RECLAMATION

Managing Water in the West

Yakima River Basin Integrated Water Resource Management Plan

Feasibility Planning Report
Kachess Drought Relief Pumping Plant
FINAL DRAFT

Kittitas County, Washington

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office

State of Washington
Department of Ecology
Office of Columbia River

February 2016

MISSION STATEMENTS

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Kachess Drought Relief Pumping Plant

Legend

- Major Road
- Pumping Plant
- Intake Tunnel
- Pipeline (Alternative 1 Only)
- Discharge Structure

RECLAMATION
Managing Water in the West

DEPARTMENT OF ECOLOGY
State of Washington

N
W E
S

0 5,000
Feet

0 1
Miles

Note: General location of the Keechelus-to-Kachess (KKC) Conveyance Tunnel discharge structure. The KKC is a separate but related project currently in the feasibility design phase.

Keechelus Reservoir

NF-4832 (Keechelus Frontage Rd)

Kachess Lake Rd

KKC (See Note)

via Kachess Rd

Kachess Reservoir

NF-4818 (Kachess Dam Rd)

Cle Elum Reservoir

Yakima River

90

NF-4828 (West Kachess Rd)

Alternative 1, East Shore Pumping Plant

Alternative 2, South Pumping Plant

Kachess River

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Glossary of Acronyms and Abbreviations

ASR	aquifer storage and recovery
Basin Study	Yakima River Basin Study
BTE	bull trout enhancement (program)
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
DAHP	Washington State Department of Archaeology and Historic Preservation
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ID	Internal Diameter
Integrated Plan	Yakima River Basin Integrated Water Resource Management Plan
kaf	thousand acre-feet
KDRPP	Kachess Drought Relief Pumping Plant
KKC	Keechelus-to-Kachess Conveyance
NED	National Economic Development
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPV	net present value
OMR&P	operations, maintenance, replacement, and power
PEIS	Programmatic Environmental Impact Statement
Reclamation	U.S. Department of the Interior Bureau of Reclamation
RED	Regional Economic Development
redd	A depression in a river bed or lake bed dug by fish to deposit eggs
SAR	smolt-to-adult survival rate
SEPA	State Environmental Policy Act
Service	U.S. Fish and Wildlife Service
SOAC	System Operations Advisory Committee
TBM	tunnel boring machine
TWSA	total water supply available
USFS	U.S. Forest Service
VFD	variable-frequency drive

WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation
YRBWEP	Yakima River Basin Water Enhancement Project

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Executive Summary

Introduction

The U.S. Department of the Interior Bureau of Reclamation performed a feasibility study in partnership with the Washington State Department of Ecology to investigate the proposed Kachess Drought Relief Pumping Plant (KDRPP) as a component of the Initial Development Phase of the Yakima River Basin Integrated Water Resource Management Plan (Integrated Plan). The project area is located in Kittitas County, Washington, approximately 15 miles northwest of the City of Cle Elum. This Feasibility Planning Report discusses the background, purpose, alternatives, costs, and expected outcomes of the KDRPP.

The purpose of the KDRPP is to access stored water in Kachess Reservoir that is currently unavailable, in order to improve water supply during periods of drought, with a goal of approaching not less than 70 percent of proratable water rights whenever feasible. The KDRPP would deliver up to an additional 200,000 acre-feet of water from Kachess Reservoir during drought years and in years following droughts when the reservoir is refilling to its normal operating levels, by installing a new deeper outlet works and pumping system to access existing stored water that cannot currently be accessed. The project would make maximum use of the existing reservoir storage for this purpose without altering the existing Kachess Dam or the footprint of Kachess Reservoir.

The project would create a new outlet from Kachess Reservoir by constructing a new intake, tunnel, pumping plant, and release structure. The project would allow the reservoir to be drawn down approximately 80 feet lower than the existing gravity outlet, thereby allowing access to an additional 200,000 acre-feet of water that is stored in the reservoir at an elevation immediately below the existing gravity outlet. This additional water is "inactive" reservoir storage as it is located at an elevation below the existing outlet (2,192.75 feet).

There is a close relationship among KDRPP and two other components of the Initial Development Phase of the Integrated Plan that Reclamation and Ecology are proposing to carry out at Keechelus and Kachess Reservoirs. These are (1) the proposed Keechelus Reservoir-to-Kachess Reservoir Conveyance (KKC), and (2) the proposed Bull Trout Enhancement (BTE) program. The two agencies are preparing an Environmental Impact Statement that addresses different configurations of the KDRPP, KKC and BTE. This report analyzes KDRPP independently from KKC and BTE, except where specifically noted.

In May 2015, some of the proratable irrigation districts that may participate in funding of this project requested Reclamation and Ecology perform a Value Analysis Study to evaluate proposals that may reduce project costs. Reclamation held a Value Analysis workshop in June 2015 with HDR, Yakama Nation, and irrigation district staff. Based on the results of the Value Analysis a floating pumping plant option would reduce the construction cost as compared to what has been evaluated in this feasibility study.

The proratable irrigation districts propose to privately finance the project and therefore have taken the lead to design a floating pumping plant that would pump up to 200,000 acre-feet of storage from the inactive pool of Kachess Reservoir.[1] A separate report will be prepared to document development of this alternative to a similar level as the feasibility alternatives, as appropriate.

Draft legislation approved by the Senate Energy and Natural Resources Committee in November 2015 indicates that KDRPP would be funded using non-Federal funding sources. Since Federal authorization and appropriations are not requested for the project at this time, Reclamation and Ecology have decided to leave this Planning Report in "final draft" status. Under these circumstances, the specific procedures required under the *Principles and Requirements for Federal Investments in Water Resources* (CEQ 2013) do not apply, and Reclamation will perform only the limited work needed to document the process to date. Reclamation and Ecology will continue to support KDRPP for advancement as a component of the larger Integrated Plan, contingent on results of ongoing studies and environmental analyses as well as support from project sponsor(s), funding availability from non-Federal sources, and all other applicable information.

Background

Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. To advance this mission within the Yakima Project, Reclamation and Ecology worked with the Yakama Nation and Yakima River basin stakeholders to develop the 2011 Yakima River Basin *Integrated Water Resource Management Plan* (Integrated Plan) (Reclamation and Ecology, 2011d). Development of the Integrated Plan serves several elements of Reclamation's Strategic Plan for Fiscal Years 2014-2018, including managing water and related resources in the Columbia River Basin; strengthening tribal nations; protection and recovery of endangered species; and addressing climate change and resilience.

The current lack of facilities in which to store the full water supply of the basin, operational constraints, and the legal framework affecting water resources in the Yakima River basin illustrate the challenges for residents, businesses, Tribal communities, and ecosystem resources. The Integrated Plan aims to address the following challenges for Yakima River basin water users:

- *Water reliability for the Yakama Nation.* The Yakama Nation water supply needs must be met as there is potential for expensive and time-consuming litigation in resolving treaty issues in regard to water rights. The Integrated Plan would help

[1] During fall 2015 the Roza Irrigation District explored the viability of a temporary, emergency floating pumping plant with a capacity of 50,000 acre-feet, to provide water if the 2015 drought extended into the 2016 irrigation season. Roza terminated investigation of the temporary facility in December 2015. Information from that effort can be used in considering feasibility of a larger, permanent, floating pumping plant.

assure Tribal officials that their instream and out-of-stream water supply needs would be met.

- *Water reliability for proratable water users*. In severe drought years, proratable water users receive sharply diminished supplies from the Yakima Project — in one year, as little as 38 percent of their full allotment. Junior users can be cut off completely. These diminished water supplies reduce agricultural production and associated jobs. Fruit growers may also face early loss of vines and trees that could have remained economically productive, sometimes for several additional years.
- *Water reliability for municipal and domestic water users*. Most municipal and domestic water users in the Yakima River basin rely on junior water rights for their drinking water. The Yakama Nation and irrigation users, including proratable irrigation users, hold water rights and entitlements that are senior to most municipal and domestic uses. In drought conditions, municipal and domestic water users face the very real risk that their supplies could be cut off as a result of litigation brought by senior water users. This affects current residents and limits the ability of local communities to grow and develop. The State of Washington and local governments have identified averting such litigation as a key objective.
- *Ecosystem restoration in the Yakima River basin.* Restoration on a watershed scale includes habitat and floodplain restoration in combination with land management that would ultimately improve conditions for listed species of fish (bull trout and steelhead) that rely on the Yakima River system and potentially avoid a need for Federal enforcement actions that would undermine economic uses of water in the basin.
- *Climate change effects on the Yakima River basin*. Scientists studying the Columbia River basin predict that less water will be stored as snowpack in the Cascade Range in future decades compared with current conditions. Snowpack currently provides a substantial portion of runoff into the Yakima River basin. Reduced snowpack in the future would compromise water supply, streamflow, and aquatic habitat conditions. There is no single type of action that can address the multiple effects of climate change on snowpack, runoff conditions, water temperature, aquatic life, and forest health. Reclamation and Ecology have determined that an integrated approach that includes consideration of water storage, water conservation, streamflow management, fish passage, and habitat improvements offers the best opportunity to mitigate climate change impacts on the Yakima River basin's aquatic habitat and economy.
- *Adverse effects on forest resources, land, and terrestrial habitat*. The Yakima River basin also faces risks associated with large wildfires, fragmented land ownership, and land-use practices that have adverse impacts on forest resources, land, and terrestrial habitat. These risks exacerbate the other risks to water resources and aquatic habitats in the basin. The Integrated Plan includes approaches to coordinate land and water management to help manage these risks.

The Integrated Plan encompasses seven elements: (1) habitat and watershed protection and enhancement, (2) reservoir fish passage, (3) surface storage, (4) enhanced water conservation, (5) structural and operational changes, (6) groundwater storage, and (7) the use of market-based forces to reallocate water and habitat among willing buyers and sellers. The goals of the Integrated Plan are to protect, mitigate, and enhance fish and wildlife habitat;

provide increased operational flexibility to manage instream flows to meet ecological objectives; and improve the reliability of the water supply for irrigation, municipal supply and domestic uses.

The seven elements each include recommended projects to meet the goals (Reclamation and Ecology, 2012d). The KDRPP proposal is included in the surface water storage element, the KKC proposal is included in the structural and operational changes element, and the BTE is part of the habitat and watershed protection and enhancement element. These proposed actions would contribute to achieving the overall goals of the Integrated Plan. Chapter 4 of the Integrated Plan PEIS evaluates the impacts of the proposals at a programmatic level. The PEIS provides further assessment of Integrated Plan outcomes (Reclamation and Ecology, 2012c). Reclamation and Ecology are currently developing an EIS that evaluates the project level environmental impacts associated with the KDRPP, KKC, and BTE.

Reclamation and Ecology intend that components associated with the elements of the Integrated Plan be implemented with a balanced approach, so that the full and synergistic benefits of the Integrated Plan for ecosystem improvement and water supply can be achieved. A balanced approach means advancing projects associated with each element of the plan during the same development phase. The Initial Development Phase, covering the first ten-year period (2014-2023), advances all seven plan elements and represents approximately one-quarter of the estimated plan cost (about $900 million).

The purpose of the KDRPP is to better utilize the storage volume available in Kachess Reservoir by allowing water below the existing outlet to be withdrawn during drought years. This would contribute to meeting the goals of the Integrated Plan. While KDRPP alone cannot meet all of the goals of the plan, KDRPP would improve drought year water supplies, complementing the actions in the plan that meet other goals. Reclamation has performed the KDRPP feasibility study, including preparation of this Feasibility Planning Report, as one step in advancing the Integrated Plan. As a whole, the Integrated Plan would benefit fish and irrigation and offer a synergy that would otherwise be unattainable without the plan.

KDRPP Alternatives

The KDRPP design evaluated in this final draft Feasibility Planning Report would create a new outlet from Kachess Reservoir by constructing a new underwater intake, tunnel, pumping plant, and release structure. Reclamation and Ecology considered a wide range of alternatives for the project prior to selecting two alternatives for consideration in this feasibility study. The following two action alternatives[2] were evaluated:

- Alternative 1 – East Shore Pumping Plant: Alternative 1 would withdraw water through a 771-foot-long intake tunnel leading to a new pumping plant located on the east shore of Kachess Reservoir. From the pumping plant, water would flow through

[2] The EIS for the KDRPP and KKC refers to the KDRPP East Shore Pumping Plant alternative as Alternative 2A and the KDRPP South Pumping Plant as Alternative 2B. For the purpose of this Feasibility Planning Report, the KDRPP East Shore Pumping Plant is referred to as Alternative 1 and the KDRPP South Pumping Plant is referred to as Alternative 2.

a pipeline approximately 7,755 feet to the existing discharge pool into the Kachess River.

- Alternative 2 – South Pumping Plant: Alternative 2 would use a 3,275-foot-long tunnel to convey water from the intake to a pumping plant located just south of Kachess Dam, and release it into the existing discharge pool on the Kachess River.

In May 2015, some of the proratable irrigation districts that may participate in funding of this project requested Reclamation and Ecology perform a Value Analysis Study to evaluate proposals that may reduce project costs. Reclamation held a Value Analysis workshop in June 2015 with HDR, Yakama Nation, and irrigation district staff. Based on the results of the Value Analysis a floating pumping plant option would reduce the construction cost as compared to what has been evaluated in this feasibility study.

The proratable irrigation districts propose to privately finance the project and therefore have taken the lead to design a floating pumping plant that would pump up to 200,000 acre-feet of storage from the inactive pool of Kachess Reservoir.[3] A separate report will be prepared to document development of this alternative to a similar level as the feasibility alternatives, as appropriate.

Figure 1 and Figure 2 illustrate the East Shore Pumping Plant and South Pumping Plant Alternatives, respectively. Table 1 summarizes characteristics of the two project alternatives. Reclamation and Ecology estimate the construction cost (including field cost and non-contract cost) to be approximately $385 million for Alternative 1 and $383 million for Alternative 2. When escalation to the midpoint of construction is included, these costs become $399 million for Alternative 1 and $397 million for Alternative 2.

Reclamation and Ecology will complete further geotechnical investigations and the Final Environmental Impact Statement (FEIS) prior to selecting the preferred alternative.

[3] During fall 2015 the Roza Irrigation District explored the viability of a temporary, emergency floating pumping plant with a capacity of 50,000 acre-feet, to provide water if the 2015 drought extended into the 2016 irrigation season. Roza terminated investigation of the temporary facility in December 2015. Information from that effort can be used in considering feasibility of a larger, permanent, floating pumping plant.

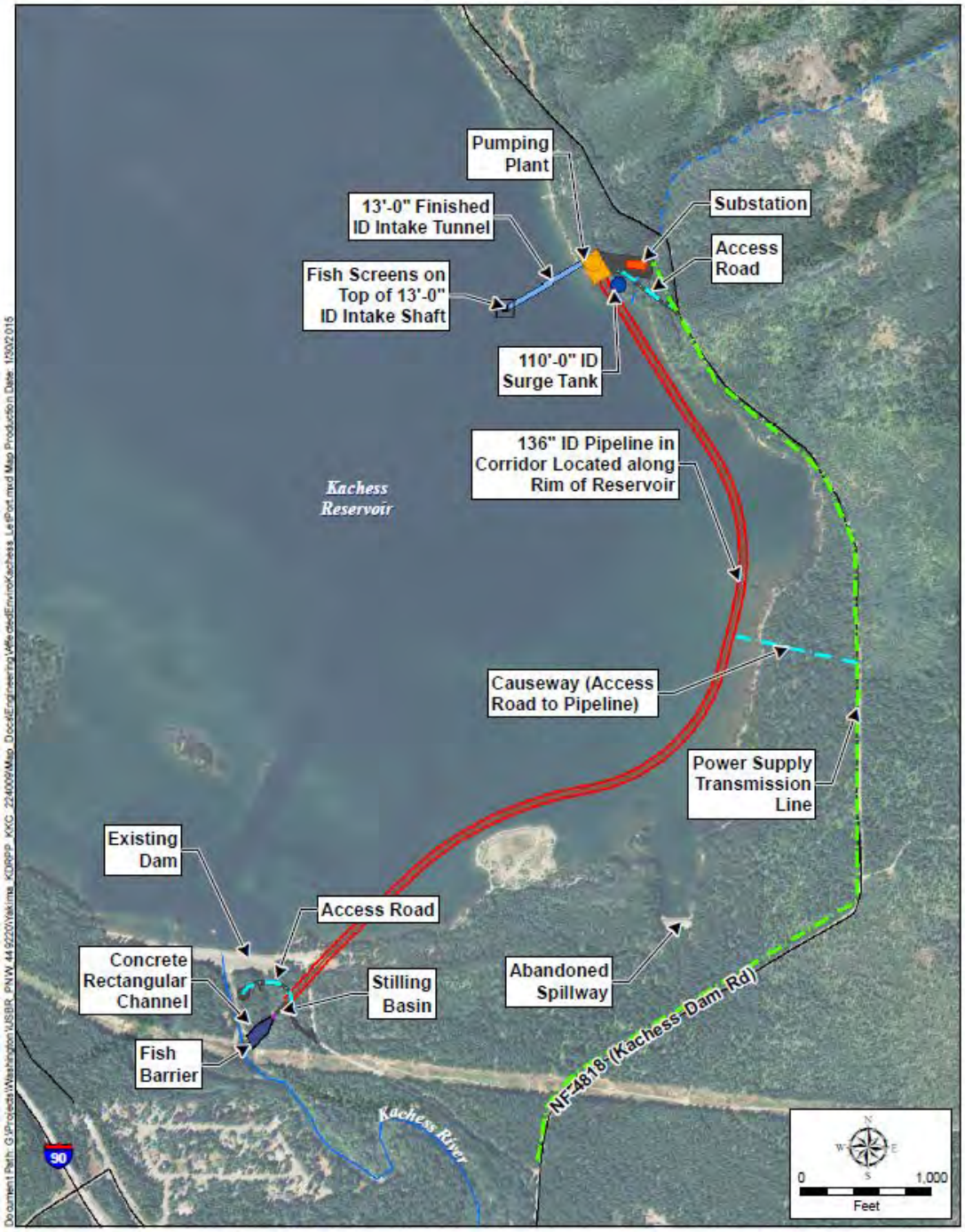


Figure 1. Plan View of Alternative 1, East Shore Pumping Plant

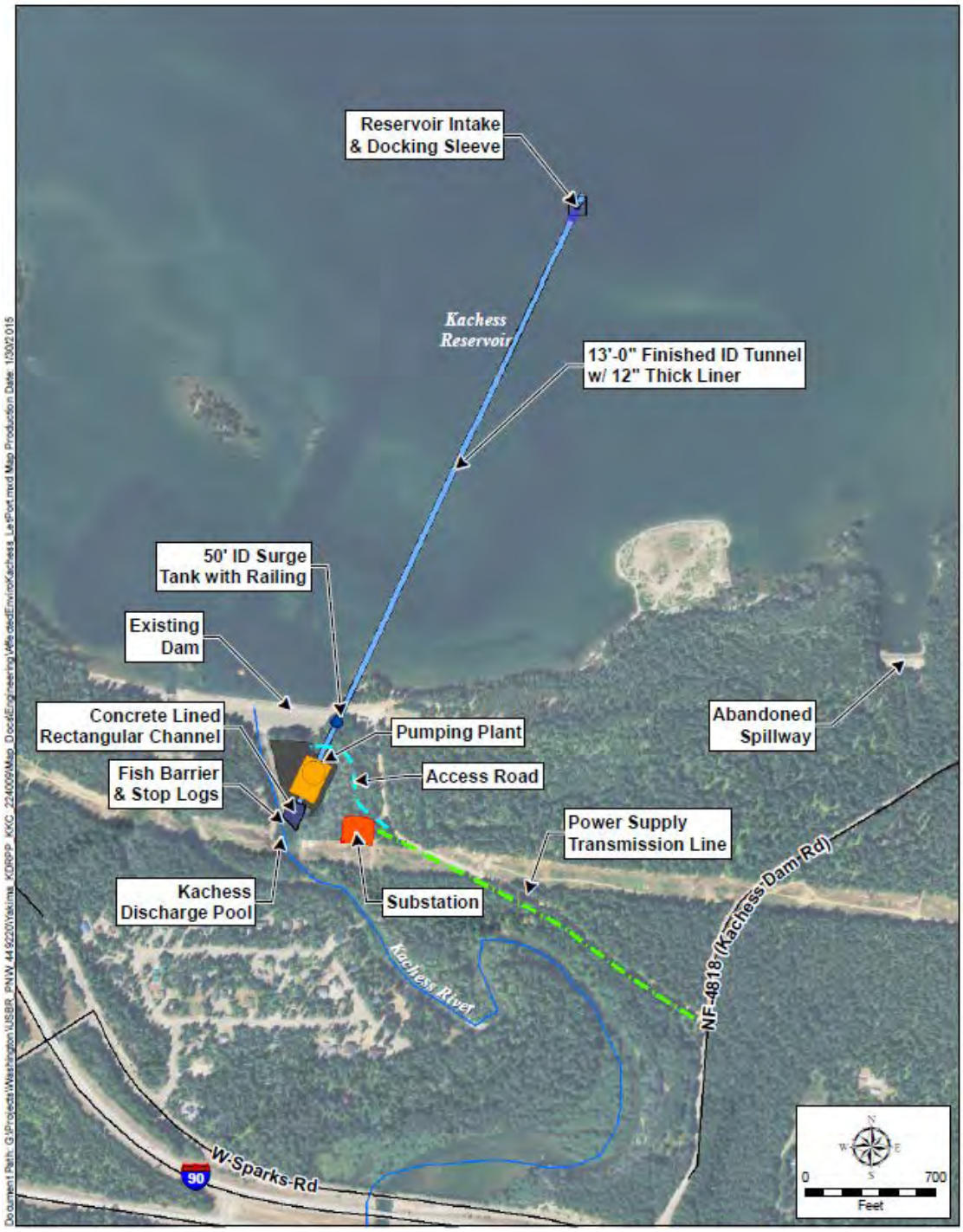


Figure 2. **Plan View of Alternative 2, South Pumping Plant**

Table 1. Overview of KDRPP Alternatives

Project Feature	Alternative 1- East Shore Pumping Plant	Alternative 2- South Pumping Plant	Advantages and Disadvantages
Fish Screens	Yes	Yes	Power supply to the motor operated screen cleaners would be approximately 2,475 feet longer for Alternative 2.
Inlet Shaft	25-foot diameter, 52-foot deep	None	Alternative 1 would require an inlet shaft to connect the pumping plant shaft to the tunnel.
Tunnel	Mined in rock, 711-foot long	Bored in soil, 3,275-foot long	There is limited geotechnical information available for Alternative 2. More information would be required to determine any specific advantages or disadvantages for that alignment.
Surge Tank	110-foot diameter, 43-foot deep	50-foot diameter, 200-foot deep	Alternative 2 would be more complex and take approximately twice as long to construct.
Pumping Plant Shaft	110-foot diameter, 215-foot deep	110-foot diameter, 145-foot deep	The Alternative 1 pumping plant shaft would be approximately 70 feet deeper. Due to the location of the pumping plant, Alternative 1 would have greater visual impacts and may require additional property easements or acquisitions.
Power Transmission Line	~ 5 Miles of 115 kV	~ 3 Miles of 115 kV	The transmission line for Alternative 1 would be approximately 2 miles longer. Alternative 2 could potentially use the over-build approach to bring the new higher voltage power supply to the KDRPP using the existing utility line corridor that supplies power to the Kachess Dam site now.
Drought Relief Pumps	13,000 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	7,100 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	Alternative 2 would use a smaller transformer since the pumping units require less power to operate. Alternative 2 would also have lower power costs.
Pipeline	7,755 feet, 136-inch diameter steel pipe	None	The Alternative 1 would include additional pipeline maintenance requirements. Due to the pumping plant and pipeline location, Alternative 1 would result in an additional 10 acres of habitat loss.
Spillway & Stilling Basin	Yes	None	The Alternative 1 would have additional construction costs and maintenance requirements associated with the spillway and stilling basin.
Discharge Structure	Yes	Yes	This feature is the same for both alternatives.
Local Impacts during Construction	Potential traffic, noise, environmental and cultural resources impacts	Potential traffic, noise, environmental and cultural resources impacts	Alternative 2 would have less noise disturbance during construction.
Construction Cost Estimate	$385 million ($399 million with escalation)	$383 million ($397 million with escalation)	The construction costs for Alternatives 1 and 2 are approximately equal. Construction cost includes field cost plus non-contract cost.

kV = kilovolt
HP = horsepower
cfs = cubic feet per second

Cost-Risk Analysis

Reclamation and Ecology held a two-day cost-risk analysis workshop on the KDRPP project in March 2015. Cost-risk analysts from HDR Engineering led the event, which included experts on cost estimation, geology, construction engineering, and tunneling as well as members of the feasibility design team. The range of costs based on expected values at the 10^{th} and 90^{th} percentiles is relatively narrow with the 90th percentile value approximately 17 percent higher than the 10th percentile value. Risk-mitigation strategies for the South Pumping Plant Alternative provide only a minor impact on expected value costs; while risk-mitigation strategies for the East Shore Pumping Plant Alternative could have a larger effect.

Summary of Expected Results

This section describes the KDRPP water supply results. Results are the same for both of the alternatives described in the previous section.

Water Supply Results

One of the goals of the Integrated Plan is to improve water supplies for proratable users. Reclamation used the RiverWare® model to evaluate how operation of the KDRPP would affect water supplies in the Yakima River basin for proratable water users.

Table 2 summarizes modeled results for three particular metrics: the final prorationing percentage near the end of the irrigation season on September 30 of each year; the total water supply available, measured in thousand acre-feet on July 1 of each year; and the quantity of water delivered to large users over the course of the irrigation season from April 1 to September 30 of each year. The table shows how much KDRPP improves each of these metrics compared with the Integrated Plan Conservation Scenario.

Table 2. Summary of Hydrologic Modeling Results

	September 30 Prorationing (%)	July 1 TWSA (KAF)	April 1 to Sept 30 Major Irrigation Deliveries (KAF)
Integrated Plan Conservation Scenario (IP0) [1]	50	1,072	1,275
Integrated Plan Conservation Scenario (IP0) [2] with "Adverse" Climate Change Conditions	42	998	1,209
Average Improvement in <70% Years Compared with Conservation Scenario			
KDRPP [1]	9.6	91	77
KDRPP with "Adverse" Climate Change Conditions [2]	6.9	65	55

1) Results are for the 15 years when prorationing would be less than 70 percent under the Baseline scenario.
2) Results are for the 40 years when prorationing would be less than 70 percent under the Baseline scenario with adverse climate change conditions

To understand the effects of the project on prorationing, it is informative to review results for years from the extended period of record when prorationing was less than 70 percent under the baseline-modeling scenario. To distinguish the effects of KDRPP from the effects of water conservation, the results reported here assume that water conservation projects from the integrated plan have already been implemented. Modeling results indicate 14 years would remain when prorationing would be less than 70 percent. After accounting for conservation benefits, the modeled KDRPP improves annual prorationing by 9.6 percent; total water supply available (TWSA) by 90,500 acre-feet; and April through September major irrigation deliveries by 76,600 acre-feet on average during these 14 years. The modeled KDRPP achieves the Integrated Plan's prorationing goal of 70 percent in 3 of these 14 years. In the other 11 years, additional water supply projects from the Integrated Plan would be needed to achieve the 70 percent goal. During 7 of these 11 years, KDRPP would improve prorationing by 10 to 20 percentage points. Gains are hardest to achieve during the later years in a multi-year drought.

This study also explored how climate change affects this outcome during the 40 years when prorationing was less than 70 percent under the Baseline scenario with "adverse" climate change conditions. Hydrologic modeling output from the adverse climate change scenario indicates that KDRPP improves prorationing by an annual average of 6.9 percent; TWSA by an annual average of 65,000 acre-feet; and April through September major irrigation deliveries by an annual average of 55,000 acre-feet (Reclamation and Ecology, 2015a). The modeled KDRPP in "adverse" climatic conditions achieves the Integrated Plan's prorationing goal of 70 percent in 5 of these 40 years. During the 13 of the remaining 35 years, KDRPP would improve prorationing by 10 to 25 percentage points. Modeled gains are smaller or negative in the rest of the years.

Economic Analyses

Economic outcomes of the KDRPP are projected using procedures consistent with the Federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* (U.S. Water Resources Council, 1983) (*Principles and Guidelines*), which includes requirements for analysis of four "accounts." The four accounts are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). The Four Accounts Analysis performed for the KDRPP feasibility study builds on the Four Accounts Analysis of the entire Integrated Plan that Reclamation and Ecology completed in 2012 (Reclamation and Ecology, 2012a).

Relationship of KDRPP NED Analysis to Full Integrated Plan Analysis

The Integrated Plan is a comprehensive approach to manage water resources and ecosystem restoration improvements in the face of on-going climate change and recurring droughts in the Yakima River basin. Reclamation and Ecology developed the Integrated Plan in 2011 in collaboration with the Yakama Nation, irrigation districts, environmental groups, other Federal agencies, and State and county governments. The Integrated Plan addresses seven elements: reservoir fish passage, structural and operational changes to existing facilities, surface water storage, groundwater storage, habitat/watershed protection and enhancement, enhanced water conservation, and market reallocation.

Reclamation estimates the total cost for implementing the Integrated Plan between $3 and $5 billion (plus annual operation and maintenance costs estimated at $10 million), and anticipates it to be implemented over 30 years. In March 2014, the Yakima River Basin Water Enhancement Project (YRBWEP) Workgroup proposed an Initial Development Phase, covering the first ten-year period (2014-2023), which advances all seven plan elements and represents approximately one-quarter of the estimated plan cost (about $900 million). Key projects include the Cle Elum Fish Passage, Cle Elum Pool Raise, KDRPP, and KKC; and various projects associated with each element of the Integrated Plan, such as habitat and tributary restoration, agricultural conservation, and groundwater recharge projects.

Reclamation and Ecology would implement the Integrated Plan using a balanced approach. A "balanced approach" means advancing projects associated with each element of the plan during the same development phase. As a whole, Integrated Plan activities benefit fish and irrigation and offer a synergy that would otherwise be unattainable without the plan.

The KDRPP is a component within the broader Integrated Plan and is part of the Initial Development Phase. Reclamation and Ecology would implement components associated with the elements of the Integrated Plan concurrently, to achieve the full and synergistic benefits of the Integrated Plan for ecosystem improvement and water supply. The two agencies recognize that if the Integrated Plan were separated into pieces, economic analysis of the pieces would not result in all components showing favorable benefit-to-cost ratios by themselves. While, the Federal *Principles and Guidelines* typically evaluate components on an individual basis, it is appropriate to perform sensitivity analyses and display results in an array to provided decision-makers a complete picture by which to make an informed decision.

In order to maintain the balanced approach, one of the large water supply projects should be developed during the Initial Development Phase of the Integrated Plan. KDRPP was selected from the list of proposed water supply projects because Reclamation and Ecology determined it could be designed, permitted and brought on line more quickly and at lower cost than the other two projects designed to provide large increments of water supply for irrigated agriculture (Bumping Reservoir Enlargement, and Wymer Dam and Reservoir). Reclamation and Ecology intend that the Initial Development Phase should provide concurrent benefits for water supply and fisheries, and implementation of KDRPP during the Initial Development Phase contributes to the achievement of water supply objectives, balancing habitat benefits from other Integrated Plan projects and programs.

Reclamation and Ecology issued a Four Accounts Analysis of the full Integrated Plan at full build out (30-year costs) in 2012 (Reclamation and Ecology, 2012a). That report tabulated the combined benefits and costs of the full suite of Integrated Plan projects and programs. Table 3 summarizes the overall present value of the benefits and costs over the next 100 years for each benefit and cost category. Analyzed as a whole, the Integrated Plan yields a highly favorable benefit-to-cost ratio ranging from 1.4 to 3.2.

Table 3. Summary of Integrated Plan Benefits and Costs

Benefit/Cost Category	Present Value of the Integrated Plan over 100 Years (2012$)
Fish Benefits	$5.0 billion - $7.4 billion
Irrigation Benefits	$0.8 billion
Municipal and Domestic Water Supply Benefits	$0.4 billion
Costs	$2.7 billion - $4.4 billion

Source: Reclamation and Ecology, 2012a

Reclamation, Ecology, and the stakeholders involved in development of the Integrated Plan have determined it is appropriate to advance the plan because isolated non-comprehensive solutions investigated over the past 35 years have consistently failed to provide a solution that was supported by stakeholders and elected officials at the Federal, State, Tribal, and local levels. Reclamation and Ecology specifically developed the integrated approach to water management in order to provide ecosystem restoration and water supply improvements that would address long-standing needs in the Yakima River basin.

Summary of NED Findings

Table 4 summarizes the costs and benefits as well as net present value (NPV) of the KDRPP as a stand-alone project under historical and climate change conditions. The NPV is negative in all cases, because the costs are greater than the benefits. As described above, Reclamation and Ecology did not expect KDRPP to have a favorable benefit-to-cost ratio when evaluated separately from the remainder of the Integrated Plan.

Table 4. Net Present Value of Benefits and Costs of KDRPP Over 100 Years

	KDRPP ($Million)	KDRPP with Climate Change ($Million)
Agriculture Water Supply Benefits	214	315
Municipal Water Supply Benefits	0.9	1.4
East Shore Construction, Operation and Maintenance Costs	-446	-446
South Construction, Operation and Maintenance Costs	-437	-437
Lost Recreation Due to Reduced Pool Levels	-4- to -38	-8 to -75
Net Present Value, East Shore Pumping Plant	-235 to -269	-137 to -204
Net Present Value, South Pumping Plant	-226 to -260	-129 to -195

Note: Values discounted at 3.375 percent per year. In the cost category, only long-term operations, maintenance, replacement, and power costs (OMR&P) are discounted. The initial investment costs (field costs, interest during construction, and non-contract costs) are not discounted. All benefits are discounted, as they would accrue after construction is completed.

Readers should consider the results shown in Table 4 in the context of the full Integrated Plan, and more particularly the Initial Development Phase. Table 5 shows the estimated costs and benefits of the Initial Development Phase as a whole. Additional detail on unquantified costs and benefits is provided in Section 9.1.5. Even without all of the benefits quantified, the overall benefits of this phase substantially outweigh the overall costs.

Table 5. Net Present Value Benefits and Costs of Initial Development Phase

Project	Costs	Benefits
Cle Elum Fish Passage	$130M[1]	$1,300M to 1,900M
KDRPP	$437M to $446M	$215 to $317M
KKC (incremental with KDRPP)	$258M to $291M	$63 to $203M
Bull Trout Enhancement	$13M	Not quantified
Cle Elum Pool Raise	$18M	Not quantified
Habitat Projects	$85M	Not quantified
Water Conservation Projects	$70M	Not quantified
Totals	$1,011M to $1,053M	$1,578M to $2,420M (plus unquantified benefits)

[1] Costs of Cle Elum Fish Passage and Cle Elum Pool Raise are not discounted.

Summary of RED Findings

The estimated economic impacts of construction of the East Shore Pumping Plant Alternative, would be 1,781 job-years within the four-county local region and 3,034 job-years for the State of Washington as a whole. This includes $97 million in personal income in the four-county region and $155 million at the State level. The corresponding job-years for the South Pumping Plant Alternative would be 1,774 job-years in the four-county region and 3,022 job-years at the State level. Personal income under the South Pumping Plant Alternative construction would be $96.6 million in the four-county region, and $154 million for the State as a whole. In addition, the KDRPP would require 6 annual job-years through operation and maintenance for the State as a whole.

Increases in agricultural activity provided by the KDRPP alone would generate 1,293 local job-years during drought years under historical conditions, and 1,223 job-years under adverse climate change. Under historical conditions, droughts are projected to occur during 16.7 percent of years, while under adverse climate change conditions they are projected to occur during 49.4 percent of years. There would be an additional 59 job-years in the rest of Washington, and 55 job-years under the 2 corresponding conditions. The total agricultural economic output increase under historical conditions for the four-county region would be $172 million, and $162 million under adverse climate change conditions during drought years.

Summary of EQ Findings

Results of the EQ analysis suggest that under the No Action Alternative, conditions for most resources would stay the same or decline. The KDRPP alternatives would cause positive impacts to water supply and bull trout and would increase adaptability to climate change. Under the KDRPP alternatives, most other resources considered in the EQ analysis would experience negative impacts, includinge reservoir recreation, cultural, and archaeological resources.

Summary of OSE Findings

Results of the OSE analysis suggest that the KDRPP alternatives provide positive impacts to long-term productivity, but minor negative impacts from increased energy use and construction worker impacts.

Cost Allocation

Reclamation prepared a preliminary cost allocation for the Integrated Plan (Reclamation and Ecology, 2012b) based on programmatic level analysis of project features and benefits. If KDRPP (including the new proposed floating pumping plant alternative) is funded using non-Federal sources, a project-specific cost allocation would not be required.

Climate Change Modeling

Global climate change has the potential to impact water resources in the Kachess watershed and the Yakima River basin. Potential climate change-related impacts could result from changes in future temperatures and precipitation patterns, with resulting implications for stream runoff volume and timing, water temperatures, and reservoir operations.

In general, the KDRPP would have a positive impact on the ability of water agencies, the agricultural sector, and fish and wildlife to better withstand and adapt to changing conditions, including the changes associated with climate change. The predicted changes in snowpack and runoff associated with climate change would require changing KDRPP operations by producing larger and more frequent drawdowns, and would increase the number of years when the reservoir fails to completely refill. These changes could decrease the effectiveness of the KDRPP. The changes associated with climate change would increase proratable water supply shortages and thereby increase the need to operate KDRPP during drought years when water supply falls below 70 percent of proratable water rights.

Environmental Considerations

Reclamation and Ecology are preparing an EIS for the KDRPP and KKC. This will serve as the required environmental analysis document under both the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA). The Draft EIS was released in January 2015. Reclamation and Ecology plan to release a Supplemental Draft EIS in 2016 to include impact analysis on the floating pumping plant alternative. A Final EIS and Record of Decision would then be issued with all the responses to comments on the Draft and Supplemental Draft EISs.

The EIS will evaluate environmental considerations and potential impacts of the project on environment elements, such as air, soil, water resources, aesthetic values, cultural resources, wildlife, and vegetation. If the agencies select one of the KDRPP action alternatives for implementation, the results of the EIS analysis would inform the final design of the project to mitigate environmental concerns.

Consultation and Coordination

Reclamation will consult with the U.S. Fish and Wildlife Service (Service) and National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA) and has begun initial conversations about the consultation. Consultation with the Service under the Fish and Wildlife Coordination Act is on-going. Reclamation has initiated consultation with the Washington Department of Archaeology and Historic Preservation (DAHP) under Section 106 of the National Historic Preservation Act. Government-to-Government consultation with the Confederated Tribes of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Confederated Tribes of the Colville Reservation is ongoing. Reclamation has contacted the Bureau of Indian Affairs (BIA) Yakima Office and the BIA Colville Tribes Office regarding Indian Trust Assets or trust lands in the project area.

Reclamation and Ecology are committed to ongoing coordination with the Tribes and resource agencies. Reclamation will complete ESA coordination with the Service and NMFS. Reclamation will complete cultural resource surveys and will continue coordination with the DAHP on impacts to cultural resources. Reclamation and Ecology will continue to consult with the Yakama Nation, CTUIR, and Colville Confederated Tribes.

Conclusions

The East Shore Pumping Plant and South Pumping Plant alternatives are approximately equal in estimated construction cost. Reclamation and Ecology will defer selection of the preferred alternative until the EIS is complete.

The NED analysis indicates that costs are greater than benefits for both alternatives evaluated in the feasibility study. However, this is inconclusive due to the additional action alternative now under consideration. The benefits of the full Integrated Plan and the Initial Development Phase of the Integrated Plan are greater than the costs. Reclamation and Ecology are considering the KDRPP as part of the overall Integrated Plan rather than as a stand-alone project. Reclamation and Ecology will continue to coordinate with the irrigation districts and Yakama Nation to consider options for KDRPP that could be affordable for advancement as component of the larger Integrated Plan.

1.0 Location, Background, Purpose, and Authority

The U.S. Department of the Interior Bureau of Reclamation and the Washington State Department of Ecology are conducting a feasibility study to investigate the proposed Kachess Drought Relief Pumping Plant (KDRPP). This project is part of the Initial Development Phase of the Yakima River Basin Integrated Water Resource Management Plan (Integrated Plan). Subsequent sections of this chapter present the location, background, purpose, and authority for the KDRPP.

This Feasibility Planning Report is prepared in compliance with the requirements of the *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* (U.S. Water Resources Council, 1983) (*Principles and Guidelines*). The *Principles and Guidelines* represent the main set of project evaluation guidelines for Federal water management agencies. This report presents a discussion of the formulation of alternatives, a description of the alternatives considered, and the results of the *Principles and Guidelines*-specific analyses. This Feasibility Planning Report also includes information on cost estimates and a preliminary schedule for constructing the KDRPP.

A variety of sources provided information for this Feasibility Planning Report, including the Integrated Plan, Framework for Implementation Report, KDRPP Value Planning Final Report (May 2014), KDRPP Draft Feasibility Design Report, Draft EIS, and Draft Economic Analyses of Proposed Kachess Drought Relief Pumping Plant Project Technical Memorandum.

1.1 Project Location and Description

Kachess Reservoir is located in the upper Yakima River basin (Frontispiece and Figure 3) about 15 miles northwest of Cle Elum, Washington. It releases water into the Kachess River, which flows into the Yakima River at river mile 203.5. Reclamation constructed Kachess Reservoir over a natural lake. The natural lake included two basins — the upper Little Kachess Lake and the lower Big Kachess Lake. Kachess Reservoir's earthfill dam, completed in 1912, is 115 feet high and 1,400 feet long at the crest. Kachess Reservoir drains an area of 63 square miles and has an active storage capacity of 239,000 acre-feet above the existing outlet (Reclamation, 2002).

The KDRPP would create a new outlet from Kachess Reservoir by constructing a new intake, tunnel, pumping plant, and release structure. This would enable Reclamation to withdraw an additional 200,000 acre-feet of water that is stored in the reservoir at an elevation below the existing gravity outlet (2,192.75 feet). Reclamation is currently investigating two alternative alignments for the KDRPP, the East Shore Pumping Plant and the South Pumping Plant. Section 4.0, Alternatives, discusses details of each alternative.

Existing Reclamation facilities associated with this project are located in the Kachess Dam area. The KDRPP project would not modify or affect Kachess Dam itself (Reclamation and Ecology, 2015b).

Figure 3. KDRPP Conveyance Project Location

1.2 Background

1.2.1 Related Projects

There is a close relationship among the KDRPP and two other projects proposed for the Initial Development Phase of the Integrated Plan, which are located in the Keechelus and Kachess Reservoirs area. These are the Keechelus Reservoir-to-Kachess Reservoir Conveyance (KKC) and the Bull Trout Enhancement (BTE) program.

The purpose of the KKC is to better utilize the storage volumes in these two reservoirs to meet the goals of the Integrated Plan; and to reduce high flows at certain times of year in the Yakima River below Keechelus Reservoir to provide benefits to fish and wildlife, particularly Chinook and steelhead. In the event that the KDRPP is constructed, an additional purpose of the KKC project is to accelerate refill of Kachess Reservoir in years following pumping by KDRPP.

BTE would be implemented together with either the KDRPP or KKC, but would not be implemented without these projects. Reclamation and Ecology have identified bull trout enhancement projects to address a need for improving the resiliency of bull trout populations in Keechelus and Kachess Reservoirs, as well as in the Yakima River Basin as a whole. Individual projects were developed in conjunction with the Service, NMFS, Washington Department of Fish and Wildlife (WDFW), and the Yakama Nation. The BTE program would address low abundance, passage barriers, degraded habitat, dewatering and prey base threats in Keechelus and Kachess Reservoirs. The BTE program would also address passage barrier threats for the South Fork Tieton population. Passage barriers created by drawdowns of Keechelus and Kachess Reservoirs would be addressed through separate mitigation. A Bull Trout Memorandum of Understanding was signed in October 2015 by Reclamation, Yakama Nation, USFWS, USFS, Ecology, and WDFW.

Section 5.0, Related Projects, further describes the KKC and the BTE program.

1.2.2 Yakima Project

The Yakima Project provides irrigation water for a comparatively narrow strip of fertile land that extends for 175 miles on both sides of the Yakima River in south-central Washington State. The irrigable land eligible for service under Reclamation's Yakima Project totals approximately 465,000 acres. The project has seven divisions — a reservoir storage division and six water delivery divisions: Kittitas (59,123 acres), Tieton (27,271 acres), Sunnyside (103,562 acres), Roza (72,511 acres), Kennewick (19,171 acres), and Wapato. The BIA operates the Wapato Division, which receives most of its water supply from the Yakima Project for irrigation of 136,000 acres of land. Reclamation provides irrigation water for over 45,000 acres not included in the seven divisions under supplemental water supply contracts (Reclamation and Ecology, 2011d).

The Yakima Project includes five major storage reservoirs — Keechelus, Kachess, Cle Elum, Bumping, and Rimrock. Reclamation operates the Kachess and Keechelus Reservoirs as part of the Yakima Project. Congress authorized the Yakima Project in 1905, directing Reclamation to develop irrigation facilities in the Yakima River basin. The five reservoirs store and release water to meet irrigation demands, flood control needs, and instream flow requirements. Reclamation operates the reservoirs as a pooled system with no reservoir or storage space designated for a specific area. The Yakima Field Office Manager is ultimately responsible for operations of the Yakima Project (Reclamation and Ecology, 2015d).

A complex group of Federal and State statutes and regulations, as well as court decisions and orders, regulate water management in the Yakima River basin. Sections 1.6.3 and 1.6.4 of the Integrated Plan Programmatic Environmental Impact Statement (PEIS) (Reclamation and Ecology, 2012c) describe the regulations and legal decisions related to water management in the basin. The following paragraphs describe the key issues relevant to understanding the KDRPP, KKC, and BTE program.

There are two classes of entitlements, or water rights, in the Yakima River basin: nonproratable and proratable. Nonproratable entitlements are "senior" and generally held by water users who were irrigating prior to construction of the Yakima Project reservoirs. Water users with nonproratable water rights receive water first. All other Yakima Project water rights are proratable, and are junior to the senior nonproratable water rights. Holders of junior water rights share equally any water shortages. "Prorationing" refers to the process of equally reducing the amount of water delivered to proratable water right holders in deficit years based on total water supply available (TWSA). The definition of TWSA is as follows:

> *That amount of water available in any year from natural flow of the Yakima River, and its tributaries, from storage in the various Government reservoirs on the Yakima River watershed, and from other sources, to supply the contract obligations of the United States to the Yakima River and its tributaries* (Civil Action No. 21 (1945 Consent Decree) Article 4, 1st Para.).

Reclamation estimates TWSA annually based on forecasted runoff, forecasted return flows, and reservoir storage contents.

In 1981, the Reclamation Yakima Field Office Manager established the System Operations Advisory Committee (SOAC) to advise Reclamation on how to manage the Yakima Project to reduce flow-related impacts on fish. SOAC consists of fishery biologists from four member agencies: the Yakama Nation, the Service, WDFW, and irrigation entities represented by the Yakima Basin Joint Board. SOAC provides information, advice, and assistance to Reclamation on fish-related issues associated with the operations of the Yakima Project (Reclamation and Ecology, 2015d).

The following are the objectives of the current Yakima Project operation:

- Store as much water as possible up to the reservoir system's full active capacity of about 1 million acre-feet following the end of the irrigation season through early spring.
- Provide for target flows and diversion entitlements downstream from the dams, meeting Title XII flows at Sunnyside and Prosser Diversion Dams.
- Provide reservoir space for flood control operations.

The SOAC has advised Reclamation on "flip-flop" operations to mitigate the impacts on spawning fish in the Yakima River basin. Flip-flop operations involve reducing releases from one reservoir while increasing releases in another. This was instituted to encourage spring Chinook to spawn at a lower streamflow that requires less stored water to be released during the egg incubation period to protect spawning nests (redds). As an example, starting in late August and continuing to mid September, Reclamation reduces Cle Elum Reservoir releases substantially from about 3,000 cfs or greater down to near 200 cfs, and increases releases from Rimrock Reservoir substantially to meet the September and October irrigation demands downstream from the confluence of the Naches and Yakima rivers.

Reclamation performs a similar operation in years of sufficient water supply, referred to as "mini flip-flop" between Keechelus and Kachess Reservoirs, for similar reasons as discussed for the flip-flop operations that occur downstream from Easton and Cle Elum Dams. Reclamation's releases for irrigation supply from Keechelus Reservoir are substantially greater than from Kachess Reservoir during the June to mid-August period. Beginning in late August, Reclamation gradually switches the flow levels of the two reservoirs. By September and October, reservoir releases from Keechelus Reservoir are reduced to 100 cfs (or 80 cfs in dry years), and flows from Kachess Reservoir are raised to 1,000 to 1,400 cfs. However, Reclamation cannot always reduce flows from Keechelus Reservoir to the target level because Reclamation must continue to supply downstream users and sometimes needs more water from Keechelus Reservoir. Under current conditions, flows more than 10 cfs above the target level occur about 15 percent of the time, and flows of 400 cfs or greater above the target level occur about 2 percent of the time.

Yakima Project Operation of Kachess Reservoir

Reclamation fills Kachess Reservoir from mid-October to June or July with reservoir releases typically in the 20 to 60 cfs range – saving water supply for flip-flop operations explained above. After storage control and into August, Kachess Reservoir spills inflows or makes releases in the 50 to 400 cfs range. During mini flip-flop, starting in late August and continuing into October, Reclamation releases up to 1,000 to 1,200 cfs to meet demands. Diversions from the reservoir decline from the end of September to mid-October, and the cycle starts over again.

1.2.3 Relationship of Other Water and Related Resources Activities to Study

Reclamation and Ecology conduct the KDRPP Feasibility Study and EIS within the framework of the Integrated Plan. The Integrated Plan developed out of several prior initiatives, including the YRBWEP and the Yakima River Basin Water Storage Feasibility Study.

Yakima River Basin Water Enhancement Project

Congress initiated the YRBWEP in 1979 in recognition of the extreme water shortage problems in the basin. YRBWEP has the following objectives: develop a plan that would provide (1) supplemental water for presently irrigated lands; (2) water for new lands within the Yakama Indian Reservation; (3) water for increased instream flows for aquatic life; and (4) a comprehensive plan for efficient management of basin water supplies. Since 1979, State and Federal YRBWEP feasibility study activities have been ongoing with the objective

to develop and implement a comprehensive solution for efficient management of Yakima River basin water supplies (Figure 4) (Reclamation and Ecology, 2012d).

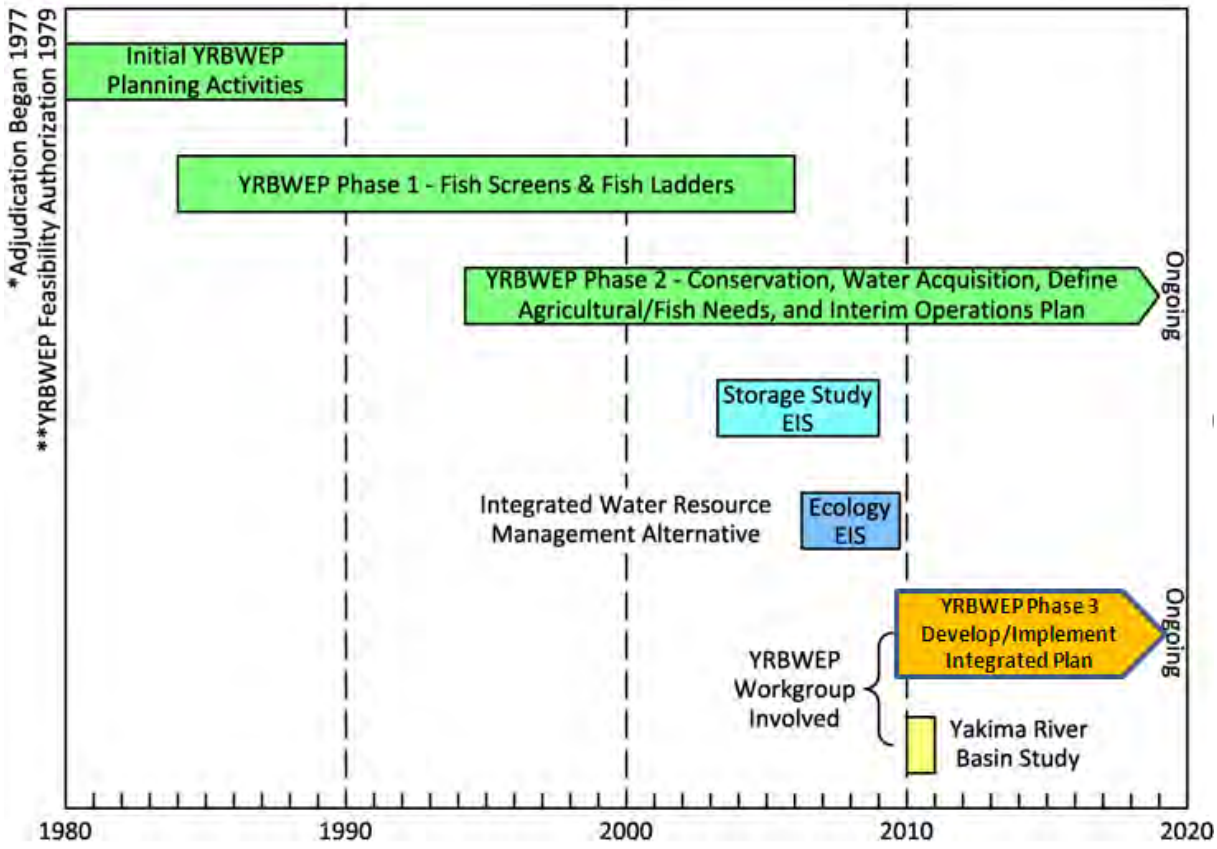


Figure 4. Yakima River Basin Water Enhancement Project Timeline

Yakima River Basin Water Enhancement Plan Phase 1

Early in the study process, the YRBWEP identified fish passage problems as needing immediate attention. Congressional legislation in 1984 (Public Law 98-381) authorized Reclamation to design, construct, and operate fish passage facilities within the Yakima River basin in accordance with the Northwest Power and Conservation Council's Columbia River Fish and Wildlife Program (YRBWEP Phase 1). Congress enacted a companion law on August 22, 1984, to provide, among other things, for operations and maintenance costs related to fish facilities (Public Law 98-381, Section 109 of Hoover Powerplant Act of 1984). The YRBWEP efforts proceeded through the 1980s, but were not fully completed, primarily due to issues and uncertainties associated with basin surface water rights adjudication (Reclamation and Ecology, 2012d).

Yakima River Basin Water Enhancement Plan Phase 2

In 1994, Congress passed legislation for YRBWEP Phase 2 (Public Law 103-434), which provided for significant water conservation and acquisition activities; studies to define the long-term water needs of fish and irrigators; improvements to the Wapato Irrigation Project; and development of an interim operations plan for management of basin water supplies.

In compliance with the 1994 YRBWEP Act (Phase 2 Legislation – Public Law 103-434), Reclamation and Ecology are cost-sharing partners in the Basin Conservation Program, with Reclamation funding 65 percent of the cost and Ecology and participating irrigation districts each funding 17.5 percent. Under this program, two-thirds of the water savings remains in the river and the irrigation districts retain one-third (Reclamation and Ecology, 2012d).

As of December 2014, Reclamation, Ecology, and irrigation entities have cost-shared to develop eight Comprehensive Conservation Plans and four conservation Feasibility Investigation Reports for Yakima River basin irrigation systems. They also implemented a number of projects to generate water savings and improve stream flows. For more information, see the Reclamation website at http://www.usbr.gov/pn/programs/yrbwep/phase2/basinconservation.html.

Yakima River Basin Water Storage Feasibility Study and Development of the Integrated Plan Alternative

In 2003, Congress directed Reclamation to conduct a feasibility study of options for additional water storage in the Yakima River basin. The authorization for the study is contained in Section 214 of the Act of February 20, 2003 (Public Law 108-7). The authorization states that the study would place "…emphasis on the feasibility of storage of Columbia River water in the potential Black Rock Reservoir and the benefit of additional storage to endangered and threatened fish, irrigated agriculture, and municipal water supply."

Reclamation began the Storage Study in May 2003. The State of Washington joined Reclamation in that effort after the State's 2003-2005 capital budget provided funding.

In 2007, Reclamation and Ecology initiated an environmental review for the Storage Study. The agencies prepared a Draft Planning Report and Environmental Impact Statement as a combined NEPA and SEPA document, entitled the *Yakima River Basin Water Storage Feasibility Study Draft Planning Report/Environmental Impact Statement* (Reclamation and Ecology, 2008).

Reclamation understood that Federal funds provided under Section 14 of the Act of February 20, 2003, were restricted to the study of Black Rock Reservoir and other potential storage facilities in the Yakima River basin. Reclamation considered the following alternatives:

- No Action Alternative
- Black Rock Reservoir Alternative
- Wymer Dam and Reservoir Alternative
- Wymer Dam Plus Yakima River Pump Exchange Alternative

The January 2008 draft planning report and EIS referred to these storage facilities as the "Joint Alternatives" because Reclamation and Ecology advanced them jointly. Under its SEPA authority, Ecology determined the need to evaluate both storage and nonstorage means of achieving the objectives. Thus, the January 2008 draft planning report and EIS considered three "State Alternatives" in addition to the Joint Alternatives:

- Enhanced Water Conservation Alternative
- Market-based Reallocation of Water Resources Alternative
- Groundwater Storage Alternative

Reclamation and Ecology held a public comment period on the January 2008 draft planning report and EIS from January 29 to March 31, 2008. A number of the comments received asserted that Reclamation and Ecology had failed to evaluate an adequate range of reasonable alternatives. Ecology consulted with Reclamation concerning whether additional alternatives should be evaluated, and Ecology concluded that the scope of the EIS should be expanded; however, Reclamation determined that its congressional authorization precluded it from expanding its analysis under NEPA to include nonstorage alternatives. Therefore, Ecology decided to separate from the joint NEPA and SEPA process for the study and to pursue completion of a stand-alone SEPA Supplemental EIS. Ecology continued to act as a cooperating agency for Reclamation's NEPA process, while Reclamation acted in a similar capacity for the SEPA process. Reclamation pursued completion of the final planning report and EIS for the Storage Study, while Ecology prepared a SEPA Supplemental Draft EIS and a Final EIS.

Reclamation released its final planning report and EIS on December 29, 2008. It included only the storage facilities in the Joint Alternatives and responses to comments on the Joint Alternatives. Reclamation determined based on the results of the final planning report and EIS that none of the storage features by themselves met Federal criteria for an economically and environmentally sound water project and recommended the No Action Alternative as the Preferred Alternative. On April 3, 2009, Reclamation announced that it had concluded the Yakima River Basin Water Storage Feasibility Study (Reclamation and Ecology, 2012d).

Ecology's Yakima River Basin Water Storage Feasibility Study and Supplemental SEPA Analysis

Ecology released its Supplemental Draft EIS on December 10, 2008, which evaluated an integrated approach to water management in the Yakima River basin. Ecology selected the Integrated Water Resource Management Alternative as the preferred alternative for the Final EIS. This alternative proposed seven elements to increase water supplies for agricultural and municipal needs and to improve habitat for anadromous and resident fish. The seven elements were fish passage, modifying existing structures and operations improvements, new surface storage, groundwater storage, fish habitat enhancement, enhanced water conservation, and market-based reallocation of water resources. Ecology prepared its EIS at a programmatic level, and issued the Final EIS in June 2009. It presents an integrated package of opportunities to address water resource problems in the Yakima River basin (Reclamation and Ecology, 2012d).

Yakima River Basin Integrated Water Resource Management Plan

In 2009, Reclamation and Ecology convened the YRBWEP Workgroup to review studies produced since the 1979 YRBWEP feasibility study authorization, including Ecology's Final EIS (2009), in order to formulate a comprehensive and integrated solution for the basin's water resource problems and ecosystem restoration needs. The Workgroup is composed of representatives of the Yakama Nation, Federal agencies, Washington State and local governments, environmental organizations, and irrigation districts. Workgroup activities have included development of an initial Integrated Plan proposal; performance of multiple analyses to examine a range of technical, engineering, and economic topics; and preparation of the Integrated Plan.

The current lack of facilities in which to store the full water supply of the basin, operational constraints, and the legal framework affecting water resources in the Yakima River basin illustrate the challenges for residents, businesses, Tribal communities, and ecosystem resources. The Integrated Plan aims to address the following challenges for Yakima River basin water users:

- *Water reliability for the Yakama Nation.* The Yakama Nation water supply needs must be met as there is potential for expensive and time-consuming litigation in resolving treaty issues in regard to water rights. The Integrated Plan would help assure Tribal officials that their instream and out-of-stream water supply needs would be met.
- *Water reliability for proratable water users*. In severe drought years, proratable water users receive sharply diminished supplies from the Yakima Project — in one year, as little as 38 percent of their full allotment. Junior users can be cut off completely. These diminished water supplies reduce agricultural production and associated jobs. Fruit growers may also face early loss of vines and trees that could have remained economically productive, sometimes for several additional years.
- *Water reliability for municipal and domestic water users*. Municipal and domestic water users rely on junior water rights for their drinking water. The Yakama Nation and irrigation users, including proratable irrigation users, hold water rights and entitlements that are senior to most municipal and domestic uses. In drought conditions, municipal and domestic water users face the very real risk that their supplies could be cut off as a result of litigation brought by senior water users. This affects current residents and limits the ability of local communities to grow and develop. The State of Washington and local governments have identified averting such litigation as a key objective.
- *Ecosystem restoration in the Yakima River basin.* Restoration on a watershed scale includes habitat and floodplain restoration in combination with land management that would ultimately improve conditions for listed species of fish (bull trout and steelhead) that rely on the Yakima River system and potentially avoid a need for Federal enforcement actions that would undermine economic uses of water in the basin.
- *Climate change effects on the Yakima River basin*. Scientists studying the Columbia River basin expect that less water would be stored as snowpack in the Cascade Range in future decades compared with current conditions. Snowpack currently provides a substantial portion of runoff into the Yakima River basin. Reduced snowpack would compromise water supply, streamflow, and aquatic habitat conditions. There is no single type of action that can address the multiple effects of climate change on snowpack, runoff conditions, water temperature, aquatic life, and forest health. Reclamation and Ecology believe that an integrated approach that includes consideration of water storage, water conservation, streamflow management, fish passage, and habitat improvements offers the best opportunity to mitigate climate change impacts on the Yakima River basin's aquatic habitat and economy.

- *Adverse effects on forest resources, land, and terrestrial habitat*. The Yakima River basin also faces risks associated with large wildfires, fragmented land ownership, and land-use practices that have adverse impacts on forest resources, land, and terrestrial habitat. These risks exacerbate the other risks to water resources and aquatic habitats in the basin. The Integrated Plan includes approaches to coordinate land and water management to help manage these risks.

The Integrated Plan encompasses seven elements: (1) habitat and watershed protection and enhancement, (2) reservoir fish passage, (3) surface storage, (4) enhanced water conservation, (5) structural and operational changes, (6) groundwater storage, and (7) the use of market-based forces to reallocate water and habitat among willing buyers and sellers. The goals of the Integrated Plan are to protect, mitigate, and enhance fish and wildlife habitat; provide increased operational flexibility to manage instream flows to meet ecological objectives; and improve the reliability of the water supply for irrigation, municipal supply and domestic uses.

The seven elements each include recommended projects to meet the goals (Reclamation and Ecology, 2012d). The KDRPP proposal is included in the surface water storage element, the KKC proposal is included in the structural and operational changes element, and the BTE is part of the habitat and watershed protection and enhancement element. These proposed actions would contribute to achieving the overall goals of the Integrated Plan. Chapter 4 of the Integrated Plan PEIS evaluates the impacts of the proposals at a programmatic level. The PEIS provides further assessment of Integrated Plan outcomes (Reclamation and Ecology, 2012c). Reclamation and Ecology are currently developing an EIS that evaluates the project level environmental impacts associated with the KDRPP, KKC, and BTE.

Reclamation and Ecology intend that components associated with the elements of the Integrated Plan be implemented with a balanced approach, so that the full and synergistic benefits of the Integrated Plan for ecosystem improvement and water supply can be achieved. A balanced approach means advancing projects associated with each element of the plan during the same development phase. The Initial Development Phase, covering the first ten-year period (2014-2023), advances all seven plan elements and represents approximately one-quarter of the estimated plan cost (about $900 million).

The following websites contain information about implementation of the Integrated Plan:

- http://www.usbr.gov/pn/programs/yrbwep/2011integratedplan/index.html
- http://www.ecy.wa.gov/programs/wr/cwp/YBIP.html

Integrated Plan Schedule: Timing, Sequence, and Triggers

Figure 5 shows the implementation schedule for the projects in the Initial Development Phase of the Integrated Plan, including KDRPP, KKC, and the BTE program. Figure 6 shows how the Initial Development Phase relates to the implementation schedule for the remaining actions in the Integrated Plan. This schedule is subject to revision as Reclamation and Ecology further define project feasibility, funding strategies, and implementation pathways. Colors used in the figures show three stages of activity: (1) studies; (2) action-specific environmental review, permitting, and design; and (3) project construction or program activation.

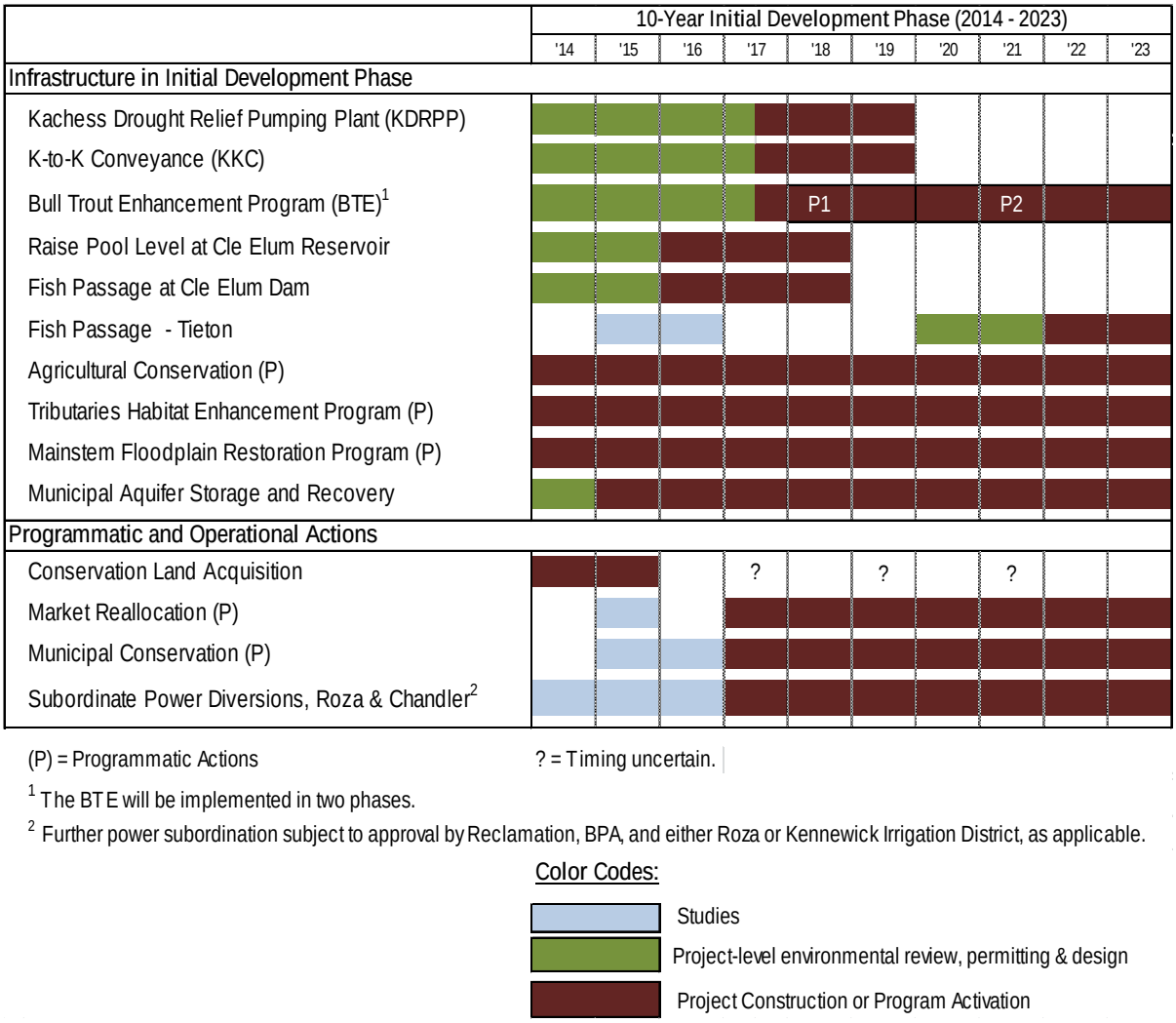


Figure 5. Implementation Schedule for the Integrated Plan Initial Development Phase

(P) = Programmatic Actions ? = Timing uncertain. T = Assess triggers for possible implementation.

[1] The BTE will be implemented in two phases.

[2] Further power subordination subject to approval by Reclamation, BPA, and either Roza or Kennewick Irrigation District, as applicable.

[3] Outcomes from studies will be used to determine actual sequencing of Wymer and Bumping Reservoir projects.

[4] Roza alternate supply to be considered as part of Wymer Project or storage/pump exchange projects such as Columbia River supply.

[5] Timing of fish passage at Bumping Lake depends on when the enlarged reservoir project is constructed.

[6] Step 1 in feasibility study of potential future storage/pump exchange projects.

Figure 6. Implementation Schedule for the Integrated Plan

Yakima River Basin Study

In early 2010, Reclamation and Ecology conducted further evaluation and analysis of the Integrated Plan with funding from the U.S. Department of Interior's WaterSMART Basin Study Program. The Yakima River Basin Study (Basin Study) supplements information provided through previous efforts to evaluate water supply and aquatic resource problems in the basin and identifies potential remedies. It characterizes and quantifies basin water resources and current and future water needs for both instream and out-of-stream uses.

The Basin Study and associated interaction with the YRBWEP Workgroup and its subcommittees specified basin needs in detail. Reclamation and Ecology further defined, evaluated, and updated actions in the Integrated Plan. The agencies further characterized expected hydrologic, fish habitat, fisheries, and economic effects for the Integrated Plan and the future without the Integrated Plan. They evaluated potential impacts of future climate change and factored them into the instream and out-of-stream projections for future water availability and demands. In addition, they modeled storage and flow projections for plan elements based on accepted climate change projections.

Reclamation and Ecology completed the Basin Study, including modeling and analysis results, cost estimates, assessments of barriers and risks, and potential economic effects, in 2011. The Integrated Plan and supporting technical documents are located on Reclamation's website at: http://www.usbr.gov/pn/programs/yrbwep/2011integratedplan/index.html.

1.3 Purpose of the KDRPP

Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Ecology's mission is to protect, preserve, and enhance the State of Washington's environment for current and future generations. The State Legislature authorized Ecology to implement actions that provide concurrent benefits for instream and out-of stream uses for the Yakima River basin. To advance these missions, Reclamation and Ecology are developing a comprehensive program of water resource and habitat improvements focused on fish passage, aquatic habitat, and water supply.

The KDRPP, as a component of the Yakima Project, would contribute to meeting the goals of the Integrated Plan. The following is the objective of the KDRPP (Reclamation and Ecology, 2015d):

- Access stored water in Kachess Reservoir that is currently unavailable in order to improve water supply during periods of drought, with a goal of approaching not less than 70 percent of proratable water rights whenever feasible.

Section 2.1, Need for Action, provides further detail on the purpose and need for the KDRPP.

1.4 Authority

Federal authority is from congressional legislation. State authority is through State legislation and the State Capital Budget as discussed below (Reclamation and Ecology, 2012d).

1.4.1 Federal Authority

Congress authorized Reclamation to conduct a feasibility study to address the water resource needs of the Yakima River basin in the following Act of December 28, 1979 (93 Stat. 1241, Public Law 96-162, Feasibility Study - Yakima River Basin Water Enhancement Project). Other authorities relevant to the YRBWEP include the YRBWEP 1979 Feasibility Study Authorization, the Hoover Power Plant Act of 1984, and the Yakima River Basin Water Enhancement Project Act of 1994.

1.4.2 Washington State Authority

Chapter 90.90 RCW, the Columbia River Basin Water Supply legislation approved by the Washington State Legislature in 2006, provides authority for the State of Washington:

> *(1) The legislature finds that a key priority of water resource management in the Columbia river basin is the development of new water supplies that includes storage and conservation in order to meet the economic and community development needs of people and the instream flow needs of fish.*
>
> *(2) The legislature therefore declares that a Columbia river basin water supply development program is needed, and directs the department of ecology to aggressively pursue the development of water supplies to benefit both instream and out-of-stream uses.*

In 90.90.010 RCW, the legislature created the Columbia River Basin water supply development account in the State treasury to use as follows:

> *Assess, plan, and develop new storage, improve or alter operations of existing storage facilities, implement conservation projects, or any other actions designed to provide access to new water supplies within the Columbia river basin for instream and out-of-stream uses.*

During the 2013 legislative session, the Legislature passed Second Substitute Senate Bill 5367, which provides specific authority for implementing the Integrated Plan. The bill states the following:

> *The department [of Ecology] is authorized to implement the integrated water resource management plan in the Yakima River basin, through a coordinated effort of affected federal, state, and local agencies and resources, to develop water supply solutions that provide concurrent benefits to both instream and out-of-stream uses, and to address a variety of water resource and ecosystem problems affecting fish passage, habitat functions, and agricultural, municipal, and domestic water supply in the Yakima River basin, consistent with the Integrated Plan.*

The bill further authorizes Ecology to assess, plan, and develop projects under the Integrated Plan, including water storage projects and structural and operational modifications to existing facilities.

Legislators included a "water supply facility permit and funding milestone" in SSSB 5367. This represents a date prior to June 30, 2025 when permits have been approved and funding has been secured to begin constructing water supply facilities that can provide at least

214,000 acre-feet of water for instream and out-of-stream uses. If the milestone is not achieved, then the Teanaway Community Forest, also approved in SSSB 5367, may be converted to a management program that is not tied to ecosystem restoration objectives of the Integrated Plan. The Legislature acquired land and established the Teanaway Community Forest as partial implementation of the habitat element of the Integrated Plan. Reclamation and Ecology have determined that the KDRPP and Cle Elum Pool Raise facilities are best suited to achieve the water supply facility permit and funding milestone.

Additional authority for the State of Washington is contained in the 2011 to 2013 Capital Budget, Yakima Basin Integrated Water Management Plan Implementation (30000278) C 49, L 11, E1, Sec 3033. This budget provided funding to implement the Integrated Plan.

Related Projects

There is a close relationship among the KDRPP and two other projects proposed under the Integrated Plan, which are located in the Keechelus and Kachess Reservoirs area. These are the KKC and the BTE program. Section 5.0, Related Projects, describes these projects.

2.0 Plan Formulation

This chapter defines the background problems, opportunities, needs, prior investigation, and public and agency participation, which contributed to plan formulation.

2.1 Need for Action

The Integrated Plan PEIS confirms that current water resources infrastructure, programs, and policies in the Yakima River basin are not capable of consistently meeting the demands for fish and wildlife, dry-year irrigation, and municipal water supply. The Preferred Alternative identified in the Integrated Plan PEIS includes a wide range of actions to respond to the basin's water supply and aquatic ecosystem needs. The Record of Decision for the Integrated Plan PEIS notes that KDRPP is an improvement necessary to help address water supply deficiencies in the Yakima River basin (Reclamation, 2013b).

Reclamation and Ecology developed the proposed KDRPP to respond to conditions in the Yakima River basin that adversely affect and are affected by Reclamation's facilities and operations. The following condition describes the need associated with the KDRPP:

- Demand for irrigation water by existing users in the Yakima River basin exceeds supply in drought years, which can lead to substantial prorationing of water deliveries and economic losses to farmers[4].

The market reallocation element of the Integrated Plan involves reducing barriers to leases and/or purchases of water that can help offset the economic impacts of drought. There are some stakeholders who view this as a viable solution. Others (including most from the irrigation community) believe it will not provide a solution due to range of issues. These issues include behavioral considerations that reduce actual water rights transfer activity

[4] Concerns regarding economic loss are discussed in the Integrated Plan Final PEIS in Section 1.3, Purpose and Need for the Action, on pages 1-5 and 1-6.

compared with theoretical predictions of efficient markets; institutional concerns with transferring rights from one district to another or from irrigation to municipal uses; and problems caused by fallowed land, including multi-year reduction in field productivity, increased costs of weed control, and loss of overall commercial activity needed to sustain the farm economy. Irrigators seeking to lease water rights in recent droughts, including 2015, found very little water available for leasing. Therefore, while market reallocation is being pursued as one element of the Integrated Plan, Reclamation and Ecology have determined that the surface water storage element is also necessary.

The objective of the KDRPP is to:

- Access stored water in Kachess Reservoir that is currently unavailable in order to improve water supply during periods of drought, with a goal of approaching not less than 70 percent of proratable water rights whenever feasible[5].

A substantial portion of the water stored in Kachess Reservoir is below the existing reservoir outlet. Thus, this stored water is not accessible under existing conditions due to the physical configuration of the dam. If made accessible, Reclamation could use this water to increase water supply during periods of drought and provide greater flexibility to deliver water to meet Reclamation's contractual obligations.

2.2 Prior Investigations

The KDRPP project is currently at a feasibility stage of development. The following prior project-level studies contributed to the development of the KDRPP feasibility design:

- *Final Planning Report/Environmental Impact Statement; Yakima River Basin Water Storage Feasibility Study* (Reclamation and Ecology, 2008)
- *Kachess Lake Inactive Storage* (Reclamation and Ecology 2011b)
- *Kachess Reservoir Inactive Storage Project Alternatives Comparison and Recommendations for Advancement* (Reclamation and Ecology, 2013)
- *Value Planning; Kachess Drought Relief Pumping Plant* (Reclamation, 2014d)
- *Hydrologic Modeling of System Improvements* (Reclamation and Ecology, 2015c)
- *Geology Report, Kachess Drought Relief Pumping Plant* (Shannon & Wilson, 2014)
- *Kachess Drought Relief Pumping Plant, Summary of Prior Geotechnical Data for Alternative 2 – South Pumping Plant* (Reclamation and Ecology, 2014b)
- *Value Analysis; Kachess Drought Relief Pumping Plant* (Reclamation 2015).

These studies contributed to the following findings and decisions regarding the KDRPP feasibility design:

[5] The basis for this threshold for prorationing is discussed in the Integrated Plan Final PEIS in Section 1.3, Purpose and Need for the Action, on pages 1-5 and 1-6.

Hydrologic Investigations

- Hydrologic analysis performed in 2014 under the Integrated Plan used an 85-year period of record. Reclamation analyzed KDRPP capacities from 600 to 2,400 cfs. The results showed that KDRPP provides optimum water supply benefits at a capacity of 800 cfs or larger; a capacity above 1,000 cfs does not increase water supply benefits. The analysis showed that, at this capacity, the KDRPP would produce significant improvements in drought year TWSA, prorationing, and total irrigation deliveries (Reclamation and Ecology, 2015c).

Engineering Investigations

- Evaluation of a gravity-tunnel concept under the Integrated Plan identified potential impacts from the disposal of tunnel muck and construction of a discharge structure at the previously undisturbed Yakima River outlet location. Additionally, the gravity-tunnel concept did not achieve the desired instream flows in the Yakima River downstream of Lake Easton, and would not fully deliver water to Kittitas Reclamation District (Reclamation and Ecology, 2013). In response, Reclamation and Ecology developed and evaluated alternatives with fewer impacts (discussed further in Section 3.1, Alternatives Formulation and Evaluation) (Reclamation, 2014d).
- Compared to the gravity-tunnel concept, the pumping plant concept would reduce environmental impacts, be capable of supplying any proratable irrigation district with water during drought years, and cost less (Reclamation, 2014d). Section 3.1, Alternatives Formulation and Evaluation, provides further detail on alternative evaluation.

Geotechnical Investigations

- In 2013, Reclamation completed three borings along the East Shore Pumping Plant tunnel alignment at the intake, mid tunnel, and pumping plant locations. Subsurface conditions along this tunnel alignment consist of 40 to 155 feet of soil overlying bedrock (Shannon & Wilson, 2014).
- There is limited geotechnical information available for the South Pumping Plant Alternative. In 2013, Reclamation completed one boring at the location of the proposed Alternative 2 intake. Reclamation completed two additional borings during the fall of 2014: one at the proposed Alternative 2 surge tank location and another at the proposed Alternative 2 pumping plant shaft location. Based upon evaluation of the local geology and Kachess Dam construction records, the design team assumed that the pumping plant shaft and tunnel alignment would be in glacial till or in sandstone (Reclamation and Ecology, 2014b).

2.3 Public Involvement

Public involvement is a process where interested and affected individuals, organizations, agencies, and governmental entities are consulted and included in the decision making process. Reclamation and Ecology have engaged the public and stakeholders at multiple stages during the formulation of the KDRPP, including during the development of the Integrated Plan, the PEIS, and the KDRPP and KKC EIS. In addition, the YRBWEP Workgroup hold regular meetings that are open to the public (discussed further in Section 2.4, YRBWEP Workgroup Participation).

2.3.1 Integrated Plan and Programmatic Environmental Impact Statement Involvement

As part of the Integrated Plan, Reclamation established a coordinated public participation program with willing agencies and groups and pursued public participation. Several agencies, entities, organizations, and groups participated in the development of the Integrated Plan. The degree of participation ranged from providing viewpoints and general observations to direct contributions to plan formulation (Reclamation and Ecology, 2012c).

During development of the Integrated Plan, Reclamation provided information to the public regarding the PEIS. Reclamation and Ecology solicited responses regarding the public's needs, values, and evaluations of the proposed Integrated Plan alternatives. The two agencies conducted joint SEPA and NEPA scoping with public meetings in the spring of 2011, and held additional public meetings to discuss the Draft PEIS in December 2011. Both formal and informal input was encouraged and used (Reclamation and Ecology, 2012c).

2.3.2 KDRPP Environmental Impact Statement Involvement

Reclamation filed a Notice of Intent in the Federal Register on October 30, 2013, regarding its intent to prepare an EIS on the KDRPP and KKC projects, informing the public of the proposed environmental analysis, and identifying opportunities for involvement during EIS preparation. On November 4, 2013, Ecology issued a SEPA Determination of Significance for the KDRPP and KKC projects. The Notice of Intent and Determination of Significance initiated the scoping process. During the scoping period, Reclamation, Ecology, and the cooperating agencies collaborated with the public and interested parties to define a range of issues and alternatives for the KDRPP and KKC EIS.

Reclamation and Ecology held public scoping meetings on November 20, 2013, in Yakima and November 21, 2013, in Cle Elum, Washington. During scoping, commenters identified certain issues regarding the KDRPP proposal. Major issues raised included operations, reservoir levels and refill, spoils disposal, traffic, hydrologic connectivity between surface and groundwater, surface water quality, slope stability and erosion, noise during construction and operation, socioeconomics and impacts on fish, recreation, groundwater wells, aesthetics, and property values (Reclamation and Ecology, 2015d). The scoping report is available at http://www.usbr.gov/pn/programs/eis/kdrpp/index.html.

On January 9, 2015, Reclamation released the KDRPP and KKC Draft EIS (discussed further in Section7.0, Environmental Considerations) for review and comment to engage interested members of the public, agencies, stakeholders, and Tribes. Public Meetings were held February 3 and 5, 2015.

Reclamation and Ecology reopened the comment period on the Draft EIS April 15, 2015 to June 15, 2015. Public Meetings were held on May 4 and 5, 2015. Reclamation and Ecology plan to release a Supplemental Draft EIS in 2016 to include impact analysis on the KDRPP floating pumping plant alternative. A Final EIS and Record of Decision would then be issued with all the responses to comments on the Draft and Supplemental Draft EISs.

2.4 YRBWEP Workgroup Participation

In 2009, Reclamation and Ecology convened the YRBWEP Workgroup to review studies produced since the 1979 YRBWEP feasibility study authorization, including Ecology's Final EIS (2009), to formulate a comprehensive and integrated solution for the basin's water resource problems and ecosystem restoration needs. The Workgroup is composed of representatives of the Yakama Nation, Federal agencies, Washington State and local governments, environmental organizations, and irrigation districts. Staff representing the State's congressional delegation also attended regularly to observe Workgroup discussions. Meetings have been open to the public with opportunities for public input; public attendance has regularly numbered 20 to 30 individuals.

The YRBWEP Workgroup met 35 times between June 2009 and December 2014 (10 times in 2009, 9 times in 2010, and 4 times each year in 2011 through 2014). From 2009 through 2010, activities included development of an initial Integrated Plan proposal; performance of multiple analyses to examine a range of technical, engineering, and economic topics; and preparation of the Integrated Plan. Following issuance of the Integrated Plan in March 2011, Reclamation and Ecology provided quarterly updates on additional or related studies, and on-the-ground implementation of select projects authorized under State or Federal authorities. Workgroup members themselves have provided quarterly briefings on related activities and efforts to advance the Integrated Plan toward implementation.

Members of the Workgroup include the following organizations:

State and Federal Agencies
Bureau of Reclamation
National Marine Fisheries Service
U.S. Fish and Wildlife Service
U.S. Forest Service
Washington State Department of Agriculture
Washington State Department of Ecology
Washington Department of Fish & Wildlife

Yakama Nation
Yakama Nation Natural Resources
Yakima/Klickitat Fisheries Project

Local Governments
Benton County
Kittitas County
Yakima County
City of Yakima

Irrigated Agriculture
Kennewick Irrigation District
Kittitas Reclamation District
Roza Irrigation District
Sunnyside Valley Irrigation District
Yakima-Tieton Irrigation District

Other Stakeholders
American Rivers
National Wildlife Federation
Trout Unlimited
Yakima Basin Fish & Wildlife Recovery Board
Yakima Basin Storage Alliance

Figure 7 summarizes the YRBWEP process for evaluating and selecting Integrated Plan projects, including the KDRPP. The current Feasibility Study, EIS, and related activities occur between the "Framework for Implementation" stage and the "Proposed Implementation" stage. Note that for KDRPP, activation of the "Proposed Implementation" stage in Figure 7 is subject to authorization by Congress.

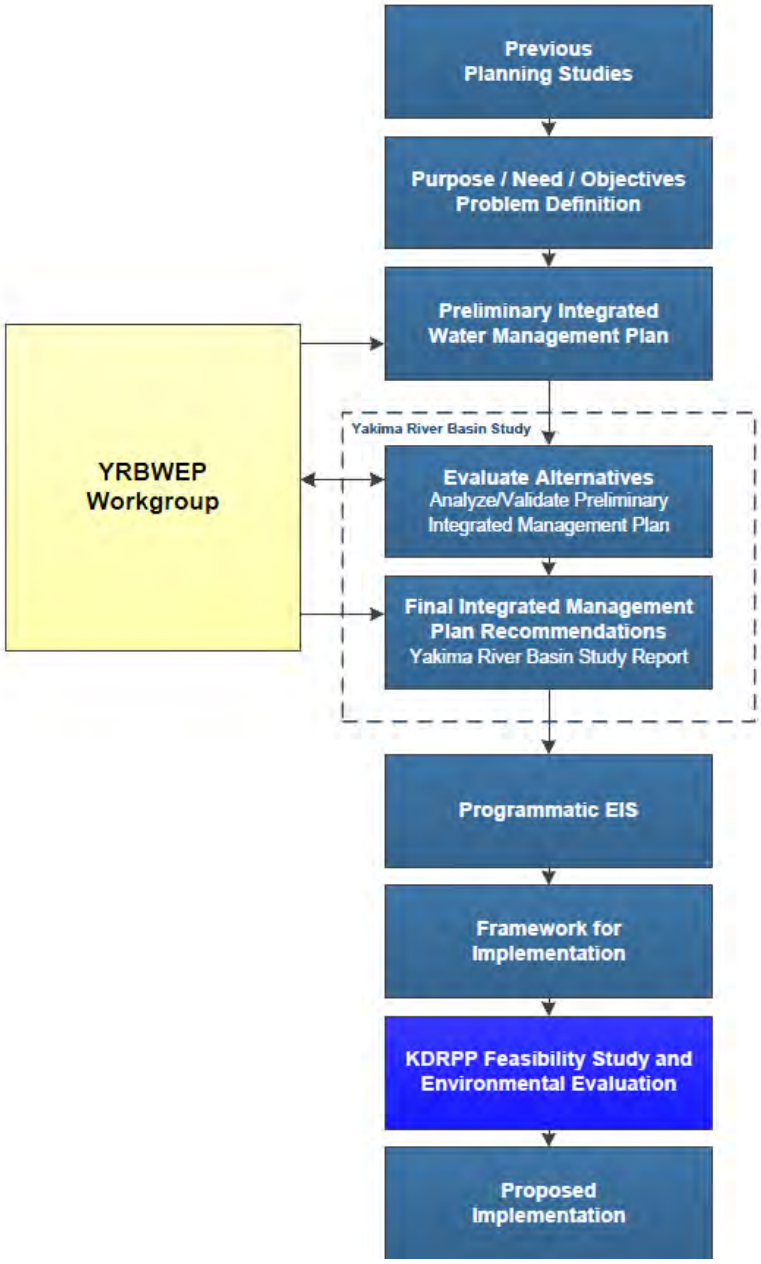


Figure 7. **Water Resource Planning Process for the Integrated Plan**

2.5 Agency Coordination

Reclamation planning and NEPA compliance activities for the KDRPP project have included extensive coordination with Federal, Tribal, State, county, and local agencies. This coordination would continue during the construction phase of the project (Reclamation and Ecology, 2015b). Agencies involved include those listed below:

- United States Forest Service (USFS) – Reclamation would construct some project facilities on Federal land within the Okanogan-Wenatchee National Forest administered by USFS. The USFS is responsible for regulating occupancy and use of National Forest land under the National Forest Management Act and Northwest Forest Plan. There would be need for coordination to finalize site selection and configurations; to minimize and mitigate impacts on forest resources and recreational users; and to coordinate construction, permanent access, and traffic considerations. Following construction, restoration of vegetation on disturbed areas outside the permanent project footprint would require coordination and compliance with USFS requirements.
- United States Fish and Wildlife Service (Service) – Reclamation would coordinate with the Service, including achieving consistency with the Fish and Wildlife Coordination Act report developed for the Integrated Plan. Reclamation would also coordinate with the Service to achieve compliance with the Federal Endangered Species Act.
- National Marine Fisheries Service (NMFS) – Reclamation would coordinate with NMFS, including achieving consistency with the Fish and Wildlife Coordination Act report developed for the Integrated Plan. Reclamation would also consult with NMFS regarding the Federal Endangered Species Act, and to verify compliance with the Magnuson-Stevens Act.
- Yakama Nation – Reclamation would coordinate with the Yakama Nation, including achieving consistency with the Fish and Wildlife Coordination Act report developed for the Integrated Plan, and in regards to cultural resources that may be present in areas that would be disturbed by construction activities or permanent facilities, as described further in Section 2.6, Tribal Consultation and Coordination.
- Washington Department of Fish and Wildlife (WDFW) – Reclamation would coordinate with WDFW, including achieving consistency with the Fish and Wildlife Coordination Act report developed for the Integrated Plan.
- Washington State Department of Ecology – Ecology is a partner with Reclamation in funding and leading development of the Integrated Plan and its various projects, including the KDRPP project. Reclamation would coordinate with Ecology's Office of Columbia River, which manages the agency's activities in this regard. Reclamation would also coordinate with Ecology's Water Quality Program related to protection of water quality during project construction.
- Washington Department of Archeology and Historic Preservation – Reclamation will consult with DAHP to determine whether the project would impact historic or cultural resources.

- Kittitas County and local cities – Reclamation would inform Kittitas County and the Cities of Easton, Cle Elum, and Ellensburg of construction planning and construction progress, to enable the cities and the county to anticipate and respond to impacts or needs affected by the project.
- Irrigation districts served by water from the Yakima Irrigation Project – Reclamation would inform irrigation districts that have Federal contracts of construction planning and construction progress. In general, Reclamation does not expect construction to affect irrigation districts, unless there is need for special provisions for drawdown of Kachess Reservoir.
- U.S. Army Corps of Engineers (Corps) – Reclamation would work with the Corps to permit the project under Section 404 of the Clean Water Act.
- U.S. Environmental Protection Agency (EPA) – Reclamation would coordinate with the EPA to review air quality for compliance with the Clean Air Act. The EPA would also review and file the EIS.

Table 6 provides a summary of Reclamation's recent coordination efforts.

In addition to overall coordination activities, Reclamation or its contractor would need to acquire a number of permits to construct the KDRPP.

Table 6. Reclamation Integrated Plan Agency Coordination Activities (2013 to 2015)

Date	Coordination Activity Description
2009 - 2015	39 meetings of YRBWEP Workgroup covering a wide range of projects and issues related to the Integrated Plan and providing specific briefings on KDRPP and KKC
April 11, 2013	Meeting with the Service and NMFS to coordinate agencies with regard to the Yakima Basin Integrated Water Resource Management Plan
May 29, 2013	Meeting with the Service, Yakama Nation, USFS, and NMFS to discuss alternative descriptions and data gaps for potential upcoming environmental compliance for the Integrated Plan and to review status of ongoing geologic investigations
June 30, 2013	Passage of Washington State legislation on the Integrated Plan
July/August 2013	Draft KDRPP and KKC alternative descriptions sent to Yakama Nation and Agencies
July 2013 - Present	Monthly meetings with Ecology and Yakama Nation staff to discuss cultural surveys, environmental compliance, and the status of Integrated Plan projects
September 24, 2013	Meeting with Ecology to discuss the KDRPP and KKC EIS
October 9, 2013	Meeting with the Service and WDFW to discuss KDRPP bull trout passage in reservoir tributaries
January 9, 2014	Meeting with Yakama Nation, the Service, NMFS, and WDFW to discuss the gap analysis
January 31, 2014	Hydrologic modeling results made available to agency partners
January 31, 2014	Scoping summary made available to agency partners
February 2014	Hydrologic modeling meeting with stakeholders and agencies
May 29, 2014	Meeting with the Service, Ecology, Yakama Nation, and WDFW to discuss BTE plan formulation.

Date	Coordination Activity Description
June 3, 2014	HDR meeting with Yakama Nation, WDFW, and the Service to discuss the effects of Kachess Reservoir drawdown on bull trout
July 8, 2014	Meeting with the Service and WDFW to discuss KDRPP bull trout passage into reservoir tributaries
July 8, 2014	Meeting with the Service, Yakama Nation, and WDFW to discuss KDRPP bulltrout passage in reservoirs tributaries, such as Box Canyon
July 16, 2014	Meeting with the Service, NMFS, Yakama Nation, WDFW to discuss how KDRPP and KKC facilities would relate to potential future fish passage facilities at Kachess and Keechelus Dams
November 6, 2014	Meeting with Yakama Nation, Service, and WDFW to discuss passage in Kachess Reservoir at Narrows and Box Canyon Creek
November 7, 2014	Meeting with the Service, Ecology, Yakama Nation, and WDFW to discuss BTE plan and memorandum of understanding
May 27, 2015	Meeting with Ecology, Yakama Nation, USFS, NMFS, Service, WDFW, KID, Roza, KRD to discuss BTE program and memorandum of understanding and provide update on KDRPP and KKC.
June 4, 2015	Meeting with Ecology, YN, KID, Roza, KRD and HDR to discuss cost estimate for KDRPP
June 15, 2015	Meeting with Yakama Nation, NMFS, Service, WDFW, to discuss fish passage at Kachess and Keechelus Dams.
June 22-26, 2015	Value Analysis for Kachess Drought Relief Pumping Plant with Ecology, Yakama Nation, KID, KRD, Roza, and WIP.
July 17, 2015	Meeting with Ecology, Yakama Nation, USFS, Service, and WDFW, to finalize bull trout memorandum of understanding
July 17, 2015	Meeting with Ecology, Yakama Nation, USFS, NMFS, Service, WDFW, KID, Roza, SVID, KRD to discuss operations of Yakima Project with Initial Development Phase of Integrated Plan, including KDRPP and KKC
August 7, 2015	Debriefing for KDRPP Value Analysis Study with Ecology, Yakama Nation, NMFSKID, KRD, Roza, WIP and HDR
February 24, 2016	Meeting with Yakama Nation, Service, and WDFW to discuss appraisal report comments on passage in Kachess Reservoir at Narrows and Box Canyon Creek

2.6 Tribal Consultation and Coordination

Reclamation and Ecology have determined that the project area lies within the ceded territory of the Yakama Nation. The Yakama Nation is a major partner in the overall Integrated Plan and has been involved in all aspects of the Integrated Plan, including the KDRPP and as a cooperating agency on the KDRPP/KKC EIS. Additionally, the Yakama Nation is conducting Historic Resource surveys to assist Reclamation and Ecology with compliance activities associated with the NHPA and Washington State preservation laws. Reclamation received a letter from the Chairman of the Tribal Council in April 2014 indicating the Yakama Nation would participate as a Cooperating Agency in the NEPA/SEPA process for KKC and KDRPP; anticipating continuation and extension of ongoing contracted activities involving evaluation of cultural and other resources; and anticipating continuation of this relationship on other phases of the Integrated Plan.

Reclamation is consulting with the Colville Confederated Tribes under the NHPA. The Confederated Colville Tribes will receive copies of the Draft EIS and the Final EIS.

Reclamation sent a letter on July 24, 2014, requesting Government-to-Government consultation with the CTUIR. Reclamation will schedule meetings to discuss the project. The CTUIR will also receive copies of the Draft EIS and the Final EIS.

3.0 Alternatives Formulation

This chapter discusses the project formulation process. Reclamation and Ecology developed the alternatives for the KDRPP in a systematic manner to ensure evaluation of all reasonable alternatives via processes that conform to the *Principles and Guidelines*.

3.1 Alternatives Formulation and Evaluation

The KDRPP was developed at a conceptual level in the Integrated Plan and in supporting technical memoranda (Reclamation and Ecology, 2011a; Reclamation and Ecology, 2011d). Section 2.2 of the Integrated Plan PEIS provides detailed information about the development of the KDRPP (Reclamation and Ecology, 2012c). Additional reports (discussed in Section 2.2, Prior Investigations) provide information that contributed to the development of the KDRPP feasibility design.

3.1.1 Screening of Alternatives

The design team screened alternatives based upon reviews and discussions of the following project criteria with Reclamation and Ecology staffs (Reclamation and Ecology, 2013).

- Provide capability to withdraw an additional 200,000 acre-feet from Kachess Reservoir and route that water downstream for use by participating proratable water users (including Roza Irrigation District, Kittitas Reclamation District, Wapato Irrigation Project, and potentially Kennewick Irrigation District).
- Design the pumping plant and tunnel with a firm capacity of 1,000 cfs.
- Design the new intake with fish screens at an elevation that is at least 10 feet below the minimum pool elevation.
- Maintain a minimum flow to Kachess River of 20 cfs (30 cfs is current operations).
- Minimize capital, operations, and maintenance costs.
- Minimize negative environmental or public impacts.
- Coordinate with State, Federal, and Tribal agencies.

During initial screening, Reclamation eliminated or modified the following concepts based on the project criteria (Reclamation and Ecology, 2013):

Pumping Plant Concepts

- Floating Pumping Plant: Reclamation installed a much smaller-capacity floating pumping plant on Cle Elum in the late 1970s, but it was unsuccessful. Due to the issues associated with the required 1,000-cfs capacity pump station (e.g., large pumps and motors, power demands, pipeline sizes), this was deemed an impractical alternative for Kachess during Value Planning Study held in January 2014. Therefore, Reclamation and Ecology did not advance it to the feasibility study. (Note: Following a subsequent Value Analysis Study in June 2015 a floating pumping plant alternative is being reconsidered by irrigation districts, because of the high costs of the alternatives requiring a deep tunnel as discussed in this Final Draft Feasibility Planning Report).
- Deep-cavity Pumping Plant: Reclamation and Ecology considered a deep-cavity pump station with vertical or horizontal centrifugal pumps and motors located within the cavity below the Lake Kachess water-surface elevation – The shaft would be excavated to the intake tunnel level and then the large pump station room cavity would be mined out of the rock at the end of the shaft. This concept would allow the vertical access shaft down to the pump station cavity to be much smaller in diameter than the shafts currently needed for the Alternative 2 vertical turbine pump station. The tunnel to the lake would be bulkheaded and tapped by pressure pipe manifolds leading to the suction side of the pumps. The pump discharge pipes would exit through the vertical shaft to the ground surface. Although this concept would allow for a smaller vertical access shaft, it would also introduce new complexities for pump station access, maintenance, and ventilation, as well as potential for accidental flooding of the cavity. This concept was modified to a circular shaft configuration, due to complexities with accessing, maintaining, and ventilating a deep cavity.

Intake Concepts

- Siphon Intake: Siphoning would only be practical for up to about 25 feet of drawdown. Since the nearly 60 feet of additional drawdown (80 feet total) would require a deeper intake, a partially siphoning intake was not further considered.
- Tunnel and Lake Tap: this concept was advanced to the feasibility study, and incorporated since an intake and tunnel could be constructed at a depth to allow a minimum of 10 feet of water over the top of the fish screens.

Based on initial screening, the project team identified the following two design concepts for evaluation in a Value Planning Study conducted in January 2014. Figure 8 illustrates the alignment of these alternatives (Reclamation and Ecology, 2013):

- Gravity Tunnel: A 13-foot-diameter gravity tunnel that would convey water 4.6 miles southeast from a new intake in Kachess Reservoir to a point on the Yakima River approximately 6 river miles downstream of Lake Easton.
- Pumping Plant: A short tunnel to convey water from a new intake to a pumping plant on the east shore of Kachess Reservoir. From the pumping plant, a buried pipeline would convey water to a new discharge structure on the bank of the Kachess River, just below the Kachess Dam.

The discharge structure for the Gravity Tunnel Alternative would be located in a previously undisturbed area in the water on the left bank of the Yakima River approximately 6 river miles downstream from Lake Easton. Significant effort would be required to isolate the structure from the river.

Potential environmental impacts associated with this alternative include the transport and disposal of approximately 185,000 cubic yards of tunnel muck (rock spoils) and the associated treatment and disposal of the groundwater encountered during tunnel construction.

Since the Gravity Tunnel Alternative discharge point is downstream from Lake Easton, this alternative would require the release of water from Keechelus Reservoir to supply irrigation water to the Kittitas Reclamation District (KRD) diversion. This release from Keechelus Reservoir would create higher flows in the upper Yakima River than the flow rates desired for fish resources in this reach of the Yakima River. Relocation of the discharge structure to Lake Easton is not feasible because of the hydraulic relationship between the elevation of the proposed new outlet at the bottom of Lake Kachess and the elevation of Lake Easton.

The Integrated Plan identified an objective of reducing flow in the Keechelus-Dam-to-Lake-Easton reach of the Yakima River, from 500 cfs at the beginning of August to 120 cfs by the first week of September each year. Modeling suggests that this cannot be achieved in some drought years in a supply configuration that relies on the Gravity Tunnel Alternative (Reclamation and Ecology 2013). September flows below Keechelus Dam could be on the order of 400 cfs to 1,000 cfs in some drought years, in order to deliver sufficient water to Lake Easton to meet the Integrated Plan's water supply objectives for KRD.

While operational refinements might improve on this modeled output, it appears unlikely that the tunnel alternative can simultaneously meet supply and flow objectives. Therefore the Gravity Tunnel Alternative was not advanced to the feasibility study.

During the Value Planning Study, the design team refined the Pumping Plant concept (Reclamation, 2014d). This concept was advanced to the feasibility study, and two alternative configurations were identified for comparison.

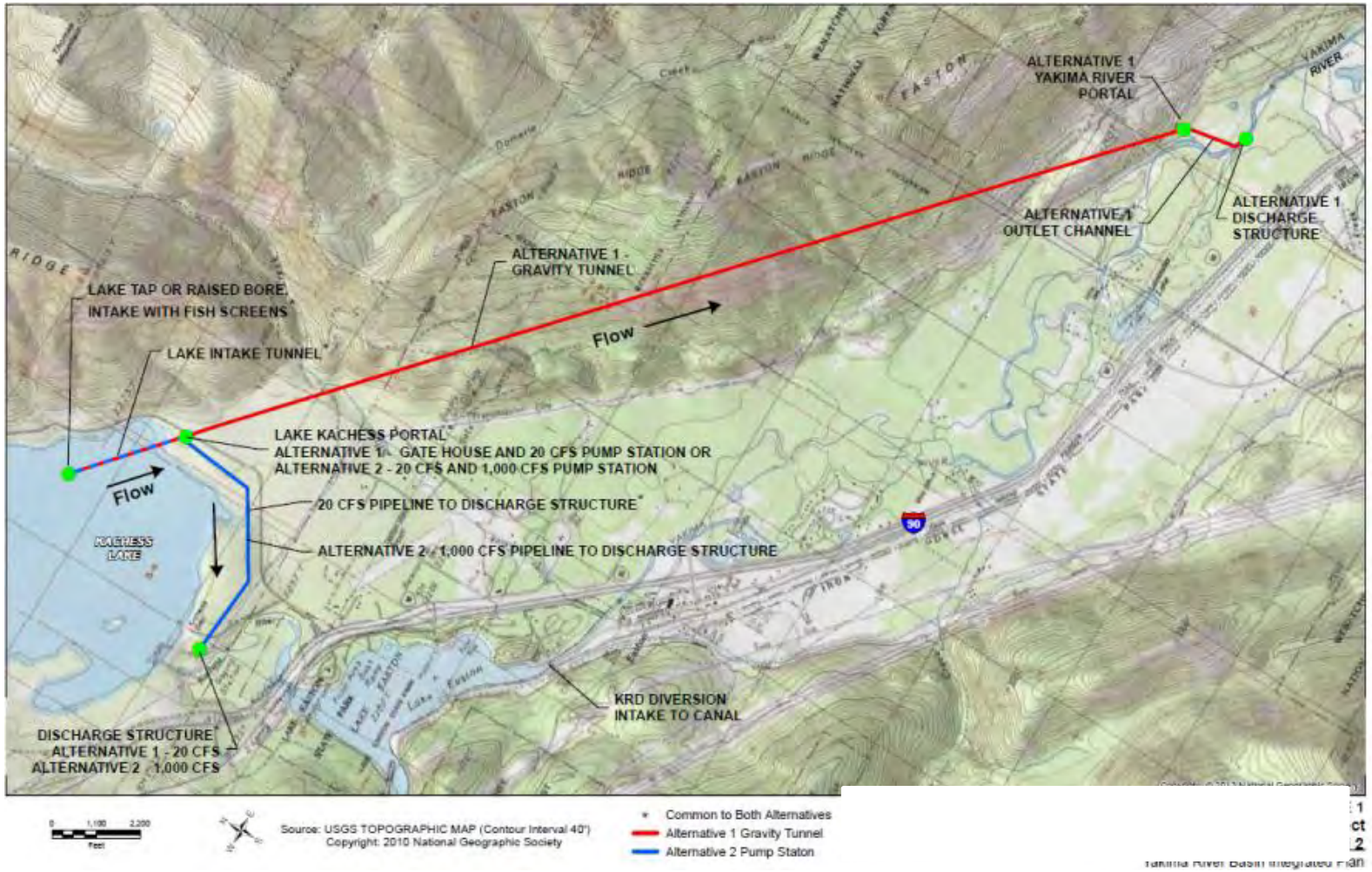


Figure 8. Original Design Alternatives

3.1.2 Selection of Feasibility Study Alternatives

After further evaluation, the design team made modifications to the original pumping plant concept (Reclamation, 2014d). Following completion of the value planning study in January 2014, Reclamation and Ecology advanced the following resulting alternatives to the feasibility study phase:

- Alternative 1 – East Shore Pumping Plant: Alternative 1 would withdraw water through a short intake tunnel to a new pumping plant located on the east shore of Kachess Reservoir. From the pumping plant, water would flow via a 7,755-foot-long pipeline across the reservoir bed to the existing discharge pool. Compared to the original pumping plant concept, the East Shore Pumping Plant pipeline route is primarily across the reservoir bed instead of along the Kachess Dam Road to reduce environmental impacts from clearing trees.
- Alternative 2 - South Pumping Plant: Alternative 2 would use a 3,275-foot-long tunnel to convey water from the intake to a pumping plant located just south of the Kachess Dam, and release it into the existing discharge pool. This alternative eliminates the need for a separate pipeline.

Section 4.0, Alternatives, provides a detailed description of the East Shore Pumping Plant and the South Pumping Plant Alternatives as evaluated in the feasibility study, including maps displaying their locations.

The Federal planning process in the *Principles and Guidelines* includes four criteria for consideration in evaluating the feasibility study alternatives: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability (U.S. Water Resources Council, 1983). *Completeness* is a determination of whether a plan includes all elements necessary to realize planned effects, and the degree that intended benefits of the plan depend on the actions of others. *Effectiveness* is the extent to which an alternative alleviates problems and achieves objectives. *Efficiency* is the measure of how efficiently an alternative alleviates identified problems while realizing specified objectives consistent with protecting the Nation's environment. *Acceptability* is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals. Section 10.0, Conclusions, provides a comparison of the feasibility study alternatives (East Shore Pumping Plant and South Pumping Plant) based on these criteria.

Decision makers also rely on the Four Accounts Analysis to facilitate evaluation and to display effects of the alternatives. Section 9.0, Four Accounts Analysis, describes the four accounts analysis for the East Shore Pumping Plant Alternative and the South Pumping Plant Alternative.

4.0 Alternatives

This chapter presents a description and summary comparison of the No Action Alternative and the alternatives considered. Reclamation and Ecology are evaluating the following alternatives in the Feasibility Study and EIS.

4.1 No Action Alternative

The No Action Alternative represents the most likely future in the absence of implementing the Proposed Action and provides a baseline for comparison of potential impacts of the proposed action and its alternatives. Under the No Action Alternative, Reclamation and Ecology would not implement the KDRPP, KKC, or BTE. Reclamation would continue to manage water supply provided by Kachess and Keechelus Reservoirs consistent with current operational practices and constraints.

For the purpose of this report, Reclamation and Ecology consider that the No Action Alternative includes the following:

- Planned and designed projects
- Authorized projects that have identified funding for implementation
- Projects scheduled for implementation

The KDRPP and KKC Draft EIS provides a detailed description of the No Action Alternative (Reclamation and Ecology, 2015d).

4.2 Action Alternatives Overview

Figure 9 and Figure 10 show the KDRPP alternatives that Reclamation identified following the Value Planning Study: Alternative 1, East Shore Pumping Plant, and Alternative 2, South Pumping Plant. The *Feasibility Design Report, Kachess Drought Relief Pumping Plant* provides further details on both alternatives (Reclamation and Ecology, 2015b).

In May 2015, some of the proratable irrigation districts that may participate in funding of this project requested Reclamation and Ecology perform a Value Analysis Study to evaluate proposals that may reduce project costs. Reclamation held a Value Analysis workshop in June 2015 with HDR, Yakama Nation, and irrigation district staff. Based on the results of the Value Analysis a floating pumping plant option would reduce the construction cost as compared to what has been evaluated in this feasibility study.

The proratable irrigation districts propose to privately finance a permanent facility and therefore have taken the lead to design a floating pumping plant that would pump up to 200,000 acre-feet of storage from the inactive pool of Kachess Reservoir. A separate report will be prepared to document development of this alternative to the same level as the feasibility alternatives. The floating pumping plant alternative is not analyzed in this Planning Report. This section summarizes the alternatives evaluated in 2014.

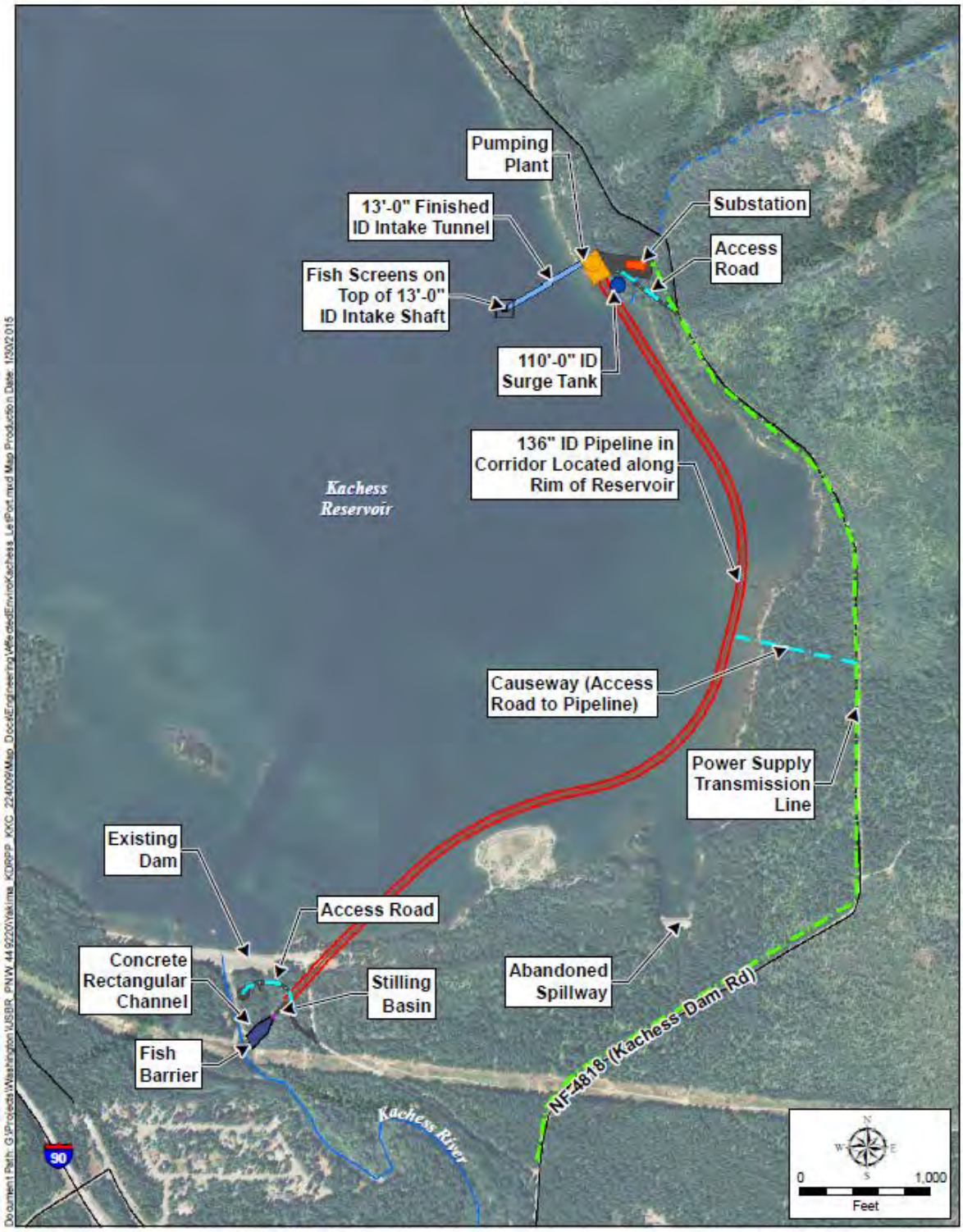


Figure 9. Plan View of Alternative 1, East Shore Pumping Plant

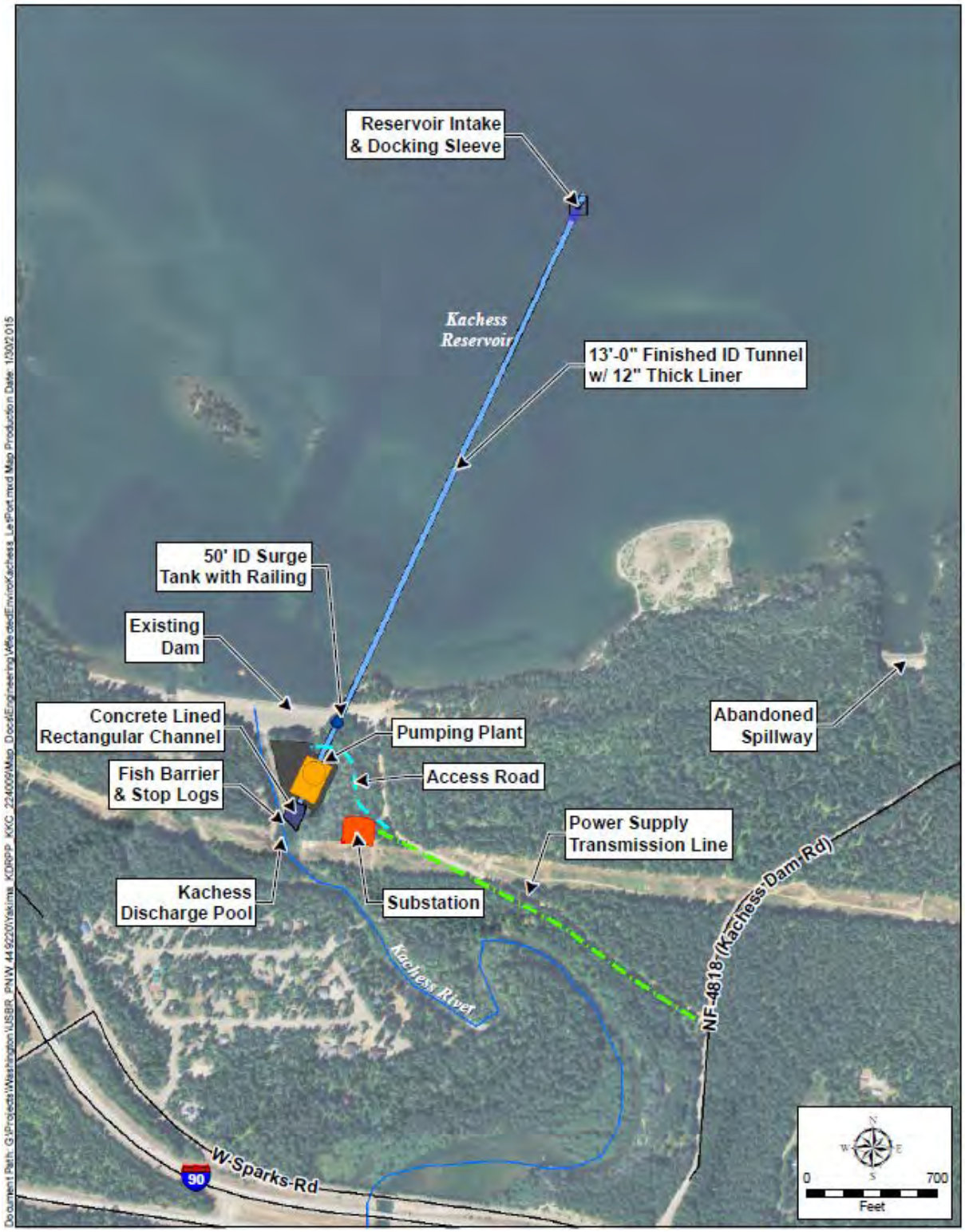


Figure 10. Plan View of Alternative 2, South Pumping Plant

4.2.1 Existing Facilities

The existing Reclamation facilities associated with this project are located in the Kachess Dam area including the Kachess Dam, outlet works, spillway, stilling basin, and gaging station. The project would not make modifications to the existing dam structure or existing facilities. The project would not penetrate or pass beneath the dam. However, Reclamation may choose to make improvements to the existing Kachess Dam Road to accommodate large vehicles during construction.

4.2.2 Alternative 1 - East Shore Pumping Plant

Proposed KDRPP Alternative 1, shown in Figure 9, would consist of an underground pumping plant located on the east shore of the reservoir, an intake tunnel that would connect the new intake and fish screen in the reservoir with the pumping plant, and a discharge pipeline. The pipeline would convey water from the pumping plant to a discharge structure located just downstream of the existing Kachess Dam outlet channel, where the water would be released to the Kachess River. Major East Shore Pumping Plant facilities would include the following:

- Intake and Fish Screen: The top of the fish screen and intake would be located at elevation 2,100, corresponding to the maximum KDRPP drawdown (El. 2,110). The fish screen design consists of six large tee screens, which would connect to a 15-foot-diameter vertical intake pipe.
- Intake Tunnel: The 15-foot-diameter, horseshoe-shaped intake tunnel would be approximately 711 feet long and extend from the pumping plant shaft to the vertical intake shaft located at the base of the vertical intake pipe in the reservoir bed.
- Pumping Plant: The pumping plant shaft would be a 215-foot-deep, 110-foot-diameter shaft constructed on the east shore of the reservoir and would house four close-coupled vertical shaft turbine-pumping units. Each pumping unit would have a 333 cfs capacity. With four units installed, one unit would serve as a standby unit in the event a unit is unable to operate. Figure 11 illustrates the four-unit symmetrical pumping plant arrangement for Alternative 1. A 52-foot-deep, 25-foot-diameter inlet shaft would connect the pumping plant shaft to the intake tunnel. An aboveground rectangular building that would house the operating deck, service bay, electrical room, pump floor area, office, and control room would overlay the pumping plant shaft.
- Surge Tank: The surge tank would be a 110-foot-interior-diameter, approximately 43-foot-deep uncovered concrete tank. The surge tank would be located close to the pumping plant (Figure 11). The surge tank would help control surge caused by sudden changes in pipeline pressure in the event of loss of power to the pumping plant when the drought relief pumping units are operating.
- Pipeline: The 136-inch-diameter, 7,755-foot-long pipeline would be routed from the East Shore Pumping Plant across the floor of Kachess Reservoir at a constant upward slope of 0.001 foot/foot to the outlet works (Figure 9).

- Outlet Works and Kachess River Discharge: The pipeline would discharge flow to the upper end of a concrete spillway. At the bottom of the chute spillway, discharge water would enter a concrete stilling basin to dissipate energy in a controlled manner. A concrete-lined rectangular channel release structure would convey discharge from the stilling basin to the existing discharge pool.
- Site Access: Kachess Dam Road, also known as USFS Road NF-4818 and FS 4818-000RD, would provide vehicular access to the KDRPP. The design includes a large gravel yard approximately 0.75 acre in size within a 7-foot-high chain link perimeter fence, located between the pumping plant building and the proposed power substation. An existing gravel side road located off Kachess Dam Road would supply access to the outlet works features. The project site would include a gate on any access road off Kachess Dam Road to prevent unauthorized vehicular access to the KDRPP.
- Power Supply Substation and Transmission Lines: A new 115 kV transmission interconnection at the existing Puget Sound Energy Easton 115 kV substation would supply electric power to the Kachess Reservoir pumping plant. Approximately three miles of new 115 kV, single wood-pole overhead transmission line would convey electric power from the Easton Substation to the proposed Kachess Reservoir substation. The proposed line would provide adequate service and would meet applicable local, regional, and national reliability criteria for periods when normal transmission sources serve loads. A 125-foot by 150-foot substation would be located approximately 150 feet east of the pumping plant and would house the transformers, switches, disconnects, and other power supply features.

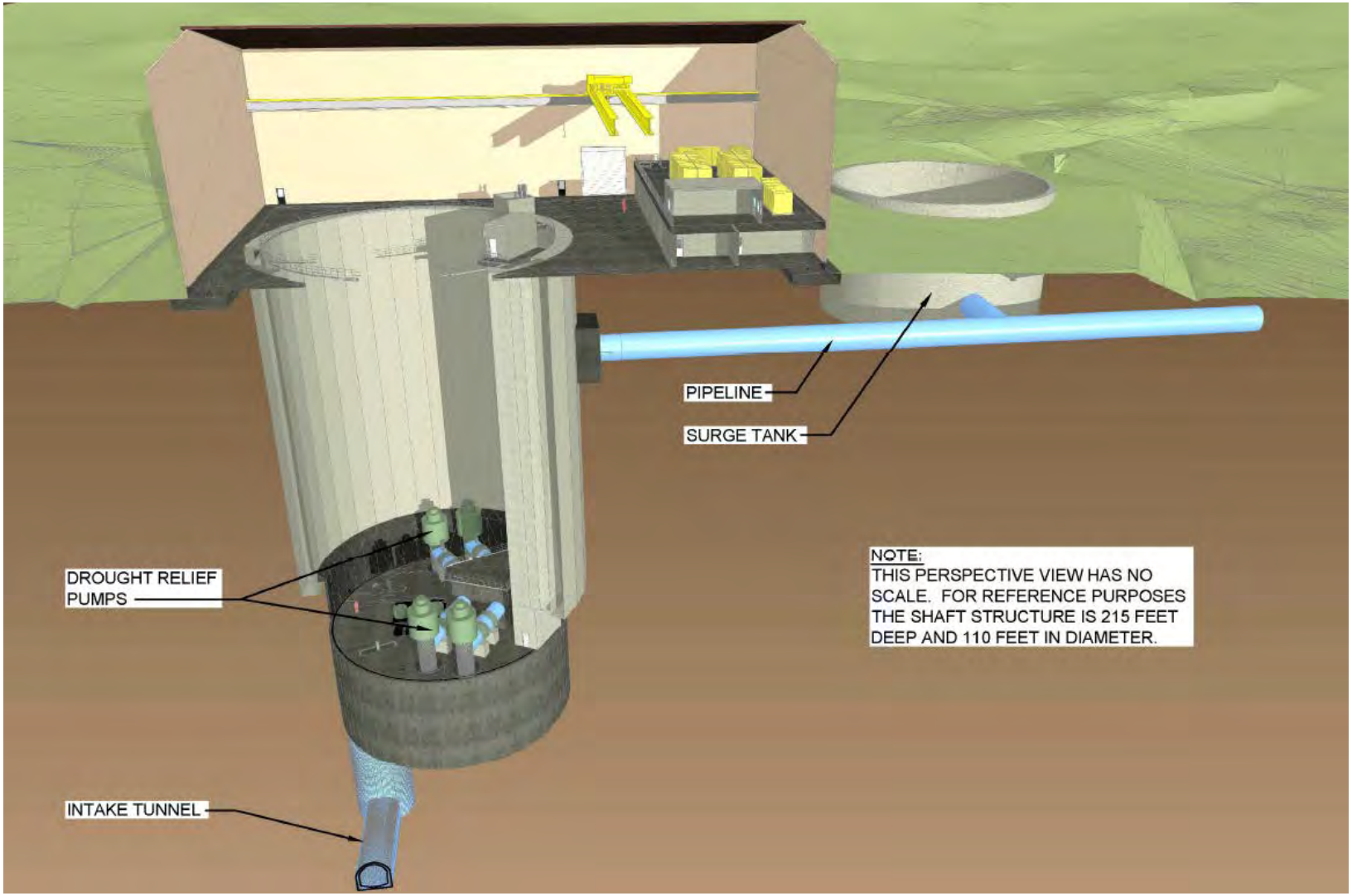


Figure 11. **Three-dimensional Cross Section View of East Shore Pumping Plant (looking east)**

4.2.3 Alternative 2 - South Pumping Plant

Proposed KDRPP Alternative 2, shown in Figure 10, would consist of an underground pumping plant located at the south end of the reservoir immediately downstream of the existing dam and an intake tunnel that connects the new intake, docking sleeve, and fish screen in the reservoir with the pumping plant. The pumping plant would lift the water and release it into the adjacent, existing outlet works discharge pool located at the downstream end of the existing Kachess Dam outlet channel into the Kachess River. Major South Pumping Plant facilities would include the following:

- Reservoir Intake and Fish Screens: The top of the fish screens and intake would be located at elevation 2,100, corresponding to the maximum KDRPP drawdown (El. 2,110). The intake and fish screens would be horizontally oriented to connect to the docking sleeve. The fish screen would include a 15-foot-diameter manifold with 12 large cylinder screens. Each cylinder screen would be 7 feet in diameter by 10.5 feet long.
- Docking Sleeve: The intake would include a docking sleeve section and intake structure. The intake tunnel would dock into the downstream end of the docking sleeve. The fish screens would dock onto the upstream end of the docking sleeve once the tunnel is completed and filled with water.
- Intake Tunnel: The intake tunnel would be approximately 3,275 feet long with a finished inside diameter of 13 feet. The invert of the intake tunnel would start at elevation 2,080 at the pumping station shaft and proceed upward at a slope of 0.20 percent to the intake at approximately elevation 2,087.6. Reclamation's contractor would use a tunnel-boring machine to excavate the tunnel.
- Surge Tank: The surge tank shaft would be a 50-foot-interior-diameter concrete-lined shaft approximately 200 feet deep. The surge tank would be located at the downstream end of the intake tunnel slightly upstream of the pumping plant. The surge tank shaft would be integral to the intake tunnel. The surge tank shaft would help control surge caused by sudden changes in pipeline pressure that would occur in the event of a loss of power supply to the pumping plant.
- Pumping Plant: The pumping shaft would be 145 feet deep and 110 feet in diameter located immediately downstream of the existing Kachess Dam and would house the four close-coupled vertical shaft turbine-pumping units. Each pumping unit would have a 333 cfs capacity. With four units installed, one unit would serve as a standby unit in the event a unit is unable to operate. Figure 12 illustrates the four-unit symmetrical pumping plant arrangement for Alternative 2 (only two of the pumps are shown).
- Kachess River Discharge: Four 7-foot-diameter discharge pipes would release flow from the pumping plant. Discharge from these pipes would enter a concrete-lined rectangular channel that would convey flow to the existing discharge pool located at the downstream end of the gravity outlet works. To minimize fish attraction, designers would slow the discharge from the pumping plant to a velocity of approximately 2 to 3 ft/sec at the existing discharge pool, by gradually increasing the width of the concrete-lined rectangular channel to 100 feet.

- Site Access: Kachess Dam Road, also known as USFS Road NF-4818 and FS 4818-000RD, would provide vehicular access to the KDRPP. An existing gravel side road located off Kachess Dam Road supplies access to the dam area. From the side road, a proposed gravel access road would extend down the steep hillside to 26-foot-wide double swing gates at the proposed gravel yard. Reclamation may decide to pave steeper parts of this road as it traverses down the hillside.
- Power Supply Substation and Transmission Lines: A new 115 kV transmission interconnection at the existing Puget Sound Energy Easton 115 kV substation would supply electric power to the Kachess Reservoir pumping plant. Approximately three miles of new 115 kV, single wood-pole overhead transmission line would convey electric power from the Easton Substation to the proposed Kachess Reservoir substation. The proposed line would provide adequate service and would meet applicable local, regional, and national reliability criteria for periods when normal transmission sources serve loads. A 125-foot by 150-foot substation would be located approximately 300 feet southeast of the pumping plant building and would house the transformers, switches, disconnects, and other power supply features.

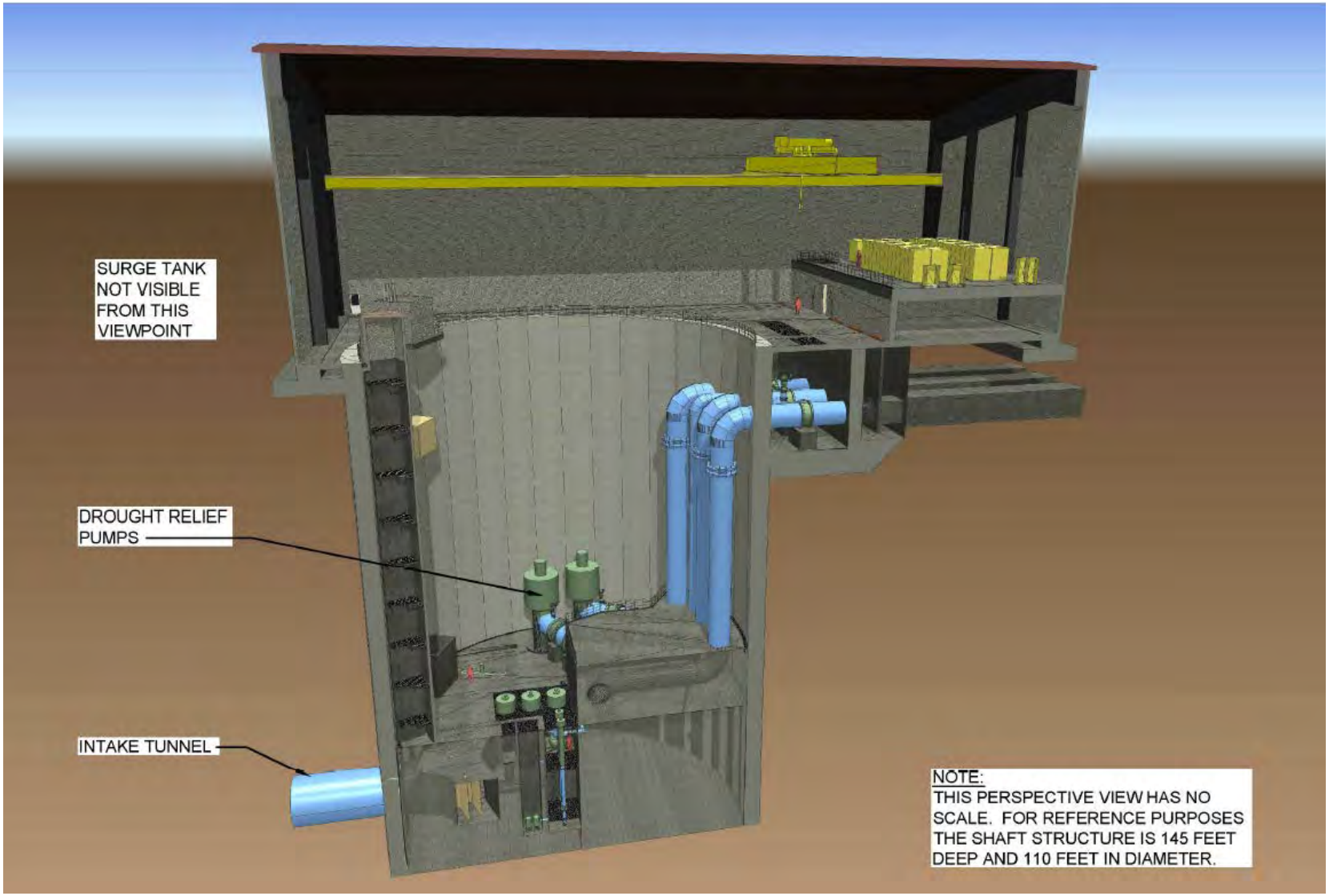


Figure 12. Three-dimensional Cross Section View of South Pumping Plant (looking east)

4.3 Project Schedule

Table 7 and Table 8 provide examples of potential construction sequencing and scheduling for the construction of the East Shore Pumping Plant and South Pumping Plant alternatives, respectively. The design team used Microsoft Project® to illustrate a possible construction schedule for Alternative 1 (Figure 13) and Alternative 2 (Figure 14). The construction schedule presents a possible construction sequence and duration, while allowing for concurrent construction activities to occur where possible (Reclamation and Ecology, 2015b).

These sequences and construction durations represent only one of several ways that a construction contractor could elect to build the facilities under each alternative, so the actual sequences and construction durations may vary significantly from these examples.

4.3.1 East Shore Pumping Plant

Table 7. Example – East Shore Pumping Plant Construction Schedule and Sequencing

Alternative 1 – East Shore Pumping Plant Temporary Construction Features and Permanent Principal Project Features	Approximate Construction Duration (Months)
Temporary Erosion and Sedimentation Control, Clearing & Grading	2
Construction Access Roads and Site Security	2
Construction Parking, Administration Offices and Staging Areas	2
Concrete Batch Plant and Material Stockpile Area	2
Construction Basin and Boat Launch Area	2
Construction Spoils Disposal Area	2
Intake Shaft and Dredging	6
Fish Screens	2
Pumping Plant Shaft	12
Tunnel Access Shaft	3
Intake Tunnel	4
Prefabricated Steel Building	4
Surge Tank	6
Pipeline	10
Concrete Outlet Works Structures	6
Substation	3
Transmission Line	6
Restoration	3

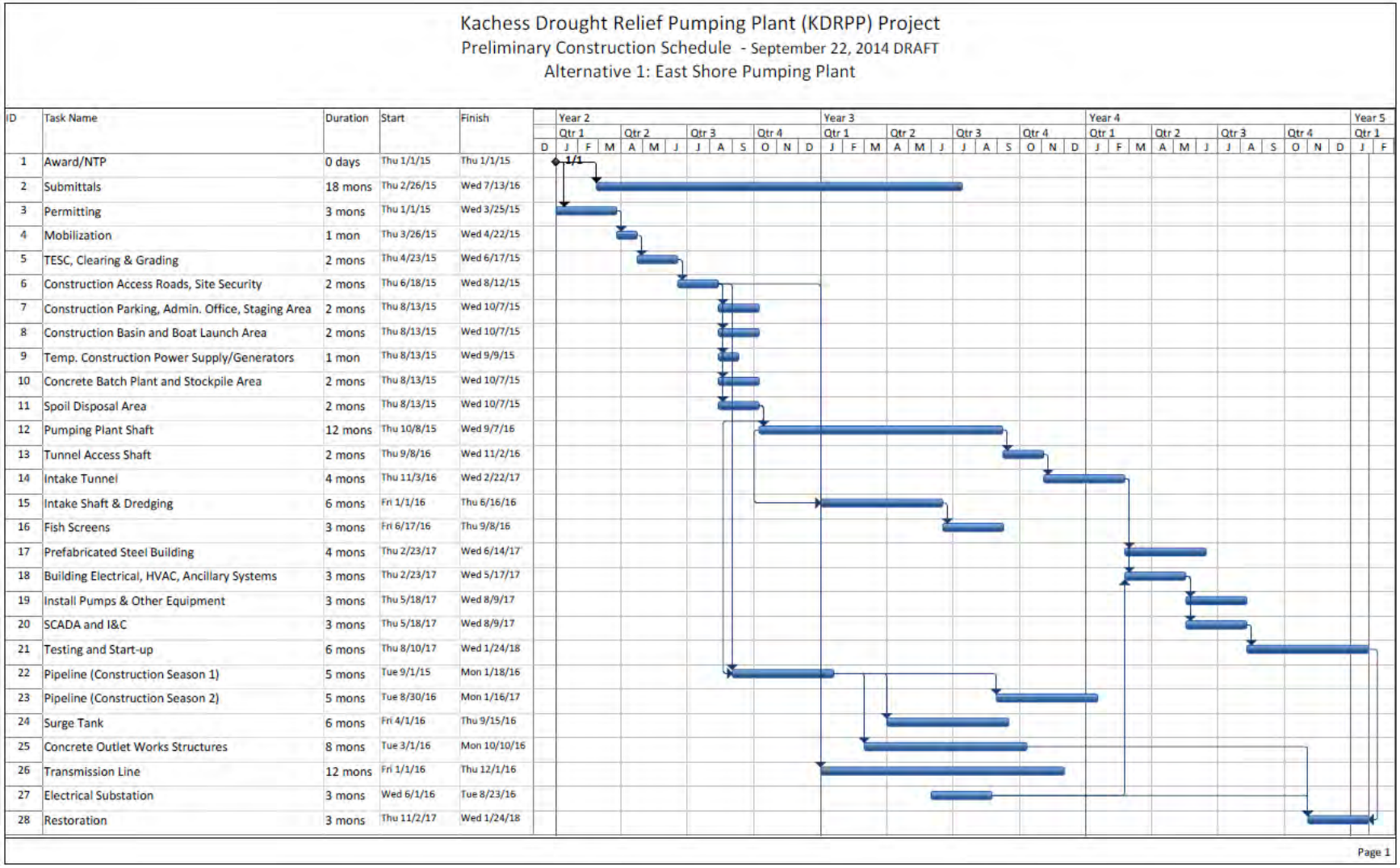
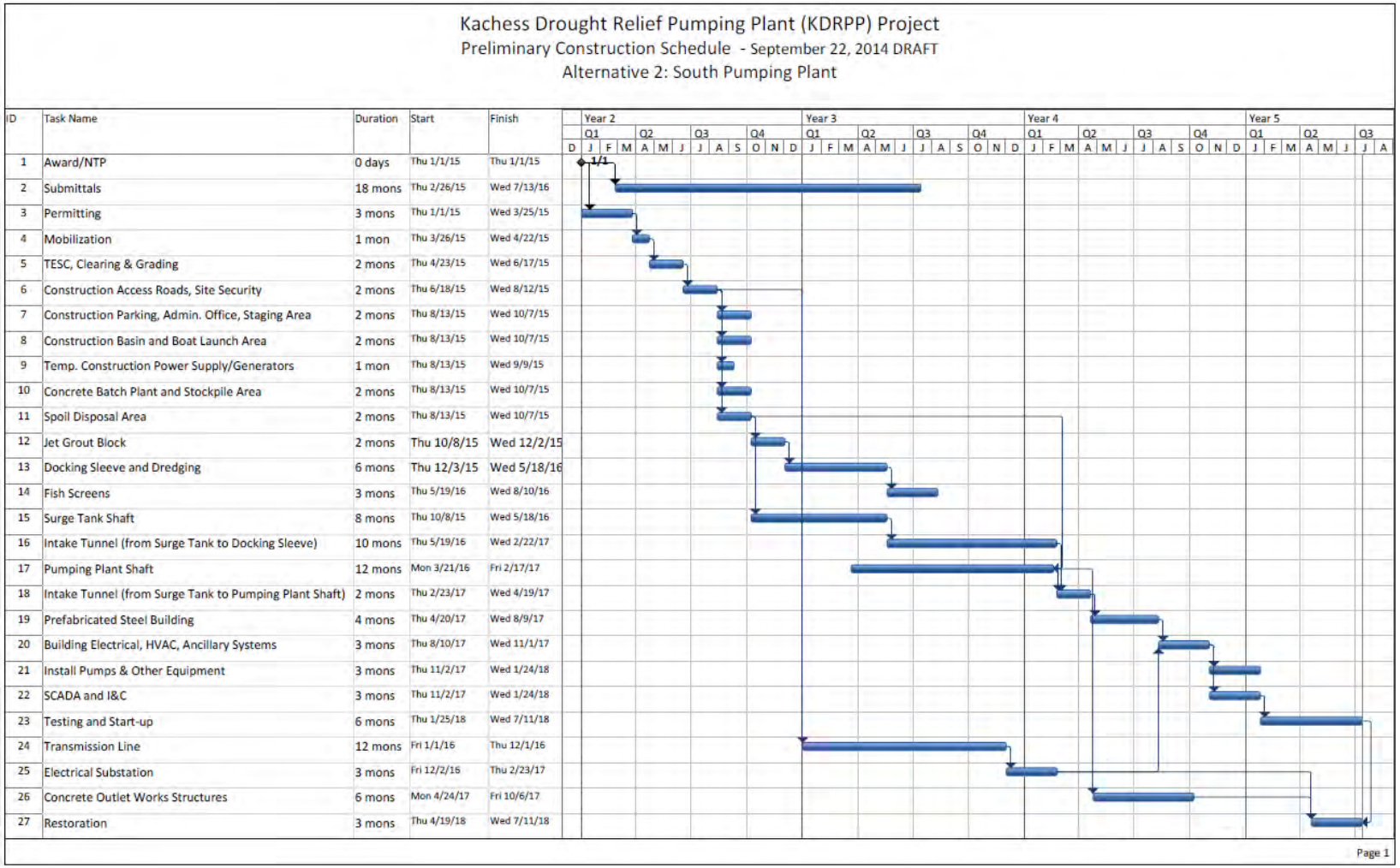


Figure 13. Preliminary Construction Schedule – Alternative 1 East Shore Pumping Plant

4.3.2 South Pumping Plant

Table 8. Example – South Pumping Plant Construction Schedule and Sequencing

Alternative 2 – South Pumping Plant Temporary Construction Features and Permanent Principal Project Features	Approximate Construction Duration (Months)
Temporary Erosion and Sedimentation Control, Clearing & Grading	2
Construction Access Roads and Site Security	2
Construction Parking, Administration Offices and Staging Areas	2
Concrete Batch Plant and Material Stockpile Area	2
Construction Basin and Boat Launch Area	2
Construction Spoils Disposal Area	2
Jet Grouted Block	2
Docking Sleeve and Dredging	6
Fish Screens	2
Surge Tank Shaft	12
Pumping Plant Shaft	12
Intake Tunnel and Tunnel between Shafts	12
Prefabricated Steel Building	4
Substation	3
Transmission Line	6
Restoration	3



ID	Task Name	Duration	Start	Finish
1	Award/NTP	0 days	Thu 1/1/15	Thu 1/1/15
2	Submittals	18 mons	Thu 2/26/15	Wed 7/13/16
3	Permitting	3 mons	Thu 1/1/15	Wed 3/25/15
4	Mobilization	1 mon	Thu 3/26/15	Wed 4/22/15
5	TESC, Clearing & Grading	2 mons	Thu 4/23/15	Wed 6/17/15
6	Construction Access Roads, Site Security	2 mons	Thu 6/18/15	Wed 8/12/15
7	Construction Parking, Admin. Office, Staging Area	2 mons	Thu 8/13/15	Wed 10/7/15
8	Construction Basin and Boat Launch Area	2 mons	Thu 8/13/15	Wed 10/7/15
9	Temp. Construction Power Supply/Generators	1 mon	Thu 8/13/15	Wed 9/9/15
10	Concrete Batch Plant and Stockpile Area	2 mons	Thu 8/13/15	Wed 10/7/15
11	Spoil Disposal Area	2 mons	Thu 8/13/15	Wed 10/7/15
12	Jet Grout Block	2 mons	Thu 10/8/15	Wed 12/2/15
13	Docking Sleeve and Dredging	6 mons	Thu 12/3/15	Wed 5/18/16
14	Fish Screens	3 mons	Thu 5/19/16	Wed 8/10/16
15	Surge Tank Shaft	8 mons	Thu 10/8/15	Wed 5/18/16
16	Intake Tunnel (from Surge Tank to Docking Sleeve)	10 mons	Thu 5/19/16	Wed 2/22/17
17	Pumping Plant Shaft	12 mons	Mon 3/21/16	Fri 2/17/17
18	Intake Tunnel (from Surge Tank to Pumping Plant Shaft)	2 mons	Thu 2/23/17	Wed 4/19/17
19	Prefabricated Steel Building	4 mons	Thu 4/20/17	Wed 8/9/17
20	Building Electrical, HVAC, Ancillary Systems	3 mons	Thu 8/10/17	Wed 11/1/17
21	Install Pumps & Other Equipment	3 mons	Thu 11/2/17	Wed 1/24/18
22	SCADA and I&C	3 mons	Thu 11/2/17	Wed 1/24/18
23	Testing and Start-up	6 mons	Thu 1/25/18	Wed 7/11/18
24	Transmission Line	12 mons	Fri 1/1/16	Thu 12/1/16
25	Electrical Substation	3 mons	Fri 12/2/16	Thu 2/23/17
26	Concrete Outlet Works Structures	6 mons	Mon 4/24/17	Fri 10/6/17
27	Restoration	3 mons	Thu 4/19/18	Wed 7/11/18

Figure 14. Preliminary Construction Schedule – Alternative 2 South Pumping Plant

4.4 Operations

Reclamation would own and operate the KDRPP. Reclamation's Yakima Operations Center would operate KDRPP remotely. There would be provision for a local operating mode also. The following subsections summarize operational considerations (Reclamation and Ecology, 2015b).

4.4.1 Kachess Reservoir Drawdown

Reclamation would pump up to 200,000 acre-feet out of Kachess Reservoir; this would lower the reservoir up to 80 additional feet in drought years, which occurred in about one-third of the model years analyzed, for a mean duration of between 179 and 191 days. Eighty feet represents the maximum drawdown, but in many drought years the drawdown would be limited to 40 feet or less. Under extreme drought conditions, the time for Kachess Reservoir to refill to normal operating levels would be 2 to 5 years following a drought. The EIS prepared for KKC and KDRPP (Reclamation and Ecology, 2015d) indicates that drawdown of the Kachess Reservoir pool would impact recreational uses, scenic qualities, and bull trout use of Kachess Reservoir and its tributaries.

In the Little Kachess basin, the new drawdown conditions are unlikely to change existing conditions because the Little Kachess basin separates from the main reservoir at elevation 2,220 (Figure 15).

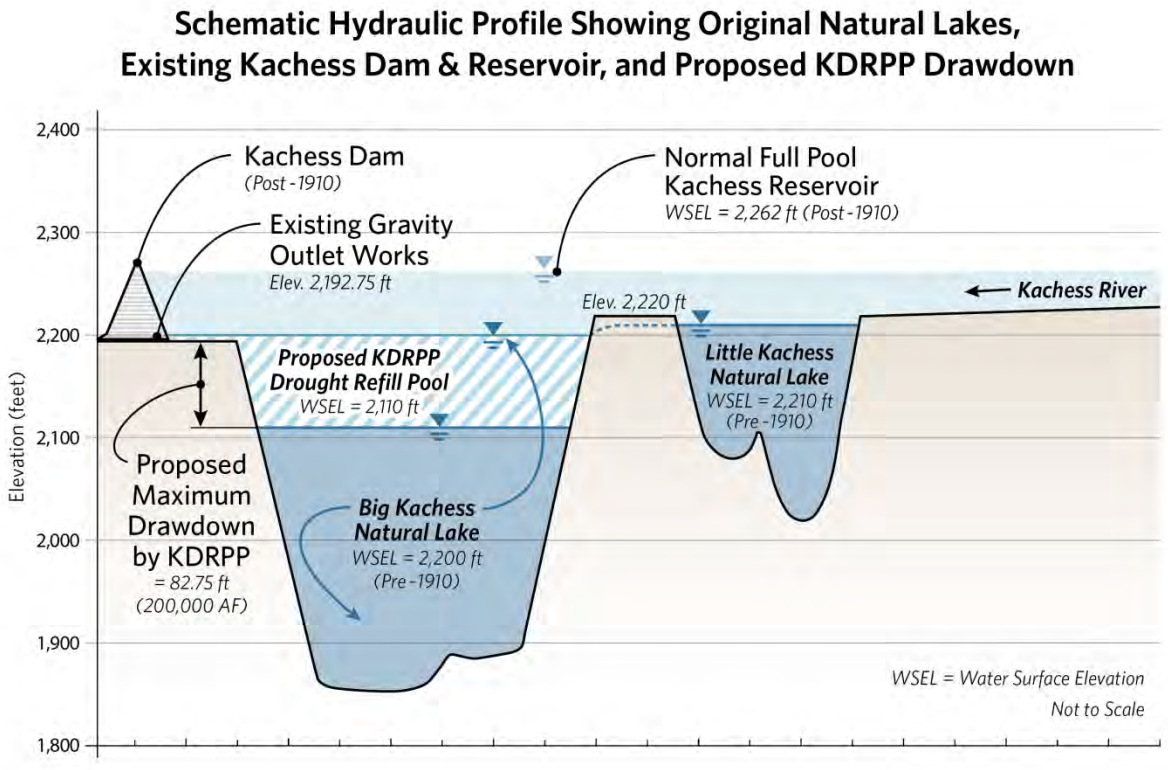


Figure 15. Kachess Reservoir Profile

4.4.2 Fish Screens

There are two common types of fish screen cleaning systems most applicable to this site and screen system: brush cleaning systems and airburst cleaning systems. The most appropriate screen cleaning system identified for these fish screens is a brush cleaning system. Electricity would power the tee screen brush cleaning systems, and a marine-rated power cord would run from the intake manifold back to the pumping station. The design team does not consider anchor ice or frazil an issue for this intake due to its depth in the reservoir.

The screen cleaning system would automatically turn on based on a maximum allowable period between cleanings, and whenever the differential head sensing system triggers the system. In the event of a loss of primary power supply to the site, it is acceptable for the fish screen cleaners to sit idle for the few hours or days when the primary power supply to the project is unavailable.

4.4.3 Pumping Units

Drought Relief Pumps

Reclamation would operate the drought relief pumps during a severe drought period and, if needed, in refill years to meet water supply demands. When called upon during a drought, these pumps would operate at up to 1,000 cfs as needed between May and October.

Fish Flow Pumps

The fish flow pumps would provide water to meet minimum instream flow requirements in the Kachess River, immediately downstream of Kachess Dam, whenever the water level in the reservoir is below the elevation of the existing gravity outlet works and the drought relief pumps are not operating.

Seepage Sump Pumps

The seepage sump pumps would operate continuously to remove seepage water that enters the pumping plant shaft from within the pumping plant.

4.4.4 Health and Safety

The various health and safety systems for the project must be fully operable at all times. In the event of loss of primary power supply to the site, the onsite emergency backup power supply would power the health and safety systems.

4.4.5 Operation and Maintenance

Each winter and spring, Reclamation forecasts possible drought conditions affecting Yakima Project operations. Reclamation updates predictions frequently based upon the amount of precipitation that has fallen and the water content contained in the existing snowpack. Reclamation would need to maintain the KDRPP, and the drought relief pumps in particular, in a ready condition for use in any year. This need requires that Reclamation spin the pumps and test the ancillary systems on a regular basis every year. During final design, it is recommended that a detailed maintenance schedule be developed for the equipment and systems needed to operate the project.

4.4.6 Replacement

Reclamation would perform a detailed inspection of project facilities on a five-year cycle. Detailed inspections would look at the condition of the fish screens, intake tunnel, pipeline (for Alternative 1), pumping plant shaft, building enclosure, discharge structure, surge tank, transmission line, and substations.

The design team anticipates a 50-year cycle of replacement for the equipment. This includes the fish screens and their cleaning system, large pumping units, ancillary systems, building enclosure, electrical system, instrumentation and controls, and power supply components.

4.5 Comparison of Alternatives

Table 9 provides a summary of the differences between Alternative 1 and Alternative 2.

Table 9. Comparison Summary of KDRPP Alternatives

Project Feature	Alternative 1- East Shore Pumping Plant	Alternative 2- South Pumping Plant	Advantages and Disadvantages
Fish Screens	Vertical Orientation	Horizontal Orientation	Power supply to the motor operated screen cleaners would be approximately 2,475 feet longer for Alternative 2.
Inlet Shaft	25-foot diameter, 52-foot deep	None	Alternative 1 would require an inlet shaft to connect the pumping plant shaft to the tunnel.
Tunnel	Mined in rock, 711-foot long	Bored in soil, 3,275-foot long	There is limited geotechnical information available for Alternative 2. More information would be required to determine any specific advantages or disadvantages for that alignment.
Surge Tank	110-foot diameter, 43-foot deep	50-foot diameter, 200-foot deep	Alternative 2 would be more complex and take twice as long to construct.
Pumping Plant Shaft	110-foot diameter, 215-foot deep, 7-foot wall thickness	110-foot diameter, 145-foot deep, 5-foot wall thickness	The Alternative 1 pumping plant shaft would be approximately 70 feet deeper. Due to the location of the pumping plant, Alternative 1 would have greater visual impacts and may require additional property easements or acquisitions.
Transmission Line	~ 5 Miles of 115 kV	~ 3 Miles of 115 kV	The transmission line for Alternative 1 would be approximately 2 miles longer. Alternative 2 could potentially use the over-build approach to bring the new higher voltage power supply to the KDRPP using the existing utility line corridor that supplies power to the Kachess Dam site now.
Drought Relief Pumps	13,000 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	7,100 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	Alternative 2 would have a smaller sized transformer since the pumping units require less power to operate. This alternative would have lower power costs.
Variable Frequency Drives	Yes	Yes	This feature is the same for both alternatives.
Throttling Valves	No	Yes	The design of Alternative 2 is more complex due to the wider range of total dynamic heads and requires throttling valves to operate at the lowest total dynamic head.
Pump Control Valves	Yes	Yes	This feature is the same for both alternatives.
Pump Discharge Pipes	Manifold into one 136-inch diameter pipe	Four separate 84-inch diameter pipes	The design of Alternative 2 is more complex due to the wider range of total dynamic heads and therefore requires four separate discharge pipes to operate at the lowest total dynamic head.
Pipeline	7,755 feet, 136-inch diameter steel pipe	None	The Alternative 1 would include additional pipeline maintenance requirements. Alternative 1 would result in an additional 10 acres of habitat loss.
Spillway & Stilling Basin	Yes	None	The Alternative 1 would have additional maintenance requirements associated with the spillway and stilling basin.
Discharge Structure	Yes	Yes	This feature is the same for both alternatives.

Project Feature	Alternative 1-East Shore Pumping Plant	Alternative 2-South Pumping Plant	Advantages and Disadvantages
Local Impacts during Construction	Potential traffic and cultural resources impacts	Potential traffic and cultural resources impacts	Alternative 2 would have less noise disturbance during construction.
Construction Cost Estimate	$385 million	$383 million	The construction costs for Alternatives 1 and 2 are approximately equal. Construction cost includes field cost plus non-contract cost. .

4.6 Preferred Alternative Not Determined

At this time, the project team has gathered only limited geotechnical data for the South Pumping Plant Alternative. If geological conditions are favorable for Alternative 2, then it appears that Alternative 2 would have lower construction and operation costs and, therefore, would likely be Reclamation's Preferred Alternative based on technical and cost considerations. If geotechnical conditions for the Alternative 2 shafts, tunnel, and intake are not favorable, then Alternative 1 would likely have less construction risk while having costs similar to those for Alternative 2. In this case, Reclamation would likely prefer Alternative 1. In addition, Reclamation will complete the environmental evaluation and issue a Final EIS prior to determining the preferred alternative.

(As noted previously, a group of proratable irrigation districts is now considering a floating pumping plant alternative, because of high costs of the alternatives requiring a deep tunnel as discussed in this Final Draft Feasibility Planning Report. Reclamation and Ecology are preparing a Supplemental Draft EIS to include the floating pumping plant alternative.)

4.7 Recommendations for Further Study

Reclamation would consider the following items for further study if the KDRPP advances to the next design phase (Reclamation and Ecology, 2015b).

4.7.1 Surveying and Base Map Preparation

- Conduct a survey of the KDRPP site and prepare base maps to inform final design, contract documents, and permit and real estate acquisition.
- Conduct a bathymetric survey in areas of the KDRPP site where the contractor would perform underwater work, including the marina and dock, intake and fish screen, tunnel, and stilling basin construction.

4.7.2 Geotechnical Exploration, Testing and Analysis

- Perform comprehensive geotechnical exploration, testing, and analysis.

4.7.3 Civil and Site Elements

- Verify shoreline setback requirements.

- Determine if an internal governmental agreement would be necessary for access and utility permits.
- Verify fire apparatus access requirements.
- Determine the maximum weight of trucks accessing the facility.
- Determine if paving of steeper roads would be necessary.
- Verify flow control requirements.
- Investigate the impacts of Ecology's decisions regarding permit-exempt well groundwater use.
- Verify water amenities and septic tank capacity.
- Determine if protection or relocation of existing dam safety, seepage, monitoring, and measuring facilities would be necessary.
- Determine the temporary construction access road route.

4.7.4 Hydraulic Data and Analyses

- Complete the existing discharge pool rating curve.
- Analyze (HEC-RAS Backwater Analysis) the water surface elevation in the existing discharge pool relative to the maximum total releases from Kachess Reservoir to determine the maximum high water elevation that can occur in this pool. Based on results, determine if flooding could occur in the vicinity of the KDRPP features.
- Expand on and update the transient analysis to provide appropriate hydraulic transient protection for the entire pumping system from intake to discharge.
- Assign a laboratory to conduct a detailed physical model for the pumping unit selected for final design. Confirm the desired performance characteristics of the pumping unit and its associated piping, metering, and valve configuration. Using a hydraulic model study, evaluate if surface and submerged vortices, pre-swirl, non-uniform distribution of velocity, or entrained air bubbles could become an issue during operation.

4.7.5 Corrosion and High Voltage Study

- Perform an analysis of soil corrosion potential for areas where the KDRPP would have buried metal features and design appropriate cathodic protection for these buried features.
- Evaluate the potential for the existing Bonneville Power Administration high voltage lines located near the discharge pool to affect project features adversely or to be a danger to construction and operator personnel. If necessary, develop appropriate mitigation measures.

4.7.6 Power Supply Analysis

- Advance discussions with the Bonneville Power Administration and Puget Sound Energy to determine which entity would supply power to the KDRPP.
- Determine if an "over-build" approach could be used to bring the new higher voltage power supply to the KDRPP using the existing utility line corridor that supplies power to the site now.
- If an over-build approach is not possible, perform a route study to determine the preferred route for a new transmission line from the existing Puget Sound Energy Easton Substation to the KDRPP.
- Perform the Puget Sound Energy interconnection study to determine the voltage levels in the area during full-load pumping while using alternative sources. If necessary, determine what upgrades would be required to the existing transmission system.

4.7.7 Pumping Unit Analyses

- Determine wear factor requirements for pumping units.
- Determine if a spare pumping unit would be required.
- Establish if extended operations at plant flows other than 1,000 cfs are required.
- Evaluate the use of variable frequency drives versus pump control valves, including comparison of capital, operation, and maintenance costs.
- Evaluate the back pressure on butterfly valves to ensure they would not cavitate.
- Consider using a throttling valve near the pipe discharge to control the pump operational point. Ensure that throttling valves would operate in a cavitation free zone.
- Investigate details of VFD and pump control valve settings and operating restrictions for the control system.
- Identify the procurement strategy for the pumping units early on in the development of the project and align this strategy with the schedule for the civil and structural design elements.

4.7.8 Ancillary Systems Analysis

- Coordinate the minimum required fish flow pumping capacity with environmental requirements.
- Determine operational requirements for fish flow pumps with respect to required heads and discharges.
- Determine the requirement for fish flow capability when the reservoir pool level is above the elevation of the gravity outlet works.

- Investigate Kachess Reservoir drawdown during fish flow pumping to ensure sufficient water volume is available and that the net positive suction head on the pump is available.

4.7.9 Electrical Control System Analysis

- Determine if reduced voltage soft starters in lieu of VFDs could operate two of the four drought relief pumps.
- Perform a value engineering analysis to determine if use of fans or other means could limit moisture build up and condensation inside the substation transformers during non-use periods.

4.8 Construction Schedule

Develop a reservoir operation and management plan for use during construction.

4.8.1 Environmental Assessment

Reclamation and Ecology are preparing an EIS for the KDRPP and KKC. The Draft EIS provides further details on the environmental considerations, analyses, and information needed as the design advances beyond the feasibility level (Reclamation and Ecology, 2015d).

5.0 Related Projects

Two other Integrated Plan projects occurring in the Keechelus and Kachess Reservoir area, closely related to the KDRPP, are the Keechelus-to-Kachess Conveyance (KKC), and the Bull Trout Enhancement (BTE) program. The following subsections summarize these projects and discuss their relationship with the KDRPP.

5.1 Keechelus-to-Kachess Conveyance

The KKC would divert water from the Yakima River immediately downstream from the Keechelus Reservoir outlet works and convey it through a new tunnel to Kachess Reservoir. While this Feasibility Planning Report focuses on KDRPP, it also discusses KKC because of important interactions between the two projects that affect the economic outcomes of the KDRPP (Section 9.0, Four Accounts Analysis). The Frontispiece map illustrates the general KKC project location in relation to the KDRPP. The *Keechelus-to-Kachess Conveyance Feasibility Design Report* (Reclamation and Ecology, 2015f) provides a detailed description of the KKC background, purpose, design features, and costs.

The purpose of the KKC is to improve fish habitat conditions, particularly spring Chinook and steelhead, by reducing flows in the upper 10.5 miles of the Yakima River below Keechelus Dam during periods of high reservoir releases (Reclamation and Ecology, 2015f). The project would convey water approximately 5 miles from the Yakima River immediately downstream of the Keechelus Dam to Kachess Reservoir by means of a new Yakima River diversion structure, portal drop shaft, 10-foot diameter deep tunnel, and discharge structure.

In the event that the KDRPP is constructed, an additional purpose of the KKC project is to accelerate refill of Kachess Reservoir in years following pumping by KDRPP. KDRPP would draw down Kachess Reservoir to a minimum pool level that is up to 80 feet below the current Kachess Reservoir minimum pool level, potentially affecting recreational uses, scenic qualities, and bull trout use of Kachess Reservoir and its tributaries. Eighty feet represents the maximum drawdown, but in many drought years the drawdown would be limited to 40 feet or less. In years following drawdown, Kachess Reservoir would need an extended period to refill to normal pool levels. KKC would reduce the duration of Kachess Reservoir drawdown in years following activation of the KDRPP. For example, compared to baseline conditions, during drought years, the KDRPP would draw the reservoir level down below the existing outlet works (elevation 2,192) for an average duration of 191 days. The KKC combined with the KDRPP would reduce the duration of drawdown to an average of 179 days. By doing so, KKC would reduce the impacts of the KDRPP (Reclamation and Ecology, 2015d). In addition, transfers of water through the KKC would tend to raise the Kachess Reservoir pool level in non-drought years, which could be beneficial for listed bull trout as they migrate from the reservoir into tributary streams for spawning.

Similar to KDRPP, the KKC project is currently at a feasibility stage of development. Reclamation is considering two proposed alternatives for the KKC in the current feasibility study. Reclamation and Ecology (2015f) provides further details on the proposed KKC alternatives.

5.2 Bull Trout Enhancement Plan

To help meet the goals of the Integrated Plan, Reclamation and Ecology propose to enhance the resiliency of bull trout populations in Kachess and Keechelus reservoirs, as well as elsewhere in the Yakima River basin. Reclamation and Ecology developed the Bull Trout Enhancement (BTE) Program in coordination with biologists from the Service, NMFS, WDFW, and the Yakama Nation. The BTE would support the objectives of the Integrated Plan by addressing problems with depleted populations of anadromous and resident fish and their habitat (Reclamation and Ecology, 2015d, Sections 1.5.1, and 2.4.7). The BTE actions are consistent with recommendations in the Yakima Bull Trout Action Plan (Reiss et al., 2012). A 2015 Memorandum of Understanding among Reclamation, WDFW, the Service, USFS, and Yakama Nation defines roles in the development and implementation of bull trout restoration and enhancement actions as part of the Integrated Plan (Reclamation Agreement No. R15MU13704).

Historically, bull trout populations in the Yakima River basin interacted with one another and contributed to the overall resiliency of the species. Passage barriers, including reservoir dams, have reduced movement of fish, limiting the potential for genetic exchange between populations. Currently, 8 of the 15 populations of bull trout in the Yakima River basin, including those in Kachess and Keechelus reservoirs, are isolated from one another.

Three populations of adfluvial fish (fish that live in lakes and migrate to rivers or streams) inhabit Kachess and Keechelus reservoirs: Box Canyon Creek and Kachess River populations in Kachess Reservoir, and the Gold Creek population in Keechelus Reservoir. Each population has chronically low abundance. The Yakima Bull Trout Action Plan (Reiss et al., 2012) identified the most common significant threats to bull trout populations as low abundance, passage barriers from storage dams and reservoir drawdowns, and dewatering in tributary streams where bull trout spawn and rear.

The BTE includes actions to improve habitat function and directly increase the abundance of bull trout in the reservoirs. For the Keechelus Reservoir (including its Gold Creek and Cold Creek tributaries) and the Kachess Reservoir, the BTE addresses low abundance, passage barriers, dewatering, and prey base threats. Additional elements of the BTE include two studies at Kachess and Keechelus reservoirs. One study would evaluate the enhancement of bull trout populations by translocating fish. The second study would evaluate means to improve productivity and food resources. The *Bull Trout Enhancement* technical memorandum provides further details of the BTE projects and actions (Reclamation and Ecology, 2014a).

The proposed enhancement projects are separate from the mitigation actions that may be required for the proposed KDRPP and KKC. The mitigation actions are described here as a reference and to clearly delineate the differences between mitigation and enhancement projects. Additional mitigation may be identified through environmental compliance processes. To address KDRPP and KKC project-specific bull trout impacts, Reclamation proposes to conduct the following activities:

- Adaptively manage Reclamation's emergency monitoring and passage program so that it is responsive to increased passage risk into spawning tributaries.
- Construct permanent fish passage structures or habitat modifications to minimize or fully address potential passage barriers
- Examine reservoir productivity and food web impacts from future use of Kachess Reservoir inactive storage.
- Address increased entrainment risk associated with new facilities.

In conducting mitigation and enhancement activities, Reclamation will adhere to state, Federal, and local regulations as well as consult with the Service and NMFS on ESA requirements. The *Bull Trout Enhancement* technical memorandum provides further details of mitigation actions (Reclamation and Ecology, 2014a).

5.2.1 Gold Creek and Cold Creek Enhancements

Gold Creek and Cold Creek are tributaries that flow into Keechelus Reservoir near the upstream end of the reservoir. Reclamation and Ecology evaluate proposed BTE actions at Gold Creek and Cold Creek, for which conceptual designs are available, at a programmatic level within the KKC and KDRPP Draft EIS (Reclamation and Ecology, 2015d). Reclamation and Ecology would undertake site-specific environmental analysis after completion of the KKC and KDRPP designs.

Gold Creek Passage and Habitat Improvements

To facilitate bull trout passage to upstream spawning grounds, improve rearing habitat, and reduce stranding, Reclamation and Ecology would undertake several specific actions:

- Restore the stream channel in the lower reach of Gold Creek by removing dikes, installing engineered logjams, adding downed wood debris, and reestablishing native plant communities.
- Improve the habitat value of Gold Creek Pond by returning it to a smaller natural functioning wetland. Restore groundwater flow to Gold Creek, relocating the trail away from the creek, replacing the outlet culvert with a bridge to allow fish passage, creating short kokanee spawning channels at the two inlet channels for bull trout forage, adding in-stream structures to create in-channel diversity, and laying down spawning gravels.
- Fill the artificial Helis Pond to restore groundwater flow to Gold Creek.
- Replace the bridge on USFS Road NF-4832 to restore the Gold Creek floodplain, a project for which the USFS has already prepared a NEPA Environmental Assessment and Finding of No Significant Impact (USFS, 2010).

Channel restoration would require in-water work and possibly short-term diversion of flows. Construction would require temporary access roads and the operation of heavy equipment in riparian areas. During construction, Reclamation and Ecology would implement erosion and sediment control plans. Immediately after construction, the agencies would restore disturbed areas and plant native species. All in-water work would be subject to work windows that minimize disturbance to bull trout and other species in the project area.

Cold Creek Passage Improvement

Reclamation and Ecology would remove a passage barrier at the mouth of Cold Creek at Washington State Park's John Wayne Trail to provide bull trout access to the creek. The proposal includes several activities:

- Remove the culvert that blocks passage
- Restore the Cold Creek stream channel
- Install a bridge over Cold Creek to replace the culvert

Removal of the culvert would require excavation of a portion of the John Wayne Trail where it crosses Cold Creek. To preserve recreational access, Reclamation could install the new bridge prior to excavation of the trail. Channel excavation and culvert removal would require in-water work and diversion of flow from the existing channel. Construction would require temporary access roads and the operation of heavy equipment in the riparian area. During construction, Reclamation and Ecology would implement erosion and sediment control plans. Immediately after construction, the agencies would restore disturbed areas and plant native species. In-water work would be subject to work windows that minimize disturbance to bull trout and other species in the project area.

5.2.2 Kachess Reservoir Tributary Enhancements

The BTE includes proposals to assess additional opportunities for improved bull trout passage and habitat conditions at Kachess Reservoir tributaries and at the South Fork Tieton River. If the assessments were favorable, Reclamation and Ecology would proceed with design of specific projects. The agencies would then conduct site-specific environmental analysis of the proposed improvements (Reclamation and Ecology, 2015d). They would consider the following proposals:

- Kachess River Assessment and Project Identification – Identify restoration actions to reduce or eliminate dewatering events in the Kachess River upstream of the reservoir.
- Box Canyon Creek Passage Assessment and Design – Assess the potential to provide bull trout passage over a natural passage barrier (Peek-a-boo Falls) and expand habitat upstream of the falls.

5.2.3 South Fork Tieton River Passage Improvement

Reclamation owns and operates Rimrock Reservoir on the Tieton River, which is part of the Yakima River basin. The BTE proposes to analyze the opportunities to provide bull trout passage at USFS Road 1200 near Rimrock Reservoir. This would include evaluating whether Reclamation could improve bull trout passage and habitat function downstream by adjusting operations at Rimrock Reservoir.

5.2.4 Bull Trout Translocation and Nutrient Enhancement

The BTE proposes to evaluate the potential to enhance bull trout populations in the Kachess and Keechelus Reservoirs by translocating bull trout from external populations to habitats at the reservoirs. Reclamation and Ecology would undertake a feasibility assessment to consider population status, habitat quality and quantity, habitat-limiting factors in reservoirs and tributaries, entrainment risk, fish health, threats, population dynamics, genetic analysis, extinction risk, and donor-recipient sensitivity analysis. If the evaluation recommends implementation, Reclamation and Ecology would obtain regulatory approvals, including Endangered Species Act consultation, and implement on-the-ground translocation activities (Reclamation and Ecology, 2015d).

To address the effects of reduced food sources on bull trout in the Kachess and Keechelus Reservoirs, the BTE includes proposals to increase nutrients in the nutrient-poor (oligotrophic) reservoirs and to increase abundance of the species' kokanee prey base. Reclamation and Ecology would conduct a study to evaluate the potential for nutrient enhancement and its associated impacts. Using results of the study, Reclamation and Ecology would identify and implement the best method for enhancing nutrients. In a related study, the agencies would determine whether the abundance of prey is a limiting factor for bull trout in Kachess and Keechelus Reservoirs, using results of Ecology and WDFW's ongoing food web study and the bull trout translocation feasibility study. If warranted, Reclamation and Ecology would evaluate stocking additional kokanee prey in the reservoirs (Reclamation and Ecology, 2015d).

6.0 Expected Results

This section summarizes expected water supply results of the proposed KDRPP. It includes results for KDRPP under both current conditions and with potential changed hydrologic conditions associated with climate change. The results described in this section and in the Four Accounts analysis in Section 9 do not include related projects such as KKC and BTE.

6.1 Water Supply Results

One of the goals of the Integrated Plan is to improve water supplies for proratable users. Reclamation used the RiverWare® model to evaluate how operation of the KDRPP would affect water supplies in the Yakima River basin for these users. Reclamation examined several metrics to assess how KDRPP would affect water supply. For this analysis, the following primary metrics were used to summarize and compare the water supply outcomes of modeled scenarios:

- *Total Water Supply Available* (TWSA), which is a combined measure of available water in streams and reservoirs
- *Prorationing*, which represents the percentage of a given year's supply that is available to proratable water right holders, who receive reduced supplies in low supply years
- *April through September deliveries*, which is the total volume of water Reclamation delivers to water users during the irrigation season.

To understand the effects of the project on prorationing, it is informative to review results for years from the extended period of record when prorationing was less than 70 percent under the baseline modeling scenario. Table 10 summarizes the water supply benefits of KDRPP alone and the KDRPP with KKC compared to the Integrated Plan Conservation Scenario. It summarizes modeled results for three particular metrics: the final prorationing percentage near the end of the irrigation season on September 30 of each year; the total water supply available, measured in thousand acre-feet on July 1 of each year; and the quantity of water delivered to large users over the course of the irrigation season from April 1 to September 30 of each year. The table shows how much KDRPP improves each of these metrics compared with the Integrated Plan Conservation Scenario. The Integrated Plan Conservation Scenario (also known as "IP0") assumes that Reclamation implements only the water conservation projects under the Integrated Plan. Modeling results indicate 14 years would remain when prorationing would fall below 70 percent.

Compared to this scenario, the modeled KDRPP would improve prorationing by an average of 9.6 percent; TWSA by an average of 90,500 acre-feet; and April through September major irrigation deliveries by an average of 76,600 acre-feet during these 14 years. The modeled KDRPP achieves the minimum prorationing goal of 70 percent in 3 of these 14 years. In the other 11 years, KDRPP alone does not achieve the goal. Simulated prorationing is, however, above 60 percent in 6 of these 11 years. During 7 of these 11 years, KDRPP would improve prorationing by 10 to 20 percentage points. Gains are hardest to achieve during the later years in a multi-year drought.

Additional projects from the Integrated Plan would be required in order to meet the goal in all years. Actual operations would likely be more flexible than the modeling assumptions to respond to particular conditions in any given dry year. This could improve prorationing levels beyond what the model results suggest.

Table 10 also shows the greater benefits achieved when combining the KDRPP with the KKC.

Table 10. Summary of Water Supply Improvement in 15 Years when Prorationing was less than 70 Percent under Baseline Scenario

	September 30 Prorationing (%)		July 1 TWSA (kaf)		April 1 to Sept 30 Major Irrigation Deliveries (kaf)	
Scenario	Average in 15 <70% Years	Minimum Year	Average in 15 <70% Years	Minimum Year	Average in 15 <70% Years	Minimum Year
Integrated Plan Conservation (IP0)	50.0	22.7	1,071.9	877.7	1,274.9	972.8
Improvement compared with the Integrated Plan Conservation Scenario (IP0)						
KDRPP Alone	9.6	17.7	90.5	93.4	76.6	180.3
KDRPP and KKC	11.4	20.4	107.7	104.7	91.9	203.6

kaf= Thousand acre-feet

6.2 Water Supply Results under Adverse Climate Change

Global climate change has the potential to impact water resources in the Kachess watershed and the Yakima River basin. Potential climate change-related impacts could result from changes in future temperatures and precipitation patterns, with resulting implications for stream runoff volume and timing, water temperatures, and reservoir operations.

Reclamation and Ecology evaluated the potential effects associated with climate change at a programmatic level in the Integrated Plan PEIS (Reclamation and Ecology, 2012c). Building on those studies, project-level hydrologic modeling studies of potential changes associated with climate change were conducted for the KDRPP and KKC EIS. The results of these studies are presented in the Hydrologic Modeling Report (Reclamation and Ecology, 2015c). The Integrated Plan considered three climate change scenarios: "less adverse", "adverse", and "more adverse". The adverse scenario incorporates a 1.7° C average increase in temperature, and a 3.7 percent average increase in precipitation during the 30-year period from 2030 to 2059. These changes are smaller than the changes predicted under certain sets of emission assumptions and global climate models, but are larger than others. Thus they are near the middle of (or central to) the range of climate changes predicted using global climate models considered and their assumptions.

The study explored how climate change affects water supply outcomes during the 40 years when prorationing would be less than 70 percent under the Integrated Plan Conservation Scenario (IP0) under "adverse" climate change conditions. Table 11 summarizes the water supply benefits under climate change. Output from the hydrologic modeling adverse climate change scenario indicates that KDRPP would improve prorationing by an average of 6.9 percent; TWSA by an average of 65,200 acre-feet; and April through September major irrigation deliveries by an average of 54,800 acre-feet during these 40 years (Reclamation

and Ecology, 2015a). The modeled KDRPP in "adverse" climate conditions achieves the Integrated Plan's prorationing goal of 70 percent in 5 of these 40 years. During 13 of the remaining 35 years, KDRPP would improve prorationing by 10 to 25 percentage points. Modeled gains are smaller or negative in the rest of the years. Overall, climate change is predicted to increase the need for Reclamation to operate the KDRPP over time. The modeling suggests that the KDRPP would continue to offer significant improvement in prorationing levels even under climate change conditions.

Table 11 also shows the greater benefits achieved when combining the KDRPP with the KKC under the adverse climate change scenario.

Table 11. Summary of Water Supply Benefits of Each Scenario under Adverse Climate Change in Years when Prorationing was less than 70 Percent under Baseline

	September 30 Prorationing (%)		July 1 TWSA (kaf)		April 1 to Sept 30 Major Irrigation Deliveries (kaf)	
Scenario	Average in <70% Years	Minimum Year	Average in <70% Years	Minimum Year	Average in <70% Years	Minimum Year
Integrated Plan Conservation (IP0)w CC	42.3	0.0	997.8	732.3	1,208.7	680.6
Improvement compared with Integrated Plan Conservation (IP0) w CC						
KDRPP Alone	6.9	2.5	65.2	15.7	54.8	22.6
KDRPP and KKC	10.4	6.9	90.2	37.5	84.0	67.6

7.0 Environmental Considerations

7.1 NEPA Compliance Activities

The National Environmental Policy Act of 1969 (40 U.S.C. Section 4321 et seq.) requires that the action agency determine whether there are environmental impacts associated with proposed Federal actions. The action agency must document this evaluation and present it to the public. The State of Washington has similar requirements under SEPA. Reclamation and Ecology are preparing an EIS for the KDRPP and KKC as a combined NEPA and SEPA document. Reclamation issued the Draft EIS on January 9, 2015.

Reclamation plans to issue a Record of Decision following completion of a Final EIS. The Record of Decision will document the decision on which alternative, if any, Reclamation will choose to implement and the reasons for its selection. When issued, the Record of Decision will complete the NEPA compliance process.

The KDRPP and KKC EIS evaluates environmental considerations and potential impacts of the project on elements of the environment, such as air, soil, water resources, aesthetic values, cultural resources, wildlife, and vegetation. If Reclamation advances the KDRPP to final design, results of the EIS analysis would inform design decisions to mitigate environmental impacts.

The Draft EIS provides a comprehensive discussion of the environmental impacts associated with the KDRPP. Notable environmental impacts are summarized here (Reclamation and Ecology, 2015d):

- Reclamation would draw down Kachess Reservoir by up to 80 feet below existing low pool conditions. It would take 2 to 5 years following a drought to refill. The drawdown of Kachess Reservoir would increase the occurrence and duration of reservoir pool levels below elevation 2,220. Below that elevation, fish cannot pass between the Kachess and Little Kachess basins. Relative to the No Action Alternative, this would occur 5 percent more often and the duration would increase by 56 days during those years.
- Fish impacts could also result from reduction in Kachess Reservoir minimum pool elevation which may increase water temperatures in Kachess Reservoir; expose the lower reservoir bed to wave action and increase turbidity; reduce available food-based prey; lessen shoreline vegetation and habitat complexity; and reduce connectivity between reservoir habitats as well as between reservoir and tributary habitats. Operation of the KDRPP could also increase the risk of entraining resident fishes with small larval stages in the new intake in Kachess Reservoir.
- Kachess Reservoir drawdowns during drought years would have significant visual impacts due to changes in overall landscape character and desirability from a recreation perspective. The drawdown would potentially conflict with scenic integrity and visual quality objectives. The East Shore Pumping Plant would have a significant impact because it would substantially contrast with and interrupt the visual character and integrity of the landscape.
- Recreational impacts from reservoir drawdown would be significant because the boat launch at Kachess Campground would be inaccessible more often than with the No Action Alternative. Loss of fishing opportunities would also be significant due to loss of boating access and impacts on fish species. The drawdown of Kachess Reservoir could significantly impact usability and quality of recreation during drought years and as the reservoir refills because of the extent and slope of the exposed reservoir bed.

7.2 Anticipated Permits and Regulatory Approvals

To construct the KDRPP and KKC projects, Reclamation and Ecology would obtain required permits and meet other requirements set forth by law, regulation, ordinance, and policy. Table 12 summarizes the potential permit requirements identified to date.

Table 12. Summary of Potential Permit Requirements and Other Approvals

Agency	Permits and Other Requirements	Jurisdiction or Purpose
Federal Agencies		
Service and NMFS	Endangered Species Act (16 USC § 1531)	Consultation to determine effects on threatened and endangered species.
NMFS	Magnuson-Stevens Fishery Conservation and Management Act (16 USC §§ 1801-1802)	Consultation with NMFS on activities that may adversely affect essential fish habitat to determine whether the Proposed Action "may adversely affect" designated essential fish habitat for relevant commercially, federally managed fisheries species within the area of the Proposed Action.
Service	Fish and Wildlife Coordination Act (16 USC 661066c)	Coordination with the Service on the effects of the proposed project on fish and wildlife.
Corps	Clean Water Act Section 404 (§ 404, 33 USC §1251 et seq.)	Permitting and minimization of impacts associated with the discharge of dredged or fill material into waters of the United States, including wetlands.
State Agencies		
Ecology	Clean Water Act Section 401 (33 USC § 1251 et seq.)	Issuance of a Section 401 Water Quality Certification to indicate reasonable assurance that a project will comply with Federal and State water quality standards and other aquatic resources protection requirements under Ecology's authority. Federal regulation delegated to the State. Triggered as part of CWA Section 404 authorization.
Ecology	Construction National Pollutant Discharge Elimination System (NPDES) (90.48 RCW); Clean Water Act Section 402 (§ 402, 33 USC § 1251 et seq.)	Issuance of a permit for construction projects engaged in clearing, grading, and excavating activities that disturb an area of at least 1 acre. Federal regulation delegated to the State.
Ecology	Chapter 90.03 RCW	Issue water rights, as necessary.
WDFW	Hydraulic Project Approval (77.55 RCW)	Granting of approval for construction projects that use, divert, obstruct, or change the natural bed or flow of State waters.
WDFW	Fish and Wildlife Coordination Act (16 USC 661066c)	Coordination with WDFW on effects of the project on fish and wildlife species.
Washington Department of Archaeology and Historic Preservation (DAHP)	National Historic Preservation Act (NHPA) (16 USC § 470 et seq.)	Section 106 Consultation to determine whether the project would impact historic or cultural resources; to be completed by Reclamation and Ecology. DAHP advises and assists Federal agencies in carrying out their Section 106 responsibilities.
Local Agencies		
Kittitas and Yakima Counties	Critical Areas Ordinance, Shoreline Master Program	Granting of approval for actions on private land within the Counties shoreline jurisdiction.

Source: Kachess Drought Relief Pumping Plant Project and Keechelus Reservoir-to-Kachess Reservoir Conveyance Draft Environmental Impact Statement (Reclamation and Ecology, 2015d)

8.0 Cost Estimate

This section summarizes estimated costs of the alternatives. Estimates were prepared using the same assumptions and unit prices to be directly comparable from a cost standpoint. *Kachess Drought Relief Pumping Plant Field Cost Estimates* (Reclamation and Ecology, 2015e) and *Ancillary Costs of Kachess Drought Relief Pumping Plant* (HDR, 2015) describe additional information on methods and results of cost estimation. Costs described in this section include the following:

- Field costs
- Non-contract costs
- Operation, maintenance, replacement and power costs
- Interest during construction

8.1 Quality Assurance

Reclamation utilizes a quality assurance plan to ensure comprehensive identification and accurate quantification during cost estimating.

The HDR cost estimating team for this study employed quality assurance procedures throughout the development of the KDRPP field cost estimate. The team developed the feasibility-level cost estimate format and approach by building on the appraisal-level cost estimate and in consultation with Reclamation Technical Service Center estimators. HDR and Jacobs Associates cost estimators prepared the draft field cost estimate based on the feasibility-level design. HDR also engaged additional staff from HDR, Brierley Associates, and Engineering Solutions to perform independent quality reviews of the field cost estimate. The cost estimating team evaluated the independent reviewers' comments and incorporated revisions, where appropriate. Reclamation staff then thoroughly reviewed the draft cost estimate, provided comments, and discussed them with the cost estimating team. A final estimate was then prepared.

8.2 Field Cost Estimate

Field cost estimates for the KDRPP were prepared in fall 2014. A technical memorandum titled, *Kachess Drought Relief Pumping Plant Field Cost Estimates* (Reclamation and Ecology, 2015e) documents the field cost estimates. "Field costs" are capital costs from procurement to construction closeout. Field costs include mobilization by the construction contractor, materials, fabrication, and installation. Field costs also include construction contingencies and sales tax, as well as allowances for unlisted items and procurement strategies. The following section summarizes the KDRPP field cost estimate approach and results.

8.2.1 Field Cost Estimating Approach

The cost estimating team developed the field cost estimates at the feasibility level in accordance with the following sections of the Reclamation Manual:

- FAC P09, Policy
- FAC 09-01, Cost Estimating
- FAC 09-02, FAC 0-02, Construction Cost Estimates and Project Cost Estimates

The Reclamation Manual provides policies, directives, and standards for Reclamation activities. The "FAC" series pertains to project planning activities, including feasibility-level studies.

The cost estimating team developed the field cost estimates using a combination of stochastic and deterministic methodology, whichever was the most appropriate for each aspect of the project. "Stochastic methodology" involves estimation-based variables, such as total cost per unit of storage or flow, based on similar projects constructed elsewhere with appropriate adjustments for location and time. "Deterministic methodology" involves calculations from definable project information. This information is usually developed to the point where specific quantities may be estimated (e.g., reinforced concrete walls) and costs determined by using forecast unit prices (e.g., price per cubic yard) for those estimated quantities (Reclamation and Ecology, 2015e).

The feasibility study quantified the work to the greatest extent practical from existing feasibility design documents, standard designs for similar work, and supplemental drawings to provide a mix of deterministic and stochastic methodologies. Notes were included within the individual estimate item descriptions to document the assumptions and clarifications necessary to estimate the project. The cost estimating team used the following procedures, tools, and database to develop these field cost estimates:

1. First, the cost estimating team reviewed the feasibility design documents, drawings, photos, and reports in sufficient depth to have an understanding of the feature characteristics of the proposed projects and developed questions for the design team. The design team and estimating team discussed the project features.
2. Second, the cost estimating team developed the pay items for each project element to comply with the Reclamation Uniform Classification Accounts Pay Items.
3. Next, the design team provided the estimating team with the project work breakdown structure and developed quantities for the estimators to use. The design team also provided estimates for items not included in the RS Means Construction Cost database.
4. In addition, the cost estimating team contracted Gregg Sherry, P.E. of Brierley Associates, to advise on tunneling, shaft, and marine work costs, and Dan Hertel, P.E. of Engineering Solutions, LLC, to advise on the heavy civil construction costs. The cost estimating team used an Opinion of Probable Cost provided by Brierley Associates from a similar sized project to verify projected costs and production rates. The cost estimating team also contracted Jacobs Associates to prepare independent cost estimates for tunnel and shaft construction. The independent cost estimates

prepared by Jacobs Associates are contained in Appendix C of the *Kachess Drought Relief Pumping Plant Field Cost Estimate* (Reclamation and Ecology, 2015e).

5. Finally, the cost estimating team estimated the work in Timberline EOS Extended Estimating software, using the latest RS Means Construction Cost database. The RS Means database contains over 75,000 individual unit prices updated quarterly. The bases of labor costs were wages for 46 building trades in 314 major cities in North America. The bases for costs at individual locations were indices for 989 zip code locations.

The cost estimating team indexed construction costs shown in this section to the midpoint of construction. Therefore, the costs shown are different from those used in the economic analysis described in Section 9. The economic analysis uses unescalated costs.

Table 13 is a summary of the markup percentages used in each field cost estimate. The design team examined Reclamation documents and previous estimates for project-by-project features and combined them with the cost estimating team's experience for this type of work to select appropriate markup percentages for each of the following components (Reclamation and Ecology, 2015e). Reclamation would revisit markup values once specific requirements related to field activities and reporting for the construction contractor are established.

Table 13. Summary of Markup Percentages

Indirect Cost Element	Percentage
Contractor's field overhead	12.00%
Prime Contractor Mobilization / Demobilization Cost	3.00%
Unlisted Minor Items	4.00%
Design and Scope Changes Minor	4.00%
Cost Refinements Minor	2.00%
Contractor's Bonds and Insurance Cost	1.50%
Contractor's Fee	12.00%
Construction contingencies (includes overruns on quantities, quantity gap, FTE minimal work hours adjustments, ect.)	25.00%
Escalation to the Midpoint of Construction (anticipate 2nd QTR 2017)	6.05%
Sales Tax Estimate	8.20%
Gross Receipts Tax (GRT)	0.484%

Based on the nature and size of the work, the cost estimating team did not include any markup percentage for procurement strategy, but rather based each estimate on an open competition, sealed bid procurement strategy.

8.2.2 Specialty Item Quotes

For specialty items, the cost estimating team obtained quotes from manufacturers and suppliers for the field cost estimates. (Reclamation and Ecology, 2015e provides documentation of specialty quote items.) The team obtained quotes for the following items:

- Drought Relief Pumps

- Large variable frequency drive (VFD)
- Ball & Large Butterfly Valves
- Plug and Check Valve - Dezurik
- Pumping Plant Steel Pipe (within Building)
- Pipeline Steel Pipe (Alternative 1- East Shore Pumping Plant)
- Gate & Check Valves - ACIPCO
- Flowmeters
- Fish Screens
- Fish Flow-Unwatering-Drainage Pumps
- Elevator
- Bridge Crane
- Bonneted Gates

8.2.3 Summary of Field Cost Estimate

Table 14 summarizes the total field cost estimates developed for the two KDRPP alternatives (Reclamation and Ecology, 2015e). Line items for project components are shown in 2014 dollars (second quarter). Escalation to the midpoint of construction is then added to produce the total field cost.

The low and high costs reported in Table 14 represent a slightly narrower range (-15 percent to +30 percent) than the range used for KKC (-20 percent to +40 percent). This is because a large share of the costs of KKC represents underground construction, and only limited geotechnical information for the KKC tunnel route and shaft locations was available at the time Reclamation prepared the cost estimate. KDRPP also includes major underground features, but they represent a smaller portion of the total cost than KKC, and Reclamation has more information on subsurface conditions at key locations.

Table 14. Field Costs for KDRPP Alternatives

Project Components	Alternative 1 (in millions $$)	Alternative 2 (in millions $$)
01 Site Work	$ 1.74	$ 1.44
02 Fish Screens	$ 2.89	$ 3.59
03 Surge Tank (Alt 1)	$ 6.55	$ -
03 Surge Tank Shaft (Alt 2)	$ -	$ 12.43
04 Tunnel Access Shaft, Tunnel & Intake Shaft (Alt 1)	$ 8.88	$ -
04 Tunnel & Docking Station (Alt 2)	$ -	$ 41.09
05 Pumping Plant Shaft	$ 31.47	$ 22.08
06 Drought Relief Pumping Units	$ 40.69	$ 35.68
07 Ancillary Systems	$ 22.70	$ 21.32
08 Building	$ 11.31	$ 11.83
09 Pipeline (Alt 1 only)	$ 20.91	$ -
10 Outlet Works	$ 0.90	$ 0.89
11 Electrical	$ 13.30	$ 10.57
12 Instrumentation & Controls	$ 0.68	$ 0.94
13 Power Supply	$ 8.16	$ 7.05
Materials & Labor Cost Subtotal	$ 170.19	$ 168.91
Contractors Field Overhead (12%) / Mobilization - Demobilization (3%)	$ 25.53	$ 25.34
Estimated State Sales Tax (8.2%)	$ 11.59	$ 12.02
Subtotal	$ 207.31	$ 206.26
Unlisted Items (4%), Scope Changes (4%), Cost Refinement (2%)	$ 20.73	$ 20.63
Subtotal	$ 228.05	$ 226.89
Contractor Fee (12%)	$ 27.37	$ 27.23
Contract Cost Subtotal	$ 255.41	$ 254.12
Undefined Scope of Work (SOW) Contingency (25%)[1]	$ 57.01	$ 56.72
Escalation to the Midpoint of Construction (6.05%)[1]	$ 13.80	$ 13.73
Subtotal	$ 326.22	$ 324.57
Bond & Insurance (1.5%)	$ 4.89	$ 4.87
Estimated Gross Receipts Tax (0.484%)	$ 1.60	$ 1.59
Subtotal	$ 332.72	$ 331.03
Field Cost Total	$ 332.72	$ 331.03
Forecast Field Cost Low (-15%)	$ 282.81	$ 281.37
Forecast Field Cost High (+30%)	$ 432.53	$ 430.34

1) Contingency and Escalation costs are calculated from the Unlisted Items, Scope Changes, Cost Refinement Subtotal.

8.3 Ancillary Costs

The following are other cost categories needed to complete the feasibility study:

- Non-contract costs
- Operations, maintenance, replacement and power costs
- Interest during construction

Summarized below are these ancillary cost categories. The *Ancillary Costs of Kachess Drought Relief Pumping Plant* memorandum (HDR, 2015) describes them in detail.

8.3.1 Non-Contract Cost Estimate

"Non-contract costs" are work or services provided in support of the project. They include investigations, design and specifications, construction management, environmental compliance, archeological considerations, and operation and maintenance during construction (if applicable); as well as lands and rights; and relocation of property by others. Reclamation FAC 09-01 "Cost Estimating" and FAC 09-02 "Construction Cost Estimates and Project Cost Estimates" provide further explanation of non-contract cost estimates.

HDR and Reclamation staffs reviewed these guidance materials and identified cost categories applicable to KDRPP. Table 15 shows the categories and estimated costs. Reclamation used the more expensive of the two alternatives considered in the feasibility study, which is the East Shore Pumping Plant to estimate non-contract costs. HDR, 2015 provides further documentation for each cost category.

Table 15. Summary of Non-Contract Costs

Item	Staff Days	Staff Cost	Other Costs	Total
I. Design Data Collection				
A. Land Survey	10	$20,000	$80,000	$100,000
B. Geotechnical Investigation	200	$290,000	$4,600,000	$4,890,000
C. Special Studies	0	$0	$1,300,000	$1,300,000
D. Design Engineering	10,500	$17,590,000	$150,000	$17,740,000
E. Cost Estimating, 60%, 90% and 100%	170	$250,000	$0	$250,000
F. Procurement	24	$19,200	$0	$19,200
G. Design Oversight	470	$470,000	$30,000	$500,000
Subtotals	11,374	$18,639,200	$6,160,000	$24,799,200
II. Construction Engineering				
A. Construction Engineering & Management	23,700	$28,900,000	$3,600,000	$32,500,000
B. Materials Testing	0	0	$200,000	$200,000
C. Project Management	990	$1,740,000	$30,000	$1,770,000
D. Safety Program	24	$19,200	$0	$19,200
Subtotals	24,714	$30,659,200	$3,830,000	$34,489,200
III. Other Items				
A. Lands and Rights	12	$80,000	$25,000	$105,000
B. General Costs	N/A	N/A	N/A	N/A
C. Environmental Mitigation	N/A	N/A	$6,020,000	$6,020,000
D. Legal Services	40	$48,000	$0	$48,000
E. Permit Acquisition	40	$32,000	$0	$32,000
F. Value Engineering	180	$180,000	$20,000	$200,000
Subtotals	272	$340,000	$6,065,000	$6,405,000
Totals (rounded)	40,000	$50,000,000	$16,000,000	$66,000,000

8.3.2 Operation, Maintenance, Replacement, and Power Costs

Operations, maintenance, replacement, and power costs include the following components. The *Ancillary Costs of Keechelus-to-Kachess Conveyance* Memorandum (HDR, 2015) provides details of these costs. Costs reported here are for the more expensive alternative to operate, which is the East Shore Pumping Plant Alternative.

- Annual costs of operating and maintaining the project: $261,900 per year
- Annual costs of power in all years: $48,300 per year
- Annual pumping power costs in years when KDRPP is operational: $502,500
- Annual pumping power costs in years when KDRPP is not operational: $29,100
- Maintenance inspections: $94,500 once every 4 years
- Periodic costs for replacement or refurbishment of major equipment or infrastructure elements: $64,594,800 once every 50 years

In present value terms, for Alternative 1, total costs of operations, maintenance, replacement and power over 100 years would be $34.1 million, or $341,000 per year on average. For Alternative 2, this would be $27.1 million over 100 years, or $271,000 per year on average.

Under the No Action Alternative, Reclamation would not construct new facilities and, therefore, would not incur construction costs. Since the KDRPP would not be in place, the operations, maintenance, replacement, and power costs for the No Action Alternative is zero. Reclamation would continue its operations, maintenance, replacement, and power costs on existing facilities.

8.3.3 Interest during Construction

Interest during construction represents the Federal cost of interest while constructing the project. (It does not include interest on the costs of design, planning, or permitting.) To calculate interest during construction, HDR used a spreadsheet provided by Reclamation. Estimated interest during construction is $ 26,760,000 for the East Shore Pumping Plant and $26,650,000 for the South Pumping Plant (HDR, 2015).

8.4 Total Cost

Table 16 lists the estimated total 100-year costs for the East Shore Pumping Plant and South Pumping Plant. Reclamation prepared these cost estimates for comparison between the alternatives. Both alternatives used the same assumptions and unit prices to allow costs to be directly comparable (Reclamation and Ecology, 2015d). Costs are in present value terms, discounted at 3.375 percent.

Table 16. Comparison of East Shore Pumping Plant and South Pumping Plant Estimated Costs (Present Value)

Cost Categories	East Shore Pumping Plant	South Pumping Plant
Field Cost	318,920,000	317,301,000
Interest During Construction	26,761,000	26,648,000
Noncontract Cost	66,000,000	66,000,000
Subtotal: Construction Cost	411,681,000	409,949,000
O&M Cost (100 years)	8,121,000	7,925,000
Power Costs (100 years)	14,078,000	8,448,000
Replacement Cost (100 years)	11,885,000	10,780,000
Subtotal: OMR&P	34,084,000	27,153,000
100-YearTotal	445,765,000	437,102,000

Note: O&M costs in this table are discounted at 3.375 percent
O&M = operations & maintenance; OMR&P = operations, maintenance, replacement and power.

8.5 Cost-Risk Analysis

Reclamation uses cost-risk analysis to provide confidence in cost estimates and help make informed decisions while evaluating a project. Reclamation and Ecology held a two-day cost-risk analysis workshop on the KDRPP project in March 2015. Cost-risk analysts from HDR Engineering led the event, which included experts on cost estimation, geology, construction engineering, and tunneling as well as members of the feasibility design team. Participants examined the material quantities and unit rates in the base cost estimate and established uncertainty ranges for these values. They identified a range of risks and opportunities that could increase or decrease the construction schedule duration, construction cost, or both. For each risk/opportunity event, the workshop team estimated a probability of occurrence and level of impact. The group also identified risk-response strategies that could mitigate each risk item.

The HDR Engineering cost-risk analysis team used information from the workshop to model the overall uncertainty of cost and schedule. Monte-Carlo simulation was used to generate differing combinations of risk/opportunity events based on their respective probabilities of occurrence. This provided probabilistic estimates of the expected value of project costs for each of the two alternatives. The range of costs based on expected values at the 10^{th} and 90^{th} percentiles is relatively narrow, with the 90th percentile value approximately 17 percent higher than the 10th percentile value. Risk-mitigation strategies for the South Pumping Plant Alternative provide only a minor impact on expected value costs; while risk-mitigation strategies for the East Shore Pumping Plant Alternative could have a larger effect. The top risk mitigation strategies for the East Shore Pumping Plant Alternative are:

- If the KKC environmental review encounters significant delays, consider completing the environmental review for KDRPP separately from KKC.
- Change Kachess Reservoir operations during construction to bring the pool level below 2200' for a total of six months over the three-year construction period (either all at once or split across construction seasons). This is needed for construction of the shallow buried pipeline along the southeast shoreline of the reservoir.

The top risk mitigation strategies for the South Pumping Plant Alternative are:

- If the KKC environmental review encounters significant delays, consider completing the environmental review for KDRPP separately from KKC.
- Pre-qualify the tunnel-construction contractor and provide performance-based specifications for the tunnel-boring machine.

Additional geologic investigations along the South Pumping Plant Alternative alignment would be useful for refining the cost of this alternative.

9.0 Four Accounts Analysis

Economic outcomes of the KDRPP are projected using procedures consistent with the Federal *Principles and Guidelines* (1983). It builds on the Four Accounts Analysis of the entire Integrated Plan completed in October 2012 (Reclamation and Ecology, 2012a). That analysis described the economic effects of the Integrated Plan in the aggregate. The 2012 analysis did not assess the effects of specific projects included under the Integrated Plan. For the KDRPP, ECONorthwest applied the models and data developed and compiled for the overall plan to the fullest extent appropriate for the individual project analyses, with data updates and adjustment to 2014 dollars. The four accounts are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE).

The subsections below present results for each of the four accounts. The *Economic Analyses of the Proposed Kachess Drought Relief Pumping Plant Project* technical memorandum (Reclamation and Ecology, 2015a) provides details on the analysis of these four accounts. The results described in this section do not include related projects such as KKC and BTE. Results for KKC are presented in a separate planning report for that project.

9.1 Relationship of KDRPP NED Results to Full Integrated Plan Results

The Integrated Plan is a comprehensive approach to managing water resources and ecosystem restoration improvements, responding to recurring droughts in the Yakima River basin and the risk of climate change. Reclamation and Ecology developed the Integrated Plan in 2011 in collaboration with the Yakama Nation, irrigation districts, environmental groups, other Federal agencies, the State of Washington, and local governments. The Integrated Plan addresses seven elements: reservoir fish passage, structural and operational changes to existing facilities, surface water storage, groundwater storage, habitat/watershed protection and enhancement, enhanced water conservation, and market reallocation. As a whole, the Integrated Plan would benefit fish and irrigation and offer a synergy that would otherwise be unattainable without the plan.

Reclamation and Ecology estimate the total cost for implementing the Integrated Plan at $3 to $5 billion (plus annual operation and maintenance costs estimated at $10 million), and anticipate its implementation over 30 years.

Reclamation and Ecology would implement the Integrated Plan in phases, using a balanced approach. A "balanced approach" means that during each phase, Reclamation and Ecology would advance activities representing the full spectrum of Integrated Plan components (e.g., storage, fish passage, water conservation, habitat restoration, etc.). Concurrent implementation of balanced elements provides the best opportunity to achieve synergistic benefits of the Integrated Plan for ecosystem improvement and water supply

In March 2014, Reclamation and Ecology identified an Initial Development Phase, covering the first ten-year period (2014-2023). It would advance all seven plan elements and would represent approximately one-quarter of the estimated plan cost (about $900 million). The Initial Development Phase would include implementation of Cle Elum Fish Passage, Cle

Elum Pool Raise, Kachess Drought Relief Pumping Plant, and Keechelus-to-Kachess Conveyance; and components associated with each element of the Integrated Plan, such as habitat restoration, agricultural conservation, and groundwater recharge. The Initial Development Phase would also supplement a $99 million acquisition of watershed lands under the Integrated Plan, executed in 2013 by the State of Washington in the Teanaway River subbasin (the Teanaway River flows into the Yakima River).

In order to maintain the balanced approach, one of the large water supply projects should be developed during the Initial Development Phase of the Integrated Plan. KDRPP was selected from the list of proposed water supply projects because Reclamation and Ecology determined it could be designed, permitted and brought on line more quickly and at lower cost than the other two projects designed to provide large increments of water supply for irrigated agriculture (Bumping Reservoir Enlargement, and Wymer Dam and Reservoir). Reclamation and Ecology intend that the Initial Development Phase should provide concurrent benefits for water supply and fisheries, and implementation of KDRPP during the Initial Development Phase contributes to the achievement of water supply objectives, balancing habitat benefits from other Integrated Plan projects and programs.

Reclamation and Ecology recognize that if the Integrated Plan were separated into pieces, economic analysis of the pieces would not result in all components showing positive benefit-to-cost ratios by themselves. However, the Federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles and Guidelines*) (Water Resources Council, 1983) indicate that components should be analyzed individually. Reclamation developed the information presented in this section in order to address this requirement.

Reclamation and Ecology issued a Four Accounts analysis of the Integrated Plan at full build out (30-year costs) in 2012 (Reclamation and Ecology, 2012a). That analysis tabulated the combined benefits and costs of the full suite of Integrated Plan projects and programs. Analyzed as a whole, the Integrated Plan yields a highly favorable benefit-to-cost ratio ranging from 1.4 to 3.2. The costs of the KDRPP represent approximately 11 percent of the total cost of the Integrated Plan. The quantified benefits of the KDRPP represent slightly less than 3 percent of the total quantified benefits of the Integrated Plan if Reclamation and Ecology do not consider the effects of climate change. This rises to 4 percent if the agencies do consider the effects of climate change.

9.2 National Economic Development

The National Economic Development (NED) account displays changes in the economic value of the national output of goods and services attributable to the individual project. The Federal objective is to contribute to national economic development consistent with protecting the Nation's environment. The NED account measures the beneficial and adverse monetary effects of projects and actions in terms of changes in the value of the national output of goods and services. It includes value estimates for project benefits and costs (Reclamation and Ecology, 2015a).

9.2.1 Overview of Federal Guidance

The definition of beneficial effects in the NED account includes increases in three categories: (1) the economic value of the national output of goods and services from a plan; (2) the value of output resulting from external economies caused by a plan; and (3) the value associated with the use of otherwise unemployed or under-employed labor resources.

Adverse effects in the NED account are the opportunity costs of resources used in implementing a plan. These adverse effects include implementation outlays, associated costs, and other direct costs.

The NED analysis includes the following set of basic assumptions:

- Installation period (the number of years required for installation)
- Installation expenditures (costs incurred for each year of installation)
- Period of analysis (lifespan or time horizon of the project over which benefits and costs occur, which includes installation and a period of time sufficient to capture significant beneficial or adverse effects, not to exceed 100 years)
- Benefit stream (the pattern of benefits that materialize over the period of analysis, calculated in average annual equivalent terms)
- Operation, maintenance, and replacement costs (the pattern of costs that materialize over the period of analysis necessary to maintain the stream of benefits)
- Discount rate (the rate at which both benefits and costs are adjusted)

The following sections describe the assumptions and results of the NED analysis.

9.2.2 Assumptions for the Analysis

- Analytical Approach: The directions outlined in Chapter II of the *Principles and Guidelines* provide methods to estimate each type of benefit and cost included in the KDRPP economic analyses. The quantitative analyses focus on benefits and costs expected to arise from significant project effects. The *Economic Analyses of the Proposed Kachess Drought Relief Pumping Plant Project* report analyzes KDRPP relative to a baseline scenario without climate change, and under adverse climate change conditions. Where relevant, the analyses address interactive effects with the KKC as well (Reclamation and Ecology, 2015c).
- Installation Period and Installation Expenditures: The analysis tailored the installation period to the construction period for each project component and alternative, as detailed in the feasibility design studies. Expenditures come from the feasibility design study field cost estimates and from noncontract costs (Reclamation and Ecology, 2015e; HDR, 2015). Section 8.0, Cost Estimate, provides more detailed information on project costs.
- Period of Analysis: The analysis considers all projects and effects within a 100-year timeframe that begins when project benefits start to occur. For the KDRPP, this period begins in the year following completion of construction. Therefore, construction costs occur prior to the 100-year project timeframe.

- Benefit Stream: Benefits include improved net farm earnings that are possible because of increased irrigation water supply and avoided groundwater pumping costs for municipal water supply. Reclamation carefully structured the NED analysis to avoid "double-counting" of benefits. Irrigation and municipal benefits derive from additional supply held in storage. The breakdown of irrigation and municipal benefits is based on relative shares of water supply allocated to different water users within these categories. This approach avoids overlaps in quantifying benefits.
- Benefit Prioritization and Uncertainties. These benefit categories were selected for analysis because they are the most pronounced categories of effects on valuable goods and services quantifiable for KDRPP. The hydrologic model used to analyze outcomes generally prioritizes reach-by-reach streamflow objectives under the Integrated Plan ahead of improvements in water supply. Once the model achieves flow objectives, it assigns available water to be held in storage up to the limits of storage capacity and other operational rules. The NED analysis addresses uncertainties in water supply benefits primarily through consideration of extensive water supply and drought historical data, and simulation of effects on those data of adverse climate change conditions.
- Operation, Maintenance, and Replacement Costs: The proposed projects include operation and maintenance costs for the full timeframe, as well as scheduled capital replacement costs based on equipment lifespans. The following subsections provide discussion of the specific categories of costs evaluated for each project alternative.
- Discount Rate: The analyses incorporate a discount rate of 3.375 percent where appropriate, which is the applicable rate that Federal agencies use in the formulation and evaluation of water and related land resources plans in fiscal year 2015, October 1, 2014 to September 30, 2015 (Reclamation, 2014a). Discounting of costs and benefits begins in the first year of the 100-year period of analysis, which for the KDRPP is the first year after completion of construction.

9.2.3 National Economic Development Quantified Benefits

The following subsections provide discussion of the specific categories of benefits evaluated for each project and alternative.

Water Supply for Agriculture

Analysis of water supply outcomes from KDRPP (presented in Section 6.1, Water Supply) showed that under historical conditions, the KDRPP would provide substantial drought relief beyond baseline conditions. When probabilistically weighing intervals across all years under historical climate conditions, KDRPP provides $7.5 million annually in terms of increased net farm earnings relative to the baseline, and $214 million in net present value (NPV) summed over the 100-year timeframe and discounted at 3.375 percent. When combined with KKC, these benefits increase to $8.7 million annually and $248 million over 100 years (Table 17).

Results are slightly different when accounting for climate change conditions. For modeling purposes, this assumed climate change would begin approximately 20 years in the future, or year 2037. Under the "adverse" climate change scenario, the annual benefits of KDRPP alone climb to approximately $15 million and yield $315 million over the 100-year timeframe in NPV. The addition of KKC increases annual benefits to approximately $22 million and discounted 100-year benefits to $414 million (Table 17).

There is considerable uncertainty regarding likely future drought severity and frequency patterns for the Yakima River basin. Choosing varying lengths of historical data generate quite varied average annual estimates. When combined with adverse climate conditions, these estimates can vary even more widely. If adverse climate change conditions are assumed for the entire 100 year timeframe, the benefit of the KDRPP over 100 years climbs to $417 million, and the total benefit of the KKC combined with the KDRPP climbs from $432 million to $618 million.

Table 17. Net Farm Earnings Benefits of KDRPP

	KDRPP Alone	KDRPP with KKC
Annual, with Historical Conditions	$7.5 million	$8.7 million
100-Year NPV, with Historical Conditions	$214 million	$248 million
Annual, with Climate Change	$15 million	$22 million
100-Year NPV, with Climate Change	$315 million	$432 million

Note: NPV calculations based on 3.5 percent discount rate.

Water Supply for Municipal Use

The City of Yakima has 5,083 acre-feet of proratable entitlements, as well as other water rights (Reclamation and Ecology, 2011c). The city is moving forward with plans for aquifer storage and recovery (ASR) by injecting water through its wells into the aquifer during nondrought years, and anticipates meeting all drought needs via this strategy. The City of Ellensburg also has proratable water rights, of 6,000 acre-feet (Reclamation and Ecology, 2011c). Ellensburg does not yet have an ASR program.

Reclamation estimated the benefits of the KDRPP to the City of Yakima based on avoided cost of groundwater pumping during droughts. For the City of Ellensburg, they estimated benefits based on avoided costs of leasing replacement water during droughts. The sum of these benefits for the two communities represents $0.9 to $1.4 million over the 100-year timeframe for KDRPP alone (Table 18). If the City of Ellensburg developed an ASR program, these avoided costs in total for the two cities would be less than $500,000 for the 100-year timeframe. If ASR is unsuccessful and the City of Yakima as well as the City of Ellensburg purchased water, the avoided costs could climb to approximately $2 million over 100 years.

Table 18. Avoided Municipal Water Costs, Cities of Yakima and Ellensburg Combined

Scenario	Prorationing	Acre-feet Available	Drought Year Avoided Cost	Average Annual	NPV
Current Conditions					
Baseline	48.3%	5,354	-	-	-
KDRPP only	58.8%	6,517	$194,699	$32,450	$926,691
KKC and KDRPP	60.5%	6,710	$227,029	$37,838	$1,080,573
Climate Change Conditions ("Adverse" Scenario)					
Baseline	42.3%	4,689	-	-	-
KDRPP only	49.2%	5,457	$128,691	$63,551	$1,367,802
KKC and KDRPP	52.7%	5,838	$192,518	$95,070	$1,892,306

9.2.4 National Economic Development Unquantified Benefits

KDRPP has other categories of potential benefits that could arise that are unquantified at this time. The analysis of NED benefits for irrigated agriculture focused on commodity production and prices, since these aspects lend themselves to quantitative analysis. However there are other effects on farmers, farmworkers and related industries that may not be captured in this analysis. For example, the prospect of recurring droughts creates uncertainty in farm planning that may lead producers to make sub-optimal choices regarding investments and financing of land, planting of perennial crops such as vines and tree fruits, irrigation equipment and capital facilities. This in turn may dampen the farm economy's ability to achieve its production potential. When droughts do occur, they create substantial short-term disruption in farm activities, related support industries, and employment. This disruption causes additional effects that are not quantified in the economic analysis. For example, workers can be displaced and both they and their children suffer losses in productive capacity as a result. None of these effects have been quantified in the NED analysis.

The increased flexibility and option value of KDRPP operations, both for consumptive uses (primarily irrigation) and instream habitat effects, would likely provide situational benefits that are difficult to predict. Water transactions for example, require adaptability so that water can be used even if the geography or timing of demand varies somewhat. It is not possible to predict the full range of potential future water transactions that could be beneficial and might be facilitated by the flexibility in the storage the KDRPP would provide, either alone or in conjunction with the KKC.

The option value might also allow more efficient uses of other water supply system components in the Yakima River basin. For example, if additional water supply capacity is available because of the KDRPP, Reclamation might use other storage more freely, such as drawing down another reservoir to lower levels that might otherwise seem too risky without the availability of additional dry-year supply under KDRPP. This could become more important to the extent that multi-year droughts become more frequent, and managing available storage capacity becomes more challenging.

Bull Trout Enhancement Program

The U.S. Fish and Wildlife Service listed bull trout populations in both Keechelus Reservoir and Kachess Reservoir watersheds as "threatened" under the Endangered Species Act. These two sub-populations are among the numerically lowest populations in the Yakima River basin. The BTE program would generate long-term benefits for bull trout populations in both the Keechelus and Kachess Reservoir watersheds. Reclamation and Ecology would activate the BTE in conjunction with either the KKC or the KDRPP.

Reestablished year-round tributary passage from Keechelus Reservoir into Gold Creek and Cold Creek; and potentially from Kachess Reservoir into the upper Kachess River would increase the number of spawning fish and the redds they deposit. While quantitative projections are not available, Federal biologists indicate this would lead to increased population productivity and abundance. Artificial nutrient enrichment of these watersheds would most directly increase juvenile abundance with the expected improvement in the prey base for sub-adult and adult bull trout residing in the reservoirs. This would also result in expected increase in growth, condition factors, and survival rates, which over time would result in an increase in population abundance and productivity. In addition, artificial nutrient enrichment would be beneficial to the future reintroduction of sockeye into these two reservoirs. If proven feasible, there is the potential to expand the amount of spawning and juvenile rearing habitat in Box Canyon Creek above the lowest impassable falls by approximately 3 miles, which would lead to increased population abundance for the Box Canyon population. Reestablished passage into Cold Creek in the Keechelus Reservoir would open up approximately 2.2 miles of habitat that is currently inaccessible.

The BTE plan also has the potential to accelerate the rate of population recovery greatly in terms of abundance and increased genetic diversity for the Keechelus and Kachess populations by translocation of fish from healthier populations in the Yakima River basin.

Reclamation expects these collective actions to increase bull trout abundance, productivity, and genetic diversity for the Keechelus and Kachess populations. Because of these actions, these populations should become more resilient to the natural fluctuation in environmental factors that can negatively impact population abundance and productivity. These actions would also provide benefits for overall ecosystem health in the reservoirs and their tributaries.

Bull trout are a particularly scarce fish species, and high scarcity creates opportunities for high value improvements. Research on the value of listed threatened and endangered species consistently demonstrates the substantial importance to people of protecting and maintaining these rare species (Loomis and White, 1996). Reclamation has not quantified the value of the BTE program because the small fish populations involved are difficult to model accurately, and because means of establishing monetary equivalents are not readily available.

9.2.5 National Economic Development Quantified Costs

The KDRPP involves two alternative construction options based upon two possible locations for the pumping plant: the East Shore Pumping Plant and South Pumping Plant Alternatives. Both alternatives would take an estimated four years of construction to complete. Both alternatives involve annual operation and maintenance expenses, including energy costs. They also involve intermittent additional costs over time, the largest of which involves some capital equipment replacement at 50 years. Together, these costs equate to $561 million undiscounted or $446 million discounted for the East Shore Pumping Plant, and $530 million undiscounted or $437 million discounted for the South Pumping Plant. The capital construction costs over the first four years dominate overall costs. Section 8.0, Cost Estimate, summarizes the costs associated with the KDRPP.

Construction and operation of KDRPP has the potential to generate other financial and nonfinancial costs. These could include effects such as disruption of access to homes or facilities, or other construction or operational disturbances. Reduced pool levels for Kachess Reservoir, relative to the baseline, could have negative effects for recreation and amenity-based public and private property adjacent to and near Kachess Reservoir.

Summary of NED Benefits and Costs

Table 19 summarizes benefits and costs quantified for KDRPP. The NPVs are negative, because the costs are greater than the benefits. As described in Section 9.1, Reclamation and Ecology recognize that KDRPP would not have a favorable benefit-to-cost ratio when evaluated separately from the remainder of the Integrated Plan.

Table 19. Net Present Value of Benefits and Costs of KDRPP Over 100 Years

	KDRPP ($M)	KDRPP with Climate Change ($M)
Agriculture Water Supply Benefits	214	315
Municipal Water Supply Benefits	0.9	1.4
East Shore Construction, Operation and Maintenance Costs	-446	-446
South Construction, Operation and Maintenance Costs	-437	-437
Lost Recreation Due to Reduced Pool Levels	-4- to -38	-8 to -75
Net Present Value, East Shore Pumping Plant	-235 to -269	-137 to -204
Net Present Value, South Pumping Plant	-226 to -260	-129 to -195
BTE Benefits	Not quantified	Not quantified
BTE Costs	-6.7 to -13.3	-6.7 to -13.3

Note: Values discounted at 3.375 percent per year. In the cost category, only long-term operations, maintenance, replacement, and power costs (OMR&P) are discounted. The initial investment costs (field costs, interest during construction, and non-contract costs) are not discounted. All benefits are discounted as they would accrue after construction is completed.

The values shown in Table 19 do not include additional, unquantified costs and benefits. Table 20 lists these costs and benefits.

Table 20. Unquantified Benefits and Costs of the KDRPP

Unquantified Benefits	Unquantified Costs
As an element of the overall Integrated Plan, Reclamation and Ecology expect the KDRPP to reduce conflict over management of water resources and fisheries in the Yakima River basin, reduce potential for litigation, and improve certainty for stakeholders. Availability of additional supply from Kachess Reservoir would enable Reclamation to manage other reservoirs less conservatively to maximize overall fisheries and water supply benefits. Increased flexibility of Yakima Project operations enabled by the KDRPP and other projects may provide other undefined benefits for fisheries and water supply, and greater opportunities to employ market-based transactions to allocate water among uses. In establishing the 50,000-acre Teanaway Community Forest in the Yakima River basin headwaters area in 2013, the State Legislature established a linkage between that forest and the KDRPP. If a water-supply milestone of 214,000 acre-feet of new supply is not achieved by June 30, 2025, the TCF could revert to the State's common school trust, meaning that special provisions for watershed protection, recreation, and habitat protection and enhancement would no longer apply to these forested lands. The KDRPP would provide nearly all of the water required to achieve the milestone, and appears to be the only water-supply project of this magnitude that could be viable for approval, funding, and construction by this deadline. The agencies would implement BTE only if the KKC or the KDRPP were implemented. The BTE would provide benefits to listed bull trout by improving access to reservoir tributaries for spawning, improving nutrient availability, and improving genetic diversity.	Potential reductions in value of private properties used for residences or vacation homes on the shoreline of Kachess Reservoir. Travel restrictions, noise, and other construction impacts on local residents near the Kachess Reservoir, during the four-year construction period for the KDRPP.

Readers should consider the results shown in Table 19 and Table 20 in the context of the full Integrated Plan, and more particularly the Initial Development Phase. Table 21 shows the estimated costs and benefits of the Initial Development Phase as a whole. Even without all of the benefits quantified, the overall benefits of this phase substantially outweigh the overall costs.

Table 21. Net Present Value Benefits and Costs of Initial Development Phase

Project	Costs	Benefits
Cle Elum Fish Passage	$130M[1]	$1,300M to 1,900M
KDRPP	$437M to $446M	$215 to $317M
KKC (incremental with KDRPP)	$258M to $291M	$63 to $203M
Bull Trout Enhancement	$13M	Not quantified
Cle Elum Pool Raise	$18M	Not quantified
Habitat Projects	$85M	Not quantified
Water Conservation Projects	$70M	Not quantified

[1] Costs of Cle Elum Fish Passage and Cle Elum Pool Raise are not discounted.

9.3 Regional Economic Development

The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each project. Evaluations of regional effects use nationally consistent projections of income, employment, output, and population. This account evaluates the beneficial and adverse impacts of projects and actions on the economy of the affected region, with particular emphasis on income and employment measures. The affected region reflects the geographic area where Reclamation and Ecology expect significant impacts to occur. Both monetary and nonmonetary terms can be measures of impacts (Reclamation and Ecology, 2015a).

9.3.1 Overview of Federal Guidance

Three measures of the effects of the plan on regional economies are output, income, and employment:

- Regional Output: The value of goods and services produced is the broadest measure of economic activity. It is the sum of expenditures, employee income, proprietor income, profits, and taxes.
- Regional Income: The positive effects of a plan on a region's income are equal to the sum of the NED benefits that accrue to that region, plus transfers of income to the region from outside the region.
- Regional Employment: The positive effects of a plan on regional employment are directly parallel to the positive effects on regional income, so that analysis of regional employment effects uses the same categories and the same conceptual bases as the analysis of positive regional income effects.

The regions used for RED analysis are those regions within which the plan would have particularly significant income and employment effects, described below.

9.3.2 Assumptions for the Analysis

Analytical Approach. The RED analysis applies IMPLAN® (Impact Analysis for PLANning) modeling software to examine the economic impacts of the Integrated Plan across the region. IMPLAN® is an input-output model that utilizes local industry-level data and traces spending associated with a specific project as it moves through the defined impact area. The RED analysis uses IMPLAN® default conditions and other regional economic data to represent the baseline conditions. ECONorthwest used the most-current available IMPLAN® data (2012) in the RED analysis.

Regional Definition. The Yakima River basin defines the region for the analysis. As for the 2012 RED analysis of the Integrated Plan, ECONorthwest used counties of the Yakima River basin (Kittitas, Yakima, and Benton) in addition to Franklin County, which incorporated the entire Kennewick-Richland-Pasco metropolitan area into the analysis (Figure 1). ECONorthwest also identified economic impacts that would occur for the State of Washington as a whole. Although effects associated with implementing these projects would occur outside these counties, for the purposes of the RED analysis, this area adequately captures the regional effects of implementing the projects.

For purposes of this analysis Reclamation assumed that roughly 10 percent of the capital cost expenditures would accrue in the four-county area, 60 percent would accrue in other Washington State counties, and 30 percent would accrue in other U.S. States. The exact breakdown of these expenditures would depend on the procurement approach, and the contractor(s) Reclamation and Ecology select to perform the work. Reclamation would likely draw 100 percent of operations and maintenance labor from the four-county area.

Categories of Impacts. The analysis incorporates the following categories of impacts:

- Spending associated with construction
- Spending associated with operation, maintenance, replacement and power
- Changes in the value of agricultural production

Accounting for Local Contributions. RED impacts only capture those that are not paid for by local contributions. In other words, these impacts do not include the local money that is simply transferred from one group to another within the defined region. Reclamation and Ecology assume that, for the KDRPP, local contributions would pay 25 percent of capital and local sources would pay 100 percent of operating expenses.

This impact analysis does not account for impacts of changes in population potentially attributable to the KDRPP. Although effects analyzed in the NED analysis may result in changes in the value of other goods and services that could affect the level of income and employment in the region (e.g., changes in recreation and property values), existing data are insufficient to include them in the RED modeling using IMPLAN®. The RED analysis also analyzed spending associated with construction, operation, and maintenance of BTE projects and presented these results separately.

9.3.3 RED Analysis Findings

The RED analysis utilizes identified expenditures associated with KDRPP to identify the value of economic output, the volume of employment, and the amount of income generated by construction and operation of KDRPP (Reclamation and Ecology, 2015a).

The RED analysis is broken down into the four-county immediate region, the remainder of Washington State, and the State as a whole. To the extent that Reclamation and the State of Washington would spend these funds within the four-county region without KDRPP, the net impacts would be less. However, it is unlikely that the State and Federal governments would spend the same dollars in the four-county region without KDRPP, rather than assigning them to water infrastructure projects elsewhere. The irrigation and agriculture impacts though, do likely represent the net impacts for the region. Without the available water supply, fields would not be in production, produce would not be sold, and revenue would not be generated. The share of final consumer demand for agriculture within the four-county region might be spent similarly without the KDRPP, but the vast majority of these impacts would likely not occur within the region without the water made available by the KDRPP.

KDRPP Construction, Operation, and Maintenance Expenditures

The KDRPP would include $412 million in expenditures for construction of the East Shore Pumping Plant Alternative and $410 million for the South Pumping Plant Alternative (including field cost, non-contract cost, and interest during construction). For purposes of economic modeling, Reclamation assumed a four-year construction period. Additionally, the KDRPP would require $1.5 million for the East Shore Pumping Plant and $1.2 million for the South Pumping Plant in average annual expenditures for operations, maintenance, replacement and power (Reclamation and Ecology, 2015a).

The total construction impacts for the four-county region, when including indirect and induced expenditures for the construction of the KDRPP would involve 1,774 to 1,781 job-years and $97 million in personal income, depending on the construction alternative (Table 22 and Table 23). For the State as a whole, the value of personal income would be $154 to $155 million with 3,022 to 3,034 job-years.

Table 22. East Shore Pumping Plant Alternative Construction Impacts Over the Full Construction Period, $ Millions

Region / Impact Measure	Direct	Indirect	Induced	Total	Multiplier
4 County Region					
Output	$196.4	$20.7	$49.4	$266.6	1.36
Personal Income	$76.3	$6.3	$14.4	$97.0	1.27
Job Years	1,192	166	423	1,781	1.49
Rest of Washington					
Output	$89.8	$36.8	$61.5	$188.1	2.09
Personal Income	$28.8	$10.4	$18.4	$57.6	2.00
Job Years	601	202	450	1,253	2.09
Total Washington State					
Output	$286.2	$57.5	$111.0	$454.7	1.59
Personal Income	$105.1	$16.7	$32.8	$154.6	1.47
Job Years	1,793	368	873	3,034	1.69

Table 23. South Pumping Plant Alternative Construction Impacts Over the Full Construction Period, $ Millions

Region / Impact Measure	Direct	Indirect	Induced	Total	Multiplier
4 County Region					
Output	$195.6	$20.7	$49.3	$265.5	1.36
Personal Income	$76.0	$6.3	$14.3	$96.6	1.27
Job Years	1,188	165	421	1,774	1.49

Region / Impact Measure	Direct	Indirect	Induced	Total	Multiplier
Rest of Washington					
Output	$89.4	$36.6	$61.2	$187.3	2.09
Personal Income	$28.7	$10.3	$18.3	$57.3	2.00
Job Years	598	202	448	1,248	2.09
Total Washington State					
Output	$285.0	$57.3	$110.5	$452.8	1.59
Personal Income	$104.7	$16.6	$32.6	$154.0	1.47
Job Years	1,786	367	869	3,022	1.69

During a typical year of operation, the KDRPP would generate approximately 6 job-years with total personal income of $225 thousand to $281 thousand (Table 24 and Table 25). These job-years would last for the life of KDRPP.

Table 24. East Shore Pumping Plant Alternative Operating Impacts, Average Annual

Region / Impact Measure	Direct	Indirect	Induced	Total	Multiplier
4 County Region					
Output	$484,461	$92,789	$125,818	$703,067	1.45
Personal Income	$158,359	$29,914	$36,628	$224,901	1.42
Job Years	3.2	0.7	1.1	5.0	1.54
Rest of Washington					
Output	$0	$134,148	$48,966	$183,114	-
Personal Income	$0	$42,139	$14,069	$56,208	-
Job Years	0.0	0.8	0.3	1.1	-
Total Washington State					
Output	$484,461	$226,937	$174,784	$886,181	1.83
Personal Income	$158,359	$72,053	$50,697	$281,109	1.78
Job Years	3.2	1.5	1.4	6.1	1.89

Table 25. South Pumping Plant Alternative Operating Impacts, by Type, Average Annual

Region / Impact Measure	Direct	Indirect	Induced	Total	Multiplier
4 County Region					
Output	$439,393	$84,157	$114,113	$637,663	1.45
Personal Income	$143,627	$27,131	$33,221	$203,980	1.42
Job Years	2.9	0.6	1.0	4.5	1.54
Rest of Washington					
Output	$0	$121,669	$44,411	$166,080	-
Personal Income	$0	$38,219	$12,760	$50,979	-
Job Years	0.0	0.7	0.3	1.0	-
Total Washington State					
Output	$439,393	$205,826	$158,524	$803,743	1.83
Personal Income	$143,627	$65,350	$45,981	$254,958	1.78
Job Years	2.9	1.3	1.3	5.6	1.89

BTE Construction Expenditures

The Bull Trout Enhancement Plan would include $13.3 million in expenditures for construction. For economic modeling, Reclamation assumed a four-year construction period. These expenditures would generate 59 job-years within the four-county region, and 98 job-years for the State as a whole, with $5 million in personal income for the total. If Reclamation also constructs the KKC, then BTE effects would be shared with the KKC.

Agricultural Expenditures

The incremental impact of KDRPP, under historical climate conditions, results in 1,293 additional job-years derived from improved irrigation supply during droughts in the four-county region and a total of 1,351 additional job-years statewide (Table 26). Any given year has a 16.7 percent probability of experiencing a drought. While the majority of these impacts are experienced in the agriculture sector, they also accrue in transportation and trade (Reclamation and Ecology, 2015a).

Table 26. KDRPP Impacts during Drought Year, Marginal to Baseline, Historical Conditions

Region / Impact Measure	Direct	Indirect	Induced	Total	Multiplier
4 County Region					
Output	$99,139,604	$35,089,664	$37,365,977	$171,595,246	1.73
Personal Income	$16,886,013	$16,686,677	$10,463,142	$44,035,832	2.61
Job Years	497	490	305	1,293	2.61
Rest of Washington					
Output	$0	$7,530,230	$4,252,054	$11,782,284	-
Personal Income	$0	$1,303,769	$1,044,547	$2,348,316	-
Job Years	0	34	25	59	-
Total Washington State					
Output	$99,139,604	$42,619,894	$41,618,031	$183,377,530	1.85
Personal Income	$16,886,013	$17,990,446	$11,507,689	$46,384,148	2.75
Job Years	497	524	331	1,351	2.73

Under adverse climate change conditions, the value of KDRPP's contributions to water availability in drought years result in 1,223 job years in the four-county region with personal income of $41.7 million (Table 27). Any given year under adverse climate change conditions has a 49.4 percent probability of experiencing a drought. Since Reclamation expects that droughts will be more frequent under climate change, these incremental effects would occur more often than the effects shown in Table 26 (Reclamation and Ecology, 2015a).

Table 27. KDRPP Impacts during Drought Year, Marginal to Baseline under Adverse Climate Change

Region / Impact Measure	Direct	Indirect	Induced	Total	Multiplier
4 County Region					
Output	$93,676,790	$33,130,960	$35,391,382	$162,199,132	1.73
Personal Income	$15,964,642	$15,786,344	$9,910,213	$41,661,199	2.61
Job Years	470	464	289	1,223	2.61
Rest of Washington					
Output	$0	$7,081,187	$4,021,204	$11,102,390	-
Personal Income	$0	$1,228,743	$987,540	$2,216,283	-
Jobs Years	0	32	24	55	-
Total Washington State					
Output	$93,676,790	$40,212,147	$39,412,585	$173,301,523	1.85
Personal Income	$15,964,642	$17,015,087	$10,897,753	$43,877,481	2.75
Job Years	470	495	313	1,278	2.73

9.4 Environmental Quality and Other Social Effects Methodology

A team that included staff from Reclamation, Ecology, and environmental consultants to the agencies conducted the EQ and OSE evaluations. All members of the team had worked on the KDRPP and KKC Draft EIS (Reclamation and Ecology, 2015d) and have expertise in environmental analysis, engineering, and Yakima Project operations. Reclamation and Ecology conducted the EQ and OSE evaluations in a workshop format. Participants applied their subject area expertise, experience, and knowledge of the project and project area in their evaluations. Workshop participants also utilized information and analysis documented in the Draft EIS. All decisions made during the workshops used group consensus.

The Reclamation and Ecology team met to conduct the initial EQ and OSE evaluation on February 4, 2015. Reclamation and Ecology reviewed the evaluation with technical experts from Federal and Washington State resource agencies, the Yakama Nation, and Yakima River basin irrigation districts to receive additional input on the evaluations.

The Reclamation and Ecology team considered the input of the technical experts; revised resource categories, subcategories, weighting, and scoring; and made final decisions on the EQ and OSE evaluations.

The process used during the EQ and OSE workshops involved five major steps:

1. Identifying environmental resource categories from the Draft EIS that were most important for decision making
2. Prioritizing the resource categories
3. Dividing some resource categories into subcategories to better capture the benefits and impacts of the alternative

4. Weighting the EQ and OSE categories or subcategories
5. Scoring the benefits and impacts of the EQ and OSE categories or subcategories

9.4.1 Overview of Federal Guidance

The *Principles and Guidelines* include criteria for evaluating alternatives based on the EQ and OSE accounts to display the effects of the alternatives. The *Principles and Guidelines* define these accounts as follows:

- **The EQ account** displays nonmonetary effects on significant natural and cultural resources. This account displays the effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources, which cannot be adequately measured in monetary terms within the NED and RED accounts.
- **The OSE account** registers plan effects from perspectives that are relevant to the planning process, but not reflected in the other three accounts.

9.4.2 EQ Assumptions for the Analysis

Table 28 lists the EQ resource categories selected by the team along with a brief explanation of the resource categories. The Reclamation and Ecology team identified the resource categories that would have the most effect on the purpose and need for the KDRPP and those that the KDRPP would potentially impact the most. The team divided some resource categories into subcategories to allow for more refined evaluation of the benefits and impacts.

The Draft EIS evaluated other resources, but Reclamation and Ecology did not include them in the EQ evaluation because the evaluation focuses on resources that are most important for decision-making. The agencies did not include vegetation and wetlands in the EQ evaluation because they are committed to mitigating impacts to ensure no net loss to wetlands or vegetation. Although the reservoir drawdown could decrease water levels in drinking water wells around the reservoir, the agencies did not include groundwater in the EQ evaluation because they would develop appropriate mitigation strategies to ensure drinking water would be available.

The team assigned weights to resource categories based on their priorities and scaled so the weights totaled to 1.0. The team then weighted the EQ subcategories. Similar to the prioritization process, the team assigned weights to subcategories based on the participants' estimation of how the subcategories would meet the purpose and need of the KDRPP and potential impacts on the resources. Within each category, the subcategory weights total 1.0. The team multiplied category weights by the subcategory weights to obtain the final weights for the EQ resources. Section 9.3.5 summarizes the weights and results of the EQ evaluation.

Table 28. EQ Resource Categories

EQ Resource Category	EQ Resource Subcategories	Background
Water resources	Water supply Instream flows	Improved water supply is part of the purpose and need for the KDRPP. As used here, water supply includes the benefits that would occur from improved water supplies that have not been monetized in the NED or RED, such as benefits of a more stabilized economy. Instream flows are included to represent the benefits other than fisheries benefits that accrue from improved streamflows, such as improved water quality, aesthetics, etc.
Bull trout	Food-based prey Habitat Passage	Enhancements to bull trout habitat is part of the purpose and need for the KDRPP. This category includes the subcategories of food-based prey, habitat, and passage that the team considered to be key indicators of improvements to the productivity and function of aquatic habitat conditions for bull trout.
Fish	Fish abundance Fish passage	"Fish abundance" accounts for overall improvements in fish populations, health, and distribution that will occur under the plan. This resource category includes anadromous and resident fish not listed as threatened or endangered under the ESA. "Fish passage" refers to ecosystem benefits of providing fish with access to more habitat.
Surface water quality	Reservoir water quality	Changes in reservoir level could impact reservoir water quality.
Wildlife	Wildlife	Construction could disrupt wildlife species in the area and the proposed action could improve wildlife habitat in some areas.
Other threatened and endangered species	Northern spotted owl MCR steelhead	The northern spotted owl and Mid-Columbia-River (MCR) steelhead are federally listed species that the project could affect.
Visual quality	Visual quality	The increased reservoir drawdown and the KDRPP facilities could change the visual quality at the reservoir.
Land Use	Property or easement acquisition	The project would require acquisition of some real property or easements.
Recreation	Reservoir recreation Changed character of recreation	The increased reservoir drawdown could affect recreation at Kachess Reservoir. The BTE habitat improvements could change the character of recreation at Gold and Cold creeks.
Cultural resources	Cultural and archaeological resources	Construction of the KDRPP facilities and BTE habitat improvements at Gold and Cold creeks could disturb cultural resources.
Climate change	Adaptability to climate change	The KDRPP is included in the Integrated Plan as a project to help meet the Integrated Plan's purpose of anticipating climate change and increasing Reclamation's flexibility in responding to those changes.
Construction impacts	Construction impacts Transportation	Construction could cause temporary impacts, such as increased emissions, fugitive dust, noise, and vibration. Construction vehicles could increase traffic on local roads and Interstate 90.

9.4.3 OSE Assumptions for the Analysis

The team identified and prioritized elements of the OSE account. As noted above, the OSE account includes perspectives that are not included in the NED, RED, or EQ accounts. The team identified three resource categories to include in the OSE account -- urban and community impacts, long-term productivity, and energy requirements and energy conservation. OSE accounts often include environmental justice, but the team decided not to include that category because the Draft EIS did not identify any potential environmental justice impacts (Reclamation and Ecology, 2015d). Table 29 lists and describes the OSE categories. Section 9.3.5 summarizes the weights and results of the OSE evaluation.

Table 29. OSE Resource Categories

OSE Resource Category	OSE Resource Subcategories	Background
Urban and community	Construction worker impacts	This category is included to capture the impacts that would occur in communities surrounding the construction area from the large number of construction workers employed on the project. These impacts include housing demand.
Long-term productivity	Improved fish populations Resilience to climate change Improved irrigation reliability	Long-term productivity includes the nonmonetary and social benefits that accrue from the project. Sub categories include improved fish populations, resilience to climate change, and improved irrigation reliability.
Energy requirements and energy conservation	Increased energy use	This category includes the extent that the KDRPP would increase energy use in the Yakima River basin.

9.4.4 EQ and OSE Impact Rating

After the team identified, ranked, and weighted the EQ and OSE resource categories, the team rated the impacts. The EQ and OSE evaluations compared the impacts of the No Action Alternative and the two action alternatives (the KDRPP East Shore Pumping Plant and the KDRPP South Pumping Plant) as described in the Draft EIS. The team rated the impacts by comparing the impacts of the No Action Alternative and the two action alternatives to the existing baseline conditions.

During the rating process, the Reclamation and Ecology team rated the No Action Alternative based on current Yakima Project operations and the projects and actions identified to occur under the No Action Alternative. For all alternatives, the team considered impacts and benefits over a 50-year period. The team also considered potential impacts of climate change, changes in vegetation and wildlife, and anticipated development that would occur over the next 50 years for both alternatives.

To compare the effects of the alternatives, the team developed a scale, which accounts for both positive and negative impacts. It also uses a zero rating to indicate no change relative to existing conditions. The scale is listed below:

0 = no change from existing conditions

3 = major positive impact	-3 = major negative impact
2 = moderate positive impact	-2 = moderate negative impact
1 = minor positive impact	-1 = minor negative impact

The team rated the impacts using the same consensus-based approach as the rankings and ratings. To determine the final scores for the EQ and OSE evaluations, the team multiplied the resource category scores for each alternative by the category or subcategory weight. The resulting numbers reflect both the potential significance of the effect and the relative importance of the resource category or subcategory.

9.4.5 Environmental Quality and Other Social Effects Analysis Results

Table 30 summarizes the EQ analysis results. This table indicates that under the No Action Alternative, conditions for most resources would stay the same or decline. The KDRPP alternatives would cause positive impacts to water supply and bull trout and would increase adaptability to climate change. Under the KDRPP alternatives, most other resources would experience negative impacts, including reservoir recreation and cultural and archaeological resources. The EQ results suggest that the KDRPP provides positive impacts for the resources that most directly address the purpose and need of the project -- surface water and bull trout -- while also improving the adaptability to climate change. Figure 16 shows the EQ results graphically.

Table 31 summarizes the OSE analysis results. This table indicates that the KDRPP alternatives provide positive impacts to long-term productivity, but minor negative impacts from increased energy use and construction worker impacts. Figure 17 shows the OSE results graphically.

Table 30. Comparative Display of Alternatives for EQ Categories

EQ Resource Category			No Action Alternative		KDRPP East Pumping Plant		KDRPP South Pumping Plant	
		Weight	Significance	Score	Significance	Score	Significance	Score
Surface water	Water supply	0.15	-2	-0.3	2	0.3	2	0.3
	Instream flows	0.15	-1	-0.15	-1	-0.15	-1	-0.15
	Subtotal	0.30		-0.45		0.15		0.15
Bull trout	Food-based prey	0.10	-1	-0.10	1	0.10	1	0.10
	Habitat	0.10	-2	-0.20	2	0.20	2	0.20
	Passage	0.10	-2	-0.20	3	0.30	3	0.30
	Subtotal	0.30		-0.50		0.60		0.60
Fish	Fish abundance	0.02	-2	-0.04	-2	-0.04	-2	-0.04
	Fish passage	0.02	0	0	1	0.02	1	0.02
	Subtotal	0.04		-0.04		-0.02		-0.02
Surface water quality	Reservoir water quality	0.04	0	0	-1	-0.04	-1	-0.04
	Subtotal	0.04		0		-0.04		-0.04
Wildlife	Wildlife	0.04	0	0	1	0.04	1	0.04
	Subtotal	0.04		0		0.04		0.04
Other threatened and endangered species	Northern spotted owl	0.02	0		-1	-0.02	-1	-0.02
	MCR steelhead	0.02	-2	-0.04	-2	-0.04	-2	-0.04
	Subtotal	0.04		-0.04		-0.06		-0.06
Visual quality	Visual quality	0.04	0	0	-2	-0.08	-2	-0.08
	Subtotal	0.04		0		-0.08		-0.08
Land use	Property/easement acquisition	0.04	0	0	-1	-0.04	-1	-0.04
	Subtotal	0.04		0		-0.04		-0.04

EQ Resource Category			No Action Alternative		KDRPP East Pumping Plant		KDRPP South Pumping Plant	
Recreation	Reservoir recreation	0.02	-1	-0.02	-3	-0.06	-3	-0.06
	Changed character of recreation	0.02	0	0	-1	-0.02	-1	-0.02
	Subtotal	0.04		-0.02		-0.08		-0.08
Cultural resources	Cultural and archaeological resources	0.04	0	0	-3	-0.12	-2	-0.08
	Subtotal	0.04		0		-0.12		-0.08
Climate Change	Adaptability to Climate Change	0.04	-2	-0.08	1	0.04	1	0.04
	Subtotal	0.04		-0.08		0.04		0.04
Construction impacts	Construction impacts	0.02	-1	-0.02	-1	-0.02	-1	-0.02
	Transportation	0.02	-2	-0.04	-2	-0.04	-2	-0.04
	Subtotal	0.04		-0.06		-0.06		-0.06
Totals		1.00		-1.19		0.33		0.37

Note: Totals and subtotals may not sum exactly due to rounding. MCR steelhead = Mid-Columbia River steelhead.

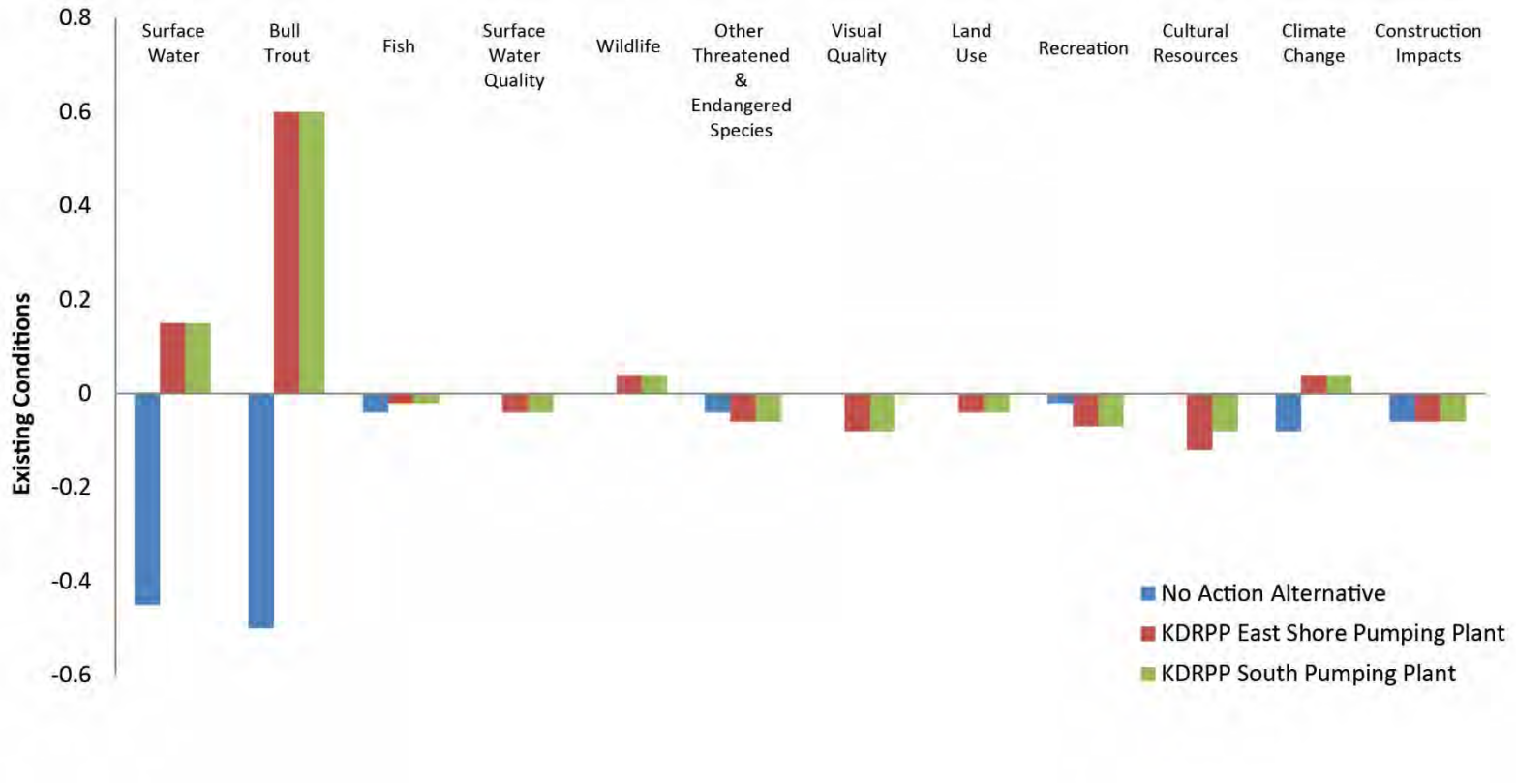


Figure 16. EQ Resource Category Results

Table 31. Comparative Display of Alternatives for OSE Categories

OSE Resource Category			No Action Alternative		KDRPP East Pumping Plant		KDRPP South Pumping Plant	
		Weight	Significance	Score	Significance	Score	Significance	Score
Urban and community impacts	Construction worker impacts	0.15	0	0.00	-1	-0.15	-1	-0.15
	Subtotal	0.15		0.00		-0.15		-0.15
Long-term productivity	Improved fish populations	0.23	0	0.00	0	0.00	0	0.00
	Resilience to climate change	0.23	-2	-0.47	2	0.47	2	0.47
	Improved irrigation reliability	0.23	-2	-0.47	2	0.47	2	0.47
	Subtotal	0.70		-0.93		0.93		0.93
Energy requirements and energy conservation	Increased energy use	0.15	0	0.00	-1	-0.15	-1	-0.15
	Subtotal	0.15		0.00		-0.15		-0.15
Total		1.00		-0.93		0.63		0.63

Note: Totals and subtotals may not sum exactly, due to rounding.

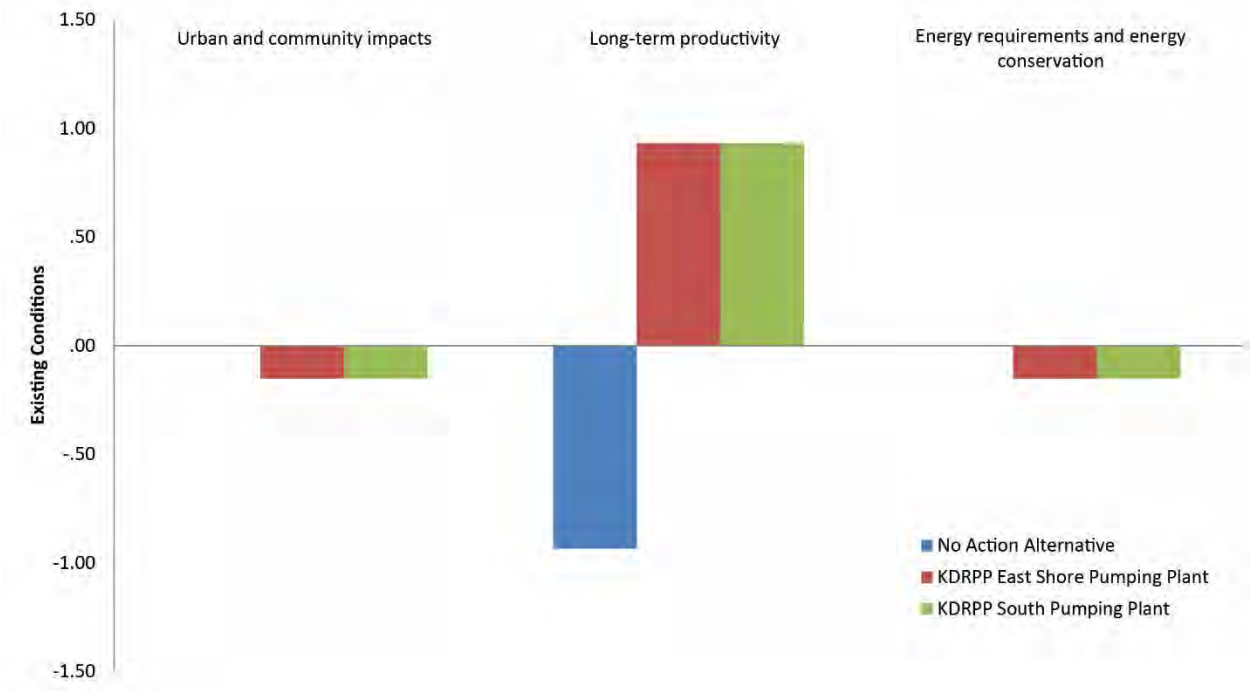


Figure 17. **OSE Resource Category Results**

9.5 Financial Feasibility

9.5.1 Cost Allocation Analysis

Reclamation uses cost allocation as a transitional step leading from economic evaluation to repayment analysis. Allocation is not a means of justifying an alternative or project but follows the determination of economically feasible project alternatives.

The objective of cost allocation is to distribute economically justified project costs of feasible alternatives equitably among the purposes served. The purposes allocated to can be either reimbursable or nonreimbursable based on existing legislative authority. Formulation of plans by incremental analysis normally assures that the cost of the plan increments is justifiable for each project purpose. Based on the assumption that Reclamation applied project formulation principles, equitable cost distribution may be obtained by preventing costs allocated to any purpose from exceeding corresponding benefits. This establishes, for reimbursable project functions, the cost base from which repayment schedules are developed.

Principles of cost allocation are as follows:

- Allocate each purpose directly, at a minimum, the identifiable separable cost (costs omitted from total project costs if one purpose is excluded).
- Do not assign project purpose costs in excess of benefits or the assigned costs should not be greater than the cost of a single-purpose alternative that Reclamation could likely build as a Federal project. Thus, the lesser of either benefits or the most likely Federal alternative costs is the justifiable expenditure or maximum allocation for a purpose.
- Allocate the remaining costs, after identifying separable costs and deducting them from the justifiable expenditure, to each purpose in the same ratio as the remaining benefits.
- Include all costs necessary to achieve benefits claimed.

Reclamation prepared a preliminary cost allocation for the Integrated Plan (Reclamation and Ecology, 2012b) based on programmatic level analysis of project features and benefits. If KDRPP (including the new proposed floating pumping plant alternative) is funded using non-Federal sources, a project-specific cost allocation would not be required

Repayment

Reimbursable project functions included in the Integrated Plan are agricultural irrigation and municipal and domestic water supply. Construction costs allocated to agricultural irrigation are generally reimbursable without interest, while those allocated to municipal and domestic supply are reimbursable with interest. For the Integrated Plan, cost-share partners such as the State of Washington, local governments, or other parties, may participate in reimbursement. For the KDRPP, representatives from select proratable irrigation divisions have stated that benefitting districts would repay the capital and operation and maintenance costs.

10.0 Conclusions and Recommendations

This chapter summarizes Reclamation and Ecology's findings and conclusions from the analyses conducted for the KDRPP.

10.1 Findings

Reclamation developed the alternatives discussed in this Feasibility Planning Report using processes that conform to the *Principles and Guidelines* (U.S. Water Resources Council, 1983). The four criteria for evaluating a Federal water resource project are as follows:

- Completeness – The extent to which the alternative provides and accounts for all necessary investments and actions to implement the plan
- Effectiveness – The extent to which the alternative alleviates the problems and accomplishes the objectives
- Efficiency – The extent to which the alternative is cost effective in accomplishing the project objectives
- Acceptability – The workability and viability of the plan in terms of acceptance by Federal, State, Tribal, and local governments and the public, and compatibility with existing laws, regulations, and public policies

Table 32 summarizes these criteria and how they apply in helping to compare the feasibility study alternatives.

Table 32. Summary Comparison of KDRPP Alternatives

Comparison Criteria					
Alternatives	Completeness	Effectiveness	Efficiency	Acceptability	Relative Ranking
No Action Alternative	Not complete, because the No Action Alternative does not address water supply objectives.	The No Action Alternative does not address water supply objectives.	N/A	Does not achieve goals identified by Reclamation, Ecology and stakeholders.	*Low*
Relative Rank	*Low*	*Low*	*N/A*	*Low*	
Alternative 1- East Shore Pumping Plant	Further geotechnical investigation would be needed in order to refine field cost estimates.	Provides substantial water supply benefits.	Field cost is comparable to Alternative 2.	Acceptability is generally high due to the improvements in water supply for proratable users and the benefits to the regional economy. Local residents have concerns regarding additional drawdown of reservoir during drought years.	*Medium/High* [1]
Relative Rank	*High*	*Medium*	*Low*	*Medium*	
Alternative 2- South Pumping Plant	Further geotechnical investigation would be needed in order to refine field cost estimates.	Same as Alternative 1.	Field cost is comparable to Alternative 1.	Same as Alternative 1.	*Medium/High* [1]
Relative Rank	*High*	*Medium*	*Low*	*Medium*	

[1] This is a provisional ranking, pending collection of additional geotechnical data. If that data becomes available, Reclamation will revise the ranking of the action alternatives accordingly.

10.1.1 Technical Viability

Based on feasibility-level engineering and design, both of the action alternatives are technically viable.

10.1.2 Economically Justified

Feasibility studies conducted by Reclamation are detailed investigations specifically authorized by law to determine the desirability of seeking Congressional authorization for implementation of a preferred alternative. The preferred alternative is normally the NED Alternative, which reasonably maximizes net national economic development benefits. The Integrated Plan proposes a suite of projects that together maximize the net national development benefit. This Feasibility Planning Report includes only one of the actions listed in the Integrated Plan. This action is part of the NED Alternative comprising the full Integrated Plan; however, it does not individually produce benefits greater than its cost. The alternatives do result in positive effects on regional income and regional employment as shown in the RED analysis. This Feasibility Planning Report presents the alternatives because of these positive effects and the role the KDRPP plays within the overall Integrated Plan.

10.1.3 Financially Feasible

After Reclamation finds a project to be economically justified, it undertakes analyses to determine if the Federal project cost outlays are recoverable from the project beneficiaries. Financial feasibility is the process of analyses identifying reimbursable and nonreimbursable financial costs and the ability to recover reimbursable costs from project beneficiaries. The analyses consist of a cost allocation and subsequent repayment analyses. Reclamation has not yet performed the financial feasibility analysis at the project level.

Representatives of some proratable irrigation districts have stated that benefitting districts would pay for the construction, operation and maintenance of this project, provided the resulting water supply is made available for their use and not part of TWSA.

10.1.4 Four Account Analysis

The following subsections summarize the results of the NED, RED, EQ, and OSE analyses.

Summary of NED Findings

Under historical climate conditions, KDRPP provides $7.5 million annually in terms of increased net farm earnings relative to the baseline, and $214 million in NPV summed over the 100-year timeframe and discounted at 3.375 percent. When combined with KKC, these benefits increase to $8.7 million annually and $248 million over 100 years. Under the "adverse" climate change scenario, the annual benefits of KDRPP alone climb to approximately $15 million and yield $315 million over the 100-year timeframe in NPV. The addition of KKC increases annual benefits to approximately $22 million and discounted 100-year benefits to $414 million.

Municipal water supply benefits to the Cities of Yakima and Ellensburg under drought conditions represents $0.9 to $1.4 million over the 100-year timeframe for KDRPP alone. If the City of Ellensburg developed an ASR program, these avoided costs in total for the two cities would be less than $500,000 for the 100-year timeframe. If ASR is unsuccessful and the City of Yakima in addition to the City of Ellensburg purchased water, the avoided costs could climb to approximately $2 million over 100 years.

Both alternatives involve annual operation and maintenance expenses, including energy costs. They also involve intermittent additional costs over time, the largest of which involves some capital equipment replacement at 50 years. Together, these costs equate to $561 million undiscounted or $446 million discounted for the East Shore Pumping Plant, and $530 million undiscounted or $437 million discounted for the South Pumping Plant. The capital construction costs over the first four years dominate overall costs.

Construction and operation of KDRPP has the potential to generate other financial and nonfinancial costs. These could include effects such as disruption of access to homes or facilities, or other construction or operational disturbances. Reduced pool levels for Kachess Reservoir, relative to the baseline, could have negative effects for recreation and amenity-based public and private property adjacent to and near Kachess Reservoir.

Summary of RED Findings

The estimated economic impacts of construction of the KDRPP East Shore Pumping Plant Alternative would be 1,781 job-years within the four-county local region and 3,034 job-years for the State of Washington as a whole. This includes $97 million in the four-county region and $155 million at the State level. The corresponding job-years for the South Pumping Plant Alternative would be 1,774 job-years in the four-county region and 3,022 job-years at the State level. Personal income under the South Pumping Plant Alternative construction would be $96.6 million in the four-county region, and $154 million for the State as a whole. KDRPP would also require 6 annual job-years through operation and maintenance for the State as a whole.

Increases in agricultural activity provided by KDRPP alone would generate 1,293 local job-years during drought years under historical conditions, and 1,223 job-years under adverse climate change. Under historical conditions, droughts occur during 16.7 percent of years, while under adverse climate change conditions droughts are projected to occur during 49.4 percent of years. There are also an additional 59 job-years in the rest of Washington, and 55 job-years under the 2 corresponding conditions. The total economic output increase under historical conditions for the four-county region would be $172 million during drought years, and $162 million under adverse climate change conditions during drought years.

The BTE Plan would include $13.3 million in expenditures for construction. For economic modeling, Reclamation assumed a four-year construction period. These expenditures would generate 59 job-years within the four-county region, and 98 job-years for the State as a whole, with $5 million in personal income for the total. If Reclamation also constructs the KKC, then BTE effects would be shared with the KKC.

Summary of EQ Findings

Results of the EQ analysis suggest that under the No Action Alternative, conditions for most resources would stay the same or decline. The KDRPP alternatives would cause positive impacts to water supply and bull trout and would increase adaptability to climate change. Under the KDRPP alternatives, most other resources considered in the EQ analysis would experience negative impacts, especially reservoir recreation, cultural, and archaeological resources.

Summary of OSE Findings

Results of the OSE analysis suggest that the KDRPP alternatives provide positive impacts to long-term productivity, but minor negative impacts from increased energy use and construction worker impacts.

10.2 Conclusions

The construction cost for the KDRPP South Pumping Plant and the East Shore Pumping Plant are approximately equal. Further geotechnical information would be needed to determine which of these two options would be preferred. Operating costs would be higher for the East Shore Pumping Plant Alternative.

The NED analysis indicates that costs are greater than benefits for both alternatives. However benefits of the full Integrated Plan and the Initial Development Phase of the Integrated Plan are higher than the costs. Reclamation and Ecology are considering the KDRPP as a component of the overall Integrated Plan rather than as a stand-alone project.

In May 2015, some of the proratable irrigation districts that may participate in funding of this project requested Reclamation and Ecology perform a Value Analysis Study to evaluate proposals that may reduce project costs. Reclamation held a Value Analysis workshop in June 2015 with HDR, Yakama Nation, and irrigation district staff. Based on the results of the Value Analysis a floating pumping plant option would reduce the construction cost as compared to what has been evaluated in this feasibility study.

The proratable irrigation districts propose to privately finance a permanent facility and therefore have taken the lead to design a floating pumping plant that would pump up to 200,000 acre-feet of storage from the inactive pool of Kachess Reservoir. A separate report will be prepared to document development of this alternative to a similar level as the feasibility alternatives, as appropriate. Since federal authorization and appropriations are not requested for this project at this time, Reclamation and Ecology have decided to leave this Planning Report in “final draft” status.

In addition, under these circumstances the specific procedures required under the Principles and Requirements do not apply, and Reclamation will perform only the limited work needed to document the process to date.

Reclamation and Ecology will continue to coordinate with irrigation districts and the Yakama Nation in consideration of KDRPP as a component of the larger Integrated Plan.

11.0 References

Brekke, et al, 2010 — Brekke, L., B. Kuepper and S. Vaddey, 2010. *Climate and Hydrology Datasets for use in the RMJOC Agencies' Longer-Term Planning Studies.* December 2010.

CEQ, 2013 — Council on Environmental Quality. 2013. *Principles and Requirements for Federal Investments in Water Resources*. March 2013.

Fast et al., 1991 — Fast et al. 1991. *Yakima River spring Chinook enhancement study, final report*. BPA Fish and Wildlife Publication. Project No. 1982-16, Contract No. DE-A179-1983BP39461.

HDR, 2015 — HDR Engineering, Inc. 2015. *Ancillary Costs of Kachess Drought Relief Pumping Plant (KDRPP).* Memorandum. U.S. Bureau of Reclamation. March 2015.

Layton et al., 1999 — Layton, D., G. Brown, and M. Plummer. 1999. *Valuing Multiple Programs to Improve Fish Populations.* Washington State Department of Ecology.

Loomis and White, 1996 — Loomis, J. B., and White, D. S. 1996. *Economic benefits of rare and endangered species: summary and meta-analysis*. Ecological Economics, 18(3), 197-206.

Mullan et al., 1992 — Mullan, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, J.D. McIntyre. 1992. *Production and habitat of salmonids in Mid-Columbia River tributary streams*. USFWS Monograph I. Leavenworth, WA. 489 pp.

Public Law 98-381 — Yakima River Basin Water Enhancement Project, Phase 1. 1984. Public Law 98-381 Section 109 of the Hoover Powerplant Act of 1984.

Quinn, 2005 — Quinn, Thomas. 2005. *The behavior and ecology of Pacific Salmon and Trout*. pg 254

Reclamation, 2002 — Bureau of Reclamation. 2002. *Interim Comprehensive Basin Operating Plan, Yakima Project, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington.

Reclamation, 2008 — Bureau of Reclamation. 2008. *Yakima River Basin Water Storage Feasibility Study Final Planning Report/Environmental Impact Statement*. December 19, 2008.

Reclamation, 2013a — Bureau of Reclamation. 2013. *Change in Discount Rate for Water Resources Planning. Federal Register.* https://www.federalregister.gov/articles/2013/11/12/2013-27089/change-in-discount-rate-for-water-resources-planning. November 2013.

Reclamation, 2013b — Bureau of Reclamation. 2013. *Record of Decision for the Yakima River Basin Integrated Water Resource Management Plan Final Programmatic Environmental Impact Statement*. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Columbia-Cascades Area Office, Yakima, Washington.

Reclamation, 2014a — Bureau of Reclamation. 2014. *Change in Discount Rate for Water Resources Planning*. Federal Register. https://www.federalregister.gov/articles/2014/12/29/2014-30426/change-in-discount-rate-for-water-resources-planning. December 29.

Reclamation, 2014b — Bureau of Reclamation. 2014. *Design, Estimating and Construction Review Report Keechelus-to-Kachess Conveyance Project.* Prepared by U.S. Bureau of Reclamation. September 2014.

Reclamation, 2014c — Bureau of Reclamation. 2014. *Expected Improvement in Fish Productivity in the Keechelus Reach with Implementation of the Proposed Keechelus-to-Kachess Conveyance (KKC) Memorandum*. U.S. Department of the Interior, Bureau of Reclamation. October 2014.

Reclamation, 2014d — Bureau of Reclamation. 2014. *Value Planning Final Report; Kachess Drought Relief Pumping Plant*. Prepared by U.S. Bureau of Reclamation. May 2014.

Reclamation, 2015 — Bureau of Reclamation. 2015. *Value Analysis; Kachess Drought Relief Pumping Plant*. Prepared by U.S. Bureau of Reclamation. Draft. September 2015.

Reclamation and Ecology, 2008 — Bureau of Reclamation and Washington State Department of Ecology. 2008. *Draft Planning Report/Environmental Impact Statement for the Yakima River Basin Water Storage Feasibility Study.* U.S. Department of the Interior, Bureau of Reclamation and Washington State Department of Ecology.

Reclamation and Ecology, 2011a — Bureau of Reclamation and Washington State Department of Ecology. 2011. *Costs of the Integrated Water Resource Management Plan.* Technical Memorandum. Prepared by HDR Engineering and Anchor QEA, for the U.S. Bureau of Reclamation. Contract No. 08CA10677A ID/IQ. March 2011.

Reclamation and Ecology, 2011b — Bureau of Reclamation and Washington State Department of Ecology. 2011. *Lake Kachess Inactive Storage.* Technical Memorandum. Prepared by HDR Engineering, Inc. and Anchor QEA, for the U.S. Bureau of Reclamation. Contract No. 08CA10677A ID/IQ. March 2011

Reclamation and Ecology, 2011c — Bureau of Reclamation and Washington State Department of Ecology. 2011. *Water Needs for Out-of-Stream Uses.* Technical Memorandum. Prepared by HDR Engineering, Inc. and Anchor QEA, for the U.S. Bureau of Reclamation. Contract No. 08CA10677A ID/IQ. June 2011.

Reclamation and Ecology, 2011d — Bureau of Reclamation and Washington State Department of Ecology. 2011. *Yakima River Basin Study; Volume 1, Proposed Integrated Water Resource Management Plan.* Prepared by HDR Engineering, Inc., Anchor QEA, ECONorthwest, ESA Adolfson, and Golder Associate, for the U.S. Bureau of Reclamation. Contract No. 08CA10677A ID/IQ. April 2011.

Reclamation and Ecology, 2011e — Bureau of Reclamation and Washington State Department of Ecology. 2011. *Yakima River Basin Water Resources.* Technical Memorandum. Prepared by Anchor QEA, for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. 08CA10677A ID/IQ. March 2011.

Reclamation and Ecology, 2012a — Bureau of Reclamation and Washington State Department of Ecology. 2012. *Four Accounts Analysis of the Integrated Plan.* Technical memorandum. Prepared by ECONorthwest, Natural Resource Economics, and ESA. U.S. Bureau of Reclamation and Washington State Department of Ecology. Contract No. 08CA10677A ID/IQ. October 2012.

Reclamation and Ecology, 2012b — Bureau of Reclamation and Washington State Department of Ecology. 2012. *Preliminary Cost Allocation for Proposed Integrated Water Resource Management Plan*. Technical memorandum. Prepared by HDR Engineering, Inc. for the U.S. Department of the Interior, Bureau of Reclamation. Contract No. 08CA10677A ID/IQ. October 2012

Reclamation and Ecology, 2012c — Bureau of Reclamation and Washington State Department of Ecology. 2012. *Yakima River Basin Integrated Water Resource Management Plan, Final Programmatic Environmental Impact Statement.* Prepared by ESA and HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation. March 2012.

Reclamation and Ecology, 2012d — Bureau of Reclamation and Washington State Department of Ecology. 2014. *Yakima River Basin Integrated Water Resource Management Plan, Framework for Implementation Report.* Prepared by HDR Engineering, Inc., Anchor QEA, ECONorthwest, Natural Resource Economics, and ESA, for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. 08CA10677A ID/IQ. October 2012.

Reclamation and Ecology, 2013 — Bureau of Reclamation and Washington State Department of Ecology. 2013. *Kachess Reservoir Inactive Storage Project Alternatives Comparison and Recommendations for Advancement*. Technical memorandum. Prepared by HDR Engineering, for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. 08CA10677A ID/IQ. October 2013.

Reclamation and Ecology, 2014a — Bureau of Reclamation and Washington State Department of Ecology. 2014. *Bull Trout Enhancement; Kachess Drought Relief Pumping Plant and Keechelus-to-Kachess Conveyance.* Prepared by Anchor QEA, for the U.S. Bureau of Reclamation. September 2014.

Reclamation and Ecology, 2014b — Bureau of Reclamation (U.S. Department of the Interior) and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant, Summary of Prior Geotechnical Data for Alternative 2 – South Pumping Plant.* Technical memorandum. Prepared by HDR Engineering, Inc., for U.S. Bureau of Reclamation, Contract No. 08CA10677A ID/IQ. September 2014.

Reclamation and Ecology, 2015a — Bureau of Reclamation and Washington State Department of Ecology. 2015. *Economic Analyses of the Proposed Kachess Drought Relief Pumping Plant Project.* Technical memorandum. Prepared by ECONorthwest, for the U.S. Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. (DRAFT). April 2015.

Reclamation and Ecology, 2015b — Bureau of Reclamation and Washington State Department of Ecology. 2015. *Feasibility Design Report, Kachess Drought Relief Pumping Plant.* Prepared by HDR Engineering, Inc., for the U.S. Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. (DRAFT). March 2015.

Reclamation and Ecology, 2015c — Bureau of Reclamation and Washington State Department of Ecology. 2015. *Hydrologic Modeling of System Improvements, Phase 1 Report*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. . November 2015.

Reclamation and Ecology, 2015d	Bureau of Reclamation and Washington State Department of Ecology. 2015. *Kachess Drought Relief Pumping Plant and Keechelus Reservoir-to-Kachess Reservoir Conveyance Draft Environmental Impact Statement.* Prepared by ESA and HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation. Contract No. R13PC10006 ID/IQ. January 2015.
Reclamation and Ecology, 2015e	Bureau of Reclamation and Washington State Department of Ecology. 2015. *Kachess Drought Relief Pumping Plant Field Cost Estimate.* Technical memorandum. Prepared by HDR Engineering, Inc., U.S Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. March 2015.
Reclamation and Ecology, 2015f	Bureau of Reclamation and Washington State Department of Ecology. 2015. *Keechelus-to-Kachess Conveyance Feasibility Design Report.* Prepared by HDR Engineering, Inc., Brierley Associates, Dr. Mole, Inc., and Engineering Solutions, LLC, for the U.S. Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. (DRAFT). March 2015.
Sampson et al., 2013	Sampson, M.R., D.E. Fast, and W.J. Bosch (editors). 2013. *Yakima-Klickitat Fisheries Project Monitoring and Evaluation – Yakima Subbasin, Final Report for the performance period May/2012-April/2013*. Project number 1995-063-25, 241 electronic pages.
Reiss et. al, 2012	Reiss, Y.K., J. Thomas, E. Anderson, and J. Cummins. 2012. *Final Yakima Bull Trout Action Plan.* September 2012.
Shannon & Wilson, 2014	Shannon & Wilson, Inc. 2014. *Geology Report, Kachess Drought Relief Pumping Plant (KDRPP)*. Kittitas County, Washington.
USFS, 2011	U.S. Forest Service. 2011. *Environmental Assessment – Gold Creek Bridges and F.S. Road #4832 Reconstruction*. Cle Elum Ranger District, Okanogan-Wenatchee National Forest, Kittitas County, Washington. June 2011.
U.S. Water Resources Council, 1983	U.S. Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.* U.S. Government Printing Office. March 1983. Washington D.C.

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