee safety devices, and maintenance and upgrades of its existing facilities, including Bowman Dam. Additionally, the District has invested in efforts to upgrade its mapping and GIS capabilities. Most recently, the District has participated in a basin-wide effort to develop a comprehensive Habitat Conservation Plan and has commenced system efficiency evaluations through its System Optimization Review study of which this study is a component. The

District continues to make such improvements and remain involved as a partner in the community and to perpetuate its mission of irrigation supply to its patrons.

The historic flow measurement data gathered to develop flow rate estimates for hydroelectric power generation was from USBR Hydromet telemetry data sites downloaded from the worldwide web. Ochoco Reservoir discharges were found by combining the data from the OCHOQJ (Ochoco Main Canal) and OCHOQD (Ochoco Creek) gauges. As these telemetry sites reside immediately adjacent to the proposed project, no adjustment was necessary for canal losses and consequently the data is considered very good for estimating purposes. Data from 2007 through 2010 was downloaded for use in estimating flow rates for the site.

SUMMARY FEASIBILITY PROJECT DETAILS

The project is located as indicated above and as shown in Figure 1. The Ochoco Irrigation District diverts water into the Ochoco Main Canal generally during its irrigation season between the first week in April and the second week in October of each year depending upon the weather and other factors addressed annually by its Board of Directors. Additionally, it passes some water at other periods and at various flow rates that are immediately returned to Ochoco Creek just downstream of the Ochoco Reservoir. Details of 2007, 2008, 2009 and 2010 flow rates available at the hydroelectric power generation site are included later in this study.

The site for the project was selected based upon the existence of District facilities at the District's Ochoco Reservoir. Although details for such facilities will not be provided herein, the facilities are capable of providing pressurized water from the reservoir at the head-end of the Ochoco Main Canal. This pressurized water, in conjunction with the flows passed annually provides the basis for power production at the site. The site is also located within approximately 460-FT of the interconnect utility and such close proximity would affect lower interconnection costs (see Figure 2).

Several technologies were evaluated for application at the site including Kaplan, Francis, and Natel Machine technologies. Additionally, international versus domestic suppliers were evaluated. The most competitive technologies evaluated for the site were Chinese Francis and American Natel Energy options.

When evaluating the Francis turbine alternative, it was assumed that a conventional arrangement including a horizontal turbine and generator arrangement, an inlet control valve, a bypass valve, valve controls, a small powerhouse building, connection to existing facilities, utility interconnect poles and conductor, a transformer, draft tube, and minor discharge pool modifications were included.

When evaluating the Natel Energy machine, the head limitation of the machine required that energy head modulation be included, therefore it was assumed that a valve such as a Ross or sleeve multi-orifice type valve would be included to accomplish head regulation. Details for such modulation would require full development in design and alternate methods may be used to accomplish similar results. Other aspects as identified for the Francis turbine technology were also included for the Natel option.

Geotechnical evaluations were not within the scope of this study therefore no information is available to ascertain excavation issues. Rock is present at the site; therefore it is assumed that excavations will be into large cobble for installation of mechanical and structural features in the relatively small project footprint. During final design it is recommended that a geotechnical investigation be performed to develop final design criteria for the powerhouse building and to insure the integrity of the subsurface material for placement of a plant at that location.

Location Map

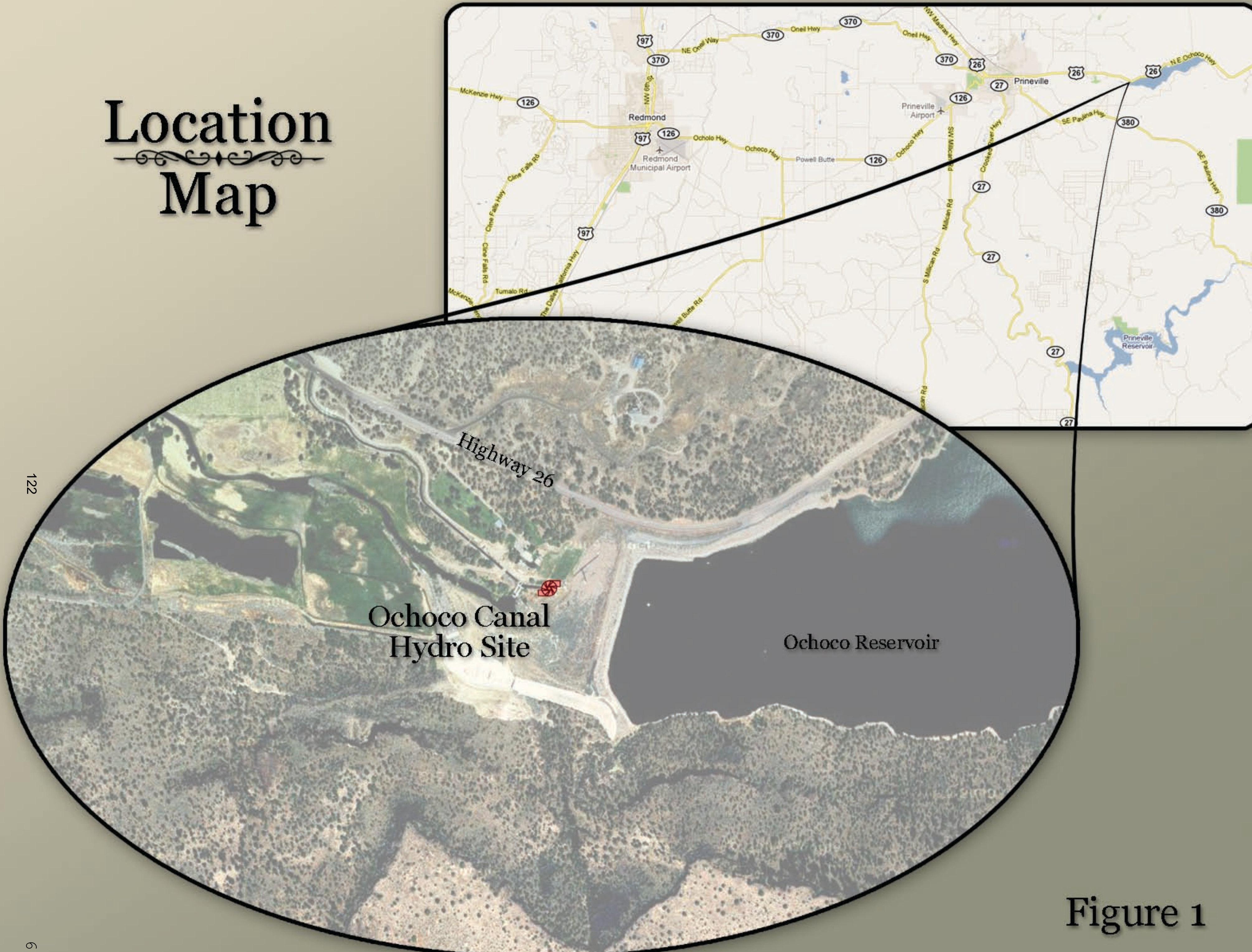

Figure 1

Site Map

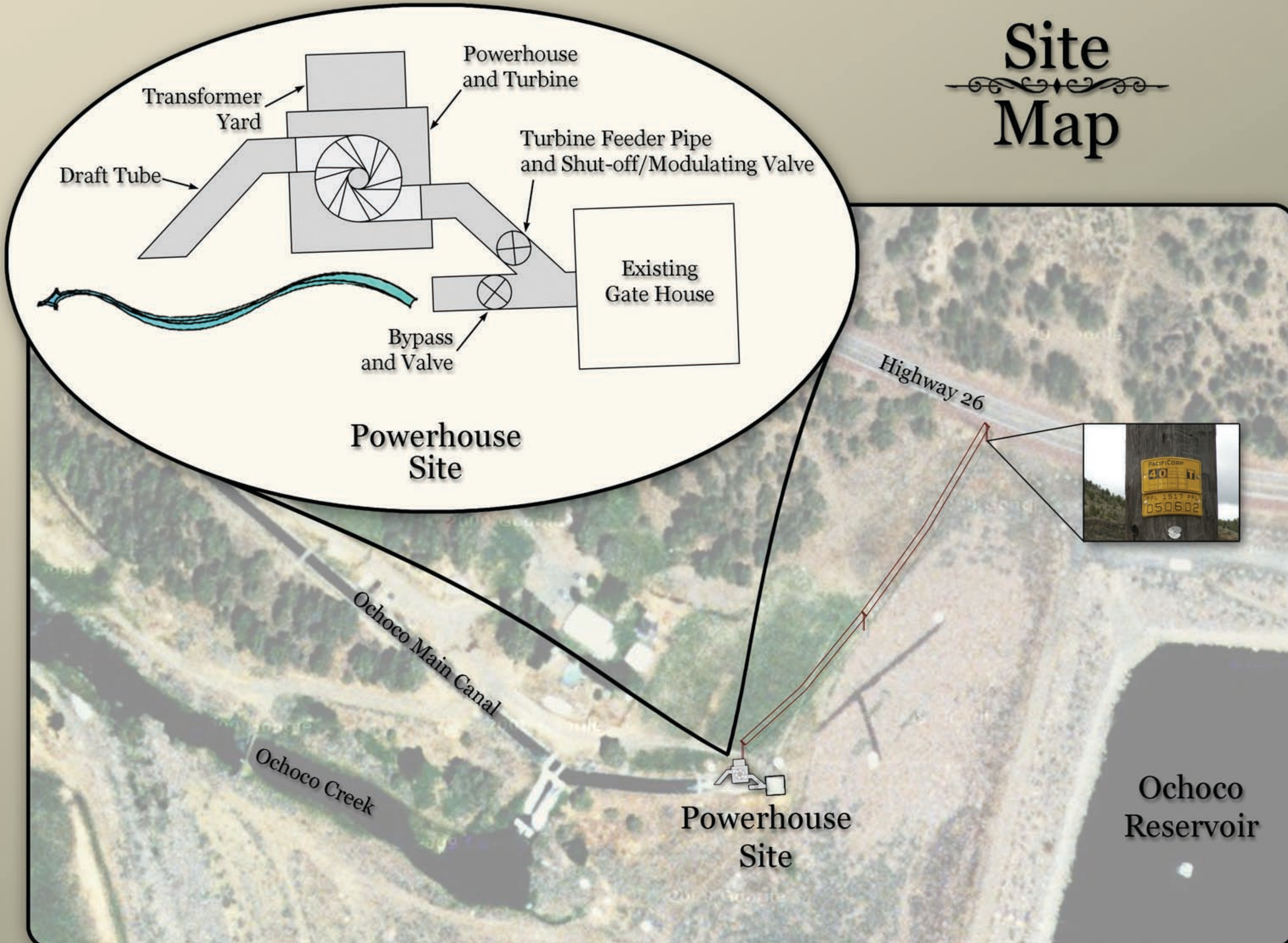

Figure 2

PROBABLE GROSS HEAD

Available head at the site is based upon the water surface elevation in the Ochoco Reservoir and therefore fluctuates based upon annual demands, filling and withdrawal cycles, etc. Water surface elevation above mean sea level is monitored by telemetry that is uplinked to the USBR Hydromet system under gauge code OCH. Water surface elevation in the reservoir fluctuated between elevation 3098 and 3130 in the period from 2007-2010. This gross elevation estimate should be confirmed during design as elevations vary given final tail water and intake designs.

HISTORICAL FLOW DATA

The historic flow measurement data gathered to develop flow rate estimates for hydroelectric power generation was from USBR Hydromet telemetry data sites downloaded from the worldwide web. Ochoco Reservoir discharges were found by combining the data from the OCHOQJ (Ochoco Main Canal) and OCHOQD (Ochoco Creek) gauges. As these telemetry sites reside immediately adjacent to the proposed project, no adjustment was necessary for canal losses and consequently the data is considered very good for estimating purposes. Data from 2007 through 2010 was downloaded for use in estimating flow rates for the site. This data has been included below for each year from 2007 through 2010.

2007 ESTIMATED FLOW RATES AT OCHOCO CANAL

2007												
	January	February	March	April	May	June	July	August	September	October	November	December
1st	61.0	9.6	10.1	21.8	132.2	113.5	137.1	84.1	61.7	40.3	6.1	6.7
2nd	48.1	9.6	10.1	17.6	131.2	108.4	145.9	89.0	61.8	35.9	6.1	6.7
3rd	62.1	9.6	10.1	54.3	123.1	99.1	141.8	95.8	61.1	33.6	6.1	6.6
4th	117.2	9.6	10.1	24.4	117.2	97.5	137.2	100.2	56.8	32.3	6.1	6.5
5th	140.3	9.6	10.1	37.7	117.2	84.8	136.2	99.6	48.5	29.3	6.4	6.4
6th	140.3	9.6	10.1	54.7	116.5	74.6	141.3	98.1	45.6	27.7	6.4	6.4
7th	140.1	9.6	10.1	61.1	106.5	68.0	140.9	98.1	45.9	27.6	6.4	6.4
8th	140.4	9.6	10.1	73.8	103.1	65.1	140.4	95.4	46.1	27.5	6.4	6.4
9th	141.6	9.6	11.2	73.9	106.6	62.7	138.1	88.8	46.4	27.5	6.4	6.7
10th	129.7	9.6	15.4	74.4	115.8	57.7	136.2	89.0	46.6	27.4	6.7	6.9
11th	121.5	9.6	15.7	74.5	120.7	55.5	132.4	89.0	46.8	27.3	6.7	6.4
12th	117.0	9.6	20.7	79.8	120.5	56.9	127.2	89.3	46.8	26.5	6.7	6.1
13th	116.1	9.6	23.8	87.9	121.0	57.7	127.7	95.0	47.1	24.2	6.7	6.1
14th	116.1	9.6	23.9	96.7	127.6	65.1	127.9	97.0	47.6	23.1	6.7	6.1
15th	117.6	9.6	24.1	111.6	128.8	74.7	128.2	103.9	48.0	11.4	6.7	6.1
16th	80.2	9.6	32.5	111.9	131.7	74.6	124.2	103.9	48.3	5.8	6.7	6.1
17th	51.4	9.6	51.5	112.7	143.4	72.9	120.4	104.0	48.6	5.8	6.7	6.1
18th	37.3	9.7	63.9	113.0	148.3	72.4	120.5	104.3	47.5	5.6	6.7	6.1
19th	37.2	9.8	95.0	111.5	148.2	79.2	109.5	104.1	47.2	5.6	6.7	6.1
20th	37.4	9.6	110.1	96.5	147.6	96.3	89.2	97.5	47.0	5.6	6.7	6.2
21st	36.9	9.6	109.0	90.0	143.9	100.5	73.5	84.5	47.3	5.5	6.7	6.1
22nd	37.3	9.8	110.1	88.5	132.1	99.8	77.7	75.0	47.6	5.3	6.7	6.1
23rd	37.4	10.0	111.5	88.9	130.3	99.2	79.4	65.1	47.9	5.2	6.7	6.1
24th	34.7	9.9	110.9	89.4	138.5	102.6	79.0	61.1	52.9	5.2	6.7	6.1
25th	22.3	10.1	110.2	94.5	136.8	109.2	93.4	68.8	48.9	5.3	6.7	6.1
26th	15.7	10.1	101.0	101.8	126.8	107.6	102.5	68.8	46.8	5.8	6.7	6.1
27th	14.4	10.1	95.0	114.3	125.4	107.8	81.5	68.6	47.0	6.1	6.7	6.1
28th	14.4	10.0	82.2	127.4	126.8	112.8	72.4	69.1	45.0	6.1	6.7	6.1
29th	11.8		53.3	132.5	121.9	126.9	72.6	73.7	43.7	5.8	6.7	6.1
30th	9.6		27.2	132.4	118.0	134.7	73.3	75.8	43.7	5.9	6.7	6.1
31st	9.6		21.8		112.9		73.9	66.5		6.0		6.1

2007 FLOW DATA RANGE

2007	Operation Days	Minimum Volume (cfs)	Average Volume (cfs)	Peak Volume (cfs)
January	31	9.58	70.87	141.61
February	28	9.56	9.70	10.05
March	31	10.05	48.39	111.51
April	30	17.57	84.97	132.45
May	31	103.06	126.46	148.26
June	30	55.54	87.91	134.66
July	31	72.36	112.30	145.89
August	31	61.14	87.20	104.28
September	30	43.71	48.87	61.77
October	31	5.19	16.52	40.33
November	30	6.09	6.53	6.70
December	31	6.09	6.26	6.92
Average			69.15	

2008 ESTIMATED FLOW RATES AT OCHOCO CANAL

2008	January	February	March	April	May	June	July	August	September	October	November	December
1st	6.1	6.1	6.1	37.1	83.2	249.1	134.1	91.2	73.6	59.8	4.3	3.1
2nd	6.1	6.1	6.1	37.1	72.7	211.0	131.6	81.5	71.1	59.4	4.2	3.1
3rd	6.1	6.1	6.1	37.2	71.8	187.0	130.2	79.2	71.6	52.0	4.1	3.1
4th	6.1	6.1	6.1	37.2	72.8	157.1	132.2	84.1	72.3	50.1	3.9	3.1
5th	6.2	6.1	6.1	37.2	79.9	131.0	130.7	93.2	72.1	51.1	3.9	3.1
6th	6.1	6.1	6.1	37.2	81.7	126.9	130.8	102.1	71.1	49.3	3.9	3.1
7th	6.1	6.1	6.1	37.5	76.1	120.9	128.7	94.5	73.7	46.7	3.7	3.1
8th	6.1	6.1	6.1	37.5	85.4	115.7	134.6	91.8	68.3	46.0	3.5	3.1
9th	6.1	6.1	6.3	37.7	92.5	93.5	133.9	92.0	62.8	46.1	3.7	3.1
10th	6.2	6.1	6.2	44.1	87.3	68.9	139.1	91.8	58.1	46.3	3.7	3.1
11th	6.3	6.1	6.1	59.0	84.4	68.5	145.0	92.5	54.9	46.5	3.5	3.1
12th	6.3	6.1	6.2	57.0	84.1	67.9	148.6	98.1	55.5	24.7	3.5	3.1
13th	6.2	6.1	6.4	73.5	83.8	67.6	138.8	100.6	56.3	8.1	3.5	3.1
14th	6.3	6.1	6.4	103.4	80.4	68.4	147.5	106.6	57.0	5.3	3.5	3.1
15th	6.4	6.1	6.4	115.0	79.4	69.0	153.5	109.3	57.4	5.3	3.3	3.1
16th	6.3	6.1	6.4	100.0	89.8	69.5	142.2	109.4	58.1	5.3	3.1	3.3
17th	6.1	6.1	6.5	85.1	100.7	70.2	133.9	106.5	59.2	5.1	3.1	3.3
18th	6.1	6.1	6.6	80.9	104.8	70.4	127.3	99.0	59.0	5.1	3.1	3.2
19th	6.1	6.1	6.7	82.4	115.9	91.6	120.0	97.6	58.7	5.1	3.1	3.1
20th	6.1	6.2	6.7	72.5	117.2	105.4	106.2	91.0	59.1	4.6	3.1	3.1
21st	6.1	6.3	6.7	67.0	116.2	104.0	100.1	81.2	59.6	4.7	3.1	3.1
22nd	6.1	6.4	6.7	67.1	107.3	98.9	95.3	76.1	59.8	4.6	3.1	3.1
23rd	6.1	6.4	6.7	72.3	88.2	99.8	82.2	76.8	59.5	4.6	3.1	3.1
24th	6.1	6.4	6.8	90.6	84.0	108.4	79.6	77.2	59.5	4.6	3.1	3.1
25th	6.1	6.4	6.9	98.3	128.7	120.0	72.6	78.2	59.5	4.6	3.1	3.1
26th	6.2	6.4	7.0	100.2	129.0	127.0	71.2	79.1	59.7	4.6	3.2	3.1
27th	6.4	6.4	7.0	105.4	115.4	124.8	71.8	78.8	60.0	4.6	3.1	3.1
28th	6.4	6.1	7.0	101.2	154.4	127.7	71.0	79.0	60.1	4.6	3.1	3.1
29th	6.3	5.8	7.0	96.8	382.5	132.8	96.3	79.4	60.2	4.6	3.1	3.1
30th	6.1		35.9	94.7	369.4	132.4	109.9	79.7	60.1	4.5	3.1	3.1
31st	6.1		35.9		306.8		110.5	79.9		4.5		3.1

2008 FLOW DATA RANGE

2008	Operation Days	Minimum Volume (cfs)	Average Volume (cfs)	Peak Volume (cfs)
January	31	6.09	6.16	6.37
February	28	5.83	6.15	6.37
March	31	6.05	8.34	35.90
April	30	37.10	70.07	114.98
May	31	71.78	120.19	382.48
June	30	67.60	112.83	249.13
July	31	71.03	117.72	153.47
August	31	76.07	89.59	109.41
September	30	54.93	62.26	73.66
October	31	4.49	21.68	59.81
November	30	3.07	3.41	4.33
December	31	3.06	3.09	3.26
Average			67.65	

2009 ESTIMATED FLOW RATES AT OCHOCO CANAL

2009	January	February	March	April	May	June	July	August	September	October	November	December
1st	3.1	3.5	3.3	26.7	21.2	137.7	114.7	111.3	73.8	43.6	3.9	2.9
2nd	3.1	3.5	3.3	26.7	21.0	114.6	120.2	115.5	73.9	42.3	3.9	2.8
3rd	3.1	3.5	3.3	26.7	20.9	93.1	125.8	108.2	78.9	38.7	3.9	2.7
4th	3.1	3.6	3.3	26.9	20.8	73.5	138.3	104.6	76.2	38.5	3.9	2.7
5th	3.1	3.7	3.3	27.0	18.0	53.5	143.8	105.7	72.8	37.0	3.9	2.7
6th	3.5	3.7	3.3	27.1	15.3	41.7	143.3	100.2	72.8	33.8	4.0	2.6
7th	3.7	3.7	3.3	27.5	13.7	32.5	141.3	97.2	69.6	28.7	4.0	2.5
8th	3.5	3.7	3.3	27.8	13.6	33.5	140.2	96.6	64.6	27.0	3.9	2.5
9th	3.4	3.7	3.3	28.0	13.6	38.3	140.4	97.3	58.5	25.4	3.9	2.5
10th	3.4	3.7	3.3	28.2	14.3	38.2	147.0	90.3	55.4	24.4	3.9	2.7
11th	3.5	3.7	3.3	28.5	20.0	38.0	150.4	87.7	57.2	24.0	3.9	2.7
12th	3.5	3.7	3.4	31.2	19.4	29.6	150.4	88.0	57.8	23.9	3.9	2.7
13th	3.5	3.6	3.4	33.3	31.4	26.3	150.0	89.4	58.0	7.6	3.8	2.7
14th	3.5	3.5	3.5	35.2	44.0	26.8	152.4	86.9	57.9	4.7	3.7	2.7
15th	3.5	3.4	3.5	29.8	50.9	29.7	151.8	87.8	56.1	4.3	3.7	2.6
16th	3.5	3.5	3.5	35.0	53.9	32.4	158.2	87.8	54.3	4.3	3.7	2.5
17th	3.5	3.5	3.5	35.5	65.6	37.7	161.6	85.0	51.1	4.3	3.6	2.5
18th	3.3	3.5	3.5	36.1	82.3	40.0	161.8	80.4	49.3	4.3	3.6	2.4
19th	3.3	3.4	3.4	36.4	105.9	44.5	161.8	83.4	49.5	4.3	3.5	2.2
20th	3.3	3.4	3.4	36.6	120.3	39.0	156.6	85.6	49.6	4.2	3.5	2.2
21st	3.3	3.5	3.5	36.8	122.2	38.8	153.6	89.0	49.4	4.1	3.6	2.2
22nd	3.3	3.5	3.5	39.7	122.4	38.6	140.6	91.3	49.4	4.1	3.5	2.2
23rd	3.5	3.5	3.5	55.6	122.5	37.5	126.6	93.9	46.1	4.1	3.5	2.2
24th	3.5	3.5	3.5	56.0	124.8	37.6	122.4	97.9	44.1	4.1	3.2	2.2
25th	3.5	3.5	3.5	53.0	126.6	49.6	123.0	96.3	47.4	4.1	3.1	2.2
26th	3.5	3.5	3.5	51.7	128.9	53.7	123.0	97.8	47.6	3.6	3.1	2.2
27th	3.5	3.3	3.5	46.7	138.5	68.6	109.0	95.1	47.5	3.7	3.0	2.2
28th	3.5	3.3	3.5	34.8	144.0	75.2	91.2	93.9	45.4	4.0	2.9	2.2
29th	3.5		3.5	24.2	145.0	84.0	84.7	91.3	43.8	3.9	2.9	2.2
30th	3.5		45.2	21.5	145.5	108.1	106.1	84.2	43.4	3.9	2.9	2.2
31st	3.5		35.1		145.8		107.3	75.4		3.9		2.2

2009 FLOW DATA RANGE

2009	Operation Days	Minimum Volume (cfs)	Average Volume (cfs)	Peak Volume (cfs)
January	31	3.07	3.37	3.66
February	28	3.26	3.51	3.67
March	31	3.26	5.75	45.15
April	30	21.53	34.34	56.03
May	31	13.55	72.00	145.80
June	30	26.27	53.07	137.70
July	31	84.69	135.41	161.83
August	31	75.41	93.38	115.46
September	30	43.44	56.71	78.90
October	31	3.63	15.12	43.55
November	30	2.88	3.57	3.96
December	31	2.19	2.46	2.88
Average			52.14	

2010 ESTIMATED FLOW RATES AT OCHOCO CANAL

	2010											
	January	February	March	April	May	June	July	August	September	October	November	December
1st	2.2	2.4	2.7	3.3	33.7	74.4	93.5	95.6	79.1	35.9	5.3	4.3
2nd	2.2	2.4	2.7	3.3	33.8	80.6	98.7	89.6	78.6	35.8	5.3	4.2
3rd	2.2	2.4	2.7	3.3	34.6	151.6	98.7	80.7	74.4	35.9	5.1	4.1
4th	2.2	2.4	2.8	3.2	36.0	297.4	107.0	71.1	72.9	36.0	5.0	4.1
5th	2.2	2.4	2.8	3.3	43.6	366.2	120.8	69.2	73.3	33.0	4.6	4.2
6th	2.2	2.4	2.8	3.3	45.7	338.8	120.8	81.2	73.5	31.4	4.6	4.1
7th	2.2	2.5	2.9	3.3	45.9	250.2	136.9	84.9	73.6	31.3	4.6	4.1
8th	2.2	2.5	2.9	3.3	47.2	217.9	158.5	88.8	75.0	31.3	4.6	4.1
9th	2.2	2.5	2.9	3.3	48.8	187.0	173.1	91.9	76.4	31.3	4.6	4.1
10th	2.2	2.5	2.9	3.3	49.6	149.8	179.9	101.2	76.3	31.0	4.6	4.1
11th	2.2	2.5	3.0	3.4	68.6	141.2	178.1	106.7	76.0	27.1	4.6	4.1
12th	2.2	2.5	3.0	3.4	75.8	140.5	163.3	96.0	76.4	25.1	4.6	4.1
13th	2.2	2.5	3.0	3.4	80.1	139.0	172.2	90.9	76.8	10.7	4.6	4.1
14th	2.2	2.5	3.1	3.5	93.1	113.2	171.7	79.7	77.0	6.1	4.6	4.1
15th	2.2	2.5	3.2	3.5	99.8	89.0	167.8	78.5	77.1	6.1	4.6	4.1
16th	2.3	2.6	3.1	3.5	101.2	88.9	167.4	87.1	73.7	5.9	4.6	4.1
17th	2.3	2.6	3.2	3.5	112.4	88.1	167.4	95.2	68.4	5.9	4.6	4.1
18th	2.4	2.7	3.2	3.6	176.2	88.3	166.8	94.6	62.7	5.6	4.6	4.1
19th	2.3	2.7	3.2	3.7	153.0	90.0	157.6	97.0	60.8	5.6	4.6	4.1
20th	2.3	2.7	3.2	3.7	144.6	89.7	140.9	100.4	58.6	5.6	4.6	4.1
21st	2.3	2.7	3.3	3.7	125.9	87.2	146.6	99.8	51.3	5.7	4.6	4.1
22nd	2.4	2.6	3.2	3.8	98.1	85.9	154.1	99.8	44.3	5.8	4.6	4.1
23rd	2.4	2.5	3.3	3.8	87.9	79.4	154.0	98.9	37.7	5.8	4.3	6.8
24th	2.4	2.5	3.3	3.9	87.4	70.9	154.5	98.6	34.9	5.8	4.3	10.7
25th	2.4	2.5	3.3	4.0	80.3	78.9	153.6	98.6	35.1	5.8	4.3	12.3
26th	2.4	2.5	3.2	50.1	73.4	86.9	144.3	98.2	35.2	5.8	4.3	12.6
27th	2.4	2.5	3.3	38.8	76.0	77.7	134.0	98.6	35.2	5.6	4.3	12.6
28th	2.4	2.5	3.3	35.5	77.1	74.5	124.0	91.7	35.2	5.6	4.3	16.4
29th	2.4		3.3	35.1	76.5	82.1	110.2	79.8	36.2	5.4	4.3	33.9
30th	2.4		3.3	34.7	75.7	85.4	97.7	76.1	36.1	5.3	4.3	56.7
31st	2.4		3.2		75.0		94.8	77.2		5.3		60.7

2010 FLOW DATA RANGE

2010	Operation Days	Minimum Volume (cfs)	Average Volume (cfs)	Peak Volume (cfs)
January	31	2.20	2.27	2.36
February	28	2.36	2.53	2.70
March	31	2.70	3.06	3.27
April	30	3.24	9.37	50.12
May	31	33.65	79.25	176.17
June	30	70.88	133.02	366.20
July	31	93.51	142.22	179.89
August	31	69.16	90.25	106.70
September	30	34.94	61.39	79.10
October	31	5.30	16.07	35.98
November	30	4.29	4.58	5.33
December	31	4.10	10.11	60.70
Average			59.68	

PERMITTING/UTILITY INTERCONNECT

Expected permitting for the project will include applying for and obtaining:

1) Federal Energy Regulatory Commission (FERC) exemption. This site appears eligible for a FERC exemption. It may qualify for a conduit exemption but more likely the "5 MW or Less" exemption at an existing dam facility. The District controls the real property at the site and that is another key qualifying criteria,
2) Crook County building permit and zoning clearance for the powerhouse,
3) Oregon Water Resources Department issued water right for use of the canal water for hydropower production,
4) US ACOE permitting or maintenance exemption,
5) If Federal funding is involved in the project, the National Environmental Policy Act (NEPA) process must be followed for environmental clearance related to the project,
6) Potentially, a USBR clearance for the project.

Depending upon the funding sources involved in the project, other necessary processing may include Oregon Department of Energy bond/loan application, ODOE Business Energy Tax Credit application, Treasury Grant In-Lieu or Production Tax Credit application, US DOE Grant application, and/or Energy Trust grant application. Local traditional funders also include the Oregon Watershed Enhancement Board, Deschutes River Conservancy, and the Crooked River Watershed Council.

Interconnection with a utility requires an agreement for power purchase as well as an agreement for interconnection. The power purchase agreement will provide guidance on the term and rate for power purchase. The interconnection agreement will provide the technical terms and costs for the interconnection from the proposed plant into the utility grid.

In the case of this project, the nearest power lines to the site are owned by PacifiCorp (see Figure 2). The nearest PacifiCorp pole to the site has tag number 1517-050602. For the purposes of this feasibility study, we have assumed that the interconnect will occur at this pole, located adjacent to Highway 26 approximately 460 feet from the proposed powerhouse and that the poles will be placed within the District's property between the powerhouse and the utility. It appears that this interconnect point would be to 12kV lines and our project would step-up to this voltage. The final interconnection details will be a result of facility studies required by the utility and developed through design interaction during the project design process.

There are no known reasons at the time of this study that a power purchase agreement and an interconnect agreement may not be obtained. PacifiCorp has standard PUC requirements and associated agreements that it will follow in the process of developing the PPA and Interconnection agreements. For the purposes of this study, the current PacifiCorp Schedule 37 rates have been used to estimate project revenue. It should be noted that the Schedule 37 rates are subject to change and have been routinely changed every few years. Such rate changes can dramatically affect project viability.

PENSTOCK and NET HEAD DEVELOPMENT

For the purposes of this feasibility level evaluation, the flow rates provided above from irrigation years 2007-2010 were used to develop head losses and net head estimates at the plant site.

TRADITIONAL FRANCIS-TYPE TURBINE: Specifics for the existing dam outlet civil works are not included herein. The Ochoco Main Canal headworks has an approximate water surface elevation of 3053.5 at high water level. Based upon the existing dam outlet civil works and range of discharge flows up to 175 CFS, an average head-loss adjustment of 8.5-FT was applied between the reservoir and the draft tube return to channel. This adjustment includes an estimated 5-FT of losses through the turbine and draft tube that must be carefully evaluated and adjusted during design and is critical to project viability. For the period from 2007-2010, the feasibility-level net heads ranged from 34-FT to 68-FT.

NATEL ENERGY TURBINE: Natel Energy has developed a series of hydroelectric machines that are "stepped" in size based upon the intake cross sectional area and machine size. The SLH-50 is a machine that is sized for an intake of 1/2 Square Meter. Its current maximum safe head is approximately 23-FT, net and this was assumed for the purposes of this evaluation. Although reservoir head would fluctuate, a modulating valve would be used to adjust incoming head to maintain a total of 23-FT of net head across the machine.

TURBINE and GENERATOR

We investigated several alternatives for project equipment including hydroelectric-machines, Kaplan-type turbine systems, Francis turbine systems and international manufacturers. After evaluating project cost sensitivity, the most feasible options were foreign Francis turbines and domestic Natel Energy technologies. Domestic Francis turbines may also be competitive in time, but at the time of this feasibility study, domestic Francis turbines were approximately 3-times more costly than their Chinese counterparts. The Chinese are currently manufacturing nearly ½ of all turbines delivered in the world and certain manufacturers there have been in operation for over 50 years therefore reducing risk. However, the decision to purchase Chinese equipment must be carefully considered by the project owner given operation and maintenance responsiveness timeframes, replacement part availability, and other constraints based upon manufacturer proximity.

We provided the manufacturers with feasibility pricing level flow range and gross head (net to the intake side of the turbine or machine) operating parameters for each site. Chinese Francis and Natel Energy options were compared and the following basic information was provided by the manufacturers:

CHINESE FRANCIS TURBINE AND GENERATOR:

Design Parameters: Head = 60 ft, Flow = 140 cfs (range 40 CFS-160 CFS), Capacity = 500 kW, Francis turbine. Turbine/generator combined efficiency = 0.73 – 0.83. Turbine and generator cost = $250,000

The cost for the turbine and generator package includes:

- Horizontal Francis Turbine
- 500 kW Generator
- Excitation
- Governor
- Spare parts and special tools

Turbine equipment materials used are defined in accordance with the applicable standards. The selected equipment have been manufactured and tested for more than 50 years with continuous improvements and modification. We believe that the proposed equipment satisfies the requirements of the project with high quality and reliability.

Turbine equipment materials used are defined in accordance with the applicable USA standards.

NATEL ENERGY:

- Installed Capacity = 233 kW
- Estimated Machine/Draft/Valve loss <0.5m at 150 CFS
- 23-FT Net Head
- Capacity to 150 CFS at 23-FT Net Head
- SLH-50: Throat Area = 1/2 SQ Meter
- 25-FT head rating = **$234,375 Turbine/Generator/Control Package**
- Approx. 81% wire to water efficiency at 125 CFS, Approx. 77% wire to water efficiency at 150 CFS

The Francis style turbine can operate through the range of flow rates and can therefore generate a greater quantity of power over the period of system operation. Civil works necessary to properly set a Francis system, however, require significant excavation and concrete work. The Natel Energy machine may be set at any point in the penstock water column therefore the civil works necessary to support it may be minimized, however it is limited in that it can not pass more than 150 CFS for this site. As may be seen from the manufacturer information provided, the initial basic turbine and generator package costs are similar.

ENERGY/REVENUE PRODUCTION ESTIMATE

Given the flow rates estimated above and given the estimated turbine/generator and machine/generator efficiencies provided by the manufacturers above, the feasibility-level estimated power production would be:

2007 ESTIMATED POWER PRODUCTION (kWh)		
MONTH	CHINESE KAPLAN	NATEL ENERGY
January	144,777	66,657
February	0	0
March	121,296	43,572
April	254,785	88,071
May	393,857	142,806
June	244,795	94,068
July	287,754	126,813
August	191,401	96,848
September	37,061	19,926
October	0	0
November	0	0
December	0	0
	1,675,726	**678,762**

2008 ESTIMATED POWER PRODUCTION (kWh)		
MONTH	CHINESE KAPLAN	NATEL ENERGY
January	0	0
February	0	0
March	0	0
April	159,991	62,296
May	318,913	113,544
June	325,879	114,409
July	342,148	132,266
August	228,310	101,162
September	136,894	63,679
October	22,207	10,967
November	0	0
December	0	0
	1,534,343	**598,322**

2009 ESTIMATED POWER PRODUCTION (kWh)		
MONTH	CHINESE KAPLAN	NATEL ENERGY
January	0	0
February	0	0
March	0	0
April	18,780	7,372
May	177,717	70,447
June	80,277	32,804
July	333,630	152,906
August	196,380	105,265
September	80,456	47,120
October	0	0
November	0	0
December	0	0
	887,241	**415,915**

2010 ESTIMATED POWER PRODUCTION (kWh)		
MONTH	CHINESE KAPLAN	NATEL ENERGY
January	0	0
February	0	0
March	0	0
April	0	0
May	221,371	77,254
June	335,747	117,769
July	425,753	160,597
August	236,960	101,910
September	115,992	52,087
October	0	0
November	0	0
December	9,536	4,003
	1,345,358	**513,619**

AVERAGE POWER PRODUCTION 2008-2010 (kWh)		
YEAR	**CHINESE KAPLAN**	**NATEL ENERGY**
2007	1,675,726	678,762
2008	1,534,343	598,322
2009	887,241	415,915
2010	1,345,358	513,619
AVERAGE	**1,360,667**	**551,654**

The "blended Peak/Off-Peak" Pacificorp Schedule 37 was used to estimate revenue for the project. Based upon these rates, the annual revenue over the feasibility-level estimate period of 17 years (through the end of the Schedule 37 period) would be:

ESTIMATED REVENUE - AVERAGE PRODUCTION 2007-2010					
YEAR	ON PEAK	OFF PEAK	BLENDED ESTIMATE	CHINESE FRANCIS	NATEL ENERGY
2012	5.87¢	4.36¢	5.20¢	$70,769	$28,692
2013	6.14¢	4.50¢	5.41¢	$73,659	$29,864
2014	7.96¢	6.10¢	7.14¢	$97,097	$39,366
2015	8.16¢	6.27¢	7.32¢	$99,638	$40,396
2016	8.39¢	6.46¢	7.54¢	$102,526	$41,567
2017	8.60¢	6.65¢	7.74¢	$105,263	$42,677
2018	8.87¢	6.87¢	7.98¢	$108,636	$44,044
2019	8.76¢	6.74¢	7.87¢	$107,018	$43,388
2020	8.85¢	6.79¢	7.94¢	$108,002	$43,787
2021	9.33¢	7.23¢	8.40¢	$114,292	$46,337
2022	9.84¢	7.70¢	8.89¢	$120,990	$49,053
2023	9.33¢	7.15¢	8.36¢	$113,810	$46,142
2024	9.03¢	6.81¢	8.05¢	$109,487	$44,389
2025	9.47¢	7.22¢	8.47¢	$115,293	$46,743
2026	9.65¢	7.36¢	8.64¢	$117,501	$47,638
2027	9.68¢	7.35¢	8.65¢	$117,668	$47,706
2028	10.04¢	7.67¢	8.99¢	$122,325	$49,594

FEASIBILITY LEVEL COST ESTIMATE FOR PROJECT

The following cost estimates provides feasibility level cost estimating for the proposed project site given the two technology types compared. An estimate was prepared for alternative turbine procurement internationally and machine domestically such that benefit versus cost may be determined for each. It should be noted that the installation costs may vary significantly from those shown below depending upon the level of self-performance by the District, actual negotiated interconnect costs, final project design, geotechnical investigation results, and permitting.

FEASIBILITY LEVEL COST ESTIMATE CHINESE FRANCIS TURBINE				
ITEM	**QTY**	**UNITS**	**COST/UNIT**	**SUBTOTAL**
Turb./Gen/Controls	1	LS	$350,000	$350,000
Install system	1	LS	$200,000	$200,000
Building	700	SF	$350	$245,000
Civil Works	1	LS	$500,000	$500,000
Permits/Processing	1	LS	$100,000	$100,000
Electrical Service	1	LS	$15,000	$15,000
Electrical Interconnect	1	LS	$250,000	$250,000
Contingency	10%			$166,000
Design/Legal/C.M.	10%			$182,600
			TOTAL	**$2,008,600**

FEASIBILITY LEVEL COST ESTIMATE NATEL ENERGY SLH-50				
ITEM	**QTY**	**UNITS**	**COST/UNIT**	**SUBTOTAL**
Natel SLH-50/Gen/Switchgear	1	LS	$350,000	$350,000
Install system	1	LS	$75,000	$75,000
Building	500	SF	$250	$125,000
Civil Works	1	LS	$450,000	$450,000
Permits/Processing	1	LS	$100,000	$100,000
Electrical Service	1	LS	$15,000	$15,000
Electrical Interconnect	1	LS	$250,000	$250,000
Contingency	10%			$136,500
Design/Legal/C.M.	8%			$120,120
			TOTAL	**$1,621,620**

FINANCING and/or GRANT OPTIONS

The Oregon Department of Energy administers the Business Energy Tax Credit Program. For a municipal organization such as OID, the program has traditionally followed a pass-through process to allow the District to pass on credits to a private entity with an Oregon tax burden. To facilitate this process, an incentive is credited to the private business utilizing the tax credits. This net grant opportunity to the District is approximately 33% of the project cost. At the time of preparation of this study, the BETC program access was limited. However, it is anticipated that the program may be perpetuated in some form therefore has been included as a program to pursue if available at such time as the project may move forward.

The Energy Trust of Oregon provides incentive funds for hydropower projects that are marginally viable or non-viable in the absence of such incentive funds. The Energy Trust evaluates projects on a case by case basis and based upon the proposed production and marginality of the project makes a determination at what level, if any, they will participate financially.

A US Department of Energy competitive grant program has been issued with an application deadline closing in late spring, 2011. This program is geared toward new innovative technologies and/or USBR Districts therefore the OID may qualify for this grant, especially for the Natel technology.

For private project ownership, the US Treasury Department has several programs including the “in-lieu” grant that provides 30% of allowable project costs. This program generally expires in December, 2011 and a minimum of 5% of the project must be in-place by that deadline. For the purposes of evaluation, this program was applied as an option to the Francis turbine technology cost estimate.

Green Tag renewable energy credits (RECs) may be generated by the project. These credits may be sold in Oregon and potentially outside the state as well. Credit values vary and may be investigated at the time of project financing development. For the purposes of this evaluation, no value for RECs was applied however it is conceivable that the value for RECs may become a significant revenue factor in the coming years.

Although water conservation may not be a key element on the project, alternative energy production is a priority of the State and Nation. The United States Bureau of Reclamation, Oregon Watershed Enhancement Board, and Natural Resources Conservation Service may be approached regarding the long term benefits of the project and on-going grants available.

Financing options for the project include private commercial financing, Federal Renewable Energy Bonds, or Oregon Department of Energy SELP loan. Private rates likely range from 6% to 8% APR. Renewable Energy Bonds are low cost but require the District to issue the bonds under its name on behalf of the project and the associated bond issuance carries costs. The ODOE SELP program is currently lending at approximately 7% for a 15-year term. For the purposes of this evaluation, we assumed a term of 20-years and 7% interest for project dept amortization.

SIMPLE PAYBACK/BENEFIT vs. COST OF THE PROJECT

The following table provides a simple cost benefit analysis for the project given the two technologies evaluated and a 17 year average revenue projection based upon the current Schedule 37 rate structure. For the Francis technology, potential Treasury Grant dollars and Energy Trust of Oregon participation were also evaluated and for the Natel technology, ETO and US DOE grant potential were additionally evaluated.

BENEFIT/COST RATIO	**CHINESE FRANCIS TURBINE**	**NATEL ENERGY MACHINE**
Project Cost Without Financial Assistance	$2,008,600	$1,621,620
Ammortization Given 20 Year Term and 7% Int.	$186,864	$150,324
Average Annual Revenue over 17 Years	$106,116	$43,123
Benefit/Cost Ratio	**0.57**	**0.29**
With DOE Grant 50%	NA	$0
With Treasury Grant 30%	$2,008,600	NA
Possible ETO Participation	$100,000	$100,000
Net Project Debt.	$1,908,600	$1,521,620
Ammortization Given 20 Year Term and 7% Int.	$121,500	$66,120
Benefit/Cost Ratio	0.87	0.65

Generally speaking, a benefit/cost ratio of 1.0 or greater indicates a project that is immediately viable. The table above indicates that given the assumptions indicated and even with the application of available programs, neither technology is financially viable over the debt repayment period of 20-years.

Given up-front funding of the project with no carry of debt, the simple payback period for the project ranges from about 12 years for the Chinese Francis with Treasury Grant and ETO funding to just over 16 years for the Natel Energy Machine with DOE and ETO funding.

Although the project is not considered viable given the evaluation performed, the project is very sensitive to new energy programs and/or the increase in renewable energy credit values. For example, given the Treasury Grant program combined with Oregon BETC program proceeds, the project would be viable. Or if RECs may be sold for $0.03/kWh at some point in time (that may be conceivable given programs outside of Oregon), then the project would likely be viable.

Given the assumptions applied, above, however, the apparent best project would be a Chinese Francis turbine with emphasis on pursuit of funding to the greatest extent practicable. Given grant and ETO funding assumptions indicated above, the benefits lag the costs by a factor of 0.87 to 1.0.