Yakima River Basin Integrated Water Resource Management Plan

Appraisal Design Report
Kachess Drought Relief Pumping Plant
Floating Pumping Plant Alternative

U.S. Bureau of Reclamation

Contract No. R13PC10006 ID/IQ

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DRAFT

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MISSION STATEMENTS

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List of Acronyms

BPA	Bonneville Power Administration
cfs	Cubic feet per second
Ecology	Washington State Department of Ecology
EDF	Energy Dissipation Factor
EL	Elevation
ESA	Endangered Species Act
ESM	Engineered Streambed Material
ft	Foot or feet
ft-lbs/ft^3/s	Foot-pounds per cubic foot per second
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
KDRPP	Kachess Drought Relief Pumping Plant
KKC	Keechelus to Kachess Conveyance
kV	Kilovolt (1,000 volts)
MVA	Megavolt Amperes
NETA	National Electrical Testing Association
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PSE	Puget Sound Energy
Roza	Roza Irrigation District
SCADA	Supervisory Control and Data Acquisition
SDEIS	Supplemental Draft Environmental Impact Statement
USFS NF	United States Forest Service National Forest
VFD	Variable Frequency Drive
VFI	Vacuum Fault Interrupter
WDFW	Washington Department of Fish and Wildlife

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Project Overview

As part of the continued refinement of the Kachess Drought Relief Pumping Plant project, the Bureau of Reclamation and Washington State Department of Ecology (Ecology), in collaboration with Roza Irrigation District (Roza), are evaluating a floating pumping plant at Kachess Reservoir in Kittitas County, Washington. The floating pumping plant would access water below the existing gravity outlet of the reservoir for use in drought years. This is a new configuration of the Kachess Drought Relief Pumping Plant (KDRPP) that has been proposed as part of the Yakima River Basin Integrated Water Resource Management Plan (Integrated Plan). Similar to the two other configurations presented in the Feasibility-Level Design Reports for KDRPP and for Keechelus to Kachess Conveyance (KKC) (Reclamation and Ecology 2017 and 2018a) , the floating pumping plant would be capable of pumping up to 200,000 acre feet of water supply in a drought year from the inactive pool of Kachess Reservoir. In order to support overall operations of Reclamation's Yakima Project, HDR in consultation with Reclamation's Yakima Field Office selected a minimum design flow rate of 1,000 cubic feet per second (cfs) for the floating pumping plant.

This appraisal design technical report describes the principal project features and essential characteristics of the floating pumping plant proposal to inform the impact analyses for the KDRPP Planning Study and the KDRPP and KKC Supplemental Draft Environmental Impact Statement (SDEIS). This report also outlines a construction approach and summarizes typical operations and maintenance procedures. HDR has developed this information in consultation with Reclamation, Ecology, and Roza.

HDR developed the following figures to support the description of the principal project features:

- Figure 1: Schematic Hydraulic Profile for the pumping plant.
- Figure 2: Overall Site Plan providing the general locations for the principal project features of the floating pumping plant.
- Figure 3: Project Site Plan showing principal project features that are located on or adjacent to Kachess Reservoir.
- Figure 4: Control Building and Kachess Reservoir Substation Site Plan.
- Figure 5: East Shore Boat Ramp Site Plan.

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KACHESS RESERVOIR SCHEMATIC HYDRAULIC PROFILE

(Showing Historical Natural Lakes, Existing Kachess Dam & Reservoir, and Proposed Drawdown ~ Not to Scale)

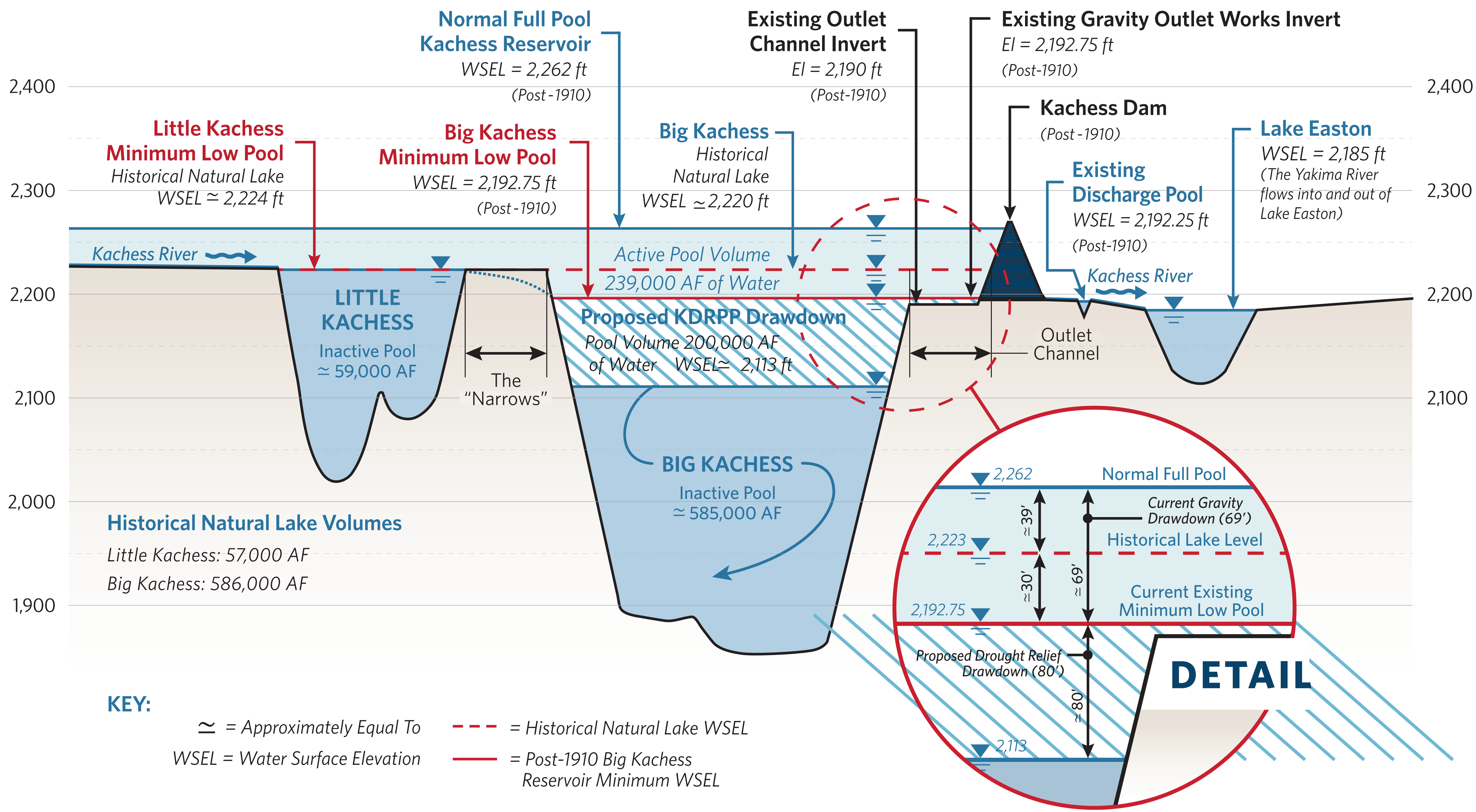

Figure 1
Schematic Hydraulic Profile

Updated September 2016

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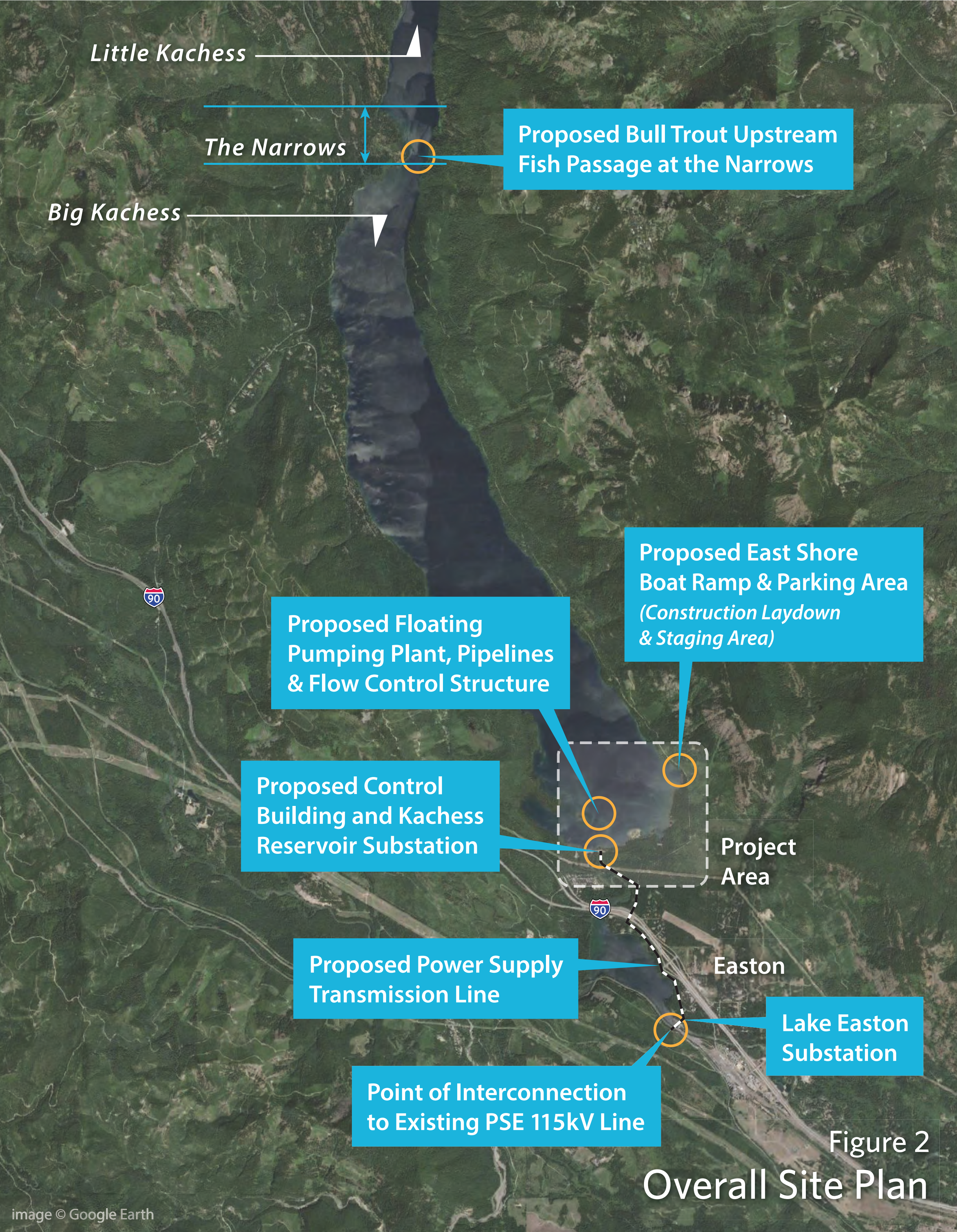

Figure 2
Overall Site Plan

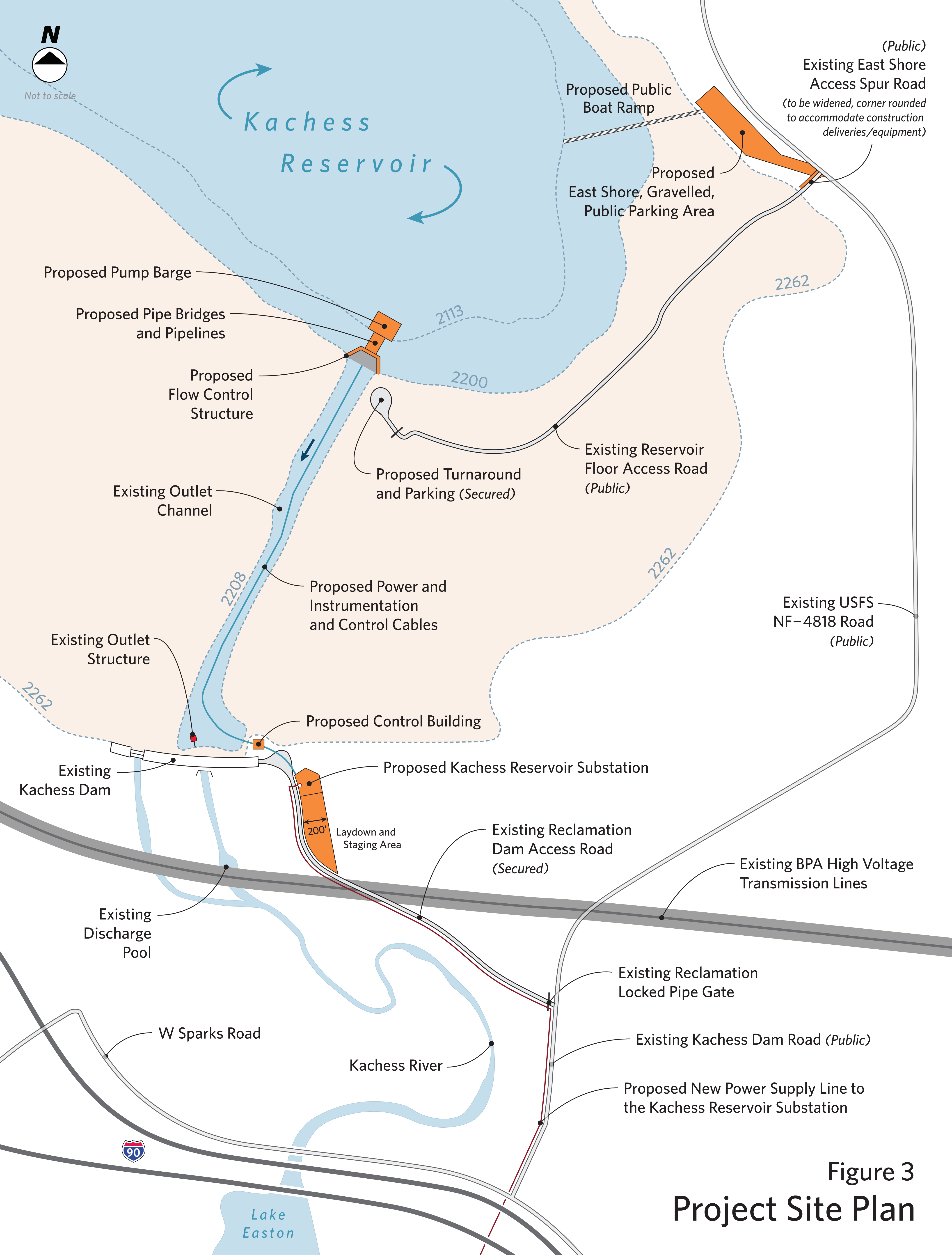

Figure 3
Project Site Plan

Figure 4
Control Building and Substation Site Plan

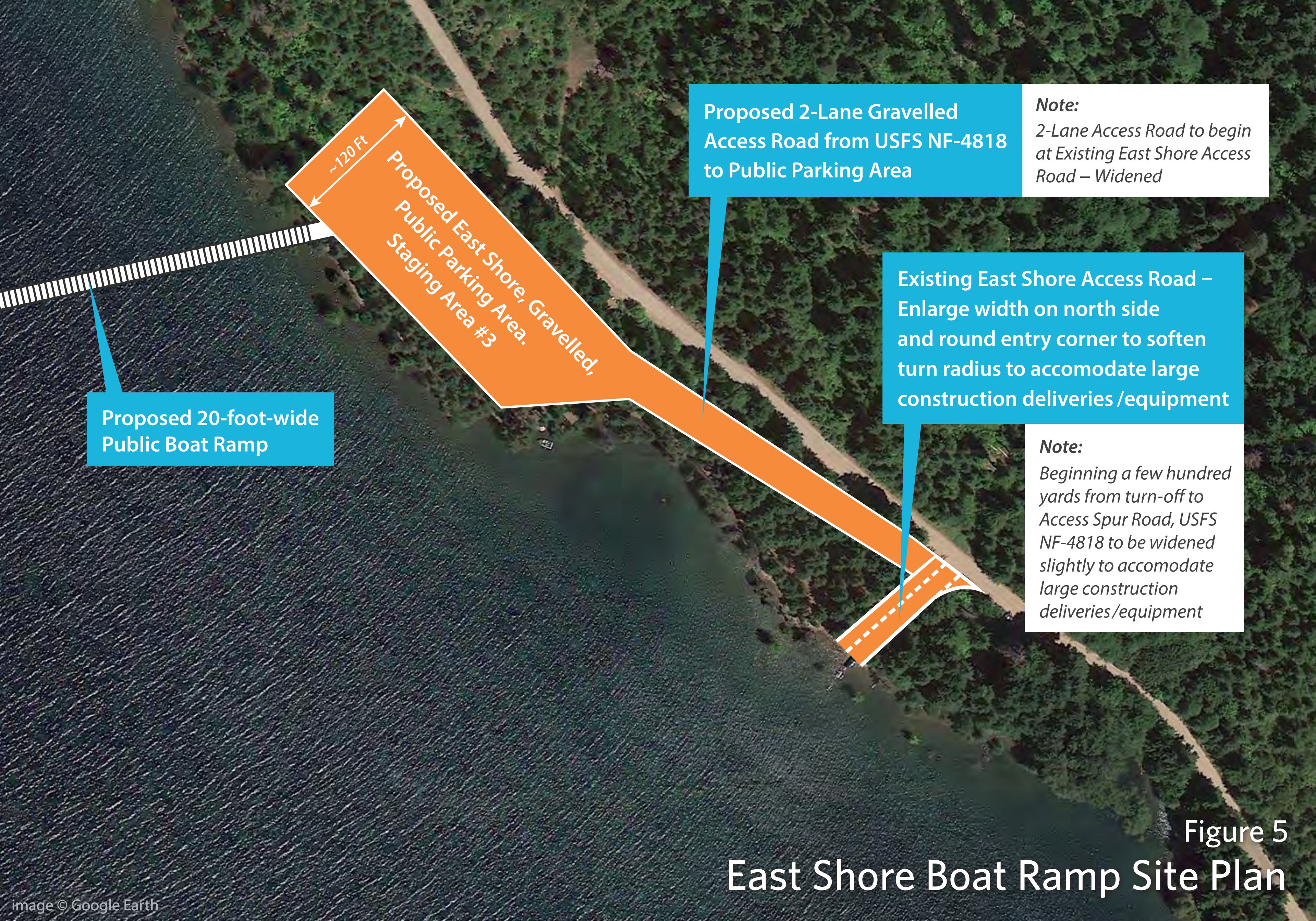

Figure 5
East Shore Boat Ramp Site Plan

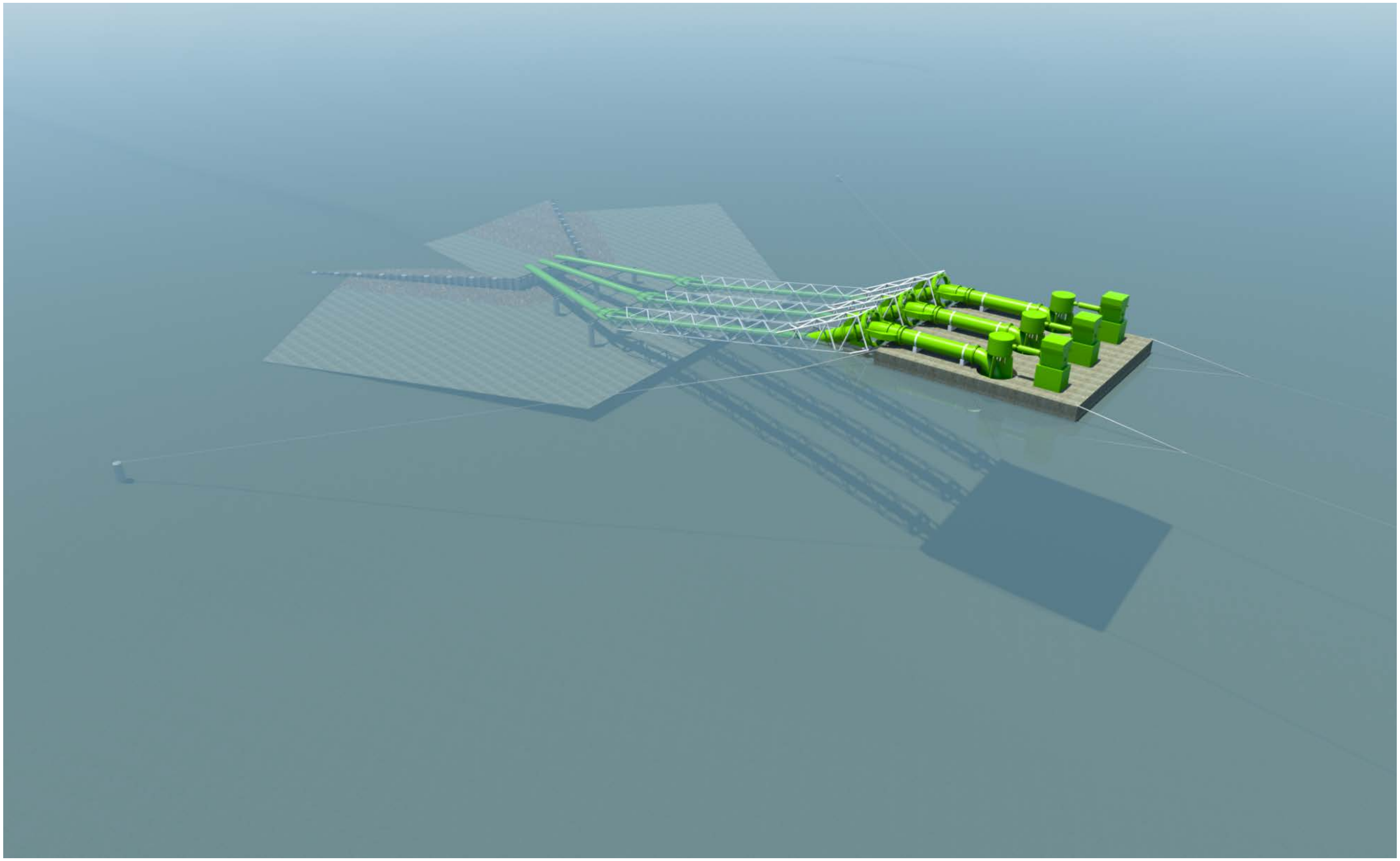

Figure 6. Floating Pumping Plant at Kachess Reservoir Maximum Pool – Gravity Operation

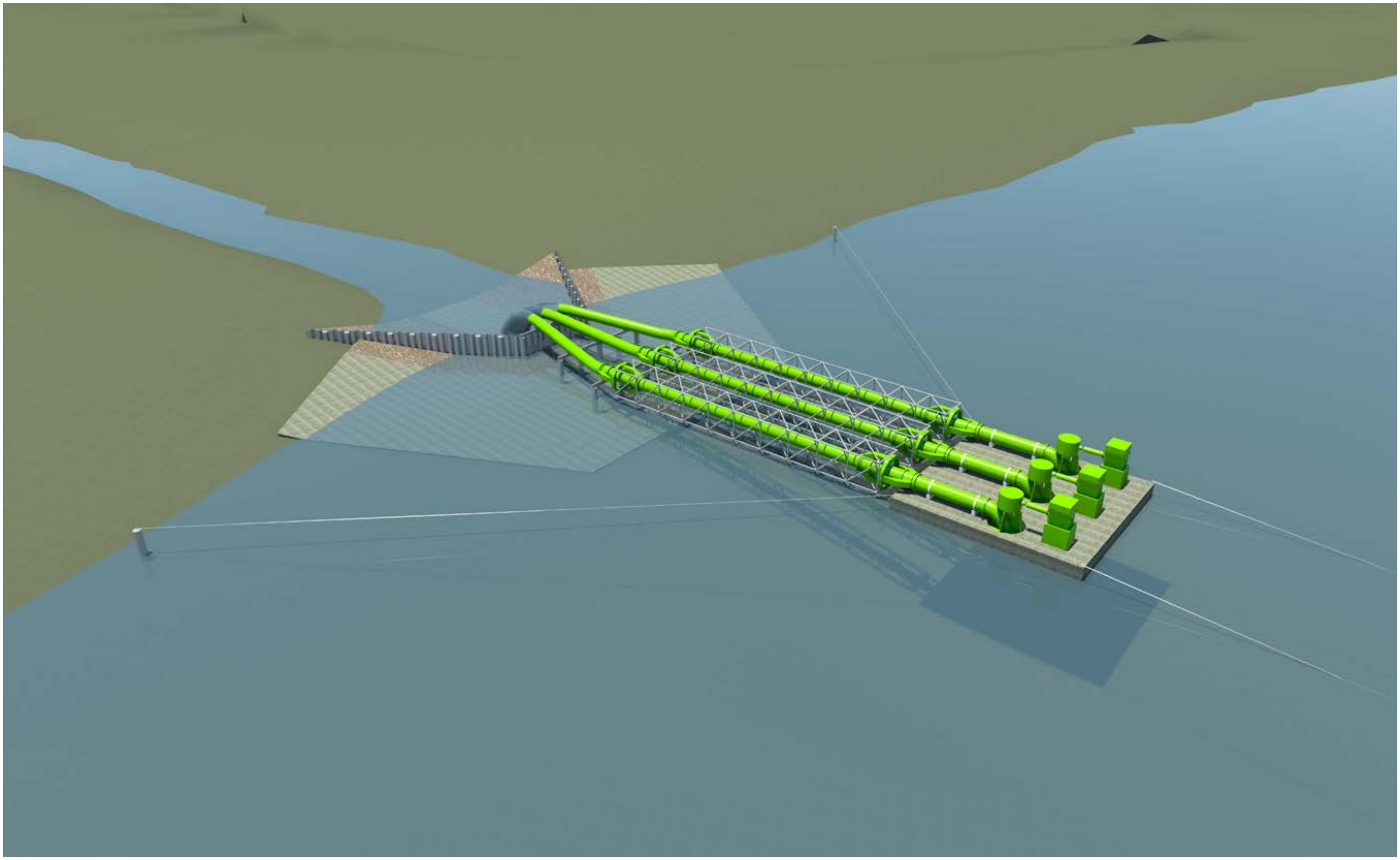

Figure 7. Floating Pumping Plant at Kachess Reservoir Maximum Pool – Initiation of Drought Relief Pumping

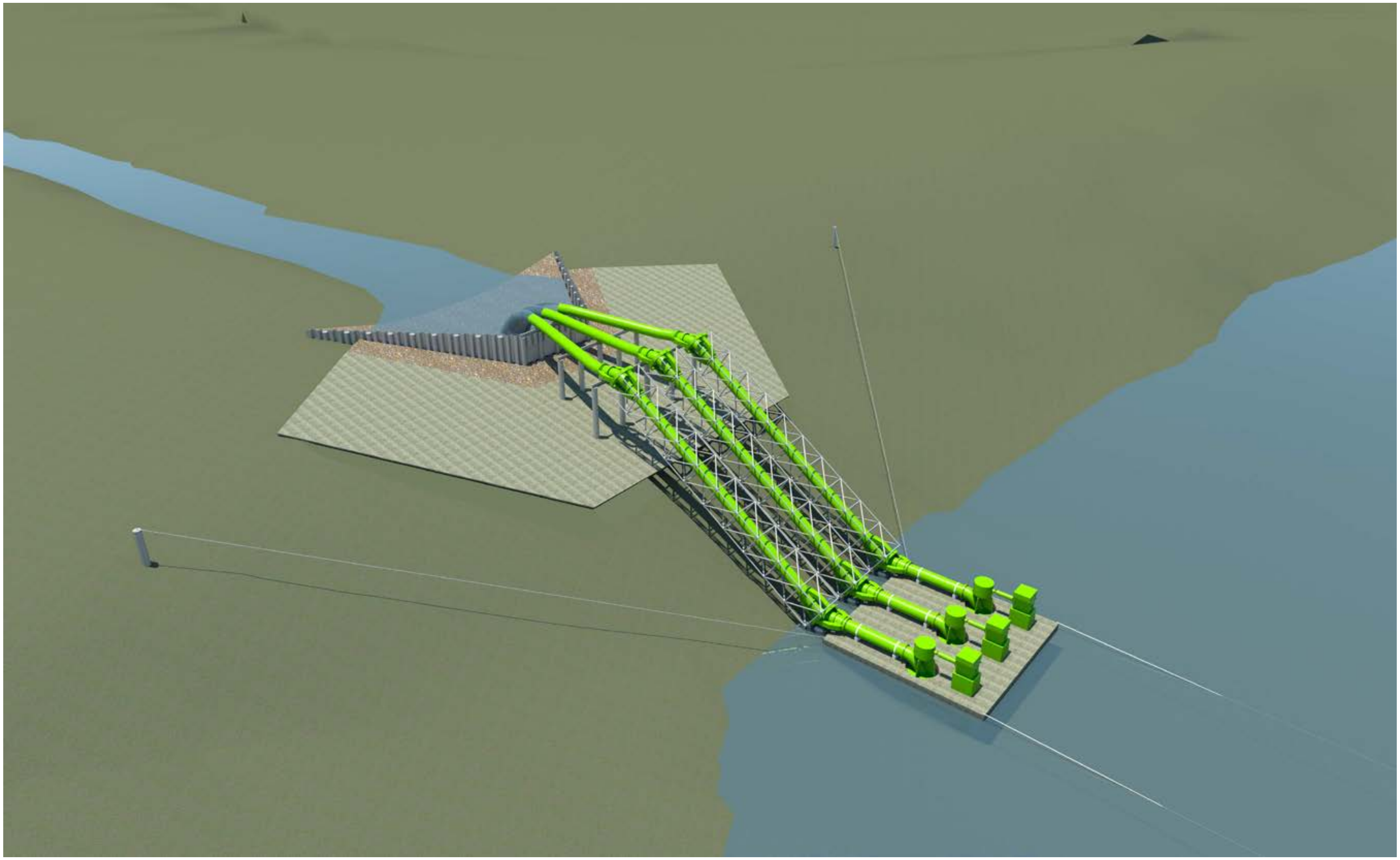

Figure 8. Floating Pumping Plant at Kachess Reservoir Minimum Pool – Lowest Drought Relief Pumping

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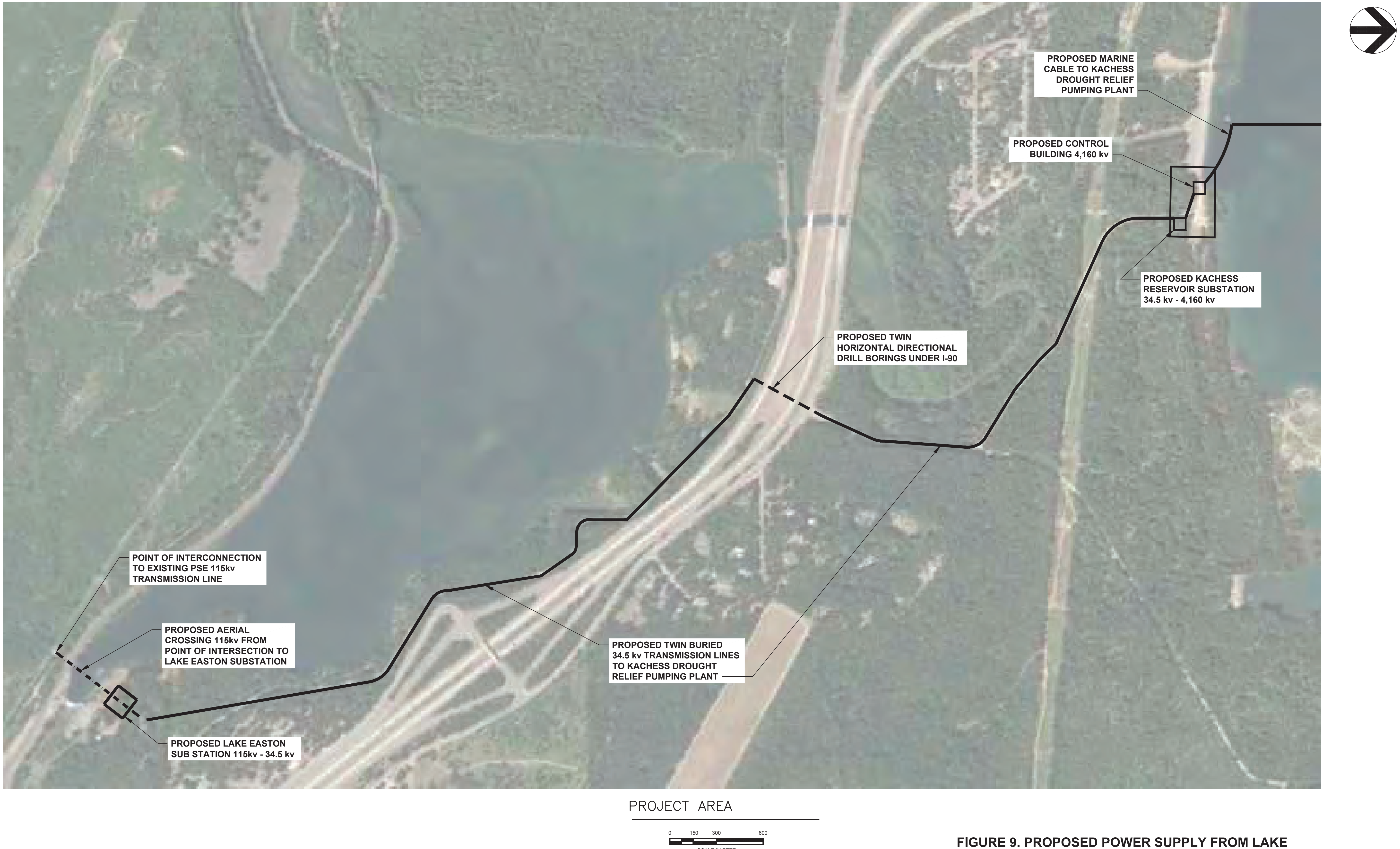

FIGURE 9. PROPOSED POWER SUPPLY FROM LAKE EASTON TO FLOATING PUMPING PLANT

SCALE: 1"=30'

PLAN - OVERHEAD 115kv TRANSMISSION LINES

FIGURE 10

1.0 Principal Project Features

1.1 Access Roads and Parking Area

The construction contractor would use existing onsite access roads only for project construction, operation and maintenance of the proposed facility, with the exception of a short, 300-foot-long by 30-foot-wide access road (0.2 acres) as described below. A total of approximately 28.3-acres of existing access road would be used.

1.1.1 Existing Kachess Dam Road

(0.25-mile-long, paved, then 0.25-mile-long gravel, public, maintained road approx. 30 feet wide [1.8 acres])

Kachess Dam Road is an existing public access road that becomes USFS NF- 4818 at about the 0.5-mile mark. The Kachess Dam Road is the only road that would be used to access the principal project features for construction and ongoing project operation and maintenance activities once the project is placed into service. North of the Kachess Dam Road 0.5 mile marker is Reclamation's "authorized vehicles only" access road to Kachess Dam. Entry to this road is restricted by Reclamation's locked, steel pipe gate, see Figure 3.

1.1.2 Existing Reclamation Dam Access Road

(0.8-mile-long, secured, maintained, gravel road [2.9 acres])

The "authorized vehicles only" road is owned and maintained by Reclamation and is the only access road that would be used for construction and ongoing operation and maintenance activities for the following specific principal project features: the project switchyard and the control building..

1.1.3 Existing USFS NF-4818 Road

(6.1-mile-long, public, maintained, gravel road, width varies from approx. 20 to 30 feet wide [22.2 acres])

The construction contractor would use the existing USFS NF- 4818 road for construction and ongoing operation and maintenance activities for the following specific principal project features: the flow control structure, the pipe bridges and pipelines and the pump barge.

1.1.4 Existing East Shore Access Spur Road

(0.1-mile-long, public, unimproved, unmaintained, primitive, native material road approx. 16 feet wide [0.2 acres])

The existing, unimproved east shore access spur road is heavily used by recreational vehicles and recreational users of Kachess Reservoir to access the reservoir's southeastern shoreline. This existing access road connects the existing USFS NF-4818 Road to the floor of the reservoir at the reservoir's high water mark (EL 2262) on the southeast corner of the reservoir. This existing access spur road leads to an on-reservoir access road that runs to the most upstream end of the Kachess Dam outlet channel and also to a shoreline access road that runs north up the eastern shoreline of Kachess Reservoir.

1.1.5 Existing Reservoir Bed Access Road

(0.5-mile-long, public, unimproved, unmaintained, native reservoir-bed material road, with a variable width ranging from 12 to 20 feet wide [1.2 acres])

This existing road has been established by the diversity of recreational vehicles that enter onto the reservoir floor via the existing east shore access spur road. In 2015, as part of the Kachess Emergency Temporary Floating Pumping Plant project, Yakama Nation cultural resource experts established an alignment along this existing road that would avoid impacts on identified potential sensitive cultural and historical sites. The Yakama Nation's defined alignment was surveyed, and an acceptable alignment for project use was established. A proposed new secured turnaround and parking area would be located at the far end of this defined road alignment, adjacent to the existing outlet channel. The construction contractor would place fill to raise the elevation of the turnaround and parking area to allow for access at water surface elevations approaching 2235. The contractor would use the turnaround and parking area during construction and Reclamation or Roza would use them subsequently for ongoing project operation, maintenance, and repair activities; whenever the reservoir water surface elevation is sufficiently low to make the access road and turnaround area accessible.

1.1.6 Proposed East Shore Boat Ramp Parking Area and Access Road

(A new 1.5-acre public, gravel-surfaced parking area; approx. 120 feet by 400 feet; and a new 300-foot-long by 30-foot-wide access road to the parking area [0.2 acres])

Access to the proposed parking area for the east shore boat ramp would be off of the existing, but widened, east shore access spur road by means of a new graveled road approximately 300 feet long and 30 feet wide running from the existing USFS NF-4818 road to the proposed new parking area. See Figures 3 and 5. The construction contractor would initially use the proposed new access road and parking area. Once construction is complete, this access road and staging area would be gravel surfaced for use by the general public. Together, the improved east shore access spur road, the new east shore boat ramp access road and parking area would allow the public to make use of the new boat ramp. Project maintenance and operations personnel would continue to use these facilities for routine and periodic operation and maintenance upon completion of construction.

1.1.7 Narrows Access

Reclamation would obtain access to the Narrows for construction, operation and maintenance of the proposed new bull trout upstream passage facilities by one of two alternatives. The alternatives are: use of one or both of the two west shore access road alternatives, or by marine access via barge that would launch from the south end of the reservoir from an existing access road. Under all access options, access to the construction staging areas would be used specifically for construction, operation and maintenance, and monitoring of the Narrows bull trout upstream fish passage facility. Reclamation would restrict access to roads across the reservoir floor to this area to authorized vehicles only, to limit access to this important endangered species act (ESA) listed species mitigation feature. These alternatives are presented in Figures 11 and 12 described below.

1.1.7.1 *Proposed West Shore Narrows Access Road from South (Option A)*

Under this access option, the Narrows would be accessed via Forest Service Road NF-4948 to Bakers Lane. From Bakers Lane, existing roads that run to the shore of the reservoir south of Washington State's Kachess Campground would be used to gain access to the bed of the reservoir. From the shoreline, the construction contractor would use a temporary road on the reservoir bed (approximately 0.4 miles long and 20 feet wide [0.9 acres]) to gain access to the Narrows for construction of the bull trout upstream passage features (see Figure 11 Narrows Access Options).

1.1.7.2 *Proposed West Shore Narrows Access Road from North (Option B)*

Under this access option, the Narrows would be accessed via Forest Service Road NF-4948 to Bakers Lane. From Bakers Lane, existing roads that run to the shore of the reservoir north of Washington State's Kachess Campground would be used to gain access to the bed of the reservoir. From the shoreline, the construction contractor would use a temporary road on the reservoir bed (approximately 0.8 miles long and 20 feet wide [1.8 acres]) to gain access to the Narrows for construction of the bull trout upstream passage features (see Figure 11 Narrows Access Options).

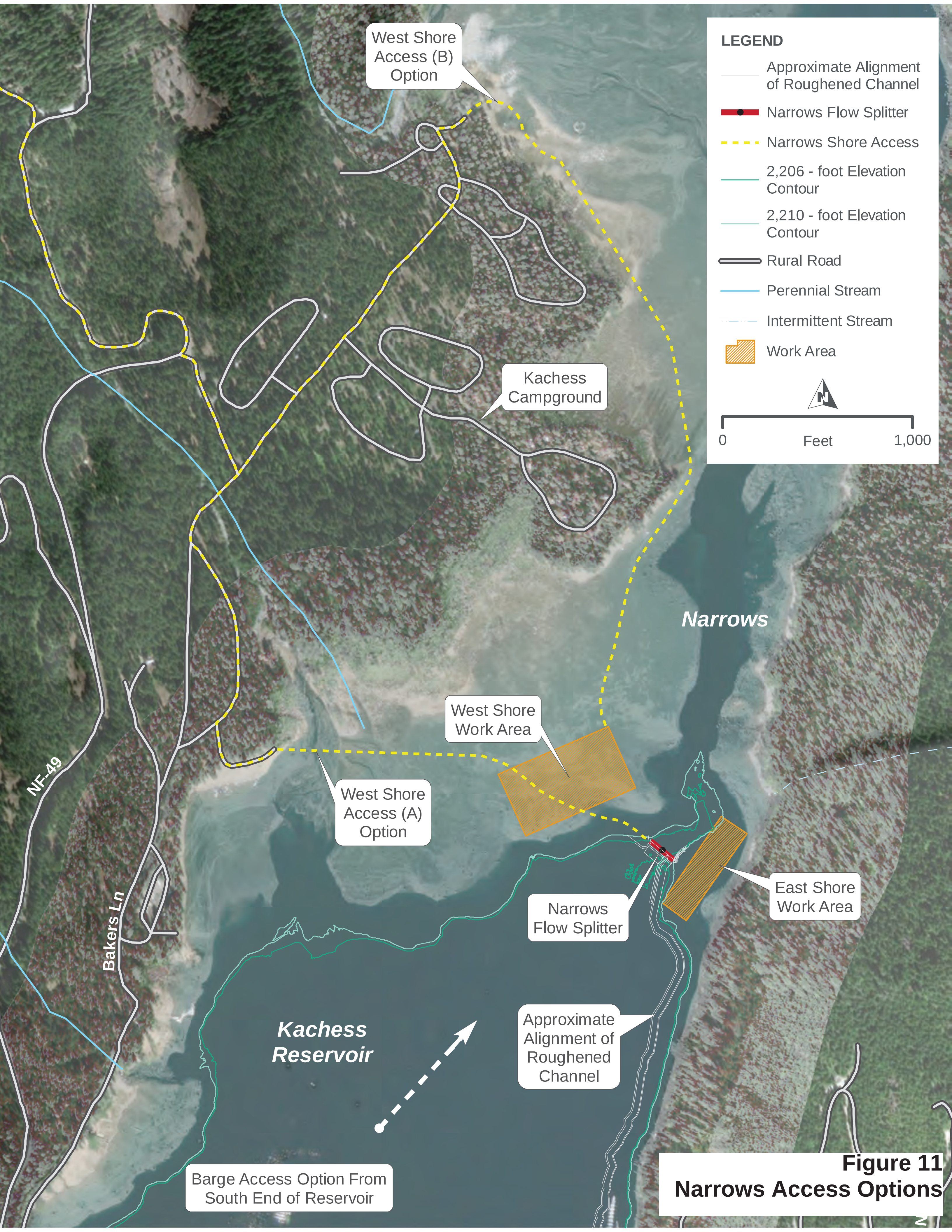

Figure 11
Narrows Access Options

1.1.7.3 *Proposed Marine Access via Barge from South*

Existing roads that provide access to the shore of Kachess Reservoir at the south end of the reservoir would be used gain access to the reservoir. From there, a barge would be used to transport equipment and supplies to the Narrows for construction of the bull trout upstream passage features. The construction contractor would drive equipment and materials off the barge and across the reservoir floor to the construction staging area near the downstream end of the Narrows (see Figure 11 Narrows Access Options).

1.1.8 Proposed Narrows Work Areas

Both an east shore and a west shore work area have been identified and are shown in Figure 12 Narrows Work Areas. The construction contractor would use these work areas for construction of the Narrows flow bifurcation weir and the roughened channel. The east shore work area is approximated 600 feet by 400 feet (5.5 acres) and the west shore work area is approximately 600 feet by 200 feet (2.8 acres).

1.2 Staging Areas and Clearing-Only Areas

Three construction staging areas and one clearing-only area are described below. An approximate total of 7.2 acres for staging would be needed; that would have an approximate total of 6.2 acres of clearing needed.

1.2.1 Staging Area 1

(New area approximately 4 acres, requires 4 acres of clearing)

Staging Area 1 is located on the east side of and adjacent to Kachess Dam access road, immediately north of the existing Bonneville Power Administration (BPA) high-voltage transmission line corridor (see Figure 4). This area would serve as the primary on-site storage area for steel pipe pile, steel sheet pile, structural steel members, steel pipeline, barge components, pumps, motors, and right angle drives. At the proper time, the construction contractor would transport these materials to Staging Area 3 and the eastern shore of Kachess Reservoir for assembly. The contractor would construct or assemble the flow control structure, pipe bridges and pumping barge either at their permanent location or they would assemble them on shore and float them to their permanent location. Once the various materials for construction have been used and Staging Area 1 is vacant, it would then become the site for construction of the Kachess Reservoir Substation.

1.2.2 Staging Area 2

(Existing area approximately 1.0 acres, requires 0 acres of clearing)

This area is located on the east side of and immediately adjacent to Kachess Dam access road, see Figure 4. This area is presently occupied by a stockpile of earthen material placed there during re-construction of the Kachess Dam intake structure. The area is located about 200 feet from the full pool shoreline on the dam's left abutment and about 500 feet east of the dam. The contractor would use Staging Area 2 for construction of the control building. When the construction of the control building is completed, the contractor would grade this staging area and reseed it for erosion and sedimentation control.

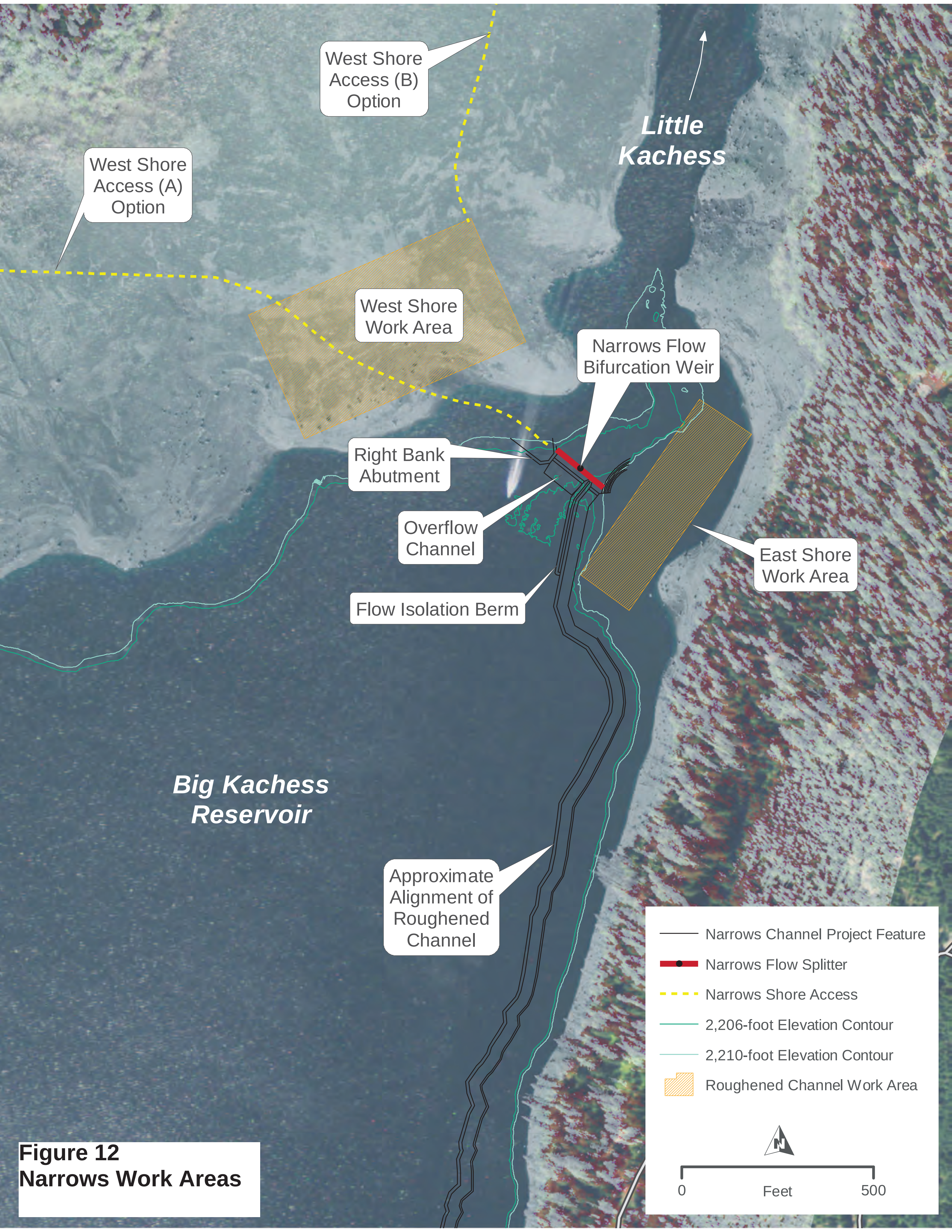

Figure 12
Narrows Work Areas

1.2.3 Staging Area 3

(New area approximately 2.0 acres, requires 2.0 acres of clearing)

This area is located on the east shore of Kachess Reservoir between the eastern reservoir shoreline and USFS NF-4818. Access to Staging Area 3 is directly off of USFS NF- 4818 via a gently sloping proposed new access road from USFS NF- 4818. The contractor would use this staging area for construction of the boat ramp, and some construction associated with the flow control structure, pipe bridges, and the pump barge. Once construction is completed, Staging Area 3 is proposed to be a public parking area for a new public use boat ramp. See Figure 5.

1.2.4 Control Building (Clearing-only Area)

(New area approximately 0.2 acres, requires 0.2 acres of clearing)

The clearing-only area is approximately 0.2-acre of land on which the control building would be constructed. This area is located near the left abutment of Kachess Dam on the shore of Kachess Reservoir above the normal high water elevation of 2,262 feet. See Figure 4.

1.3 East Shore Boat Ramp

When construction is approaching completion, the contractor would build a boat ramp on the East Shore for subsequent use by the public and operations and maintenance staff who work on the floating pumping plant. Construction of the boat ramp would not be initiated until construction activities that need to occur on that portion of the reservoir floor are completed. This is because the heavy construction equipment along with the heavy components needed for construction of the barge, pumps and motors could damage the boat ramp if it were constructed too early in the construction process. The east shore boat ramp would be approximately 600-feet-long and 20-feet-wide. Once completed, the boat ramp would be useable over the full range of both gravity and drought-relief pumping operations (i.e., from a high pool reservoir elevation of 2,262 feet to a low pool elevation of 2,113 feet).

The initial length of boat ramp that would be constructed would be from elevation 2,262 down to approximate elevation 2,193 see Figure 3. Sections of boat ramp to be built at elevations lower than this initial length of boat ramp would be constructed in future years when the drought relief pumping plant is operated and the reservoir is lowered below elevation 2,193.

1.4 Geotechnical and Foundations

The need for geotechnical and foundation designs is anticipated at multiple locations across the overall project site. Each of the anticipated foundation structures is identified below.

1.4.1 Substation Structures

These are anticipated to be simple concrete slabs on grade and low-height concrete walls.

1.4.2 Control Building Foundation

This is anticipated to be a simple concrete slab on grade.

1.4.3 East Shore Boat Ramp and Parking Area

The boat ramp is envisioned to be precast concrete beams, 20 feet long, laid on the floor of a graded, constant slope (~12 percent) with angular stone aggregate placed between beam sections.

1.4.4 Flow Control Structure

This structure would be a Combi-wall structure built of 3-foot-diameter steel pipe piles with steel sheet pile in-between pipe piles (see Figures 13). The pipe piles would be driven into position in the floor and side slopes of the existing outlet channel. Following installation, the hollow pipe piles are anticipated to be filled with concrete. The Combi-wall structure would serve both as a water retention structure (for water pumped into the outlet channel) and as an anchoring structure (for the rigid and floating pipe bridges and the floating pump barge).

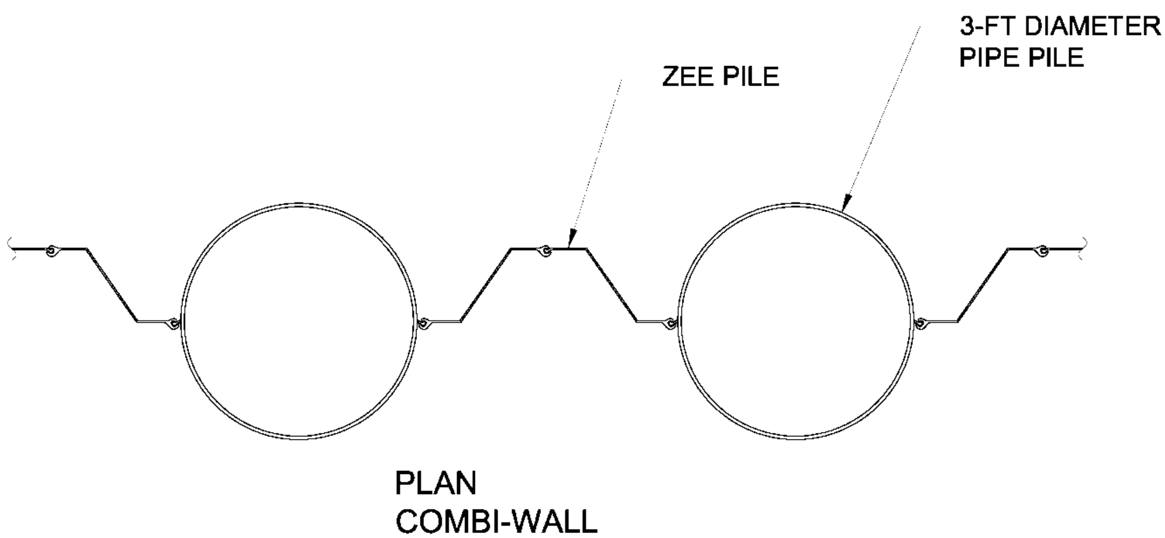

Figure 13. Plan Combi-Wall

Four (4) 8-foot-wide by 10-foot-tall steel bulkheads would be located on the south side (the dam side) of the Combi-wall structure, as opposed to being located on the north side (the reservoir side) of the Flow Control Structure. In this manner, the water pressure on the bulkheads will be encouraging sealing of the bulkheads when they are needed during drought relief pumping. These four bulkheads would be open during gravity flow operation and closed during drought-relief pumping operation.

Directly beneath the terminal ends of the discharge pipelines from the pump barge would be an 18-inch-thick, cast-in-place concrete water jet impact slab, 40 feet wide by 100 feet long. The downstream end of the slab would be fitted with energy dissipation blocks (if determined to be necessary). These would dissipate the energy of the pumped water, leaving the discharge end of the three (3) 6-foot-diameter pipelines as it drops into the outlet channel.

Adjacent to this slab would be riprap armoring on the balance of the floor and the lower side slopes of the outlet channel. The riprap would prevent scour and erosion of the existing earthen channel from the water pumped from the reservoir and into the outlet channel during drought-relief pumping. The entire flow control structure would be built on previously disturbed ground on the floor of the reservoir.

1.5 Catenary Anchorage System

The catenary anchorage system for the floating pumping plant barge consists of four (4) mooring anchors; two (2) chain catenaries and two (2) cable catenaries. The catenary anchorage system would keep the floating pumping plant barge moored in its proper position, while providing the flexibility needed to accommodate various changing reservoir conditions. Changing reservoir conditions include: the rise and fall of the reservoir water surface elevation during both gravity operations and drought relief pumping operations, reservoir currents and wind, wave and ice loadings.

1.5.1 Chain Catenaries

Each chain catenary would originate from the two corners located of the south end of the pump barge and terminate at an anchor point located immediately east and west of the flow control structure. These chain catenary anchor points would be a drilled, steel pipe piles (potentially concrete filled) and approximately 3 feet in diameter and 60 feet long.

1.5.2 Cable Catenaries

If determined to be needed, up to two cable catenaries would originate from the north end of the pump barge and terminate at an anchor point(s) located to the north of the pump barge on the floor of the reservoir. Each cable catenary would likely be equipped with a self-tensioning winch system capable of adjusting to the various changing reservoir conditions identified and described above. This cable catenary anchor point(s) are anticipated to be heavy manufactured steel anchors placed on the floor of the reservoir from a barge or other comparably large and heavy anchoring feature.

1.6 Interconnection to Existing Transmission Line

Reclamation or Roza would obtain a power supply to the pumping plant by interconnecting to PSE's existing Intermountain transmission line. The proposed point of interconnection is located on the south side of the Yakima River at the outlet of Lake Easton. The transmission line in this area is currently operated at 115 kV. PSE has been upgrading segments of the line to be able to operate at 230 kV. The transmission tap required for this substation would be constructed to 230kV standards and clearances to allow for operation at either voltage.

The transmission line would require a new, guyed single-pole 3-way tap structure less than 100 feet in height, in the Intermountain transmission line. The line would then span the Yakima River and Lake Easton just upstream of the Kittitas Reclamation District diversion dam. The line would run to a second guyed single-pole structure less than 100 feet in height located on the north side of the Yakima River and Lake Easton. The line would feed the substation on the north side of the dam. There would be one single-circuit, radial transmission line providing power to the substation.

Also within PSE's transmission line, two line disconnect switches would be required to isolate the tap from the transmission system. The line switches would be installed on existing PSE transmission structures adjacent to the new tap structure.

The transmission line would require a centerline easement 100 feet wide, with 50 feet on either side of the centerline. The alignment would be approximately 800–feet-long, from the existing PSE transmission line to the new substation. The transmission line would also require a guying easement of 80 feet x 10 feet, to the southwest of the PSE transmission line from the tap structure. PSE standards would be used for conductor sizing and structure requirements.

1.7 Lake Easton Substation

The Lake Easton Substation is anticipated to be constructed on the north side of Lake Easton dam. The substation would be a single bus design with the sole purpose to feed the pumping plant. The substation would require an approximate 115 feet x 110 feet plot of land. Transformer oil spill containment is included in the design. The substation transformer would be installed for dual high side voltage of 115 and 230 kV. The substation would be built to PSE standards and house the required equipment, including:

- Isolation switches with Motor Operated Disconnects on the transmission line. These switches would likely be installed on the first structure outside of the substation.
- A 115/230 kV power transformer.
- An air break disconnect switch.
- A circuit switcher (without integrated switch).
- An open-air 34.5 kV feeder structure/tree feeder breakers.
- A mobile substation hookup.

- Drive access within the station.
- Station service transformers.
- A control house.
- SCADA equipment.
- Associated protection equipment.
- Snow melting equipment to critical substation components.

The substation site is currently designed with no redundant 115/230 kV source feed or redundant transformer because this would increase the cost. The reliability of similar installations is very good without increased redundancy. In the case of the Kachess reservoir, maintenance can be performed on the substation during the times when the irrigation pumps are not operating. If additional redundancy is deemed necessary, Reclamation and Roza would consider additional costs and modifications during final design. The substation layout would have room for PSE to bring in a mobile substation, if it is ever needed.

1.8 Cable Loading Analysis

The estimated total loading for the pumping plant is 16 Megavolt Amperes (MVA). An additional 4 MVA load is planned to accommodate potential growth and allow for system losses. The construction contractor would install two conduits from the Lake Easton Substation to the Kachess Reservoir Substation, and each would be loaded with approximately half the required capacity. In the event that one of the circuits is damaged or taken out of service, the entire load can be served by the remaining single circuit. With a total of 20 MVA, at 34.5 kV, a single, three-phase feeder must be able to adequately carry 335 amps under a contingency if one feeder needs to be taken out of service for maintenance. Heat trapped within conduit and cable often requires the cable ampacity to be de-rated from the manufacturer's published specifications. HDR conducted a thermal de-rating analysis on this installation to determine proper cable selection.

The 34.5 kV feeders are designed with two feeders for multiple reasons. First, it was determined early in this investigation that there would be two conduits installed along the route; therefore, it made sense to install energized cable in each conduit run. A redundant circuit allows both feeders to operate partially loaded, which extends the cable life. It is recommended to utilize both circuits for normal operation. In the event of a fault, cable dig in, or need to take equipment out of service at the pad yard, the entire load can be easily transferred and fed through a single transformer or vacuum fault interrupter (VFI) and still serve the entire pump station load.

1.9 Cable Routing and Construction

Two buried conduits, each having a 34.5 kV transmission cable installed in it, would run from the Lake Easton Substation to the Kachess Reservoir Substation a total distance of approximately 8,750 feet (1.67 miles). The conduits would cross beneath Interstate 90 by means of twin horizontal directional drilling (HDD) borings. The conductor cables would be placed in approximate 16-inch diameter high density polyethylene (HDPE) conduits (oversized to ease the cable pulling loads over these longer distances). The construction contractor would place the buried conduits in a shallow trench constructed to PSE specifications. The contractor would minimize conduit bends to ease cable pulling. Vault spacing is dictated by the physical capabilities of the cable to withstand the pulling tensions.

The power cables would be located within existing road right of way for as much of the distance as possible. From the Lake Easton Substation to the HDD crossing of I-90, it is possible that portions of the route would require clearing within or along the roadway, either in the existing road right of way or adjacent to it. From the HDD crossing of I-90 to the Kachess Reservoir Substation, the route is located entirely within existing road right of way. The vast majority of the distribution line route is located on property owned by Reclamation. A short reach located between Interstate 90 and Lake Easton is located on Washington State Agricultural Trust Land, and Reclamation has a crossing agreement for that land.

1.10 Kachess Reservoir Substation

The proposed 34.5 to 4.16 kV Kachess Reservoir Substation would be located on the Northern end of the 3-acre staging area adjacent to Kachess Reservoir. The substation yard would be kept relatively small (approximately 100 feet by 90 feet) with the majority of controls and switching located in the pump station control house. Transformer oil spill containment is included in the design. The substation yard would consist of the following:

- Two primary 34.5 kV meters
- Two 34.5 kV vacuum fault interrupters (VFIs)
- Two 15/20 MVA, 34.5-4.16 kV pad-mounted transformers.
- A fenced enclosure containing a generator would be located at the north end of the substation.

The VFIs would each be configured with two source feeds and two taps. This configuration would allow maximum variability to feed the transformers and increased redundancy. The backup generator would not be sized to feed the pumping load. Rather, it would be sized to power only those systems needed to keep the project minus the pumping units operational.

Both 34.5 kV circuits would be used for normal operations. In the event of a fault, cable dig in, or need to take equipment out of service at the pad yard, the entire load can be easily transferred and fed through a single transformer or VFI and still serve the entire pumping plant load.

Control Building A pre-engineered control building having approximately 3,200 square feet of floor space would be located on the shoreline of Kachess Reservoir on the point of land near the left abutment of Kachess Dam. The building will be designed to accommodate all structural and seismic design criteria applicable to this site. The control building would house switchgear, instrumentation, and a variable frequency drive (VFD) for each of the three pump motors, as well as appurtenant instrumentation, control, and communication equipment.

1.11 Submarine Power and I&C Cables

Four (4) submarine power and instrumentation and control cable bundles would run from the control building out to the pump barge. Beginning at the control building, the bundles would be buried and contained within conduit. Conduit bundles would run from the control building down the side slope of the outlet channel to the floor of the outlet channel (a distance of about 500 feet). Conduit protection of the bundles would end where the cables reach a location on the floor of the outlet channel that is always below the surface of the water in the outlet channel. Beginning where the conduit ends, the cable bundles would simply lay directly on the floor of the outlet channel out to the flow control structure (a distance of about 2,000 feet). From the base of the flow control structure, the cable bundles would once again be located in conduit that is attached to the downstream side of the flow control structure. From there, the conduit-enclosed cable bundles would be secured to the pipe bridges that connect the flow control structure to the pump barge (a distance of about 200 feet). The cable bundles would terminate at each motor that drives each pump-motor set on the pump barge.

1.12 Flow Control Structure

The construction contractor would build an approximately 300-foot-long flow control structure across the north end of Kachess Reservoir's existing outlet channel where the upstream end of the channel originates when the reservoir is in a drawdown condition. This area is exposed when the reservoir is at low pool. The flow control structure would have four large openings equipped with steel bulkheads (approximately 10 feet tall by 8 feet wide each) to allow reservoir water to pass through the flow control structure when the project is releasing water above the existing outlet works (gravity outflow). The combined total flow area of these four bulkheads would be approximately 320 square feet. The bulkheads would be on the downstream (south) side of the flow control structure.

Prior to the project being started up and operated in the drought relief pumping mode, Reclamation would close the bulkheads to prevent water that is pumped from the reservoir into the outlet channel from flowing back into the reservoir. Thus, the flow control structure also serves as a barrier across the end of the outlet channel when the project is being operated in the drought relief pumping mode.

Discharge pipelines from the pumps on the barge terminate at the top of the flow control structure and discharge directly into the existing outlet channel. When operating for drought-relief pumping, the flow control structure would have a maximum head differential applied to it of approximately 18 feet, an upstream water surface elevation of 2,208 feet, and a top of ground elevation of 2,190 feet.

The flow control structure serves as a principal component of the pump barge moorage system. The flow control structure would serve as both a cofferdam during construction for dewatering and as permanent structure for project operation and maintenance.

1.13 Dredging

Dredging of an estimated 6,000 cubic yards would be required to create a horizontal bench directly beneath the pump barge to a depth approximately 25 feet lower than the maximum drawdown elevation of the reservoir. Dredging is required to maintain an acceptable vertical clearance between the suction bells of the pump units and the reservoir bed below. Dredged material would not be brought to the surface for upland disposal. Rather, dredged material would be returned to the bed of the reservoir at a nearby location a sufficient distance away to limit any return of the material to the dredged location. Turbidity curtains may be required to contain turbidity at the underwater spoil disposal site.

1.14 Personnel Safety

Since this alternative has numerous principal project features located directly on the water, personnel safety for ingress and egress to and from the barge, personnel safety while on the barge, and personnel safety associated with the flow control structure and rigid and flexible pipe bridges would be critical to the safe operation, maintenance and repair of this facility. As the design for this project advances from Appraisal level to final design, personnel safety considerations must be incorporated into the design at all appropriate phases and locations.

1.15 Pump Barge and Anchorage

The pump barge is a permanent project feature that would remain floating on the surface of the reservoir at all times upon completion of construction. The mooring system for the pump barge is designed to allow the pump barge to operate under all conditions during all seasons of the year. Upon initiation of drought relief pumping (at a reservoir water surface elevation of approximately 2,200 feet), the total instantaneous hydraulic capacity of the vertical turbine pumps on the pump barge would be approximately 1,500 cfs. At the full drawdown depth for the maximum withdrawal of 200,000 acre-feet of water from reservoir at elevation 2,113 feet, the pumps would have a total instantaneous hydraulic capacity of 1,000 cfs.

The pump barge would be comprised of multiple metal pontoons having a rigid structural deck. The barge must support the weight of the pumps, motors, on-barge pipelines, catenary winches and their associated power, instrumentation and control equipment. Additionally, the barge must support a portion of the weight of the pipe bridges and pipelines, as well as roughly one-half of the weight of the catenaries.

The pump barge is anticipated to have approximate dimensions of 80 feet wide by 90 feet long by 7 feet deep. A catenary winch would be located in the two north corners of the pump barge to which the two cable catenaries would attach. The axial positioning of each pump-motor-pipeline set would be laid out to achieve an overall symmetrical loading of the pump barge in concert with the weight of the pipe bridges and pipelines that attach to the barge on the south side. The pumps, motors, and on-barge pipelines would all be rigidly bolted to the structural barge deck. The pumps, motors and pipelines would be attached to the deck at the time of construction, but would be removable for maintenance and repair purposes, as needed.

The pumps would be vertical turbine pumps with suction bells located about 18 feet below the surface of the water, which would be approximately 22 feet below the top of the pump barge deck. The suction bells would be fitted with 4-foot-high, horizontal suction plates with guide vanes that would allow the suction bells to draw the water into the face of the suction bell on a horizontal flow plane, as opposed to a vertical flow direction of suction.

Fish protection screening would be provided around the pump suction bells to eliminate the potential for adult or sub-adult bull trout entrainment into the pumps. The fish screening arrangement would include the use of cables, steel framing, and fastener hardware around the underside of the barge to create a static frame where high-modulus polyethylene (Dyneema®) net panels could be affixed. The framed net system would result in a soft, yet durable positive barrier system composed of mesh with ¼-inch (6.35-mm) openings. This barrier net material is similar to that which is used as barrier or guide nets at floating surface collection facilities on Upper Baker, Lower Baker, North Fork, and Swift Reservoirs. The size and configuration of the screening system would be established to meet adequate clearance and surface area requirements with anticipated approach velocities on the order of 0.4 fps.

1.16 Pipe Bridges

1.16.1 Rigid Pipe Bridge

A rigid pipe bridge would span from the north side of the flow control structure over to the south side of the flexible trussed pipe bridges. This rigid pipe bridge structure would support the three (3) 6-foot-diameter pipelines. The rigid pipe bridges would each have two spans of 35 feet each for a total length of 70 feet. The central and north set of support columns would each be comprised of five (5) drilled, 3-foot-diameter pipe piles with a wide flange beam connecting each set of five pipe piles.

1.16.2 Flexible Trussed Pipe Bridge

Three (3) 160-foot-long flexible trussed pipe bridges would span between the north side of the rigid pipe bridge and the south side of the pump barge. Cardanic joints (see Figure 14) located at each end of each trussed pipe bridge would connect the truss structure to the rigid pipe bridges and the pump barge. The Cardanic joints would allow the pump barge to move vertically through the full range of water surface elevations from the normal full pool elevation of 2262 to the maximum draw down pool elevation of 2113, a vertical range of 149 feet. The Cardanic joints also allow the pump barge to move horizontally (in the east-west direction) to accommodate wind, wave and ice loadings on the pump barge.

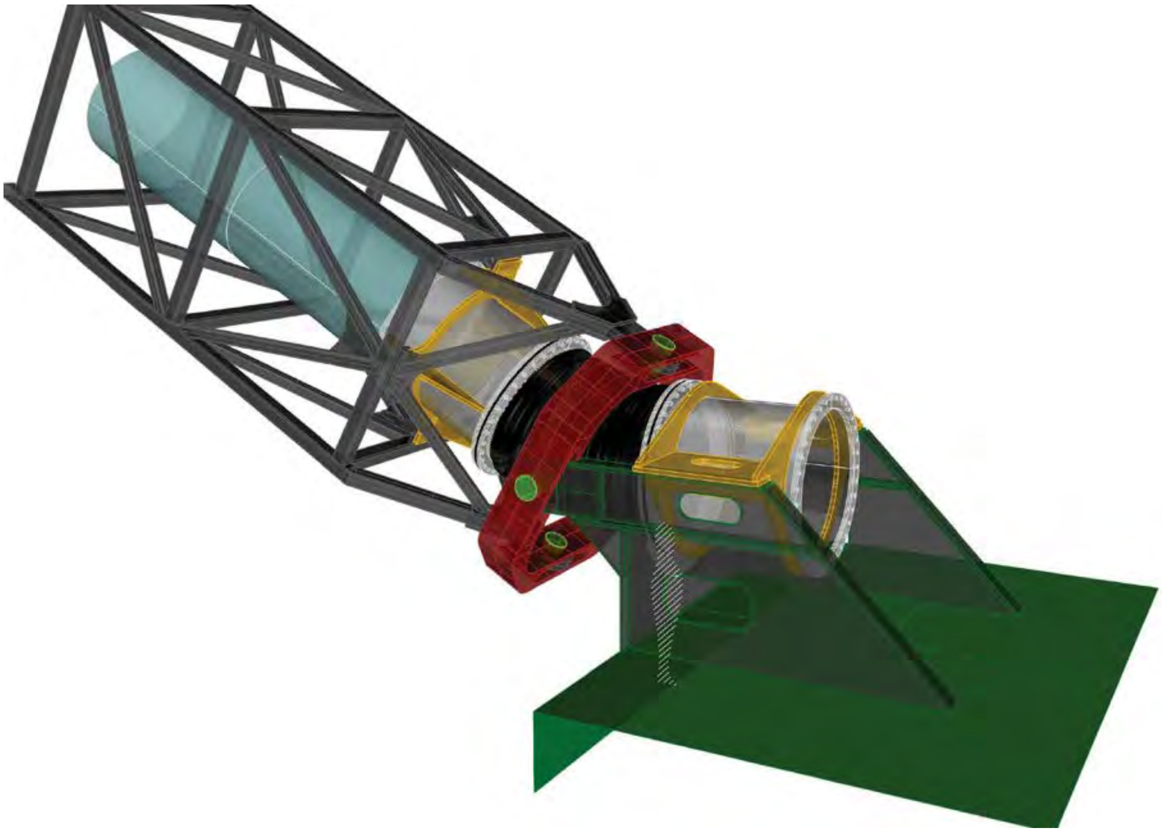

Figure 14. Cardanic Joint

The pipe bridges are designed to preclude pipe barge movement in the axial direction of the pipe bridges. The pump barge is free to move up and down with the reservoir water surface elevation, free to move east-west, and free to rotate a relatively small amount about its vertical axis.

However in the north-south direction, the pump barge would not be able to move. The pump barge would simply move up and down in a vertical arc in the north-south direction; an arc that has a constant radius of 160 feet, the span length of each pipe bridge.

The Cardanic joints, in combination with the catenary anchor system, allow the pump barge to freely move within this arc while keeping the pump barge correctly positioned at all water surface elevations and under all seasonal weather conditions experienced on Kachess Reservoir and remaining a fixed radial distance away from the flow control structure.

1.17 Discharge Pipelines

Each pump-motor-pipeline set would have its own 6-foot-diameter discharge pipeline. The total hydraulic capacity of the discharge pipelines would range from 1,500 cfs at the start of drought relief pumping to 1,000 cfs at the low pool elevation of drought relief pumping. Each discharge pipeline would be approximately 300 feet long, beginning at the discharge flange of the vertical turbine pump to the open end of the discharge pipeline.

The downstream end of each discharge pipeline would discharge pumped water as a jet into the atmosphere. Each jet of water would simply fall by gravity into the existing outlet channel. The concrete armored floor and rock armored floor and sidewalls of the existing outlet channel would allow the energy of each jet of water to dissipate without causing scour, erosion or turbidity.

From here the pumped drought relief water would flow down the existing outlet channel to the existing Kachess Dam outlet structure for release into the Kachess River. The Kachess River ends at Lake Easton, approximately 1.5 miles downstream of Kachess Dam. The Yakima River flows into and out of Lake Easton.

1.18 Narrows Upstream Bull Trout Passage in a Roughened Channel

When operation of the KDRPP reduces the pool elevation of Kachess Reservoir below a pool elevation of approximately 2,226 feet, the reservoir separates into an upper pool (Little Kachess) and a lower pool (Big Kachess), at a location known as the Kachess Narrows. As the pool elevation of Big Kachess is drawn below 2,200 feet, a steep shelf is exposed that creates an impediment to passage for resident bull trout residing in Big Kachess; see Figure 11.

The primary purpose of the roughened channel is to improve the safe and timely passage of bull trout upstream and downstream of the Kachess Narrows during periods when emergency water supply operations require reservoir levels below elevation 2,200 feet. It is believed that both adult and sub-adult life stages of bull trout could be motivated to migrate upstream of the narrows throughout the months of September through mid-November in search of spawning habitat and foraging opportunities present in the tributaries draining to Little Kachess Lake.

The following subsections describe the preliminary design criteria and major project elements developed for this conceptual design. Further discussion and related details are provided in a separate Technical Memorandum titled, *Kachess Narrows Fish Passage Concept Development*, dated February 3, 2017 (HDR, 2017).

1.18.1 Selection of Fish Passage Criteria

There are no fish passage design guidelines specific to adult and sub-adult bull trout. However, given that the swimming and leaping capabilities are less than that of adult salmonids of the Pacific Northwest, NOAA and WDFW guidelines available for the passage of juvenile salmonids are typically accepted as a general surrogate for the purposes of design for fish passage structures required to accommodate bull trout. The following paragraphs discuss the selection of both hydraulic and design flow criteria used for design concept development.

1.18.1.1 *Selection of Hydraulic Design Criteria*

There are numerous references and swimming performance data in the literature that can be used to establish acceptable juvenile or sub-adult hydraulic design criteria but there are no specific established design guidelines presented for bull trout by the resource agencies. For this project, a velocity of 1.3 fps was selected to establish acceptable limits for passage of adult and sub-adult bull trout. This is believed to be conservative given that Powers and Bates, 1997 refers to velocities of 1.0 to 1.3 fps as acceptable for salmonid fry and fingerlings, both of which can be used as surrogates for sub-adult and adult bull trout.

The acceptable limit of the Energy Dissipation Factor (EDF) is established in Washington Department of Fish and Wildlife (WDFW), 2013 based upon empirical measurements from 50 Washington State roughened channels selected by WDFW. For a roughened channel with slope of 4.5 percent the resulting acceptable EDF limit is calculated to be 11.25 ft-lbs/ft^3/s. This also relates to a calculated average cross-section velocity on the order of 4.0 fps. Therefore, the selected design guidelines for this roughened channel include a minimum hydraulic depth of 10-inches, a specific flow velocity of 1.3 fps or less, an average cross-sectional velocity of 4.0 fps or less, and an EDF of 11.25 ft-lbs/ft^3/s.

1.18.1.2 *Selection of Fish Passage Design Flows*

Guidelines provided by WDFW (WDFW2000) suggest a 10 percent exceedance flow be used as a high design flow. The 10 percent exceedance flow is used as the high fish passage design flow to accommodate the potential range of flows that are anticipated when bull trout may be migrating upstream and to establish minimum conveyance requirements for the project which influences the size and configuration of each alternative considered. National Marine Fisheries Service (NMFS) (2011) recommends a low fish passage design flow equal to the mean daily stream flow that is exceeded 95 percent of the time during periods when migrating fish are typically present. When projects occur in non-gaged stream systems (such as the Kachess Narrows), hydrologic regression analysis and/or a paired-basin comparison can be used to provide sufficient evidence to establish high and low design flows.

The 10 percent and 95 percent exceedance flows were calculated for the Kachess Narrows to determine the overall range of streamflows when fish passage should be considered. The 95 percent exceedance flow was calculated to range from 8 to 9 cfs during the anticipated period of migration. The 10 percent exceedance flow ranged from 74 to 96 cfs. For the purposes of conceptual design, the proposed roughened channel should therefore be designed to meet established fish passage performance criteria throughout the overall streamflow range of 8 to approximately 100 cfs.

1.18.2 Description of Roughened Channel Concept

The selected fish passage concept includes the construction of a roughened channel beginning at elevation 2,112 feet along the side slope of Big Kachess and extending upstream to a location near the downstream end of the Kachess Narrows, elevation 2208. The primary design and construction elements are listed below and summarized in the following paragraphs:

- Roughened channel nature-like fishway,
- Flow bifurcation weir,
- Hydraulic isolation berm, and
- Hill slope stabilization soldier pile wall.

Reclamation intends that the roughened channel would convey up to the first 100 cfs of streamflow moving through the narrows while providing adequate depths, velocities, and diminished turbulence to facilitate passage. The hydraulic inlet (upstream migrating fish exit) to the roughened channel would begin at a flow bifurcation weir with a crest elevation of 2,208 feet which occurs in the downstream portion of the narrows. The hydraulic outlet (fish entrance) would be located at an invert elevation of 2,113 feet along the reservoir bank. The roughened channel would only function as intended during times when Big Kachess is below a pool elevation of 2,208 and is intended to remain in operation until the minimum emergency pumping pool of 2,113 feet is reached (a vertical differential of 95 feet). Fish navigating through the roughened channel would exit the structure at the flow bifurcation weir and would continue their ascent through the existing narrows until they reach Little Kachess. An illustration showing the overall project layout is provided in Figure 15.

Reclamation would design the channel cross-section to meet the specific hydraulic targets expected to foster fish passage throughout the range of fish passage design flows. At this point of design development, the channel cross-section is anticipated to exhibit an overall depth of 5.5 feet and a total top width of 28 feet. The depth of channel would accommodate a maximum hydraulic depth of 2.5 feet at 100 cfs with 3 additional vertical feet of freeboard. The overall top-width would accommodate side slopes set back at a ratio of 2-horizontal to 1-vertical with a V-shaped channel bottom with side slopes set at a 4 percent cross-slope.

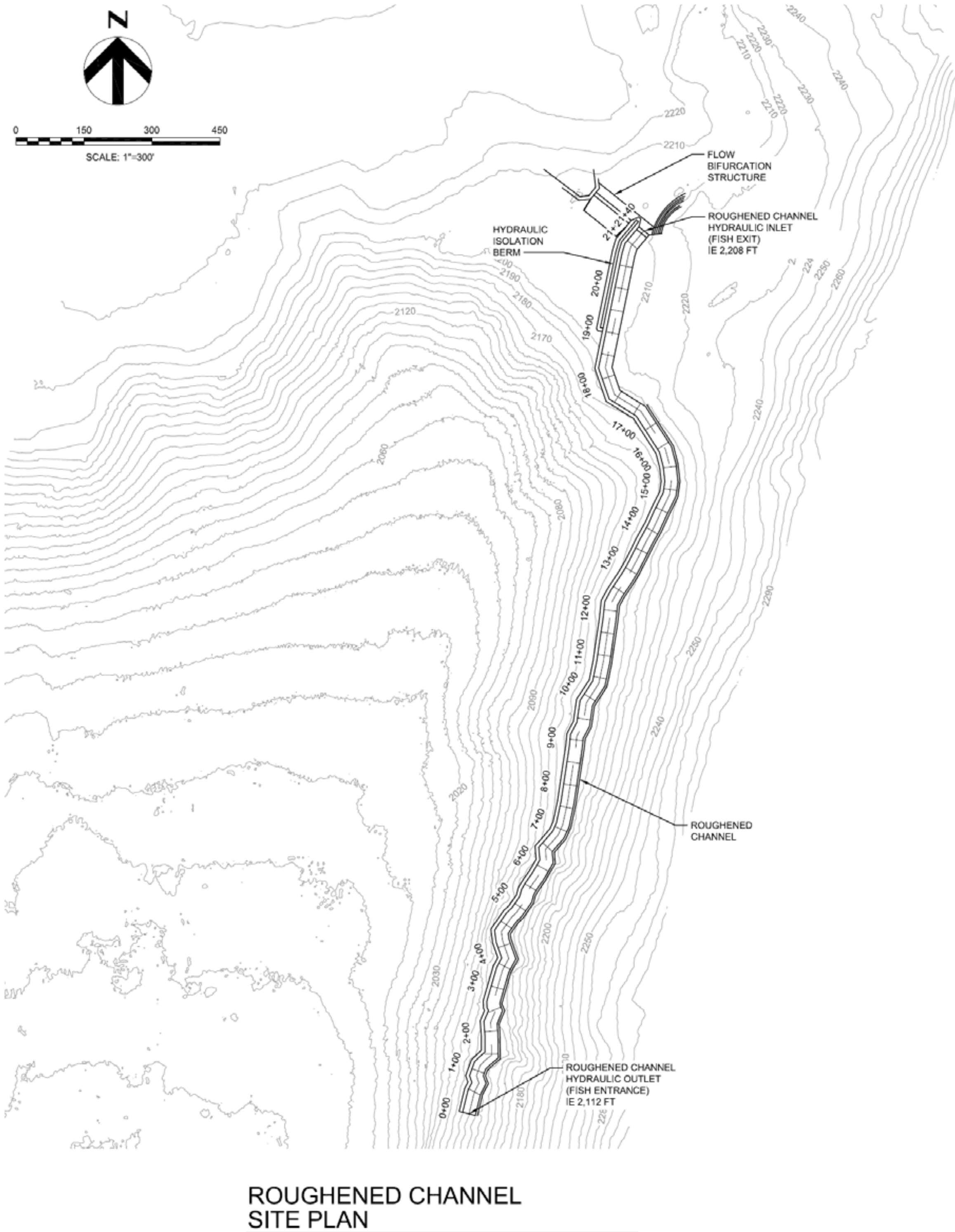

Figure 15. Layout of Roughened Channel at Kachess Narrows

In cross-section, the roughened channel would be composed of a 3-foot thick layer of Engineered Streambed Material (ESM) with bands and riffles of course rounded rock. The ESM would be a well-graded, compacted matrix of streambed cobbles and soil with maximum particle diameters of 12 inches, and up to 15 percent cohesive fines (PI > 8) smaller than the #200 sieve size. The course bands and riffle structures would be constructed using larger rounded river rock with diameters up to 28 inches. Over the channel's length the roughness elements would vary with series of cascades, riffles, rock bands, and scour pools to create variations in hydraulic conditions and in-channel refugia required for resting or escape from predators. The construction contractor would place a bentonite mat below the layer of ESM to lower the soil permeability and limit the loss of water through the bottom of the roughened channel. The general dimensions and material composition of the channel cross-section are provided in Figure 16.

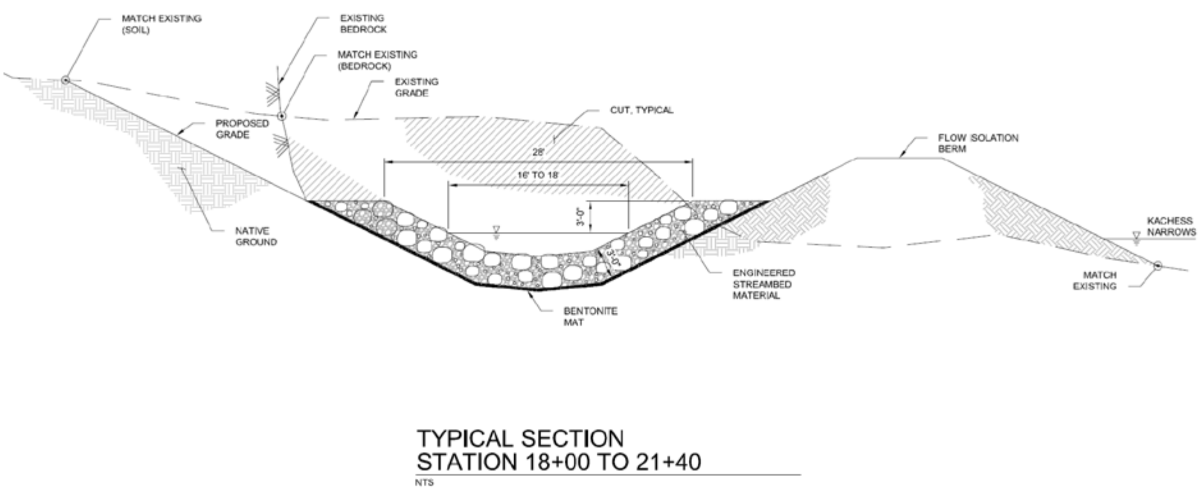

Figure 16. Roughened Channel Dimensions and Materials

The average channel gradient would be set at 4.5 percent which would extend downstream from the flow bifurcation weir 2,130 feet to reach a low target elevation of 2,112 feet. This downstream invert would provide a minimum hydraulic depth of 1-foot at the minimum emergency pumping pool elevation of 2,113 feet in Big Kachess.

A fixed, concrete flow bifurcation weir would be integrated near the downstream outlet of the Kachess Narrows at an approximate elevation of 2,208 ft and at the upstream hydraulic inlet of the proposed roughened channel. The intent of the weir would be to limit the volume of water conveyed down the roughened channel to the upper fish passage flow of 100 cfs while directing flows in excess of 100 cfs down the main channel of the Narrows. Controlling flow into the inlet of the fish passage structure would help meet the selected hydraulic design criteria over a wider range of anticipated total flows down the Narrows and it would prevent excessive inundation of the fish passage structure.

The weir structure itself would span the Narrows and would have a total length of approximately 175 feet. The width of the weir crest would be 8 feet with profile control and scour protection features extending upstream and downstream of the weir for a total of 60 feet. The weir would be split into two bays: one bay would be set at a specific elevation and length to allow the first 100 cfs down the roughened channel while the second larger bay would be configured to allow conveyance of larger flows up to 2,000 cfs. Reclamation would include abutments at both ends of the structure to prevent flanking and to integrate the structure into the existing banks of the Narrows channel.

The bifurcation weir would be composed of both grouted rock, engineered streambed material, and earth fill. A seepage wall made of lean concrete and/or sheet pile would be configured near the center of the structure to promote surface flow of water, to limit any flow passing underneath the structure, and to maintain the overall stability of the structure. The seepage wall would extend from the bottom of the weir crest down to an impermeable layer such as bedrock. Reclamation would need to verify the location of bedrock through a series of field investigations as the design process for this structure moves forward.

Reclamation would incorporate similar fish passage design criteria in the downstream tail of the bifurcation weir as in the roughened channel, so that the weir would also provide opportunities for upstream passage. This would reduce the occurrence of false attraction or migration delay when the roughened channel has exceeded its design capacity and additional water is flowing over the bifurcation weir into the head of Big Kachess.

After being split at the flow bifurcation weir, flows contained in the roughened channel would need to remain isolated from high flows being conveyed down the Narrows (when such flows are present). Reclamation would accomplish this by extending an earth embankment downstream along the waterside bank of the roughened channel. The height of the embankment would be only as high as is necessary such that typical high flow events do not overtop the embankment and flow into the roughened channel. At this conceptual stage of design, it is anticipated that this feature would be approximately 4 to 6 feet high, with a top width of 8 feet, and a total width of approximately 24 to 32 feet (with side slopes of 2 horizontal to 1 vertical). The isolation berm would begin at the most upstream end of the roughened channel and would extend approximately 240 feet downstream until it reaches the elevation contour at 2,204 feet.

The hydraulic isolation berm would be composed of imported, compactable borrow material with a low permeability clay layer on the waterside surface. Both slopes would be treated with a layer of angular rock for stability and for scour protection during infrequent high flow events when the reservoir pool elevation is below 2,200 feet.

Construction of the roughened channel would require consideration of the geologic and topographic conditions upon which it is founded and there are differing conditions expected along its length. Between Stations 18+00 feet and 21+40 feet (Figure 16), construction of the channel is expected to occur using open excavation techniques. The invert of the channel would be placed at the specified elevation, no special provisions would be added to the channel’s composition, and side slopes would be extended upward at a ratio of 2-horizantal to 1-vertical until the existing grade is reached. The channel alignment would be refined to limit the cut operations within this reach, but at this time significant excavations are expected and cuts of up to 15 feet in depth would be required. Between Stations 0+00 and 18+00 feet (Figure 17), the contractor would construct the channel on the existing reservoir shoreline and would apply differing bank stabilization strategies dependent upon whether the channel intercepts soil or bedrock conditions. In reaches where hill slopes composed of soil exist, the contractor would construct a soldier pile wall set back at a ratio 1-horizantal to 5-vertical using driven or vibrated steel H-pile and concrete battering. In reaches where bedrock is encountered, the H-pile would likely have to be drilled and grouted prior to addition of the concrete battering. A cross-section showing the integration of a soldier-pile wall is illustrated in Figure 17.

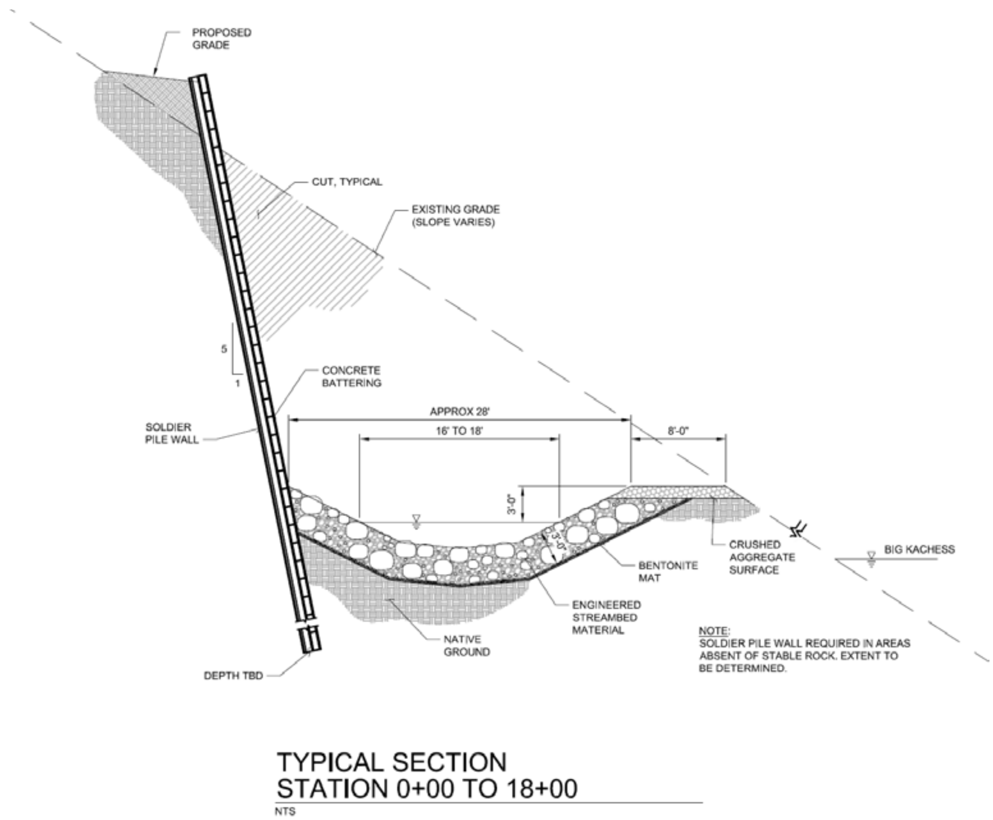

Figure 17. **Roughened Channel Cross-Section and Soldier Pile Wall**

2.0 Construction Activities

For planning purposes, the construction process can be considered in four distinct phases:

- Phase 1 – Pre-construction
- Phase 2 – Uplands Construction
- Phase 3 – Marine Construction
- Phase 4 – Reservoir Bed Construction

2.1 Phase 1 – Pre-construction

Pre-construction activities include completion of any additional required surveys (topographic, bathymetric and or real estate); completion of any additional required geotechnical explorations and or laboratory testing; completion of any pre-design studies, completion of final design and engineering, completion of contract document preparation, and bid tendering and award of construction contract(s).

Prior to the contractor mobilizing to the site and initiating on-site construction, Reclamation or Roza would need to place all long lead-time equipment orders sufficiently far in advance to assure on-time delivery of long lead-time equipment to support construction.

In addition to the ordering of long lead-time equipment, Reclamation or Roza would order as much off-site fabrication of steel items, precasting of concrete structures, and procurement and stock-piling of other materials as deemed appropriate to minimize construction costs and or accelerate the construction schedule.

Reclamation would need to modify the operation of Kachess Reservoir during the planned one-year-long on-site construction period to enable completion of Phase 3 – Marine Construction and Phase 4 – Reservoir Bed Construction. Section 2.5 of this memo provides planning level information on how Reclamation would operate Kachess Reservoir during the year in which the project is constructed.

2.2 Phase 2 – Uplands Construction (above Elevation 2262)

The construction contractor would begin uplands construction work after construction permits have been secured and weather conditions allow. The contractor would apply best management practices to avoid and minimize environmental impacts. For planning purposes, the start of on-site uplands construction work is assumed to be March 1st. Upland construction would start with the installation of temporary sedimentation and erosion control measures in areas where land disturbing activities would occur. Land disturbance associated with clearing, grubbing and rough grading would occur in the following areas:

- Lake Easton Substation
- Sections of the buried power cable (only in areas not already cleared)

- Kachess Reservoir Substation and Staging Area
- Control Building
- East Shore Parking Lot Staging Area and Access Road

Once grading has been completed, the contractor would place gravel surfacing and install perimeter security fences and gates (temporary or permanent as appropriate).

2.2.1 Lake Easton Substation

The contractor would clear an area approximately 1/3 of an acre in size for construction of the substation.

2.2.2 Buried Power Cable

From the Lake Easton Substation the buried power cable would require an approximate 20-foot-wide construction corridor over to the former US Highway 10 road.

2.2.3 Kachess Reservoir Substation

Until the switch yard and storage yard features need to be constructed later in the construction process, the contractor would use this area as the primary laydown and staging area for the project. This area is approximately 4 acres in size and is located in close proximity, approximately 1.2 miles in distance from Interstate 90 Exit 64. Other than equipment and materials that can be delivered to specific locations on-site, the contractor would store materials arriving via I-90 at this location until needed at specific on-site construction locations.

Beginning in the August – September timeframe, the contractor would construct the grounding mat and foundations for the facilities and install the high voltage and ancillary equipment.

2.2.4 Control Building

The Control Building area would be located on the left abutment of Kachess Dam, immediately adjacent to the edge of the reservoir and about 200 feet from the northwest corner of the switch yard. Once clearing, grubbing, and grading of the control building area is complete, the contractor would form the foundation to support the three large and heavy variable frequency drives (VFD) that would supply power to the barge mounted electric motors that spin the pumping units. The contractor would install buried utilities and power supply conduits to and from the operations building and would erect the cement masonry unit walls of the operations building. The roof of the operations building would have large, removable weather-proof hatches, one over each VFD, to facilitate installation and maintenance of these features; without the need for a permanent bridge crane being located in the operations building. Rather, Reclamation or Roza would use a large road-drivable crane for VFD installation and maintenance activities on an infrequent, as-needed basis. Phase 3 – marine construction describes the installation of the submarine power and instrumentation and control cables that leave the operations building and run out to the pump barge on the floor of the existing outlet channel.

2.2.5 East Shore Parking Lot and Access Road

This area would initially serve as the primary access and staging area for the marine construction activities. The construction contractor would clear tan area on the north side of the existing spur access road that would be widened. The area extends to the north and widens as it approaches the shore of the reservoir. The marine construction access is located a few hundred feet north of the where the existing spur road enters onto the reservoir bed.

The entire area to be cleared for the east shore parking lot area totals about 2.5 acres. Once this area is cleared, grubbed, graded and gravel surfacing is placed, the large marine construction equipment would be able to access the reservoir shore via this area. This new, gravel-surfaced access road would have a relatively short distance (300 to 500 feet) and a relatively gentle gradient for the marine construction equipment and construction materials to travel on from the existing USFS NF 4818 access road to the reservoir shore. The contractor would install appropriate temporary construction and permanent stormwater collection and detention facilities in this area. After construction is completed, Reclamation or Roza would maintain the gravel access road and parking lot permanently to provide access to the boat ramp.

2.2.6 Narrows Access Road and Laydown

Prior to construction of the actual upstream bull trout fish passage facilities (a flow bifurcation weir and a roughened channel), access to the construction site must be provided. The lowest elevation to which the roughened channel would be constructed during this initial construction season is about 2192.75, the lowest pool elevation that can be attained with the existing gravity outlet works. It would only be after the drought relief pumping plant is fully operational and utilized for a drought that the reservoir would be drawn down below this elevation and additional segments of the roughened channel could be constructed at lower elevations.

2.3 Phase 3 – Marine Construction (below Elevation 2262 and above Elevation 2210)

Construction work would begin no sooner than when construction permits have been secured for work below the ordinary high water mark (elevation 2,262) and when the reservoir water surface elevation is at or below approximately elevation 2,230 as regulated by Reclamation. For planning purposes, this date is assumed to be May 1st.

In advance of this date, as well as after this date, the contractor would gain access to the east shore of the reservoir via the newly constructed east shore access road and would stage marine construction equipment and materials in the east shore staging area. As the reservoir water surface elevation falls, the contractor would assemble temporary construction barges on the gently sloping exposed east shore of the reservoir. Temporary construction barges would then be used to support both large construction cranes and to transport equipment, materials and supplies on the surface of the reservoir as needed for construction of the four principal marine construction features. Shore-based cranes would be used to load the barges that transport construction materials onto the reservoir for installation and assembly.

The contractor would build the following seven project features using marine construction equipment and techniques:

- Flow control structure
- Rigid pipe bridge
- Floating pumping plant
- Flexible pipe bridges
- Temporary boat dock pipe piles
- Reservoir floor erosion protection
- Marine cable bundles

The construction sequence for each of these six features is described in the following text sections.

2.3.1 Flow Control Structure

The contractor would build the flow control structure across the upstream end of the existing outlet channel. It would be a cantilever structure referred to as a Combi-wall system; a system comprised of continuous, interlocking, alternating pipe pile and sheet pile panels. The contractor would drive pipe pile and sheet pile into the floor of the reservoir using barge mounted impact pile driving equipment. The ability for reservoir water to enter the existing outlet channel for release into the Yakima River system would be maintained throughout construction of the flow control structure and the final, closure panels would not be installed until the reservoir water surface elevation is close to the minimum pool elevation of 2192.75. The contractor would incorporate opening(s) into the Combi-wall structure to allow for installation of temporary flume(s) that would allow water to continuously flow out of the reservoir and through the flow control structure construction zone for release into the Yakima River system. The contractor would complete this feature during Phase 4 – Reservoir Floor Construction.

2.3.2 Rigid Pipe Bridge

The rigid pipe bridge would be supported on pipe pile that would also be installed in the bed of the reservoir using barge mounted, impact pile driving equipment. The requisite pattern of pipe pile would be driven deeply into the floor of the reservoir and the tops of the pipe pile would be cut off at the required height and angle, with thick steel cap plates then being welded onto the top of each pipe pile. Structural steel beams would then be welded onto the cap plates to form the rigid pipe bridge. The three (3) 6-foot-diameter steel pipelines would then be installed on the rigid pipe bridge including the Cardanic joint located on the upstream end of each pipe.

2.3.3 Floating Pumping Plant

When the floating pumping plant is being operated for drought relief pumping and the reservoir has been drawn down to the minimum pool elevation of approximately 2113, the clearance between the bottom of the suction bell plate of each vertical turbine pump and the floor of the reservoir would be approximately 5 feet. It is important to provide uniform hydraulic conditions for water traveling through the protective fish net and approaching and entering each pump. To provide the required uniform hydraulic conditions, it would be important to make the bed of the reservoir a constant, flat elevation, free of undulations or obstacles in the area immediately beneath the floating pumping plant. To achieve this, the contractor would dredge the bed of the reservoir beneath the permanent mooring location of the floating pumping plant. The contractor would use hydraulic suction dredges. The contractor would deposit dredged material relatively close to the dredge location at a nearby depression on the bed of the reservoir. The contractor would use a silt curtain to keep the turbidity plume associated with discharge of the spoils contained.

Concurrent with dredging operations, the contractor would assemble prefabricated sections of the permanent floating pumping plant barge on the exposed reservoir shore and weld them together into three (3) pump barge modules. The contractor would launch each module onto the surface of the reservoir and fit it with a vertical turbine pump, electric motor, right angle drive, self-tensioning catenary winches and ancillary electrical equipment. A 6-foot-diameter steel discharge pipe and its downstream end Catenary joint would be installed on each module. The contractor would then join the three modules together to form the completed floating pumping plant barge. Once the pipe pile catenary mooring structures have been constructed and the mooring anchor placed in the bed of the reservoir, the floating pumping plant barge would be floated to its final mooring location and the catenaries installed that secure the floating pumping plant barge in its permanent location.

2.3.4 Flexible Truss Pipe Bridges

Once installed, each flexible pipe bridge would span the gap between the floating pumping plant and the rigid pipe bridge. Each flexible truss pipe bridge is comprised of a 6-foot-diameter pipe contained within and supported by a 150-foot-long structural truss. Each end of the flexible pipe bridge, both the pipe and the truss, connects directly to the Cardanic joints located on the floating pumping plant and the rigid pipe bridge. The contractor would assemble prefabricated sections of truss and pipe on the east shore, lift them onto barges and float them into position between the Cardanic joints located on the floating pumping plant and the rigid pipe bridge. The contractor would then lift each flexible truss pipe bridge into position using barge-mounted cranes and would bolt them in final position.

2.3.5 Reservoir Floor Scour Protection

After the bulkheads have been installed in the flow control structure Combi-wall and prior to the installation of the pipe bridge structural steel members and the steel pipelines they support, the contractor would place scour protection features on the reservoir bed on the north side of the flow control structure. First, precast, preassembled articulated concrete mats would be brought out on barges from the east shore and lowered into place on the floor of the reservoir by barge mounted cranes. The mats would be placed around the steel pipe pile that supports the Rigid Pipe Bridge. These mats would extend from elevation 2183 down to approximate elevation 2156, a distance of approximately 80 feet. Appropriately sized rip rap would be placed on the floor of the reservoir from the toe of the flow control structure, approximate elevation 2190, out to the upper edge of the concrete mats, approximate elevation 2183, and a horizontal distance of about 20 feet. These features would prevent erosion of the reservoir bed from occurring at the flow control structure and the rigid pipe bridge foundations from reservoir wave action.

2.3.6 Marine Cable Bundles

There are four (4) marine cable bundles to be installed that run from the control building to the floating pumping plant. Three of the four are cable bundles providing both power and instrumentation and control lines to each of the three pumping units. The fourth bundle contains 480 volt power and other data and communication lines needed for the floating pumping plant barge. The contractor would install buried conduit from the control building to approximate elevation 2195 in the floor of the downstream end of the east side of the outlet channel. The contractor would also install conduit on the downstream side of the Combi-wall outlet control structure running up and over to each of the flexible pipe truss bridges and to each pumping unit. Each marine cable bundle would be fed into its conduits to the control building and each pumping unit from the outlet channel. Once fully installed, each conduit bundle would be either contained within protective conduit or located permanently under water on the floor of the outlet channel.

2.4 Phase 4 – Reservoir Bed Construction (below Elevation 2197 and above Elevation 2190)

The contractor would construct five features on the floor of the reservoir "in-the-dry." These features are:

- Chain catenary mooring pile bents
- Flow control structure bulkheads
- Outlet channel erosion protection
- East shore boat ramp
- Narrows fish passage roughened channel

The contractor would use vehicular access across the bed of the reservoir for construction of the first three features identified immediately above, beginning at the widened spur access road located on the east shore of the reservoir off of USFS NF-4818. From there construction vehicles would travel on the existing reservoir bed access road that runs over to the east side of the existing outlet channel. The contractor would build a short reach of new access road and work area at the west end of the existing reservoir bed access road, immediately adjacent to the outlet channel. The contractor would bring construction equipment, materials and supplies to the outlet channel using the access route described immediately above. Access for construction of the east shore boat ramp and the Narrows fish passage roughened channel would be off of the existing USFS NF-4818 Road on the east side of the reservoir coupled with two newly constructed, short access roads as described above.

Installation of the flow control structure bulkheads and the outlet channel erosion protection would require building two temporary, relatively low height cofferdams. Cofferdams would be constructed of Supersacks (see Figure 18) and sand bags that the contractor would be fill in the uplands and then place across the outlet channel upstream and downstream of the flow control structure. The contractor would build the first cofferdam approximately 10 feet outside of and parallel to the north side of the flow control structure. It would have a crest elevation of about 2195. The contractor would build the second cofferdam approximately 125 feet inside of and parallel to the south side of the flow control structure. It would have a crest elevation of about 2192. The contractor would build a flume capable of conveying up to 50 cfs of flow from the reservoir through the cofferdam area and into the outlet channel to keep the Kachess River, downstream of Kachess Dam supplied with the required minimum instream flow of 30 cfs.

The construction approach for each of these five features to be built on the reservoir bed is very different from one another, and each is described in the following text sections.

2.4.1 Chain Catenary Mooring Pile Bents

There are two chain catenary pile bents to be constructed; neither would be constructed within the cofferdam area. Tracked impact pile driving equipment would be used to install the pipe piles that form the chain catenary mooring pile bents. To access the eastern pile bent installation location the contractor would walk the tracked pile driving equipment across the side slopes and floor of the outlet channel just inside the downstream cofferdam. These two pile bents would be installed after the reservoir water surface elevation has been drawn down below approximate elevation 2205. After all pile comprising each bent has been driven, the contractor would cut off the piles at the requisite common height and then attached one to another to form the finished pile bent. Each pile bent can then serve as a rigid anchor point for each chain catenary. Each bent would be capable of resisting the large loads transferred from the floating pumping plant barge to each pile bent by means of the chain catenaries without experiencing adverse displacement.

2.4.2 Flow Control Structure Bulkheads and Erosion Protection

The contractor would install four (4) bulkheads in the north wall of the flow control structure in between pipe piles and within the steel sheet panel sections of the wall. The contractor would cut openings in the steel sheet panels and prepare the surface such that once the bulkheads are installed, the only way for water to pass through the flow control structure and into the outlet channel would be through the opening of one or more of the bulkheads.

Figure 18. Supersack Cofferdam Example

2.4.3 Outlet Channel Erosion Protection

The contractor would protect the floor of the outlet channel from the water discharged from each of the three (3) 6-foot-diameter pipelines by placing an 18-inch-thick, cast-in-place, reinforced, concrete slab on the floor of the outlet channel immediately behind the south side of the flow control structure Combi-wall. The slab would be approximately 40 feet wide by 100 feet long. The contractor would place appropriately sized rip rap on both the floor and side slopes of the outlet channel to the east and west of the concrete slab. The purpose of the rip rap and slab is to allow the high energy high velocity jets of water leaving the end of each discharge pipe to dissipate and not scour the floor or side slopes of the existing outlet channel. Chute blocks would be added to the downstream end of the concrete slab if determined to be needed. The contractor would bring both pre-mix concrete and rip rap from off-site via the existing spur and reservoir bed access roads for placement in the outlet channel.

2.4.4 East Shore Boat Ramp

After the marine construction activities have been completed and the marine construction equipment demobilized from the site, the contractor would grade the reservoir bed to a constant slope at the location of the east shore boat ramp. The contractor would bring precast concrete beams 20 feet in length to the site and place them on the graded slope beginning with the deepest beams first. Following placement of the beams the open slots between each beam would be filled with crushed rock to knit the boat ramp structure together and prevent movement of individual beams. The initial boat ramp construction would be from approximate elevation 2195 up to the 2265, a few feet higher than normal pool elevation. The upper end of the boat ramp would end at the edge of the gravel parking lot as discussed previously. The east shore boat ramp and parking lot would be an amenity for use by the public upon completion of construction. The project would also continue to periodically use these facilities for operation and maintenance purposes as well.

Reclamation or Roza would construct the remainder of the boat ramp at deeper elevations in the reservoir in subsequent years when the project is used for drought relief pumping.

2.4.5 Narrows Fish Passage Roughened Channel

Using the access and laydown areas previously described above, the contractor would begin construction of the flow bifurcation weir and upper segment of the roughened channel as soon as the reservoir water surface elevation has been lowered sufficiently to allow this construction to begin (i.e., when the bedrock that the diversion structure would be founded on is first exposed). The contractor would temporarily divert water flowing through the Narrows around the construction site to allow the diversion structure and the upper segment of the roughened channel to be constructed.

The following list provides the anticipated sequence of construction activities required for the installation of all project elements down to an elevation at or approximate to 2,192.75 feet. This corresponds with a horizontal station alignment near Station 18+00 feet as shown in Figure 15. The overall duration of this initial phase is anticipated to be five months but would ultimately be limited to the period of time where reservoir levels are conducive for construction.

1. Mobilization of equipment, personnel, and materials
2. Establish staging areas and install temporary soil and erosion control measures
3. Construct Phase 3A streamflow bypass
4. Construct right side of flow bifurcation structure:
   - Install sheet pile
   - Install sheet pile cap
   - Install crest
   - Install earth and hardened abutments
   - Install and rough grade native and imported materials (native soils, imported fill, and engineered streambed materials)
5. Construct Phase 3B streamflow bypass:
   - Install sheet pile
   - Install sheet pile cap
   - Install flow isolation berm
   - Install crest
   - Install earth and hardened abutments
   - Install and rough grade native and imported materials (native soils, imported fill, and engineered streambed materials)
6. Excavate roughened channel and stabilize banks as required
7. Lay bentonite mat
8. Install engineered streambed material
9. Finalize flow isolation berm
10. Remove streamflow bypass
11. Demonstration and commissioning
12. General cleanup and removal of construction materials
13. Site restoration and removal of temporary soil and erosion control measures
14. Demobilize and remove all construction related equipment and personnel from the site

Reclamation or Roza would construct the remainder of the Narrows fish passage roughened channel at lower elevations in the reservoir in subsequent years when the project is used for drought relief pumping: from Station 0+00 to approximately 18+00 feet. Each length would be installed as operational conditions and reservoir levels allow. The level of effort required for installation along this reach would need to be evaluated on a case by case basis and therefore the overall reach length installed during a single construction season would also vary. Construction duration would also vary by reach length and would likely be limited to the period of time where reservoir levels are conducive for construction.

2.5 Reservoir Operations for Construction

Construction of the permanent in-reservoir features (project features below water surface elevation 2,262) are expected to be accomplished over a period of time of 6 months or less. As stated previously, in-reservoir construction is anticipated to begin when the reservoir water surface elevation has been lowered to approximate elevation 2,230 which has been assumed to occur on about May 1st.

To achieve elevation 2,230 this early in the year would require Reclamation to operate the overall Yakima River System differently for both the year of construction, as well as the year prior to the year of construction. The following text provides the general approach Reclamation anticipates taking to facilitate construction of the in-reservoir project features.

2.5.1 Year Prior to Construction

During the year prior to construction, Reclamation would attempt to fully use all active storage in Kachess Reservoir by the end of the irrigation season. This means Reclamation would store all carry-over storage in the system in the other basin reservoirs and not in Kachess Reservoir.

After the irrigation season ends and through out the winter season, Reclamation would attempt to make Kachess Reservoir its first choice for winter and spring releases while allowing the other reservoirs to store water. Depending on the winter and spring precipitation amount and whether or not the precipitation comes in the form of rain or snow within the Kachess Basin, Kachess Reservoir would refill to some level that cannot be know at this time, and would not be known until the beginning of the irrigation season. Regardless, Reclamation would prioritize releases from Kachess Reservoir over releasing water from any of the other reservoirs on the system to the greatest degree possible and practical within the established basin operating guidelines.

In following the above described protocol for reservoir operations, Kachess Reservoir would be at the absolutely lowest water surface elevation possible at the start of the construction year irrigation season. Ideally, the year prior to construction would be a relatively dry year and allow Kachess Reservoir to be abnormally low at the end of the winter/spring refill period.

2.5.2 Year of Construction

In keeping with the above approach, Reclamation would then continue to prioritize all releases to be from Kachess Reservoir over all other reservoirs in the basin to the greatest degree possible and as soon as possible in the year of construction. Once the water surface elevation in Kachess Reservoir reaches approximate elevation 2,230, the construction contractor would begin to construct the in-reservoir project features from barges. Barges would be loaded on the east shore of the reservoir from the exposed reservoir floor above elevation 2,230. The water surface elevation in the reservoir would continue to fall as Reclamation continues to prioritize releases from Kachess Reservoir above all other reservoirs in the basin throughout the year of construction. Openings in the Flow Control Structure combined with temporary flume structures through the construction area would allow for continuous releases from Kachess Reservoir to continue throughout the summer and fall and until such time as inflow into Kachess Reservoir overcomes the capacity of the temporary flumes resulting from the onset of the winter rainy season, anticipated to occur in October or November.

Following the above approach for reservoir operations for construction, Reclamation would facilitate the construction of the permanent in-reservoir project features of the floating pumping plant alternative.

3.0 Floating Pumping Plant Operations

3.1 Existing Overall Yakima River Basin Operations

The Kachess Dam and impounded Kachess Reservoir are operated as an integrated part of the overall Yakima Project. The Yakima Project includes a total of five major reservoirs. The objectives of the Yakima Project operation are to:

- Store as much water as possible to the reservoir system's full active capacity of about 1 million acre-feet from 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 irrigation season starts in mid-March each year. During the initial part of the irrigation season: 1) unregulated runoff from tributaries located downstream from the five reservoirs, 2) incidental releases from the reservoirs (for target flows and flood control), and 3) irrigation return flows are generally adequate to meet irrigation diversion demands and the Title XII target instream flows at Sunnyside Diversion Dam until about June 24 (but in some years as early as April 1 and as late as August 17). Once these flows no longer meet diversion demands and Title XII instream target flows, Reclamation systematically releases water from the reservoirs, resulting in depletions in the stored water supply. Reclamation's initiation of systematic releases from the reservoirs is commonly referred to as the beginning of the storage control period.

From the beginning of the storage control period until early September, Reclamation uses releases from Cle Elum Reservoir in coordination with releases from Keechelus and Kachess reservoirs to meet mainstem Yakima River water entitlements from the Cle Elum River confluence (river mile [RM] 179.6) to Sunnyside Diversion Dam (RM 103.8). Releases from each reservoir are balanced to keep from over-drafting (or under-drafting) any one reservoir, and to meet planned storage levels, based on forecasted Yakima Basin runoff volumes. This portion of the Yakima River basin water entitlements amount to about 1.5 million acre-feet to supply diversions, mostly occurring from Roza Diversion Dam downstream, including Roza Division, Wapato Irrigation Project, and Sunnyside Division. A peak flow of about 3,600 cubic feet per second (cfs) for irrigation is moved through this reach of the Yakima River.

Starting in late August and continuing to about September 12, Reclamation reduces Cle Elum Reservoir releases substantially from about 3,000 cfs or greater down to about 200 cfs, and substantially increases releases from Rimrock Reservoir to meet the September and October irrigation demands downstream from the confluence of the Naches and Yakima rivers. This is referred to as the “flip-flop” operation. The flip-flop operation was instituted to encourage spring Chinook salmon to spawn at a lower stream flow, thereby requiring Reclamation to release less stored water to protect the spawning nests (redds) from drying out during the egg incubation period. Affected spring Chinook spawning reaches include the Yakima River from Easton Dam to the city of Ellensburg and the Cle Elum River downstream from the dam.

In years of sufficient water supply, Reclamation performs a similar operation (referred to as “mini flip-flop”) between Keechelus and Kachess reservoirs, for similar reasons as discussed for the flip-flop operation. 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 releases between the two reservoirs. Through the month of August, releases from Keechelus Reservoir are uniformly reduced. By the first of September and continuing through early October, reservoir releases from Keechelus Reservoir are held at 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 to the target level from Keechelus Reservoir, because it must continue to supply downstream users in this time period and at times more water is needed from Keechelus and Kachess reservoirs, than is available solely from Kachess. 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.

3.2 Existing Kachess Reservoir Operations

Reclamation refills Kachess Reservoir from mid-October to June or July, during which time reservoir releases are typically in the 30 to 40 cfs range. This saves the water supply for when it is needed later on during the irrigation season. After storage control and into August, Reclamation spills excess inflows to Kachess Reservoir as uncontrolled releases from Kachess Reservoir (if the reservoir is full) or makes controlled releases from Kachess Reservoir in the 50 to 600 cfs range. During mini flip-flop, starting in late August and continuing into early October, releases of up to 1,000 to 1,400 cfs from Kachess Reservoir are made to meet downstream demands. Releases from Kachess Reservoir decline starting between the end of September and mid-October, and the cycle then starts over again.

3.3 Proposed Kachess Reservoir Operations with KDRPP Alternatives

Under the KDRPP East Shore Pumping Plant, South Pumping Plant, or Floating Pumping Plant, Reclamation would continue to operate Kachess Reservoir as an integrated part of the overall Yakima Project. The proposed KDRPP facilities would allow an additional volume of water to be pumped from Kachess Reservoir and conveyed to the Kachess River immediately downstream of the dam, which in turn flows into the Yakima River at Lake Easton. During a declared drought year when prorationing is less than 70 percent, the project would provide up to 70 percent proration or an additional 200,000 acre-feet of water during a single irrigation season; or cumulatively, during an extended drought period, it could provide this volume of water over multiple irrigation seasons. Operation of the KDRPP facility would be necessary to: 1) pump any portion of the additional 200,000 acre-feet which must be derived from what is currently inactive storage (i.e., water stored in the reservoir at an elevation below the invert of the existing Kachess Dam gravity outlet works, elevation 2192.75), and 2) to maintain water supply and instream flow target releases through the Kachess River as Kachess Reservoir is drawn down into the inactive storage level, as well as to maintain the 30 cfs minimum instream flow in the Kachess River. The portion of the 200,000 acre-feet that would come from inactive storage during a single irrigation season would depend on a variety of factors related to the operation of, and inflows into, the combined reservoir system. However, Reclamation intends to operate the reservoir system with the goal of delivering all 200,000 acre-feet of water from Kachess Reservoir's inactive storage within a single irrigation season (March 1 to October 30). Note that Reclamation or Roza would pump only the volume of water necessary to provide up to 70 percent proration water supply in a single irrigation season.

Reclamation or Roza would initiate drought relief pumping at a water surface elevation of approximately 2200, just about 7 feet above the elevation of the existing gravity outlet works invert elevation. When first turned on, the drought relief pumps would be capable of delivering an instantaneous pumping rate of up to almost 1,500 cfs. This is because there is very little "lift" required of the pumps when the pumps are first turned on. However, when the pumps need to lift the water a full 80 feet vertically plus head losses in the piping system, the pumps would only be able to deliver a maximum instantaneous pumping rate of approximately 1,000 cfs maximum (the total name plate capacity of the pumps). Drought relief pumping would terminate when the reservoir has been drawn down to approximate elevation 2113, the bottom elevation of the drought relief pumping storage pool.

Whenever the pumps are not being used for drought relief pumping and the reservoir water surface elevation is below the requisite elevation to release water from the reservoir via gravity operation. Reclamation or Roza would maintain the minimum instream flow requirement of 30 cfs in the Kachess River downstream of the dam by pumping. This would continue until the reservoir has refilled to the water surface elevation that enables gravity releases.

Following drought-relief pumping, Reclamation would refill Kachess Reservoir as rapidly as possible over the ensuing winter and spring seasons. During this refill period, Reclamation would minimize releases to the greatest extent possible (maintaining a minimum flow of 30 cfs), in concert with the operation of the overall Yakima Project, and subject to water supply and instream flow needs.

Under the Integrated Plan, the water-supply goal for KDRPP combined with other water – supply infrastructure improvements is to maintain prorationing levels of project participants at no lower than 70 percent, while continuing to make all non-proratable water deliveries and achieving instream flow requirements. Achieving this goal may require altering the operations of other reservoirs somewhat. This would be particularly likely in subsequent drought water years, if Kachess Reservoir fails to refill sufficiently and/or is unable to contribute its share of water supply deliveries with use of the KDRPP pumps. Under these conditions, Reclamation could release additional water from storage in Cle Elum and/or Keechelus Reservoirs, beyond the volume that would be released under the No Action Alternative but within the bounds of the current operating criteria. Reclamation would refill these reservoirs as rapidly as possible in subsequent years.

3.4 Hydraulic Difference between KDRPP Configurations

The fundamental hydraulic difference between the Floating Pumping Plant configuration described in this technical memorandum, when compared to the East Shore Pumping Plant and South Pumping Plant, is as described here. The land-based pumping plants would have separate, smaller pumps dedicated to supplying minimum instream flow water to the Kachess River immediately below Kachess Dam, whereas the floating pumping plant uses the main pumping units to meet the minimum instream flow needs in the Kachess River immediately below Kachess Dam.

The reason why the Floating Pumping Plant would be able to operate in this manner is because unlike the land-based pumping plants that would pump water directly into the existing discharge pool located immediately downstream of Kachess Dam, the floating pumping plant would simply pump water from the reservoir and into the existing outlet channel located in the floor of the reservoir immediately upstream of Kachess Dam. The existing outlet channel is approximately 2,500 feet long, has a cross sectional area of about 2,200 square feet, and contains a volume of about 124 acre-feet of water when being operated for drought relief pumping. The main pumping units would simply pump the relatively small volume of water needed to meet minimum instream flow requirements from the reservoir into the outlet channel. From the existing outlet channel, the regulated release to meet minimum instream flow needs would be supplied to the discharge pool located immediately downstream of Kachess Dam by means of the existing, 18-inch-diameter butterfly valve located in the existing outlet structure.

4.0 Project Maintenance Requirements

This section identifies the major maintenance requirements for the various features comprising floating pumping plant. This list is likely more detailed than needed solely for purposes of the SDEIS. Some of these activities would be visible or audible to the public, while others would not.

4.1 Site and Building Maintenance

Project features falling under the civil and building maintenance category are identified here along with their proposed maintenance activities on an annual basis. Vegetation maintenance is required on an ongoing basis.

Table 1. Site and Building Maintenance Summary

Feature	Frequency	Maintenance Activity
Signage	Annual	Repair or replace as required.
Roads and Shoulders	As required	Grade and add surfacing as required.
Ditches	Annually	Clean out and shape as required.
Parking Lots	As required	Maintain surfacing materials.
Area and Security Lighting	As required	Repair or replace as required.
Fences and Gates	Annual	Inspection and repair whenever required.
Rip Rap Armoring	Annual	Inspection when possible with repair as required. [1]
Water Jet Impact Slab	Annual	Inspection when possible with repair as required. [1]
Flow Control Structure	Annual	Inspection when possible with repair as required. [1]
Flow Control Bulkheads	Annual	Inspection when possible with repair as required. [1]
Pipe Bridge Pipe Piles	Annual	Inspection when possible. [1]
Structural Steel Items	Annual	Inspection when possible. [1]
Steel Pipeline	Annual	Inspection, repair of lining and/or coating as required.
Boat Ramp	Annual	Inspection when possible. [1]
Docks	Annual	Inspection when possible with repair as required. [1]
Building Roofs	Annual	Inspection and repair whenever required.
Building Structures	Annual	Annual repair not anticipated to be needed.
Building Foundations	Annual	Annual inspection only.

Feature	Frequency	Maintenance Activity
Mechanical Systems	Annual	Periodic replacement anticipated.
Electrical Systems	Annual	Annual inspection only.

[1] Or at least every 5 years by dive inspection.

4.2 Barge Maintenance

4.2.1 Barge Hull

- Ongoing (routine) – Monitoring of barge draft (freeboard) with investigation of any anomalies to determine the cause (damage, flooding, etc.).
- Ongoing (routine) – Coatings and Paintings to be monitored for ongoing maintenance needs.
- Annual – Visual inspection of all interior hull volumes (hull plate and stiffening) for corrosion or physical damage with repair scheduled according to severity of damage.
- Annual – Inspection of zinc anodes; replace any anodes found to be at or below 50 percent of the original installed weight. Note that any indication of significant corrosion or anode loss should trigger a comprehensive inspection of electrical grounding and bonding systems.
- Five (5) Year – Thickness gauging of hull plate around the waterline, at several hull girths, in way of highly loaded foundations (pumps, motors, and mooring structures), and in areas where unusual corrosion or wear is observed. Thickness gaging to be reviewed against original element thickness and repair scheduled according to severity of thickness loss.

4.2.2 Chain Catenaries

- Annual – Visual inspection of each chain link and all connecting hardware for wear and damage.
- Five (5) Year – Thickness gauging of chain links and connecting hardware showing highest rate of wear and corrosion (typically end links and areas in contact with dirt/sand above lake level). Thickness gaging to be reviewed against original element thickness and repair scheduled according to severity of wear.

4.2.3 Winches / Mooring Lines / Anchors

- Ongoing (routine) – Maintain mooring winches per manufacturer’s specification; typically this would include routine lubrication of bearings, inspection of wire on drum, and confirmation/adjustment for adequate mooring line tension.
- Annual – Visual inspection of above water portion of each mooring line (wire rope and/or chain) and associated connecting hardware.
- Five (5) Year – Replace wire rope segments of all mooring lines.

- Five (5) Year – Visual inspection of underwater chain link segments and connecting hardware above the mud line using remote underwater video or diver for access. Video/Diver inspection shall confirm anchor submergence below mudline and/or obvious indication of movement or scouring. Any underwater components showing wear shall be replaced. Any anchor movement or scouring that uncovers the anchor would require that the anchor be reset and proof-tested.

4.3 Cardanic Joints and Flex Couplings

- Ongoing (routine) – Maintain appropriate lubrication in Cardanic pin joints.
- Ongoing (routine) – Inspect rubber flex-couplings for leaks, cracks, or other physical damage.
- Annual – Inspect all Cardanic pins and bushings for wear; replace components if wear exceeds manufacturer-specified limits.
- Five (5) to Ten (10) Years – Replace all rubber flex-couplings.

4.4 Fishery Feature Maintenance

4.4.1 Fish Screen Netting Under Barge

Annual inspection with repair and/or replacement as determined to be required to maintain integrity of screening.

4.4.2 Narrows Upstream Bull Trout Passage Roughened Channel

Annual inspection of accessible exposed channel elements. Repair or replacement not anticipated to be required.

4.5 Mechanical and Electrical Maintenance

There are many examples of large pumping systems that have operated for decades with few major equipment failures and other examples of systems that are a chronic burden to owners as a result of vibration, misalignment, and improperly specified equipment for the operating environment. Pumping system operational problems are preventable with proper design, construction, commissioning, and maintenance. Proactive and routine maintenance would prevent premature wear of rotating components and identify potential equipment issues before problems progress to a situation that results in catastrophic failure.

Large pumping equipment presents unique maintenance challenges and equipment in a marine environment creates an added layer of complexity. Maintenance of large mechanical equipment presents inherent safety challenges associated with rotating parts, medium voltage power, and lifting of large loads using suspension devices. Specialized training and equipment is essential for maintenance of pumps, motors, gear reducers, etc., with a crane. Equipment maintenance combined with working in a marine environment creates unique challenges and methodologies must be well developed during the project design phase.

In general, it is recommended that annual maintenance testing be performed for electrical equipment on the barge and the Control Building by a testing firm prior to startup of the pumps and associated equipment. This testing should follow National Electrical Testing Association (NETA) Acceptance Testing Specifications. More specifics follow under Section 4.8 Motors and Section 4.9 Variable Frequency Drives.

When working on or servicing the pumps, gear reducers, motors, and associated equipment, the upstream overcurrent protection and control equipment shall be locked out and tagged out from power sources.

4.6 Large Vertical Column-Discharge Pumps

Pumps are reasonably simple machines that, when designed, installed, and maintained properly, have relatively low maintenance requirements. With that understood, the inherent nature of rotating equipment requires a high level of precision in alignment, balance, and proper equipment specification to avoid unnecessary maintenance challenges. One essential design element for minimizing equipment maintenance is the reed critical frequency of the supporting structure and the components of the pump, gear reducer, if used, and motor. The reed critical frequency of all of these components needs to be at least 120 percent of the maximum operating speed of any of the individual components.

Pump components that require routine maintenance are generally accessible without equipment removal. Among the most challenging maintenance items for vertical column-discharge pumps are the submerged rotating components. Although, pump removal is required for inspection and repair of these components, maintenance efforts requiring pump removal should be infrequent. It is a reasonable expectation that, for pumps that are operated less than 400 hours annually, pump removal should not be required within 20 to 30 or more years following commissioning. It is essential, however, that methods of equipment removal are thoroughly developed during project design.

4.6.1 Regular Maintenance Items – Daily Pump Inspection Items during Continuous Operation

The extent of regular maintenance on large vertical column pumps is dependent upon the frequency of operation and to a certain degree, on manufacturer recommendations. For continuously operating equipment, it is advisable to observe operation on a daily basis and document operating conditions. Noticeable changes to equipment operation may indicate an impending component failure and should be further investigated. Daily maintenance and inspection items may include:

- Observations of the mechanical seals (if included) and confirm no leakage. The mechanical seal should be replaced when leakage occurs as recommended by the manufacturer[1]

[1] Frequent mechanical seal or packing failure is often a symptom of another equipment problem.

- Observation of the packing box (if included) and verify appropriate leakage. If packing leakage is excessive, adjust gland or seal water supply; replace packing if required[2]
- Inspect shaft coupling for wear, cracking, misalignment, etc.
- Listen for audible changes in equipment operation from day to day
- Document perceived changes in equipment vibration
- Inspect anchor bolts
- Document discharge flow, pressure, pump speed, and power
- Overall system visual inspection

4.6.2 Routine Maintenance – Monthly Pump Items during Intermittent and Continuous Operation

For equipment that is operated intermittently, it is important to test the pumps to assure that they are ready to operate when needed. Testing may be conducted on a monthly basis or at another interval based on the equipment provided and the recommendations of the manufacturer. Intermittent pump testing would consist of the following activities:

- Verify proper operation of oil or grease lubricating system (if included)
- Execute the documented pump start-up protocol and operate each unit individually
- Observe and document all *Regular Inspection Items* (see previous section)
- Operate each pump for a minimum of 15 minutes

4.6.3 Annual Pump Maintenance

On an annual basis, whether or not the pump has been used extensively in the previous year, the pump performance should be documented and a thorough inspection of the equipment should be conducted to verify that it is in sound working order. Annual condition monitoring is important to document equipment performance year over year. The annual maintenance effort should include the following:

- Verify that pump hold-down bolts are secured to base plate – check torque on bolts
- Verify proper operation of oil or grease lubricating system (if included)
- Replace all packing; clean and oil gland bolts; clean packing box, verify movement of packing glands (for packed pumps)
- Execute the documented pump start-up protocol and operate each unit individually
- Observe and document all *Regular Inspection Items* (see previous sections)

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[2] Frequent mechanical seal or packing failure is often a symptom of another equipment problem such as vibration induced by mechanical or hydraulic issues, bearing wear, impeller wear, shaft run out tolerances being exceeded, solids and/or particulate in seal/flushing water, inadequate seal/flushing water supply among other items.

- Perform condition monitoring and document pump operating parameters, including:
  - Pump discharge rate
  - Discharge pressure
  - Equipment rotating speed
  - Power use
  - Equipment vibration
- Repair or replace equipment as necessary, if inspections or condition monitoring indicates degradation in performance.

4.6.4 Pump Maintenance after 8,000+/- Hours of Operation

After many hours of operation, large pumping equipment may require a significant overhaul that requires pump removal and potential replacement of major parts. This activity should include collaboration with a qualified representative of the pump manufacturer. Removal of very large pumps is not a trivial task and must be thoroughly considered as part of a maintenance plan. Cranes are typically utilized for removal of vertical column-discharge pumps. For removal of pumps from a floating platform, it would be necessary to mobilize a crane on a barge. For very large pumping equipment, the pumps can be designed to be removed in two pieces to reduce the weight of the heaviest pumping components. This is referred to as a pull-out type design, which allows the internal rotating components and diffuser to be removed while the pump bell, column, and discharge head remain in place. Although it has a higher capital cost, it can reduce the cost of installation and maintenance by significantly reducing the weight of the heaviest system component.

For pumping plants that are operated continuously, this type of maintenance may be required annually or biennially. For intermittent use pumping plants, maintenance that requires pump removal may not be required for 20 to 30 years or more following commissioning. Additionally, it should not be considered a hard and fast rule that this level of maintenance is required after 8,000 hours of operation, but this is reasonable interval for planning purposes. The actual time for a pump overhaul should be determined based on review of the condition monitoring data collected during annual maintenance efforts. Factors in determining the need for major equipment overhaul may include a notable decrease in efficiency and capacity or may be prompted by reliability concerns due to a measurable increase in vibration or noise. This level of maintenance would typically include:

- Pump removal
- Inspection of impeller for damage and excessive wear
- Inspection of impeller housing for excessive wear
- Inspection of pump shaft bearings
- Inspection of pump shaft
- Repair or replacement of equipment, as necessary

4.7 Right-Angle Gear Drive

For some large vertical pump installations, right angle drives are implemented to facilitate use of a horizontal driver. This arrangement can be applied for a number of reasons such as use of an engine to drive the pumps or to allow use of a lower cost/higher speed motor. Right angle drives often include gear reducers to adjust the motor rotating speed to match the speed of large slow speed pumps.

4.7.1 Regular Maintenance Items – Daily Inspection Items During Continuous Operation

Right angle drive maintenance can be accommodated on similar intervals as pump maintenance and should be inspected on a daily basis during continuous operation. Daily maintenance and inspection items may include:

- Inspect shaft coupling for wear, cracking, misalignment, etc.
- Confirm proper function of the lube oil system, including documentation of oil levels and temperatures
- Listen to audible changes in equipment operation from day to day
- Document perceived changes in equipment vibration
- Inspect anchor bolts
- Overall system visual inspection

4.7.2 Routine Maintenance – Monthly Items during Intermittent and Continuous Operation

It is important to regularly test equipment that operates intermittently to assure that it is ready to be put into service when needed. Testing may be conducted on a monthly basis or at another interval based manufacturer recommendations. Intermittent right angle drive testing would consist of the following activities:

- Replace lube oil and filter on interval recommended by manufacturer
- Grease shaft coupling
- Execute the documented pump start-up protocol and operate each unit individually
- Verify proper operation of oil lubricating system
- Observe and document all *Regular Inspection Items* (see previous section)
- Operate the equipment for a minimum of 15 minutes

4.7.3 Annual Maintenance

On an annual basis, whether or not the equipment has been used extensively in the previous year, a thorough inspection and documentation of right angle drive performance should be completed. Annual condition monitoring is important to document equipment performance year after year and should include the following:

- Verify that right angle drive hold-down bolts are secured to base plate – check torque on bolts
- Replace lube oil and filter on interval recommended by manufacturer
- Grease shaft coupling
- Verify proper operation of oil lubricating system
- Execute the documented pump start-up protocol and operate each unit individually
- Observe and document all Regular Inspection Items (see previous sections)
- Operate each unit for a minimum of 3 hours and monitor the lube oil temperature
- Perform Condition Monitoring and document right angle gear operating parameters, including:
  - Oil temperature
  - Equipment vibration
- Repair or replace equipment as necessary, if inspections or Condition Monitoring indicates degradation in performance

Note: The most critical failure that may occur within the gear unit would be the bearings. Regular lubrication monitoring and refill is essential to prolong bearing life. The lowest bearing life of the selected gear unit is approximately 33,000 hours (based on L10G calculations). The 33,000 hours considers continuous operation at full motor power.

4.7.4 Maintenance after 8,000 Hours of Operation

(In collaboration with a qualified representative of the right angle drive manufacturer.)

As with the pumps, the right angle gear drives may require a major overhaul after many hours of operation. This may involve removal of the equipment so that it can be inspected and re-built at an off-site location. Right angle drive removal from a pump station on a floating platform would require a separate barge mounted crane.

As with the pumping units, a major overhaul of the right angle gear drive may be more or less frequent than after 8,000 hours of operation, but this is reasonable interval for planning purposes. The actual time for an overhaul is determined based on review of the data collected during annual maintenance efforts.

4.8 Motors

Motors are designed to give many years of reliable service with a minimum of attention, but trouble-free operation cannot be expected if proper maintenance is postponed or neglected. A schedule of preventive maintenance inspections should be established to avoid breakdown, serious damage and extensive downtime. The schedule depends on operating conditions (i.e., harsh winter conditions), frequency of operation, and experience with similar equipment. To assure adequate maintenance, and warranty consideration, it is essential that complete records be kept for each motor; including description and rating, maintenance schedule and repairs required and carried out. When operating in a harsh environment of snow, ice, wind, wave action, etc., it would be important to perform regular maintenance. This maintenance procedure should be as recommended by the motor manufacturer. Likewise storage instructions would need to be developed for guidance during idle seasons.

4.8.1 Regular Maintenance Items – Daily Motor Inspection Items during Continuous Operation

Daily maintenance and inspection items may include:

- Inspect shaft coupling for wear, cracking, misalignment, etc.
- Check oil levels
- Listen for audible changes in equipment operation from day to day
- Document perceived changes in equipment vibration
- Inspect anchor bolts
- Overall system visual inspection

4.8.2 Routine Maintenance – Monthly Motor Inspection Items during Intermittent and Continuous Operation

It is important to test equipment that is not in service for extended periods to assure that it is ready to operate when needed. Testing may be conducted on a monthly basis or at another interval based on the equipment provided and the recommendations of the manufacturer. Intermittent pump testing would consist of the following activities:

- Verify proper operation of oil lubricating system (if included).
- Observe and document all *Regular Inspection Items* (see previous section).
- Rotate motor shaft to prevent sag (horizontal arrangement).

4.8.3 Annual Motor Maintenance

A suggested maintenance checklist is as follows:

- Analyze lube oil for particulates and metal contaminants.

- Verify motor is clean and verify that stator and rotor ventilation passages are unobstructed.
- Check for excessive loading or service factor.
- Verify winding temperature rise is not in excess of rated value.
- Verify insulation resistance is above recommended minimum.
- Verify voltage and frequency variation.
- Check air gap.
- Verify that bearing temperatures are within limits and that lubricant is clean and proper level is maintained.
- Verify no unusual vibration or noise exists.
- Check alignment.
- Check for proper lubrication.

4.9 Variable Frequency Drives

Modern VFDs have a design life of 10 to 30 years, with the primary cause of shortened life being the availability of components after a product has been discontinued. However, manufacturers are emphasizing longer product and parts availability and would generally continue to service VFDs for 5 to 7 years after it has been discontinued for a new design.

VFDs don't require significant routine maintenance other than general inspections and monitoring. Inspection should occur on an annual basis as outlined below.

4.9.1 Annual VFD Inspection

VFD manufacturers have detailed tables of recommended maintenance for the latest technology VFDs. The recommended maintenance is typically based on 5000 hours of annual operation. For an installation that is operated intermittently (i.e., only during drought years), VFD maintenance should be minimal. The yearly recommended maintenance includes drive component maintenance and power up sequencing that can be performed at start-up. After extended idle time, it is recommended that the drives be started by a qualified technician who would review all critical drive functions.

On an annual basis, a thorough inspection and documentation of the VFDs should be completed. Annual maintenance should be minimal, but inspections are important to prevent potential problems. An annual VFD inspection could include the following:

- Air cooling system inspection, including cleaning or replacement of the air filters (for air cooled VFDs)
- Liquid cooling system inspection, including cleaning of the mesh filters and replacement of de-ionizing filter cartridges (for liquid cooled VFDs)
- Inspection of power switching components

- Inspection of integral magnetics / power filters
- Inspection of control cabinet components
- Inspection of low and medium voltage terminal connections

4.9.2 Additional Periodic VFD Maintenance

Additional periodic VFD maintenance is required as recommended by the manufacturer and may include the following:

- Replace of air cooling fans on 5 to 7 year intervals (for air cooled VFDs).
- Replace of cooling pump seals and thermostatic valve element on 7 to 10 year intervals (for liquid cooled VFDs).
- Replace power switching components on 5 to 10 year intervals.
- Maintain integral magnetics/power filters on 5 year intervals.
- Replace control cabinet batteries on 3 to 5 year intervals.
- Review firmware and hardware, including operational parameters on approximately 3 year intervals to evaluate whether updates would improve system operation.

4.10 Cost Estimate

HDR arranged for 2 independent Opinions of Probable Construction Cost (OPCC) to be prepared: one by internal estimators at HDR Constructors (HDRC) who participate in design-build projects; and one by Orion Marine Group (OMG). HDR then held an internal workshop with the estimators from both groups to review differences in the OPCCs and develop one final, reconciled OPCC for the Floating Pumping Plant Alternative. HDR documented the independent and reconciled OPCC's in a technical memorandum (HDR 2018). Results are shown in Table 2.

Table 2. Reconciled OPCC

Bid Item	Description	QTY	UNIT	RECONCILED
1000	**MOBILIZATION**	**1**	**LS**	**$4,450,000**
2000	**CIVIL**			
2100	CIVIL: LS-3 EAST SHORE PARKING AREA (3 ACRES)	1	LS	$355,000
2200	CIVIL: LS-3 EAST SHORE BOAT RAMP (20 X 600 LF) PHASE 1	1	LS	$700,000
2300	CIVIL: LS-2 CONTROL BUILDING AREA (5000 SF)	1	LS	$100,000
2400	CIVIL: LS-3 EXTEND BOAT RAMP (20X400 LF) PHASE 2	1	LS	Future Cost
2500	CIVIL: LS-3 ACCESS ROAD TO FLOW CONTROL STRUCTURE	1	LS	$300,000
3000	**MARINE**			
3100	MARINE: RESERVOIR DREDGING	1	LS	$325,000
3200	MARINE: FLOW CONTROL STRUCTURE (W/ 4 GATES)	1	LS	$3,175,000
3300	MARINE: OUTLET CHANNEL	1	LS	$1,615,000
3400	MARINE: PIPE BRIDGE STRUCTURES, RIGID	1	LS	$730,000
3500	MARINE: PIPE BRIDGE STRUCTURES, FLEXIBLE	1	LS	$3,250,000
3600	MARINE: PUMP BARGE FACILITIES	1	LS	$7,325,000
3700	MARINE: BARGE ANCHORING	1	LS	$1,200,000
4000	**MECHANICAL**			
4100	MECHANICAL: VERTICAL TURBINE PUMPS	1	LS	$11,000,000
4200	MECHANICAL: RIGHT ANGLE DRIVES	1	LS	$4,500,000
4300	MECHANICAL: MOTORS	1	LS	$2,000,000
4400	MECHANICAL: DISCHARGE PIPING	1	LS	$2,350,000
5000	**ELECTRICAL**			
5100	ELECTRICAL: INTERCONNECTION TO PSE 115 KV	1	LS	$140,000
5200	ELECTRICAL: LAKE EASTON STEPDOWN SUBSTATION	1	LS	$1,800,000
5300	ELECTRICAL: TWIN 34.5 KV BURIED TRANSMISSION LINES	1	LS	$2,200,000
5400	ELECTRICAL: KACHESS RESERVOIR STEPDOWN SUBSTATION	1	LS	$1,110,000
5500	ELECTRICAL: 4160V CABLES, KRSS TO CONTROL BLDG	1	LS	$2,132,000
5600	ELECTRICAL: ENCLOSED GENERATOR SET	1	LS	$125,000
5700	ELECTRICAL: CONTROL BUILDING & EQUIPMENT	1	LS	$5,000,000
5800	ELECTRICAL: MARINE CABLES, CONTROL BLDG TO MOTORS	1	LS	$7,519,000
5900	ELECTRICAL: ON BARGE ELECTRICAL	1	LS	$200,000
6000	**FISH**			
6100	NARROWS UPSTREAM FISH PASSAGE (PHASE 1)	1	LS	$1,918,000
6200	NARROWS UPSTREAM FISH PASSAGE (PHASE 2)	1	LS	Future Cost
7000	**PSE**			
7100	INTERCONNECTION & TRANSMISSION SYST DESIGN/REVIEW	1	LS	$250,000
	TOTAL DIRECT COSTS			**$65,769,000**

TOTAL DIRECT COSTS		**$65,769,000**
PROJECT INDIRECT COSTS		
Project Indirect (Overhead)	7.5%	$4,932,675
Project Indirect (GC's)	5.0%	$3,288,450
SUBTOTAL DIRECT PLUS INDIRECT COSTS		**$73,990,125**
OTHER INDIRECT COSTS		
Contractor's Alternative Delivery Fee	12.0%	$8,878,815
Contractor's Bonds & Insurance	2.0%	$1,479,803
WA State Sales Tax (unincorporated Kittitas Co)	8.0%	$5,919,210
B&O Tax	0.5%	$369,951
Builders Risk Insurance	1.0%	$739,901
SUBTOTAL OTHER INDIRECT COSTS		$17,387,679
TOTAL ALL DIRECT + INDIRECT COSTS		**$91,377,804**
Engineering and Design Costs (2018)	12.0%	$10,965,336
Construction Contingency (2020)	25.0%	$24,237,963
Escalation of Project to Midpoint Construction [A] (2020)	6.1%	$5,574,046
Total Project Cost [B]		**$132,155,149**

[A] The inflation factor used in the reconciled OPCC is 6.1 percent versus a 5 percent inflation factor used in the two un-reconciled OPCCs. The author believes the 6.1 percent inflation factor is more representative of current inflation estimates.

[B] Does not include the deferred future costs required to construct the lower portion of the Narrows Fish Passage Structure ($43.4 M in 2020$) and the lower portion of the Public Boat Ramp ($3.0 M in 2020$). However, these costs must be taken into consideration for project economics and financing as these two features must be built; but at an as-yet unknown time in the future.

There are 2 project features that cannot be constructed during the initial construction of the drought relief pumping plant project. They cannot be constructed until the drought relief pumping plant has been constructed and is operational and an actual drought occurs such that the pool level in Kachess Reservoir is drawn down to expose the shoreline area where construction will occur. These features are:

15. Extension of the Public Boat Ramp on the east shore of the reservoir.
16. Extension of the Volitional Fish Passage Structure located at the downstream end of the Narrows.

It will not be possible to schedule with certainty when the completion of these two project features will occur in the future. For this reason, the line item costs for these two items have been removed from the original construction contract of this OPCC; as it represents the estimated costs for the initial construction contract only.

Table 2 does not include the deferred costs for construction of the lower portion of either the Narrows Fish Passage Structure ($43.4 M in 2020$) or the lower portion of the Public Boat Ramp ($3.0 M in 2020$). However, these costs must be taken into consideration for project economics and financing as these two features must be built; but at an as-yet unknown date in the future.

The calculated Total Construction Cost for the reconciled OPCC for the project without the costs of the deferred future construction actions is $132.2 million in 2020 dollars (see Table 2).

HDR applied an expected range of accuracy to the calculated OPCC of a Low of -25 percent and a High of +40 percent. The basis of this range of accuracy is the AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System – as Applied in Engineering, Procurement and Construction for the Process Industry (Revised March 1, 2016). Applying these accuracy ranges to the calculated OPCC amount of $132.2 million results in a cost range falling between a Low of $99.1 million and a High of $185.1 million.

The OPCC for the deferred construction contract costs is $46.4 million in 2020 dollars. Applying the same accuracy ranges to the deferred construction costs results in a cost range for the deferred construction costs falling between a low of $34.8 million and a high of $65.0 million.

Table 3 presents the results of the OPCC estimate contained in this memorandum for: 1) the original construction contract costs only; 2) the deferred construction contract costs; and, 3) the original construction contract costs plus the deferred construction contract costs (all in 2020 dollars).

Table 3. Floating Pumping Plant Alternative Costs (in 2020$)

OPCC Name	Original Construction Contract Only ($Million)	Deferred Construction Contract Costs Only ($Millions)	Original Plus Deferred Construction Contract Costs ($Millions)
Low Range OPCC	$99.1	$34.8	$133.9
Computed OPCC	$132.2	$46.4	$178.6
High Range OPCC	$185.1	$65.0	$250.1

4.11 Future Investigations

The Floating Pumping Plant Alternative (FPPA) for this project is currently at an advanced appraisal design level; i.e., at an approximate 15 percent level of engineering and design. The next design level will be the feasibility design level; i.e., taken to an approximate 30 percent level of engineering and design. If Reclamation, Ecology or Roza choose to advance this alternative further, then the following investigations are recommended.

4.11.1 Safety Systems

Because the FPPA has numerous principal project features located above and on the water, a thorough review of safety requirements for this alternative focusing on safety during construction, during ongoing operations and maintenance by staff, and by the boating public is warranted as design progresses.

4.11.2 Regulatory Compliance

Completion of the NEPA/SEPA process is underway at this time with the addition of Alternative 3, the FPPA; which is being added to the two original alternatives, the East Shore and South Pumping Plant alternatives.

4.11.3 Permit Acquisition

Reclamation, Ecology and/or Roza should perform a complete analysis of all required Federal, state, and county permits required for construction at the next stage of project development. This can build on similar assessments developed previously in feasibility-level studies of the East Shore and South Pumping Plant alternatives.

4.11.4 Real Estate

This appraisal study of the FPPA documents the source of power supply for all KDRPP alternatives. Reclamation and Ecology determined the point of interconnection for the project based on consultation with Puget Sound Energy (PSE) and a siting analysis of preferred routes from the proposed intertie connection point to the project site. A preferred point of interconnection and a preferred transmission line route to the site have now been firmly established. Based on communications with Reclamation staff, it appears that the entire transmission line route, with four exceptions, is located on land owned by Reclamation. The exceptions are:

1. The point of interconnection that is located on PSE owned property.
2. Guying cables for the point of interconnection are believed to be located on private property.
3. From the Lake Easton Substation to the trenchless crossing of Interstate 90, property ownership is a mix of Reclamation owned land and WSA Trust land for which Reclamation has a right of crossing.
4. The trenchless undercrossing of Interstate 90 is on land owned by the State of Washington.

A thorough review of property ownership for the entire proposed power supply system is recommended.

4.11.5 Surveying & Base Mapping

Reclamation, Ecology, and/or Roza should perform a thorough review of existing survey data and base mapping to determine what locations require additional information. For every location lacking current, accurate information, detailed surveying should be performed and base mapping should be updated.

4.11.6 Geotechnical

Existing geotechnical data has been collected at a number of locations for the KDRRP. However, given the addition of Alternative 3, the FPPA, and the updated information now available on the power supply for all alternatives, it is recommended that a thorough review of available geotechnical information versus desired information should be performed. It is likely that additional information will be needed for the new power supply features at a minimum.

4.11.7 Civil Engineering

No known additional investigations are required for this discipline.

4.11.8 Mechanical Engineering

A comparison of the right angle drive and horizontal shaft motor option versus a planetary gear and a vertical shaft motor should be performed.

4.11.9 Hydraulic Engineering

Two hydraulic engineering analyses should be performed for this alternative. The first should be a numerical model of the flow approaching and traveling through the fish screen (netting) and into the pump intake and through the pump itself. The second should be a physical hydraulic model of the same flow analysis to confirm and or refine the hydraulic analysis and confirm the pump selection and its hydraulics.

4.11.10 Electrical Engineering

Further analysis of the power supply system and its various components should be conducted. These should include:

1. Further consultation with PSE regarding interconnection, metering, substation and high voltage conductor selection and requirements.
2. The selection and costing of marine cable from the control building to the motors.
3. The selection of variable frequency drives.

4.11.11 Instrumentation & Controls

A detailed examination of instrumentation and control system requirements will need to be performed.

5.0 References

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