FINAL REPORT

Feasibility Study

YTID Diversion Relocation to Wapatox Diversion Dam

Yakima River Basin Integrated Plan
Yakima, Washington

Prepared for

State of Washington Department of Ecology
Yakima-Tieton Irrigation District

June 2017

CH2M HILL Engineers, Inc.
Yakima, Washington

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Acronyms and Abbreviations

AID	Ahtanum Irrigation District
APE	area of potential effect
CCWUA	Cowiche Creek Water Users Association
cfs	cubic foot per second
CH2M	CH2M HILL Engineers, Inc.
CWA	Clean Water Act
DAHP	Department of Archaeology and Historic Preservation
DOE	determination of eligibility
EA	environmental assessment
ECOS	Environmental Conservation Online System
Ecology	Washington State Department of Ecology
FCR	French Canyon Reservoir
FCS	flow control station
GIS	geographic information system
hp	horsepower
kW	kilowatt
kVA	kilovolt ampere
LF	linear foot
MBTA	Migratory Bird Treaty Act
MVA	megavolt-ampere
NEPA	National Environmental Policy Act
NFCCR	North Fork Cowiche Creek Reservoir
NHD	National Hydrography Dataset
NHPA	National Historic Preservation Act
NMFS	National Marine and Fisheries Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
O&M	operations and maintenance
PLC	programmable logic controller
SEPA	State Environmental Policy Act
SMA	Shoreline Management Act
TBM	tunnel boring machine
TDH	total dynamic head

TWSA	total water supply available
TWUA	Tieton Water Users' Association
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
U.S.C.	*U.S. Code*
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCPS	Wapatox Canal Pump Station
WDFW	Washington Department of Fish and Wildlife
WISAARD	Washington Information System for Architectural and Archaeological Records Database
WNHP	Washington Natural Heritage Program
WSE	Water Surface Elevations
V	volt
YTID	Yakima-Tieton Irrigation District

SECTION 1

Introduction

1.1 Background

The Yakima-Tieton Irrigation District (YTID) delivers Tieton River water to approximately 27,900 acres of agricultural, industrial, and residential land northwest of Yakima, Washington. YTID was first organized as the Tieton Water Users' Association (TWUA) in 1906. All landowners were required to join the association and assign their water rights to the TWUA. Soon after the TWUA was formed, it entered into a contract with the U.S. government to design and construct irrigation conveyance and distribution facilities. The original distribution system consisted of a 12-mile-long Tieton Canal in the Tieton River canyon and 320 miles of open canal distribution laterals. The first irrigation water was delivered in 1910.

In the late 1970s, YTID initiated a $70 million Rehabilitation and Betterment Project, funded by the U.S. Bureau of Reclamation (USBR), the Washington State Department of Ecology (Ecology), and YTID. The entire open canal distribution system downstream of the Tieton Canal was replaced by 1986. The project included more than 230 miles of pipeline, ranging from 4 to 90 inches in diameter, 6 booster pump stations, and 2 hydroelectric generating plants. The project also included the French Canyon Dam and Regulating Reservoir (FCR). However, the 12-mile-long Tieton Canal was not replaced because of high costs and the limited repayment capability of the water users.

1.2 Project Purpose and Need

The Tieton Canal is now more than 100 years old and is the only source of irrigation water for more than 4,000 users. The existing canal has failed numerous times because of age, unstable geology, and storm events. Canal failures disrupt the delivery of water and are costly to repair.

Many of the crops grown within YTID are high-value fruit trees that are subject to permanent damage caused by lack of water. The crops, primarily apples, cherries, and pears, represent a large part of the local economy. YTID spends a significant amount of time and effort maintaining the Tieton Canal to improve its reliability. The open canal creates a barrier and a hazard to wildlife and people. Deer, elk, and other animals are lost in the canal each year.

Therefore, YTID is actively pursuing strategies to replace the canal. Three projects are currently being considered, as described in the following subsections.

1.2.1 Tieton Canal Replacement

In 2013, CH2M HILL Engineers, Inc. (CH2M) completed an alternatives study for replacing the Tieton Canal in place with box culvert, pipeline, tunnels, or combinations of each. The preferred alternative that emerged consisted of the following:

- 6-foot by 10-foot precast concrete box culvert that replaces the Main Canal from the Tieton River Diversion to the Windy Point Tunnel and a section about 0.2 mile long below the Windy Point Tunnel
- Rehabilitation or reconstruction of the existing Windy Point Tunnel
- A new, 96-inch-diameter pipeline beginning at the end of the precast box reach that parallels the Tieton River until the pipeline reaches the existing tunnel that discharges into French Canyon Reservoir

- Construction of a new 96-inch-diameter tunnel connecting the new 96-inch-diameter pipeline to French Canyon Reservoir

The preferred alternative had desirable overall attributes, considering environmental impacts, constructability, operations and maintenance (O&M), and cost. The total project cost estimate was $200 million, excluding land acquisition and environmental mitigation. Construction would occur only during the winter months for portions of the project on the existing canal alignment. It was estimated that permitting, design, and construction could take 8 to 10 years to complete.

1.2.2 North Fork Cowiche Creek Reservoir

In the fall of 2016, *a Draft North Fork Cowiche Creek Reservoir Feasibility Study* (CH2M, 2016) considered a new, larger reservoir just upstream of FCR. The North Fork Cowiche Creek Reservoir (NFCCR) is a proposed off-stream water storage reservoir located approximately 0.5 mile upstream of FCR on the North Fork Cowiche Creek. This 35,000 acre-foot reservoir would increase available water supplies in the lower Yakima River Watershed and provide agricultural and environmental benefits consistent with the goals and objectives of the Yakima Basin Integrated Plan. The NFCCR concept would not replace the Tieton Canal, but could be combined with the Tieton Canal or other alternatives for increased water supply and flexibility. The total cost of NFCCR was estimated to be $188 million. Much of the construction could occur year round without affecting existing irrigation operations.

1.2.3 Diversion Relocation to Wapatox Diversion Dam

During the NFCCR feasibility study, another alternative emerged to replace the Tieton Canal and provide additional benefits. The "Wapatox Project" (the subject of this report) would relocate the existing YTID diversion from the Tieton River to the Naches River near the existing Wapatox Canal and Diversion Dam. The project would rely on the existing Wapatox fish screen at the head of the Wapatox Canal, and require a new pump station and approximately 3 miles of tunnel and pipeline to connect to the existing YTID main pipeline located approximately 0.7 mile east of FCR. In addition to replacing the existing YTID Tieton Canal, the Wapatox Project could also provide the following benefits:

- Remove the existing YTID Diversion Dam and fish ladder in the Tieton River. The dam and fish ladder may be impeding fish passage and contributing to fish mortality.
- Benefit bull trout and steelhead with increased flow in the lower Tieton River. The YTID diversion would effectively be moved approximately 15 miles downstream, and YTID water would stay in the river longer.
- Capture Bumping Reservoir spills and unregulated flow in the Naches River, thereby increasing the total available water supply to the Yakima Basin. If the project is combined with the construction of the NFCCR, flows could be released from NFCCR at certain times and returned to the Naches River through the new pipeline (flowing in reverse).

Potential water exchanges and other beneficial elements of these three projects (alone or in combination) are further described in the referenced reports prepared for the Tieton Canal and NFCCR.

Figure 1-1 shows the locations of the three potential projects. The remainder of this report focuses on the Wapatox Project.

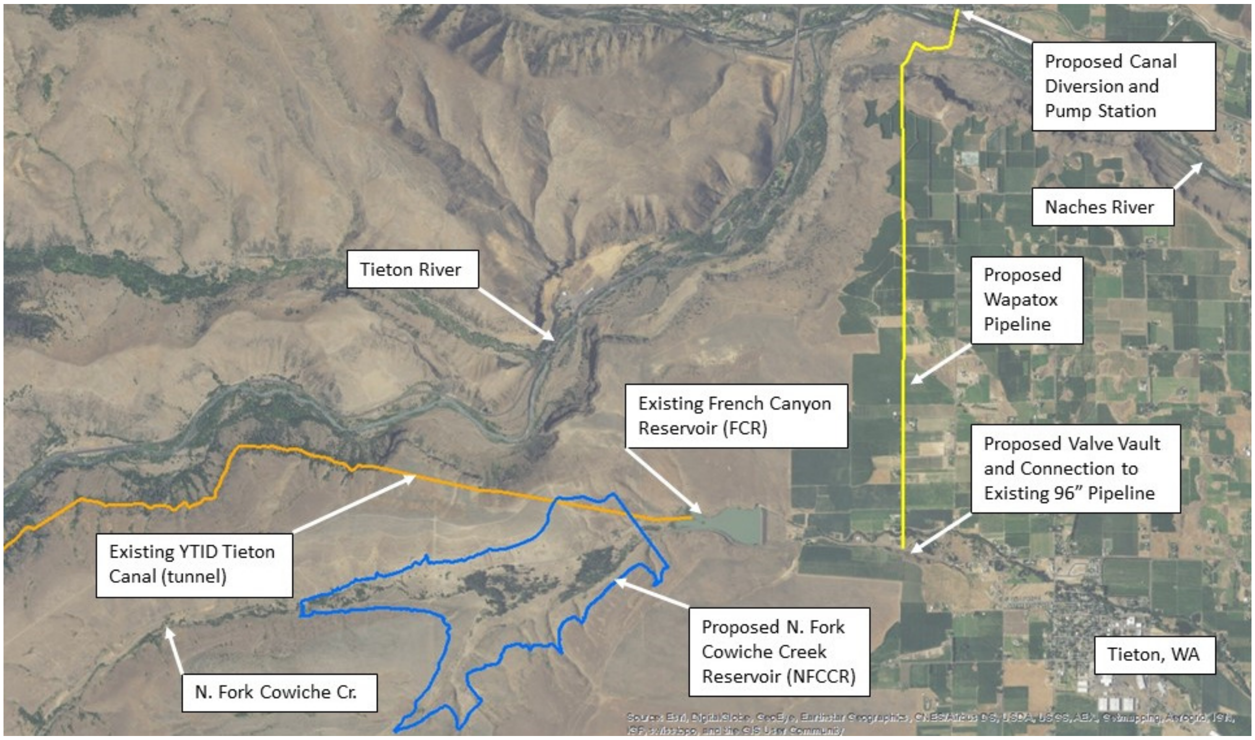


Figure 1-1. Project Area Map

1.3 Facilities and Operations

The proposed Wapatox Project (Figure 1-1) consists of a large pump station adjacent to the Wapatox Canal; a 2.8-mile-long, 96-inch-diameter pipeline and tunnel; a bridge over the Naches River to support the pipeline and provide access for construction and long-term maintenance; and structures to control and measure flow and release water back to the Naches River.

The pump station and pipeline would be operated full time during the irrigation season as a replacement of YTID's current gravity water supply from the Tieton Canal. If the project is combined with the NFCCR, the period of operation may expand to year-round, and the overall system would be operated as a pump-storage project. In the latter case, during the winter and spring months, when YTID is not using part or any of its delivery system capacity, available water from the Naches River would be diverted through the pipeline to the FCR. This water would be pumped from the FCR to the NFCCR. When the water is needed for agriculture or environmental purposes, the water would be released back to the lower reservoir and then delivered to end users or the Naches River through either the Wapatox pipeline or the YTID distribution system. The additional storage volume created by the proposed reservoir would provide opportunities to increase beneficial uses of the basin's limited resources. Additional discussion about these potential operating scenarios is provided in Section 2.

SECTION 2

Approach and Methodology

This section briefly describes the steps taken by CH2M to conduct the analysis and examine the feasibility of the project.

2.1 Collect and Review Existing Information

CH2M's initial step was to collect and review existing, relevant information related to the project, including flow records for the Naches and Tieton Rivers, historical reservoir levels in Rimrock and Bumping reservoirs, historical YTID diversions, U.S. Geological Survey (USGS) topographic maps, and geographic information system (GIS) and LiDAR data, available through Yakima County. GIS data were of most importance in understanding property ownership and parcel locations, to aid in developing facility layouts. The USGS and LiDAR data provided the basis for feasibility-level mapping and estimations of pumping head. CH2M also collected and reviewed land-use maps, archaeological studies, and environmental studies and inventories. This initial step was vital in understanding conditions and data at the main facility site and corridors, as required to evaluate project configuration, potential archaeological and environmental impacts, and operating criteria.

The project team also conducted a site visit during the fall of 2016 to make visual observations of existing facilities, topography, cultural and environmental resources, and other aspects of the project area that could affect project features and implementation.

2.2 Identifying Operational Scenarios for Feasibility Evaluation

As noted in Section 1, the Wapatox project has the potential to operate alone or in combination with a new NFCCR. To begin the analysis, CH2M established design flow rates and annual water volumes for two scenarios:

- **Scenario 1**: The new Wapatox pump station and pipeline would replace the Tieton Canal <u>without</u> the addition of the NFCCR.
- **Scenario 2**: The new Wapatox facilities would be combined with the NFCCR.

For Scenario 1, facilities should be sized at 370 cubic feet per second (cfs), consistent with earlier Tieton Canal studies, because the new system would effectively replace the existing Tieton Canal and be operated in the same way the Tieton Canal has been operated. Scenario 2 would offer the benefit of significant new storage in the system and flexibility in the timing and rate of diversions and deliveries. CH2M briefly evaluated several options with a spreadsheet model that accounted for the timing of river diversions versus water rights (detailed further in Section 5), the amount and timing of irrigation demands, and the accumulation and depletion of storage versus capacity in the NFCCR. This yielded design flow rates for Scenario 2 that could range from roughly 200 to 345 cfs. For Scenario 2, it was determined that the analysis should be based on the 345 cfs rate, for the following reasons:

- The higher capacity offers the flexibility to serve peak YTID demand <u>and</u> maintain a full reservoir. This approach would increase average annual project yield and provide carry-over storage for the following year.
- The Naches River offers ample runoff in some years, so it may be feasible to fill the reservoir more than once per year.

- The higher capacity would allow YTID to stay within current water rights between April 1 to October 31, whereas some of the lower capacities would require approval of different diversion rates and timing.

A more detailed summary of the operational scenarios is presented in Section 5.

2.3 Siting, Sizing, and Layout of Proposed Facilities

Based on review of existing information and field observation of topography, hydrology, land use, and property ownership, CH2M developed preliminary layouts for a new canal intake and pump station, river crossing, pipeline/tunnel system, Naches River discharge facilities, and flow control and measurement vaults. The pump station is sized for a nominal peak capacity of 370 cfs, based on Scenario 1, as described above and consistent with an earlier study to replace the Tieton Canal with a system capable of conveying 370 cfs. The large-diameter pipeline and tunnel system transfers water in both directions: from the new pump station to the YTID distribution just below FCR, and from that connection point back to the Naches River. Multiple pump station locations and pipeline/tunnel alignments were evaluated, as described in Section 4.

2.4 Assessing Potential Project Impacts and Compliance Requirements

Understanding project feasibility also requires accounting for potential impacts on environmental and cultural resources. CH2M completed a preliminary assessment, based on existing information and field review, of resources in the project area and the permitting and environmental compliance requirements that could be expected should the project be implemented.

2.5 Estimating Project Costs

CH2M prepared construction cost estimates, as well as annual O&M cost estimates. Life cycle costs were also evaluated as a means of estimating the long-term value of the project for comparison to other alternatives to replace YTID's main water supply and other large water resources projects in the Yakima River Basin.

2.6 Conclusions and Recommendations

The final portion of the feasibility study summarizes findings, provides recommendations for the best apparent project concepts, and provides recommendations for next steps.

Project Setting

3.1 Geology

CH2M's feasibility study report for the NFCCR project included an assessment of area geology, relevant in particular to the design and construction of a new dam and reservoir. The Wapatox project is less influenced by geologic conditions, so the information has not been updated or presented in this report. Observations in NFCCR report may be relevant to pipeline construction as the Wapatox pipeline approaches FCR, so the NFCCR report can be referenced as needed. Section 8.2 of this report includes geotechnical investigation recommendations that will ultimately provide information on geologic and geotechnical consideration for design and construction of the remainder of the pipeline, tunnel, pump station, and bridge.

3.2 Hydrology

Changing the primary location of the YTID's diversion from the existing Tieton Canal to the Wapatox Diversion Dam will alter flow patterns in the Tieton River between the existing diversion location and the confluence with the Naches River (approximately 15 stream miles), and in the Naches River between the confluence with the Tieton River and the new diversion location (approximately 0.5 stream mile). The flow in these reaches will increase, augmenting stream flows approximately equivalent to the YTID's diversion due to the location change. The drainage basin on the Naches River above Wapatox encompasses approximately 940 square miles, upstream of the diversion location, on the eastern slope of the Cascade Mountains in Washington state. The basin is roughly triangular in shape, approximately 50 miles long from north to south, and 30 miles wide from west to east. Stream elevation ranges from approximately 8,170 to 1,590 feet, and has a mean basin elevation of approximately 4,340 feet. The basin consists predominantly of evergreen forest, with some grassland, sage brush, and deciduous tree-covered areas. Mean annual precipitation in the basin as calculated by StreamStats is 54.8 inches (USGS, 2016).

Flood events of a magnitude that are expected to be equal to or exceed the average discharge during any 10-, 50-, 100-, or 500-year return period have been selected as having special significance for floodplain management. These events, termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Flow statistics for these return periods, as well as for the 2- and 25-year floods are shown in Table 3-1.

Table 3-1. Peak Flow Statistics for Naches River at Wapatox Diversion

Return Period (years)	Naches River Flow from USGS StreamStats (cfs)
2	3,900
10	7,710
25	9,990
50	11,800
100	13,800
500	18,900

3.3 Land Use

The project area lies within the Yakima Folds ecoregion of the Columbia Plateau (Clarke and Bryce, 1997). This ecoregion lies in the rain shadow of the Cascade Range, and receives 6 to 15 inches of precipitation annually. Shallow soils overtopping basalt flows support native shrub-bunchgrass communities, dominated by big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and Idaho fescue (*Festuca idahoensis*).

The proposed pump station and bridge are within the Naches River floodplain. Woody riparian species, such as black cottonwood (*Populus trichocarpa*) and willows (*Salix* spp.), dot the river banks. Other areas are dominated by ruderal species and remnant shrub-bunchgrass species. The primary land use on top of the plateau is agriculture, and native vegetation has mostly been replaced with fruit trees. Areas unsuitable for crops are dominated by big sagebrush and invasive grasses, including crested wheatgrass (*Agropyron cristatum*) and medusahead rye (*Taeniatherum caput-medusae*). Ruderal species occupy remaining habitat along roadsides and ditches.

3.4 Environmental Resources

An online literature review pertaining to state and federal environmental resources in the study area was conducted. The following databases were consulted:

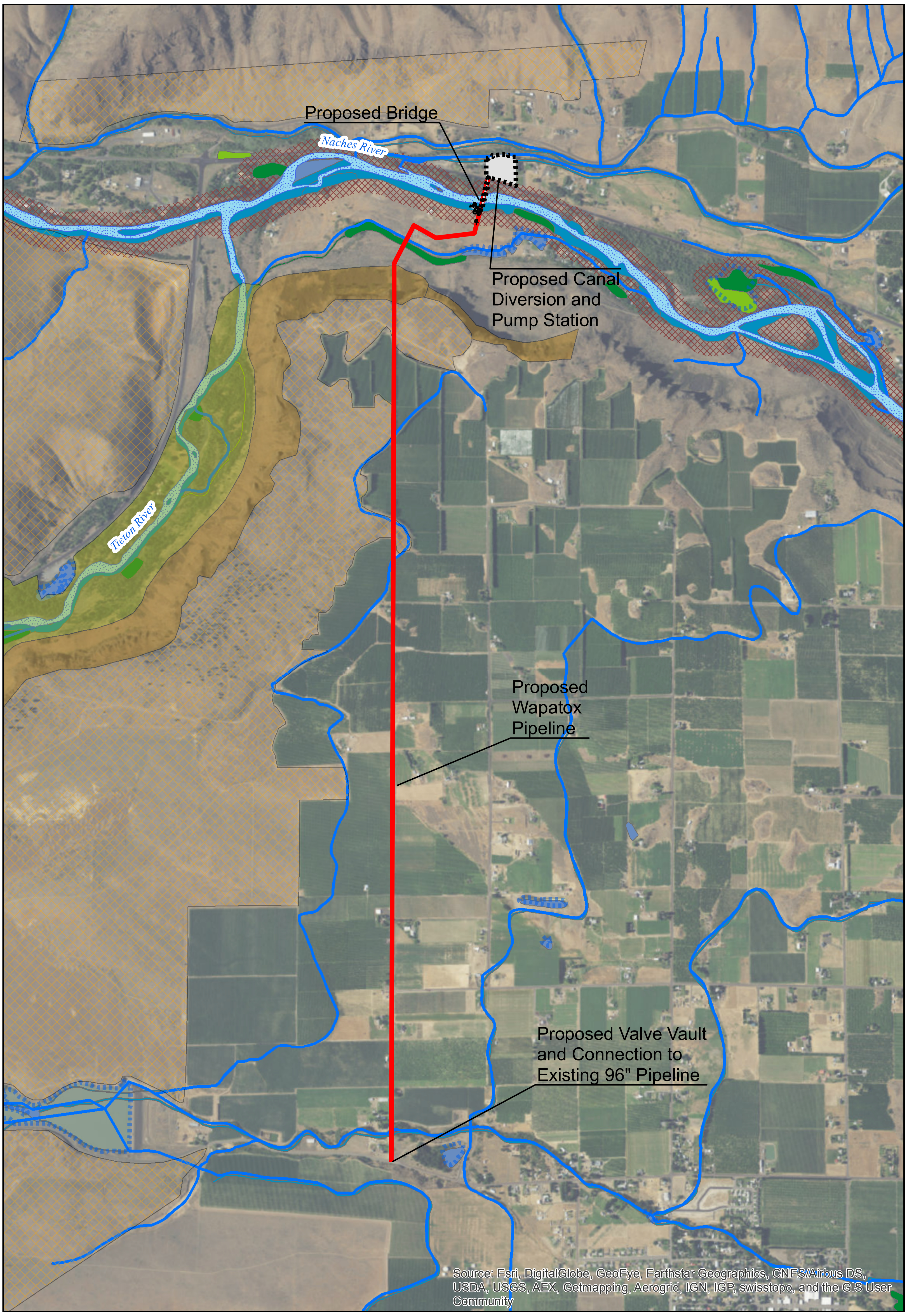
- National Wetlands Inventory (NWI)
- National Hydrography Dataset (NHD)
- U.S. Fish and Wildlife Service (USFWS) Environmental Conservation Online System (ECOS)
- Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species
- Washington Natural Heritage Program (WNHP)

GIS data from these databases were overlain with the footprint of the proposed diversion and pipeline. Figure 3-1 presents the results from the NWI, NHD, and WDFW priority habitats data. Figure 3-2 presents the WNHP and WDFW priority species data.

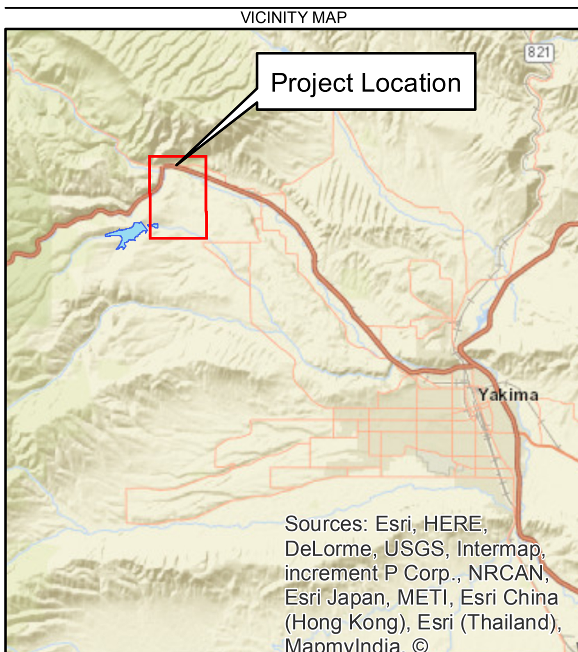
NWI and NHD: Several wetlands identified by the NWI are located within the study area. These include freshwater emergent and freshwater forested/shrub wetlands, and several freshwater ponds. Surface waters identified by the NHD in the study area include the Naches River, the North Fork Cowiche Creek, and several streams. Jurisdictional shorelines encompass areas within 200 feet of the apparent edge of riverbanks.

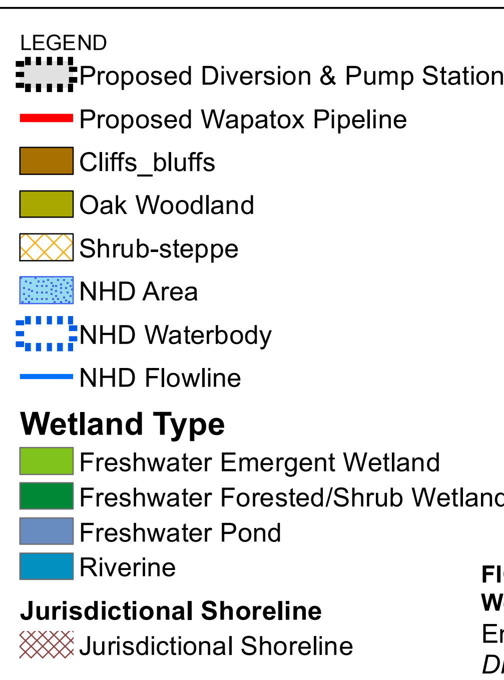
USFWS ECOS: The USFWS ECOS system indicates that seven federally listed threatened, endangered, and proposed threatened species could occur or be potentially impacted by activities in the project area. These species are: the marbled murrelet (*Brachyramphus marmoratus*; federally threatened), yellow-billed cuckoo (*Coccyzus americanus*), bull trout (*Salvelinus confluentus*), steelhead (*Oncorhynchus mykiss*), Canada lynx (*Lynx canadensis*), gray wolf (*Canis lupus*), and North American wolverine (*Gulo gulo luscus*). Bull trout and steelhead have known occurrences in the Tieton and Naches rivers.

WDFW Priority Habitats and Species: WDFW maintains a list of habitats and species that are priorities for conservation and management. Priority species include state endangered, threatened, sensitive, and candidate species; animal aggregations (for example, colonies) considered vulnerable; and vulnerable species with recreational, commercial, or tribal importance. Priority habitats have unique or significant value to a diverse group of species.



VICINITY MAP





Notes:
1. Area of interest subject to change.
2. U. S. Fish and Wildlife Service National Wetlands Inventory Data, May 1, 2016. Available at http://www.fws.gov/wetlands/data/Data-Download.html. Accessed August 10, 2016.
3. U.S. Geological Survey High Resolution National Hydrography Dataset (NHD) home page. GIS Data. Available at http://nhd.usgs.gov/. Accessed August 10, 2016.
4. Washington Department of Fish & Wildlife. Priority Habitat and Species data layer request. April 4, 2016.

FIGURE 3-1 (DRAFT)
Wetlands, Hydrography, and Habitat Map
Environmental Resources
Diversion Relocation to Wapatox Diversion Dam

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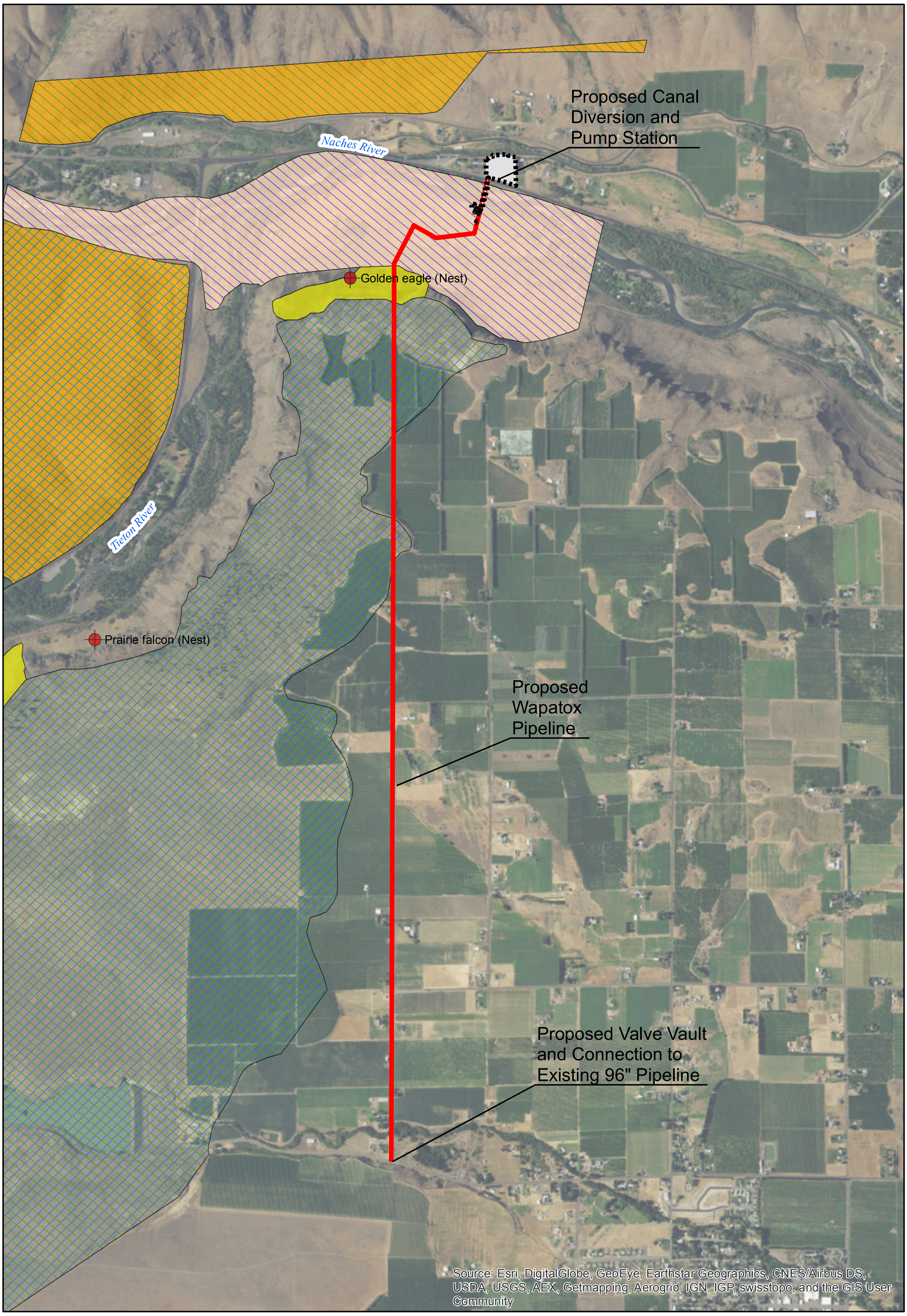
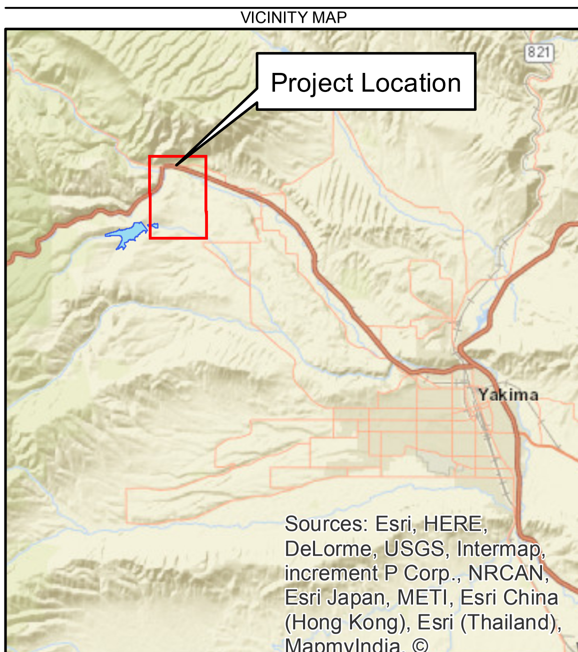


VICINITY MAP



LEGEND
- Proposed Diversion & Pump Station
- Proposed Wapatox Pipeline
- Wildlife Occurrence
- Bald Eagle
- Mule Deer
- Elk
- Golden Eagle
- Bighorn Sheep
- Wood Duck

Notes:
1. Area of interest subject to change.
2. Washington Department of Fish & Wildlife. Priority Habitat and Species data layer request. April 4, 2016.
3. Washington Natural Heritage Program Rare Plants and High Quality Ecosystems Data, August 2015. Available at: https://test-fortress.wa.gov/dnr/adminsaqa/dataweb/dmmatrix.html Accessed April 2016.

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0 500 1,000 1,500
Feet

FIGURE 3-2 (DRAFT)
Plants and Wildlife Map
Environmental Resources
Diversion Relocation to Wapatox Diversion Dam

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Two WDFW priority habitats, shrub-steppe and cliffs/bluffs, were identified in the study area (Figure 3-2). The following descriptions are taken from WDFW's *Priority Habitats and Species List* (2008):

- Shrub-steppe is characterized as a shrubland with a conspicuous but discontinuous shrub layer, one or more perennial bunchgrass layers, and no trees. Dominant shrub species in this habitat type include big sagebrush, antelope bitterbrush, and low sagebrush. Common grass species include Idaho fescue, Sandberg bluegrass (*Poa secunda*), bluebunch wheatgrass, and needle-and-thread (*Hesperostipa comata*). Areas with higher precipitation may support a forb community.
- Cliffs are classified as being greater than 7.6 meters (25 feet) high and occurring below 1524 meters (5000 feet). Cliffs are frequently used as communal roosts for birds.

WDFW identifies use of the study area by mule deer, elk, golden and bald eagles, and wood ducks. A golden eagle nest is located approximately 615 feet from the proposed pipeline. No state-listed threatened or endangered animal species are known to occur within the proposed dam and reservoir footprint. Bull trout and steelhead are both state candidate species, and have economic and cultural significance to the Yakama Nation.

WNHP Rare Plants: There are no current (that is, since 1977) occurrences of any rare plants within the project area. Historical occurrences for two species are located at the northern end of the project area. Coyote tobacco (*Nicotiana attenuata*) and Hoover's tauschia (*Tauschia hooveri*) are state sensitive species, but have not been seen within the project area since before 1977.

3.5 Cultural Resources

Cultural resources are considered any property valued (for example, monetarily, aesthetically, or religiously) by a group of people, and may include archaeological sites, built environment structures, human altered landscapes, objects, and locations of traditional or ceremonial significance (traditional cultural properties). These valued properties can be historical in character or date to the pre-contact past.

In recognition of the public's interest in cultural resources, and the benefit of preserving them, several federal, state, and local regulations have been developed for their protection. The National Historic Preservation Act (NHPA) of 1966 (as amended) is the primary law that guides management activities (36 *Code of Federal Regulations* 800). Section 106 of the NHPA requires federal agencies to take into account the effects of undertakings that are federally funded, permitted, or take place on federally administered lands, if those undertakings have the potential to affect historic properties, defined as cultural resources that are eligible for listing in the National Register of Historic Places (NRHP). For this project, federal permits would likely trigger the need for compliance with the NHPA.

3.5.1 Site Investigation Methods

Several methods were used to investigate the cultural and archaeological significance of the area within 1 mile of the proposed pipeline. A literature review/records search was conducted using the Washington Information System for Architectural and Archaeological Records Database (WISAARD). This review identifies previous cultural resources inventory and evaluation efforts, and documentation of previously identified cultural resources within and directly adjacent to the proposed reservoir.

A review of the Statewide Predictive Model, produced by the Department of Archaeology and Historic Preservation (DAHP), was also conducted. DAHP uses a broad set of environmental criteria to generate a Statewide Predictive Model. The purpose of the model is to determine the probability for archaeological resources. Variables, such as proximity to water and degree of slope, are considered.

A site visit of select potions of the proposed project area was conducted to identify any obvious concerns or visible data gaps that were not identified through a records search.

3.5.1.1 Records Search

A records search was conducted for cultural investigations and previously identified cultural resources within 1 mile of the project area. The search was carried out using the Washington DAHP's online WISAARD geospatial database. This search was conducted to identify whether there were any known cultural resources within the project area, and whether any portion of the project area has been previously surveyed.

(a) Previous Investigations

The file search identified 6 previous cultural investigations within 1 mile of the project area, which are recorded in Table 3-2. All previous cultural investigations within 1 mile of the project area involved pedestrian surveys; one investigation also included subsurface testing (Holstine and Morgan, 1996). This investigation identified four precontact sites, one of which was determined potentially eligible for listing on the NRHP (45YK113). The report recommended archaeological monitoring of project activities near and within the site, as well as avoidance of areas with possible burials, and minimization of impacts to the site by project activities (Holstine and Morgan, 1996).

One of the six surveys intersected a small area within the southern portion of the current project area. It did not identify any cultural resources within that intersection (DeLeon, 1999).

Two previous cultural investigations, outside of the project area, identified historic structures dating to the early 1900s associated with settlement of the area (DeLeon, 1999; Harder et al., 2008). These structures were either determined not eligible for NRHP status due to major modifications and a lack of structural integrity (DeLeon, 1999), or were inventoried but unevaluated for NRHP status (Harder et al., 2008).

A 2012 investigation, outside the project area, identified one historic feature, the Wapatox Canal Old Headgates, which was determined to be NRHP eligible; this resulted in a determination of adverse effects (Doncaster, 2012). Since the headgates were slated for removal, Washington State Level III documentation prior to removal, as well as a condition assessment for the Naches Drop Power Plant, were recommended.

Holstine and Morgan (1996) identified one potentially NRHP eligible precontact site (45YK113) outside the project area. This site is on the other side (west) of the Tieton River from the project area (Holstine and Morgan, 1996).

Table 3-2. Cultural Resource Reports within 1 Mile of the Proposed Alternatives

NADB #	Author	Title	Type of Survey	Cultural Resources Identified
1341423	Holstine and Morgan, 1996	Cultural Resources Survey and Testing of the Washington State Department of Transportation's Proposed State Route 12: Naches River Bridge 12/30 Replacement Project	Pedestrian Survey and Subsurface Testing	Site 45KY113 determined eligible for the NRHP; Sites 45KY51, 45KY112, and 45KY114 identified but unevaluated (do not intersect proposed alternatives)
1341448	DeLeon, 1999	Cultural Resource Survey Revocation of Withdrawn Lands Action Yakima Tieton Irrigation District Patrol Sites 1, 6, and 8	Pedestrian Survey	Historic structures determined ineligible for the NRHP (does not intersect proposed alternatives)
1341458	Cleveland, 2000	Review of WDFW Water Impoundment at the Oak Creek Wildlife Area	Pedestrian Survey	None

Table 3-2. Cultural Resource Reports within 1 Mile of the Proposed Alternatives

NADB #	Author	Title	Type of Survey	Cultural Resources Identified
1352139	Hannum, 2008	Letter to Scott Tormren RE: Bear Canyon Repeater, Location #348368	Pedestrian Survey	None
1351713	Harder et al., 2008	Cultural Resource Survey of the City of Tieton Water System Improvement Project	Pedestrian Survey	14 historic structures inventoried but unevaluated (do not intersect with proposed alternatives)
1682294	Doncaster, 2012	Wapatox Canal Old Headgates Removal Project Assessment of Potential Effects in the Vicinity of Naches	Pedestrian Survey	Wapatox Canal Old Headgates determined NRHP Eligible (does not intersect proposed alternatives))

(b) Cultural Resources

The file search identified 7 archaeological sites within 1 mile of the project area (Table 3-3). Of these, all are precontact sites, six of which are unevaluated for NRHP eligibility. There are no previously recorded cultural resources intersecting the proposed route and alternatives.

One NRHP-eligible archaeological site (45YK113) has been identified west of the project area, on the other side of the Tieton River. This site was originally recorded in 1966, and was reported to contain burial sites and cremations. However, the site was also noted to have been heavily disturbed (Rice, 1966). The site was revisited in 1991, and a site form update was conducted (Regan and Holstine, 1991). At this time, the site was described as consisting of four heavily disturbed rock-lined depressions, located on a terrace, which had been bulldozed during the creation of a firebreak. The site was again revisited, and the site form updated in 1996, at which point it was determined eligible for inclusion in the NRHP under Criterion D. In addition to the possible burial pits, fire modified rocks, lithic debitage, a late period projectile point, burned mammal bone, and historic-era debris were also identified at the site (Holstine and Morgan, 1996).

Table 3-3. Cultural Resources Identified within 1 Mile of the Proposed Alternatives

		Site age		National Register Eligibility			
Site Number	Resource Type	Pre-contact	Historic	Eligible	Not Eligible	Unevaluated	Comments
45YK50	Pre Contact Camp; Pre Contact Lithic Material	X				X	Lithic flakes identified in 1973; site dimensions and date of use undetermined
45YK113	Pre Contact Burial; Pre Contact Camp; Pre Contact Feature; Pre Contact Lithic Material	X		X			4 cremation pits, flexed inhumations, lithic debitage, burned mammal bone, ground stone, slab rock shelters, temporary storage shelters, no materials collected
45YK112	Pre Contact Rock Shelter	X				X	Rock shelters, temporary storage shelters, no materials collected

Table 3-3. Cultural Resources Identified within 1 Mile of the Proposed Alternatives

		Site age		National Register Eligibility			
Site Number	Resource Type	Pre-contact	Historic	Eligible	Not Eligible	Unevaluated	Comments
45YK52	Pre Contact Burial; Pre Contact Cairn	X				X	Cairns, talus burials
45YK51	Pre Contact Lithic Material	X				X	Flakes, chips, and projectile point
45YK114	Pre Contact Burial; Pre Contact Cairn	X				X	2 cairn burials
45YK53	Pre Contact Camp; Pre Contact Lithic Material	X				X	Flakes, chips, and projectile points

3.5.1.2 Statewide Predictive Model

Because the lands in the proposed alternatives meet certain environmental criteria, such as being close to water, the DAHP predictive model shows them as having high potential to contain archaeological resources (Figure 3-3). Most of the area within the project area is designated as high risk/probability for archaeological materials by the Statewide Predictive Model. Although the model indicates much of the proposed alternatives area is within a “high risk” or “very high risk” area for archaeological resources, the resolution of the model does not account for many site-specific, on-the-ground variables; both surface and subsurface investigation are needed to verify. According to the model, archaeological survey is “highly advised” for both high risk and very high risk probability areas.

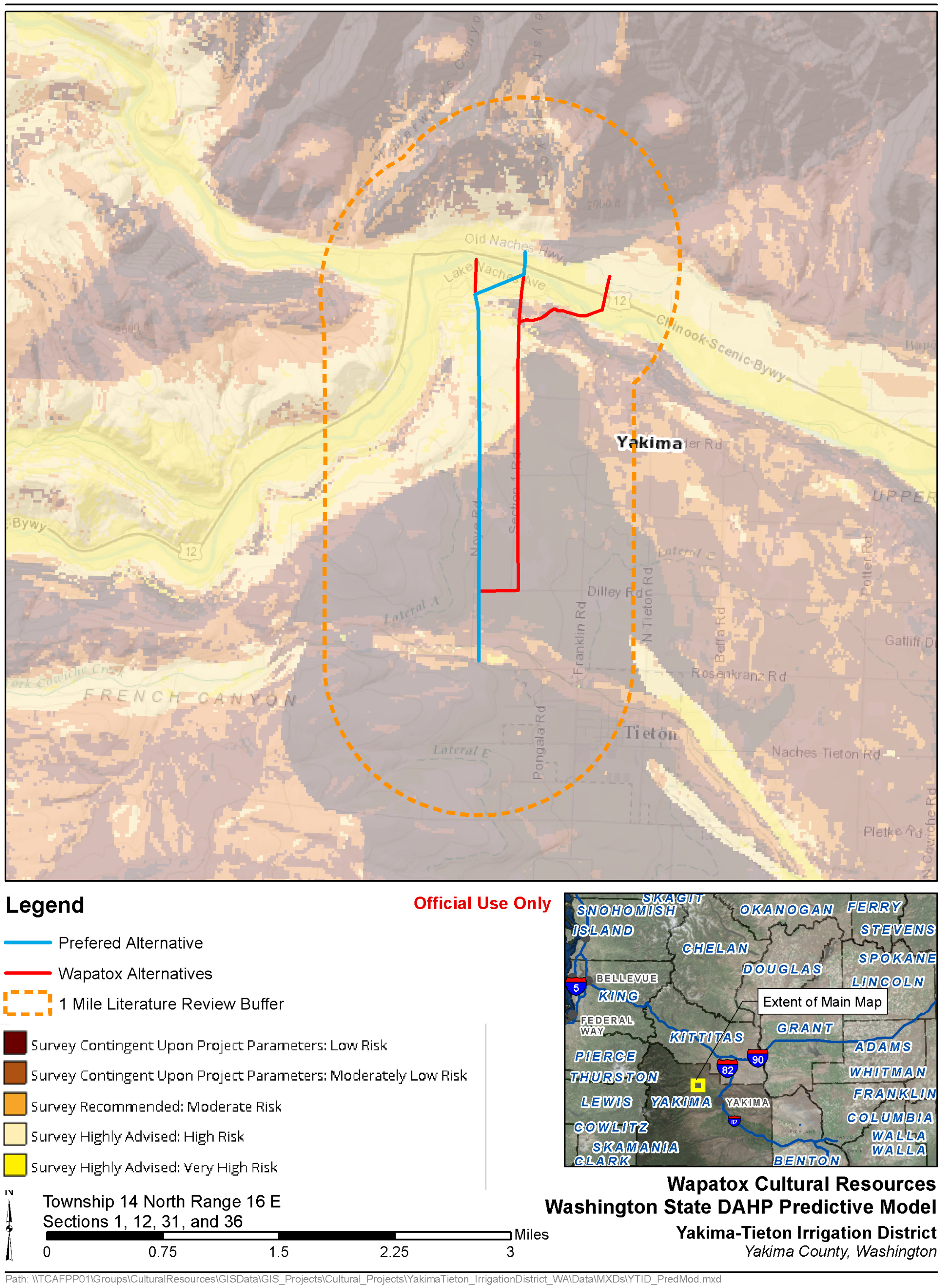


Figure 3-3. Project Alternatives Overlaid on DAHP Predictive Model

3.5.1.3 Project Site Visit

Limited fieldwork to support this memorandum was completed. Fieldwork consisted of a site visit of select publically accessible areas beyond the existing roadways, and a "windshield survey" of the proposed route following existing roads. The site visit was limited to the portion of the proposed project within the canyon that is closest to the river, and the portion of the proposed project that is atop the canyon. All proposed routes from the top of the canyon to the southernmost portion of the project were visited. That portion of the project area within the canyon that has known resources, and the highest probability for additional resources, was not visited due to its location on private property, and a lack of formal private property access permissions.

(a) Project Site Visit Investigation Results

Portions of the project area have been disturbed by recent development, including irrigation district pipelines. The site visit was limited in area, but included the northern portion of the proposed project atop the canyon, and did identify one unrecorded historical dump site, consisting of glass, ceramic, and metal historic artifacts of domestic nature. Once the project area of potential effects (APE) is defined, this resource may be within the project APE. If it is, it will have to be recorded and evaluated for NRHP eligibility.

3.5.2 Cultural Resource Effects

The majority of the proposed pipeline passes through a heavily disturbed, agricultural area, along Section 01 Road near Tieton, Washington. However, the northern end of the project area, near confluence of the Tieton and Naches rivers, is located in undeveloped area that contains known archaeological sites. According to the DAHP predictive model, this area also has a high and very high potential to contain additional unidentified cultural resources. One historic property, and 6 unevaluated precontact sites were identified within 1 mile of the proposed alternatives. Two of the recorded archaeological sites are on the same side of the rivers as the proposed pipeline. These sites could be directly and indirectly affected by the construction and installation of the pipeline. Impacts that can adversely affect cultural resources include anything that might destroy or alter the important features of those resources. Direct and indirect effects to cultural resources can result from human activities or natural events, including:

- Native American and European American use of the area is likely comparable to their use of other tributaries and riverine areas in the region.
- The geology and geomorphology of the uplands and river valley are conducive to the preservation of cultural resources (comprised primarily of stable or depositional landforms).
- There are no known sites that intersect the proposed alternatives, but it is highly possible that eligible sites will be identified once the survey is completed and determinations of eligibility (DOEs) are conducted.

3.5.2.1 Direct Impacts

Direct adverse effects to cultural resources may result from activities associated with the construction of the pipeline near cultural resources. Analysis of existing cultural resource data indicates a high potential for direct adverse impacts to any archaeological sites within the pipeline footprint, assuming that NRHP-eligible cultural resource sites are identified during inventory surveys or when DOEs are conducted on the known cultural resources. The area with the highest potential for adverse impacts to cultural resources is at the northern end of the pipeline near site 45YK112, where two rock shelters were recorded along the slope. When DOEs are completed and effects are analyzed during later project stages, it may be feasible to redesign or move support facilities to avoid some sites or to minimize adverse effects. If avoidance of adverse effects is not possible, then a Memorandum of Agreement or programmatic agreement and a cultural resources treatment plan would need to be developed and implemented.

3.5.2.2 Indirect Impacts

Indirect impacts may include disturbance, destruction, and/or increased damage to pre-contact and historic sites because of increased activities in the area for pipeline access and maintenance. Increased activity in the area may affect cultural resources in the following ways:

- Erosion from foot or vehicle traffic
- Vandalism of exposed cultural resources

The slopes at the northern end of the pipeline, which are near recorded archaeological sites and are located in a high probability area according to the DAHP predictive model, have the highest potential for indirect adverse effects to cultural resources.

3.5.3 Cultural Resources Summary

The WISAARD database lists six previous cultural resources inventory efforts within 1 mile of the proposed pipeline. All archaeological sites that have been identified within 1 mile of the proposed alternatives are precontact sites, consisting of lithic scatters, rock shelters, and rock cairns, and burials. One site has been evaluated and determined eligible for listing on the NRHP (45YK113). This site, consisting of rock cairns and possible cremation pits, is on the western side of the Tieton River, opposite the proposed project alternatives, and will not be impacted by the project activities. No previously documented historic archaeological sites are located within 1 mile of the proposed alternatives. There are no previously recorded cultural resources or historic properties of any kind intersecting the proposed alternatives.

3.6 Existing Facilities and Operations

3.6.1 YTID's Tieton Canal and Regulating Reservoir

In 1984, the YTID constructed the French Canyon Dam and Regulating Reservoir, located approximately 2 miles west of Tieton, Washington, on the North Fork Cowiche Creek. The dam forms a small regulating reservoir with a total operation storage capacity of approximately 500 acre-feet. The existing reservoir is primarily filled using YTID's Tieton Canal.

The existing reservoir also receives inflow from the North Fork Cowiche Creek during the spring and early summer. The reservoir serves to function as a small storage buffer at the upper end of YTID's service area during the normal irrigation season. Table 3-4 summarizes the typical regulating reservoir rule curve (CH2M, 1983). Water from the reservoir is distributed throughout YTID's 28,000-acre service area via approximately 200 miles of buried pressure pipelines. The water is primarily used to irrigate high-value crops, such as apples, cherries, and pears. The reservoir also provides water storage that can be used for intermittent frost protection during the off-season.

Table 3-4. Regulating Reservoir Rule Curve

Approximate Time of Year	Elevation (feet)
March through May	2,154.0
June through Mid-October	2,151.0
Mid-October through February	2,140.0

Source: CH2M, 1983.

Current normal operations at the French Canyon Reservoir are to release water through the low-level outlet pipeline or main transmission lines; use of the spillway is only anticipated during large and infrequent flood inflow events.

The Tieton Canal was constructed between 1906 and 1909, beginning at a gravity diversion dam upstream from the unincorporated community of Rimrock Retreat. The 12-mile-long canal parallels U.S. Highway 12 and the Tieton River before crossing over into the North Fork Cowiche Creek drainage basin. The canal consists of approximately 9 miles of horseshoe-shaped, precast concrete segments and 6 tunnels, totaling approximately 3 miles in length. The Tieton Canal has a design capacity of 345 cfs, but is not frequently used in excess of 300 cfs due to its current condition. Because the grade of the Tieton River is much steeper than the canal, the canal is perched several hundred feet above the river prior to crossing over into the North Fork Cowiche Creek drainage and terminating at the French Canyon Reservoir. If the Wapatox project is constructed, the Tieton Canal can be abandoned.

3.6.2 YTID's River Diversions and Water Deliveries

Under the adjudication settlement agreement, YTID can divert up to 96,611 acre-feet from the Tieton River from April 1 through October 31 each year, and up to 3,881 acre-feet from November 1 to March 31 each year. YTID can also divert up to 908 acre-feet from the North Fork Cowiche Creek from March 1-July 31 of each year. Table 3-5 summarizes total historical water volumes diverted from the Tieton River via the Tieton Canal annually by YTID from 1999 to 2015. Figure 3-4 shows the flow in the Tieton Canal during the 2015 irrigation season, which is reasonably representative of typical YTID system demand. Flow diversions typically begin in early March, peak in the mid-summer months, and end in early October.

Table 3-5. Total Annual Diversion

Year	Total Diversion (acre-feet)
1999	91,540
2000	84,483
2001	74,728
2002	73,727
2003	77,277
2004	72,547
2005	74,786
2006	66,529
2007	73,965
2008	74,431
2009	75,967
2010	67,553
2011	74,352
2012	76,732
2013	74,181
2014	81,462
2015	82,385

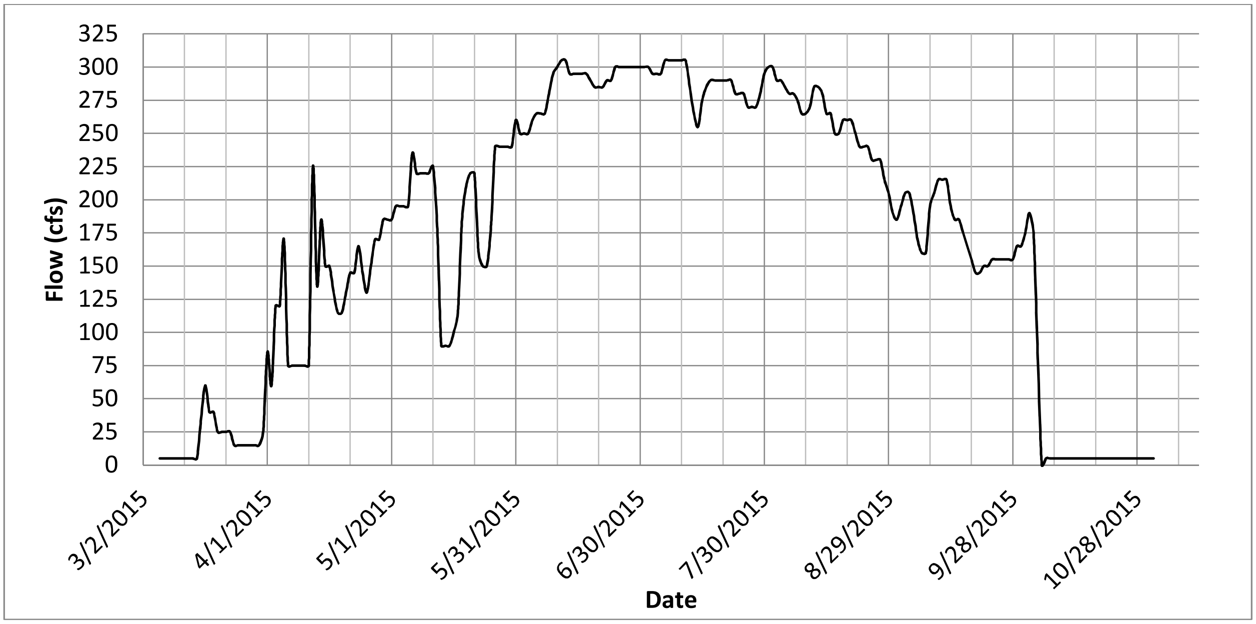


Figure 3-4. 2015 Tieton Canal Flows

The three largest water users and potential water users from the YTID Tieton Canal (YTID, Cowiche Creek Water Users, and Ahtanum Irrigation District [AID]) are all agricultural users with high demands in the middle of the summer. Demands from other uses (such as aquifer storage and recovery, municipal water, and instream supplementation) are smaller in comparison and ignored for the purposes of this feasibility study since they have not been quantified at this time. Due to the high peak summer demands and relatively small amount of existing system storage, the capacity of the Tieton Canal is more limiting than the water availability (which is discussed in detail in Section 5).

Project Scope

4.1 Overall Wapatox Transmission System

The goal of the Wapatox Project is to divert Naches River water at the existing Wapatox Diversion on the Naches River, and pump the water to the existing YTID distribution system and the existing FCR. Under some phased implementation schemes or potential water partnering scenarios, another project goal includes allowing flow to be delivered in the reverse direction from FCR into the Naches River using the Wapatox Project facilities. The project facilities required to accomplish these goals are described in this section and include:

- Wapatox Canal Pump Station—intake and pump station, including surge control and electrical switchyard
- Transmission Pipeline and Appurtenances—main pipeline, including a Naches River pipe bridge, a rock tunnel, and an isolation valve structure at the connection with the existing YTID main distribution pipeline
- Naches River Discharge Facilities—including a flow control station, a baffled apron drop structure, and connecting pipe
- Flow Metering Facility—including a bi-directional meter

Exhibit 1 in Appendix A provides an overview of the Wapatox system.

4.2 Wapatox Canal Pump Station

The Wapatox Canal Pump Station (WCPS) includes the facilities required to pump water from the existing Wapatox Canal to FCR and the existing YTID distribution system.

During the irrigation season, the WCPS will convey water through the Wapatox Project facilities to either FCR or into the YTID distribution system.

- If the demand on the YTID distribution system is higher than the pumping rate, all pumped flow will enter the distribution system and stored water in FCR will supplement the total flow, if needed. In this case, the water volume stored in FCR would be reduced.
- If the demand on the YTID distribution system is lower than the pumping rate (or zero), the pumped flow will enter the distribution system and excess pumped flow will discharge into FCR. In this case, the water volume stored in FCR would increase.

4.2.1 Facility Siting

Three alternative sites were considered for the pump station and pipeline facilities, as follows:

- **Site 1 – Naches River Upstream of Existing Wapatox Diversion Dam:** This site was considered because the pump station could use the backwater created by the existing diversion dam and reduce the transmission pipeline length. The facility would be situated on the south side of the river, just upstream of the existing diversion dam. It would include a new fish screened intake and pump station facility. At this location, a sediment control facility would probably be required to help reduce the amount of sediment diverted from the river, and discharged into the transmission and distribution pipelines. There appears to be ample space available at this location for all required facilities. The proposed site is on the inside (south side) of a bend in the Naches River. The existing diversion dam is situated in this bend, but the existing diversion is located on the outside of the bend on the north side of the river. Aerial photography, confirmed by visual field observations, suggest that the south side of the river at this location is subject to severe shoaling and a large amount of gravel and sediment has been deposited at the proposed location. Periodic river dredging would be required to support construction and operation of an intake at this location.

- **Site 2 – Naches River Downstream of Existing Wapatox Diversion Dam:** This site was considered as an alternative to Site 1 because it is in the same vicinity, but is along a straighter section of the river where less shoaling would be expected. As with Site 1, the facility would be situated on the south side of the river, but would be located about 700 to 1,200 feet downstream of the existing diversion dam. It would include a new fish screened intake and pump station facility. At this location, a sediment control facility would probably also be required to help reduce the amount of sediment diverted from the river and discharged into the transmission and distribution pipelines. There appears to be ample space available at this location for all required facilities. Also, visual field observations suggest the river may be deep enough to help limit the size of the fish screened intake.
- **Site 3 – Existing Wapatox Canal:** This site takes advantage of both the existing Wapatox diversion structure and fish screen. The candidate site is located north of the Naches River along the south side of the existing Wapatox Canal, about 600 feet downstream of the existing fish screen. The facility would be built into the south canal bank and would include an intake trash rack and pump station facility. Sediment control would probably not be required at this location due to settling behind the diversion dam and in the canal upstream of the site. The pump station site is located on the north side of the river, so it requires a longer transmission pipeline and a river and highway crossing. The candidate site occupies two existing rural residential parcels to provide ample space for the facility. Only one parcel appears to have structures at this time. Other parcels in the vicinity could also be used, but may require a slightly longer pipeline or may result in additional residential impacts.

Table 4-1 summarizes the advantages and disadvantages of the three alternative sites.

Table 4-1. Comparison of Alternative WCPS Sites

Site	Advantages	Disadvantages
1	• This involves a shorter pipeline length. • It does not require Naches River and Highway 12 pipeline crossing • The existing diversion dam is used for water level control. • Developed, private property is not impacted. • Transmission pipeline does not cross Highway 12 or Naches River.	• A new intake/fish screen facility is required on the Naches River. This alternative does not take advantage of the existing Wapatox river diversion and fish screen. • Significant shoaling is evident at intake location. Dredging in the Naches River may be required for long term operation and maintenance. • Sediment control facility is probably required. • A new Naches River bridge is required for pipeline construction and long-term access and maintenance
2	• This is the shortest pipeline route. • It does not require Naches River and Highway 12 pipeline crossing. • Developed, private property is not impacted. • Transmission pipeline does not cross Highway 12 or Naches River.	• A new intake/fish screen facility is required on the Naches River. This alternative does not take advantage of the existing Wapatox river diversion and fish screen. • Intake water level depends on river characteristics; could be shallow and could degrade over time. • Sediment control facility may be required. • A new Naches River bridge is required for pipeline construction and long-term access and maintenance.

Table 4-1. Comparison of Alternative WCPS Sites

Site	Advantages	Disadvantages
3	• This site does not require a new intake/fish screen facility on the Naches River; it takes advantage of existing Wapatox diversion and fish screen. • It offers stable water level and simpler structure due to existing intake on existing canal. • New Naches River access bridge can support the pipeline and reduce pipeline crossing cost.	• This is a longer pipeline route. • Transmission pipeline crosses Naches River and Highway 12. • In-river construction and long-term dredging in the river is not required. • A new Naches River bridge is required for pipeline construction and long-term access and maintenance.

Site 3 was selected as the candidate site for this analysis for the following reasons:

- This site does not require a new intake/fish screen on the Naches River. It uses the existing Wapatox diversion and fish screen. Taking advantage of these existing facilities is expected to be viewed more favorably by stakeholders and enhances the environmental benefits offered by this alternative.
- Site 3 is not impacted by the shoaling or sediment issues that come with new river intakes at Sites 1 and 2. Site 3 minimizes in-river construction and dredging maintenance work in the river.
- The cost of the new fish screen and sediment control facilities expected at Sites 1 and 2 would more than offset the additional cost of the longer pipeline and highway and river crossing required for Site 3.
- Since there does not appear to be a significant cost advantage for Sites 1 and 2, and the use of existing facilities at Site 3 is expected to be more favorable to stakeholders, Site 3 appears to be the best choice for developing the concepts and initial cost estimates for the Wapatox Project.

Exhibit 2 in Appendix A shows the site plan for the WCPS at Site 3. Figure 4-1 is a photo of this location.

Figure 4-1. View of Site 3 for the WCPS

4.2.2 Conceptual System Hydraulics and Candidate Pump Selection

4.2.2.1 Conceptual System Hydraulics

A conceptual hydraulic analysis was conducted to establish the performance requirements for development of the pump station facilities. The key hydraulic criteria shown in Table 4-2 were used.

Table 4-2. Key Hydraulic Criteria

Criteria	Maximum Value	Minimum Value
Flow Rate (filling and draining)	Maximum flow – 370 cfs (Case 1) Maximum flow – 345 cfs (Case 2)	Minimum flow – 70 cfs
FCR Operating Water Surface Elevations (WSE)	High: 2,156 feet	Low: 2,130 feet (extreme)
Wapatox Canal WSE (assumed)	High: 1,580 feet	Low: 1,575 feet
Friction Loss (Hazen Williams "C" Value)	High: C = 120 (highest friction-old pipe)	Low: C = 150 (lowest friction-new pipe)
Discharge Pipe Length	15,000 feet, new; 18,700 feet to FCD, Refer to Main Transmission Pipeline	
Discharge Pipe Diameter	96 inches, nominally sized at less than 8 feet per second flow velocity	

The hydraulic criteria above were used to create the system-head curve operating envelope for the WCPS. System-head curves show the relationship between the flow rate and total dynamic head (TDH) for conditions specific to the proposed pumping and pipeline system. Figure 4-2 shows the upper and lower system head curves and the resulting operating envelope for the proposed pump station. The operating envelope is the area between the upper curve, which represents the worst case TDH condition for any given flow rate, and the lower curve, which represents the best case condition. The curves were developed as follows:

- Upper (worst case) curve—static lift from the lowest Wapatox Canal WSE to the highest FCR WSE and the highest friction
- Lower (best case) curve—static lift from the highest Wapatox Canal WSE to the lowest FCR WSE and the lowest friction

The full pipeline length to FCR was used for both curves because it is the worst case for the Upper Curve; the best case curves assumes the reservoir is essentially empty and all flow would, therefore, be directed into the reservoir for filling. Operational conditions where flow only must be pumped to overcome the pressure in the existing mainline at the tie-in point fall in the operating envelope between the best and worst cases.

The TDH along the upper system head curve at the maximum design flow of 370 cfs is about 637 feet TDH and is shown as the design point on Figure 4-2. The design point is used for selecting candidate pumping equipment. An alternative design point at 345 cfs and 630 feet TDH can also be obtained from Figure 4-2. The system-head information was used to select candidate pumping equipment capable of performing at all points within the operating envelope.

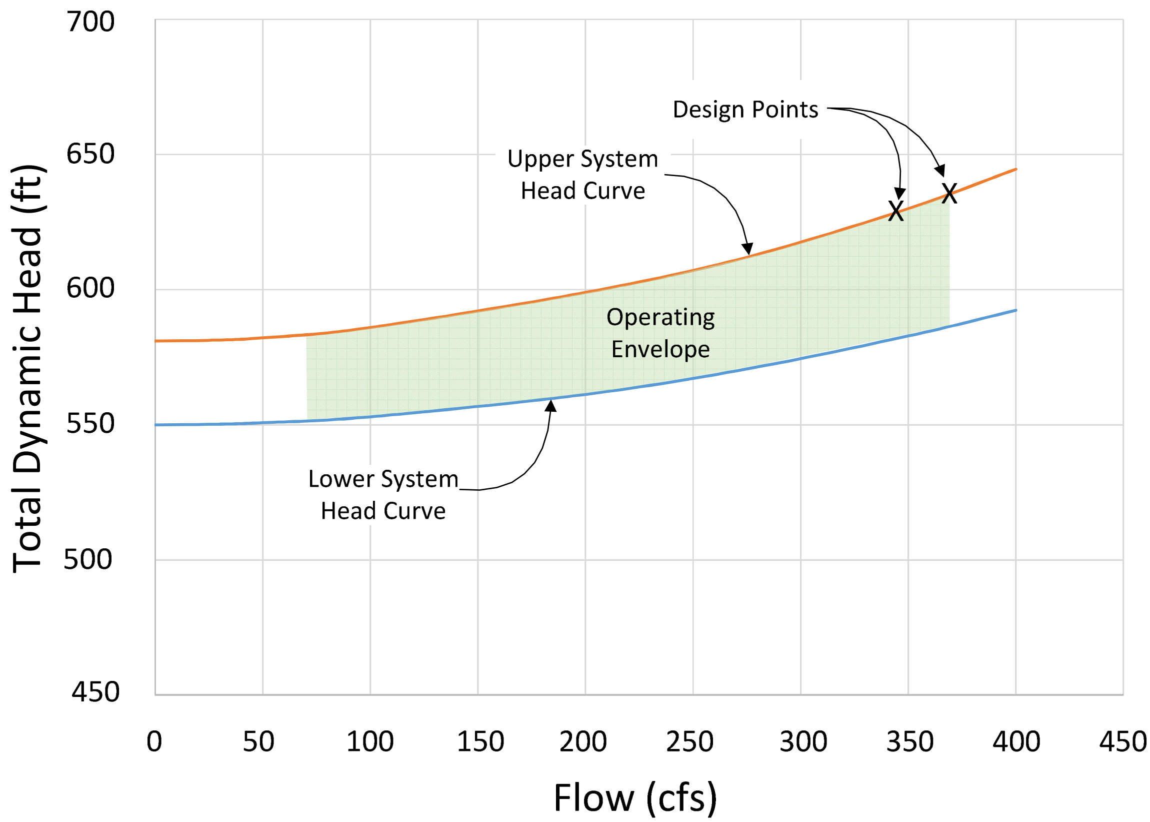


Figure 4-2. System-Head Curves and Operating Envelope for the Wapatox Canal Pump Station

4.2.2.2 Candidate Pump Selection

The system-head curves and operating envelope described above were reviewed with several major vertical turbine pump manufacturers. Each was requested to provide pump curves for pumps that were capable of meeting the design points using six, seven, and eight pumps. This corresponds to the design flow rates for individual candidate pumping units show in Table 4-3.

Table 4-3. Design Flow Rates for Candidate Pumping Units

Number of Pumps	370 cfs Design Point	345 cfs Design Point
6	61.7	57.5
7	52.9	49.3
8	46.3	43.1

The resulting offers for candidate pumping equipment provided similar results. Candidate selections were obtained for pumping units for each flow at both design points. For the same number of pumps, the difference in pumping equipment between the 370 cfs and 345 cfs design points were limited to impeller trim. Otherwise, the candidate equipment was essentially identical and had the same size and cost. Depending on the specific efficiency in the selections, only nominal motor size differences were evident. Therefore, only the 370 cfs design point is described in detail in this section. If the 345 cfs design point is selected for implementation, the capital costs are not expected to change and the technical discussions in this report are equally valid.

Annual pumping costs are dependent on the actual amount pumped and the range in pumping rates. Therefore, a system designed for 370 cfs would be expected to have higher annual pumping costs only if it pumped at the higher capacity and it pumped greater volumes. If both systems pumped at the same capacity and the same volume, the differences in annual pumping costs would be expected to be negligible.

Figure 4-3 shows eight pumps (from one manufacturer) operating at full speed and superimposed on the system head curves and operating envelope from Figure 4-2. As shown on Figure 4-3, the operating envelope falls well within the preferred operating range of the pumps. This means that the pumps can be expected to operate near their most efficient operating point at all times. Operation in the preferred operating range also facilitates longer run life and less wear than operating outside this range. Since operation is within the preferred operating range for any number of pumps under the full range of anticipated system conditions, throttling or variable speed operation are not required to facilitate proper pump performance.

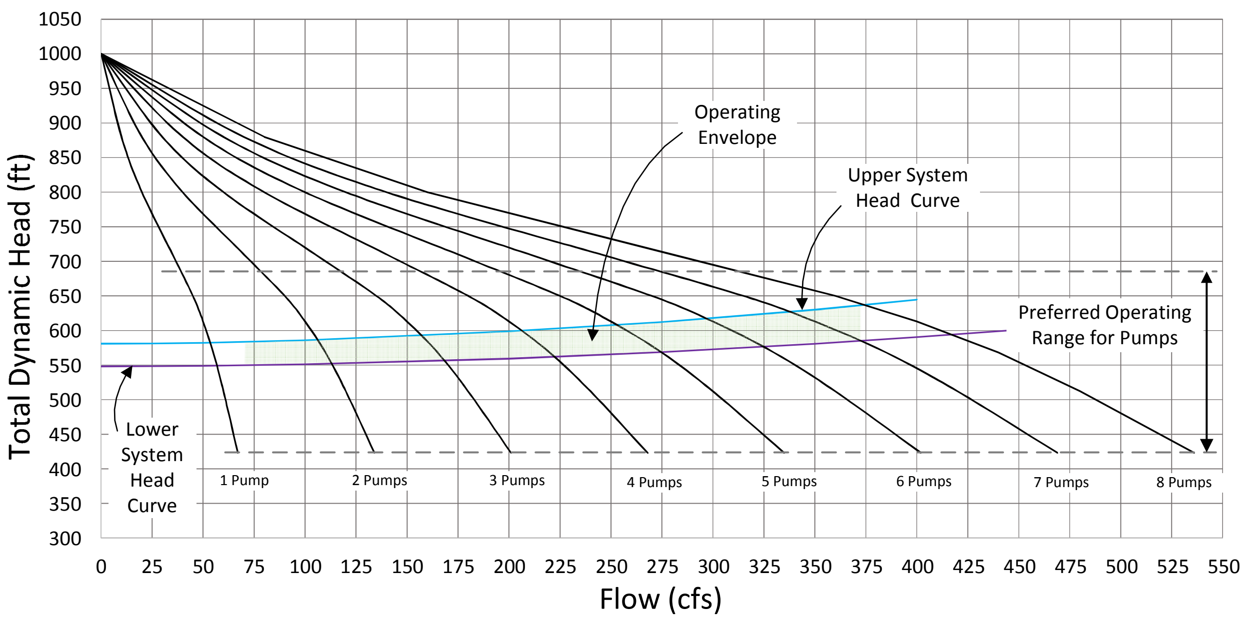


Figure 4-3. System-Head Curves and Operating Envelope for the Wapatox Canal Pump Station

The use of six or seven pumps provides results similar to those shown for eight pumps in Figure 4-3. A larger difference in constant speed flow rate at any given operating point and a higher horsepower (hp) requirement per unit would be expected. For conceptual development, the eight duty pumps shown in Figure 4-3, plus one standby pump, were selected for analysis. Eight pumps result in motors under 5,000 hp and reasonable size pumps and related equipment. Also, the difference in flow rate between operating pumps is smaller than if there were fewer, but larger, pumps. As discussed below, the smaller flow difference is beneficial for using FCR to balance mismatches between pumped flow and demand for constant speed pumping. However, the larger pump and motor combinations required for six and seven pumps are feasible and should be evaluated in greater detail if the Wapatox Project is selected for implementation.

4.2.2.3 Throttling and Variable Speed Pumping Versus Constant Speed Pumping

Figure 4-3 shows that constant speed pumping is feasible for all anticipated operating conditions. However, the constant speed pumping arrangement would only allow pumping at one specific flow rate for each combination of the number of pumps operating and operating envelope position. For example, 5 pumps would deliver about 250 cfs at the upper system head curve, while 4 pumps would deliver about 205 cfs. If a flow rate of 230 cfs was desired, the constant speed arrangement could not accommodate that desire.

Throttling or variable speed control for these pumps would be required to more precisely control flow. In the example described above, variable speed drives would allow the operating speed of 5 pumps to be reduced to deliver only 230 cfs. Given the pump curve configuration shown, variable speed drives would be capable of producing any desired flow, except at capacities below about 100 cfs. Below about 100 cfs, a small gap of unachievable flow might result between 2 pumps at reduced speeds and 1 pump at full speed.

Similarly, throttling could be used to create friction and drive the system head curves up to the constant speed pump curves to achieve almost any desired flow rate. Again, a small gap of unachievable flow might result between two pumps being throttled and one pump at full speed. Throttling of over 100 feet of head may be required in some cases.

Constant speed pumps and an active storage band in FCR can also be used to match pumping to demand. The intent would be that the proposed pumping and pipeline system would "float" on FCR. This means that flows pumped in excess of the demand would flow into FCR and supplemental flow would flow out when pumping is lower than demand. The worst constant speed flow difference, shown in Figure 4-3, is about 55 cfs between 1 and 2 pumps operating along the lower system head curve. Therefore, under this worst case scenario, a flow mismatch of 55 cfs could result between supply and demand. If this mismatch were allowed to go on for a full day, then the 5 to 6 foot operating band on FCR would be capable of absorbing the excess or providing the supplemental flow to balance the system. In actual practice, it is expected that pumps would be staged on and off at least once a day and cut the buffering volume requirement in half, or more.

Throttling requires costly flow control equipment and creating friction consumes power. Variable speed drives are costly and require frequent maintenance and replacement, but do not consume nearly as much extra power as throttling. Since FCR can be used to balance the system, throttling and variable speed pumping are not considered necessary and were not considered further in the conceptual development of the Wapatox Project.

4.2.3 Pump Station Facility Description

The development and configuration of each component of the overall pump station are described in the following subsections.

4.2.3.1 Intake Facilities

The existing Wapatox Canal headgates and fish screens are maintained and operated by USBR. The capacities and conditions of the headgates and screens were not evaluated in this study. The screens reportedly have sufficient capacity to meet the proposed WCPS demand (370 cfs), plus existing water demand from the Wapatox Canal. This study assumes that USBR will continue to own and operate these facilities.

The intake for the proposed WCPS is a relatively simple structure intended to divert water from the existing Wapatox Canal into the pump station wet well. Intake trash racks are installed on the outside of the upstream face of the pump station wet well. The trash racks serve the purpose of keeping large debris from entering the wet well and also provide a safety function to keep people and animals from being impinged on the screens or drawn into the wet well. Normally, trash racks are designed for about 1 foot per second approach velocity. Using the width of the wet well required for the pumps, the approach velocity for the WCPS is expected to be much slower. No trash rack cleaning equipment is planned since all flow passes through the existing fish screen immediately upstream on the canal.

The trash rack intake would be shaped to match the existing canal side slope. The existing maintenance road along the canal would be routed over the top of the access deck on the wet well adjacent to the trash rack. Since this location is essentially the same as the current location, no changes to the existing use of the maintenance road would result. A sill, about 1 foot above the bottom of the canal, is provided at the bottom of the trash rack. This sill is the bottom of the intake and helps minimize the amount of bedload sediment that flows into the wet well. It is anticipated that the existing canal would be concrete lined for the portion 50 feet upstream to 50 feet downstream.

Refer to Exhibits 3 and 4 in Appendix A for drawings of the intake and trash rack.

Intake Operational Concept

The intake operational concept assumes that the trash racks would be in place over the wet-well inlet openings whenever the WCPS is operating. All flow entering the wet well would pass through the rack. The rack would be a series of smaller panels that are either hinged or mounted in guide rails on the face of the structure. These installation features allow the rack panel to be removed, if necessary for maintenance, cleaning, and reinstallation. Trash racks would be lifted using a boom truck for major efforts, but could be manually cleaned using a hand held rake for minor debris. The access deck over the wet well is sized to allow a boom truck to operate between the trash rack and the pump building with outriggers in place.

4.2.3.2 Transfer Pump Station

The WCPS is intended to lift water from the Wapatox Canal to FCR under all operating WSE conditions and the full range of flows.

Pump Station Configuration

An evaluation of the preferred configuration of the WCPS was conducted to assist in its conceptual development.

Vertical turbine pumps were used to conceptualize all configuration alternatives for the transfer pump station. Horizontal pumps could be used, but at the proposed site they would require a relatively deep wet-pit/dry-pit structure in order to achieve submergence required for proper operation. The cost of the deep wet-pit/dry-pit structure was determined by inspection to preclude the use of horizontal pumps. However, if the WCPS site is moved further downstream on the canal as part of actual implementation, horizontal pumps may be able to be installed at grade and this conclusion could be reconsidered.

Submersible pumps could also be considered, but the basic facility configuration would not be substantially changed from that used for vertical turbine pumps. Submersible pump stations may not need the above-grade pump room building, which might provide some cost savings. Submersible turbine pumps and motors are typically costlier, less efficient, and have fewer performance curve choices compared to conventional vertical turbine pumps. However, submersible turbine pumps could be a viable option; a more detailed review of the long-term cost and operational trade-offs should be conducted during final design. In any case, the cost of the transfer pump station is not expected to be materially lower if submersible pumps are used.

Therefore, vertical turbine pumps represent a good baseline for developing the feasibility of the proposed project and were used for the conceptual analysis.

The following three pump station configurations were considered:

- **Can-mounted Pumps**—This alternative includes mounting each vertical turbine pump in a pump can. The pump can would be fed from a supply lateral connecting to a gate chamber behind the trash rack installed on the intake face. The pump can would extend down to the full depth required to provide suitable, net-positive, suction head conditions (down to about elevation 1,555). The pump discharge head, motor, and discharge piping would be above grade in a building (identical to the other alternatives). This type of configuration is generally one of the lowest-cost alternatives. However, the gate chamber would be relatively deep, the size and depth required for the proposed pump cans requires tight tolerance installation, and the cost difference relative to other alternatives is not expected to be substantial. However, this alternative could be reconsidered during final design if more detailed analysis can demonstrate lower cost.

- **Conventional Wet Well**—This alternative includes mounting each vertical turbine pump over a concrete wet well that extends down to the full depth required to provide suitable, net-positive, suction head conditions (down to about elevation 1,555). The wet well would be fed from the trash rack intake on the existing canal. The pump discharge head, motor, and discharge piping would be above grade in a building (identical to the other alternatives). This type of configuration is generally one of the highest cost alternatives due to the depth of the large concrete wet well structure and need for intake bays for each pump. However, it is also the most accessible and is often preferred for life-line pumping facilities.
- **Wet Well with Open Top Can**—This alternative includes mounting each vertical turbine pump over a concrete wet well that extends down only to the depth required to facilitate entry of flow into the wet well from the intake apron. A cross section, depicting this configuration, is shown on Exhibit 4 in Appendix A. An open top can would be installed in the floor of the wet well to allow the pump inlet bell to extend down to the full depth required to provide suitable, net-positive, suction head conditions and a suitable depth below the top of the can (in this case, down to about elevation 1,540). The wet well would be fed from the trash rack intake on the existing canal. The pump discharge head, motor, and discharge piping would be above grade in a building (identical to the other alternatives). This type of configuration is generally an efficient design, combining the accessible nature of the wet well with excellent hydraulic performance of the cans. It is usually cost competitive with large can-mounted facilities as described previously.

Both the can-mounted pump and wet well with open top can alternatives should be considered during final design. Site-specific cost details are needed to clearly differentiate between the two alternatives. The wet well with open top can configuration was used as the basis for the cost estimate for this analysis, since it is easier to define at this stage of project development. Also, the wet well with open top can arrangement has generally more favorable non-cost characteristics, so the can-mounted pump configuration would only be selected if it were lower cost. Therefore, the use of the wet well with open top can configuration is expected to provide conservative cost estimates for this feasibility assessment.

Pump Station Facility Description

The WCPS includes seven main components, described in the following subsections. Refer also to the drawings in Appendix A for illustrations of the concepts and additional detail.

Wet Well

The wet well would be a concrete structure used to allow flow from the existing canal to pass through the intake trash rack and be directed to the project pumps. The wet well would be about 215 feet long, to accommodate the intake screens and physical space for the pumps and motors. It would be about 57 feet wide to accommodate the access deck, maintenance space in the building, and space to transition flow from the intake to the pump cans.

The top deck of the wet well would be at elevation 1,583 to approximately match the existing site grade. The bottom of the wet well would be at elevation 1,563 to provide submergence to prevent vortex formation as flow enters the open top cans in the floor of the wet well.

Nine, approximately 6-foot-inside-diameter, open top pump cans would extend below the bottom of the wet well (that is, one beneath each pump). The cans would be intended to be stainless steel inserts grouted into a can shaft drilled (or otherwise excavated) below the bottom of the wet well. The cans would extend to a bottom elevation of about 1,540 to provide suitable, net-positive, suction head for the pumps and flow straightening distance below the wet well floor. The cans would be provided by the pump manufacturer, and the vertical turbine pumps would be installed from above into the cans, with typical clearance dimensions consistent with Hydraulic Institute standards. The exact configuration of the cans would depend on the pump manufacture's approach to the pump intake and will be developed in additional detail during final design.

Pumps, Motors, and Discharge Piping

Nine vertical turbine pumps are proposed. Preliminary selections indicate a 6-stage pump with rotational speed of 710 revolutions per minute. Each pump would be driven by a constant speed, 4,500-hp (nameplate), motor. Pump efficiency in the operating envelope would be expected to range from 83 to 85 percent.

Preliminary pump sizing information indicates 36-inch-diameter, steel column pipes, cast steel suction bells and bowl casings, and a fabricated steel discharge head with 30-inch-diameter discharge nozzle. Specific details were not provided by manufacturers, but project experience indicates the pump and motor units would extend about 18 to 20 feet above the pump room floor.

Pump discharge piping includes a dismantling coupling at the pump discharge nozzle, a 30-inch-by-42-inch reducer, a 42-inch check valve, a 42-inch isolation butterfly valve, and miscellaneous piping to connect to a 96-inch discharge header encased under the floor of the pump building.

A supplemental water supply would be required to prelubricate the open pump line shafts before each pump is started. This system could use filtered raw water or potable water. Motor lubrication integral to the motor thrust bearing would be required, and associated lube-oil cooling may also be needed.

Motors would be expected to be air-cooled using outside air supplied to the building enclosure.

Each pump and motor would include various instruments to monitor pressure, temperature, and vibration, and provide control and protective functions.

Pump Building

A pump building would be provided for environmental protection for the pumps, motors, and discharge piping. The building would be about 215 feet long, 56 feet wide, and 50 feet tall. The building walls would either be concrete masonry unit or precast concrete panels with a concrete or steel framing system. A joist-supported, built-up elastomeric roofing system (or similar) would be used. The building would include a 50-ton bridge crane to install or remove all equipment. Large roll-up doors would be positioned at either end of the building to support a drive-in concept to facilitate operations and maintenance on each end.

Large, roof-mounted, exhaust fans would draw outside air through louvers at each motor to provide ventilation and cooling. Unit heaters would be provided to maintain a minimum temperature during the winter. A series of doors would facilitate ingress and egress to the building. Suitable space would be available within the building for laydown and work areas and locating miscellaneous appurtenant systems that would be defined in greater detail later in project development.

Surge Control

A hydraulic transient analysis has not been conducted; however, a surge control system is expected to be required for a transmission main of the length and profile proposed for this project. Since no detailed analysis is available, a surge control system has been assumed to account for costs and site development features at the conceptual development level for the WCPS. Five large pneumatic air over water surge tanks are assumed. Each would be connected to the 96-inch-diameter discharge pipeline with 48-inch-diameter piping and includes a 48-inch-diameter isolation valve. Space for two air compressors would be provided in the pump building; the compressors and appurtenant surge control accessories are included in the cost estimate.

Electrical and Control Rooms

An 80-foot-long by 34-foot-wide electrical room and an 18-foot-long by 12-foot-wide control room would be included as appurtenant structures attached to the pump building. The electrical room size was estimated from assumed equipment layout for the main electrical switchgear, motor control centers (MCCs), reduced-voltage pump starters, low-voltage panel boards, and other related equipment. The control room is expected to include a local control workstation as well as a programmable logic controller (PLC), supervisory control and data acquisition, network, communications, security, and associated control equipment.

Pump motor utilization voltage is assumed to be 13.8 kilovolts for the size of motor required and to conform to typical ratings for the switchgear. Each pump is assumed to have a reduced voltage starter to limit the in-rush voltage when a pump is started.

Space for transformers for 480 and lower voltage equipment was reserved both inside and outside the electrical room.

The electrical and control room building is expected to be air-conditioned for worker comfort (including both heating and cooling systems). Heating, ventilation, and air conditioning equipment is expected to be roof-mounted.

Electrical Switchyard (Substation) and Power Supply

The power supply is assumed to include overhead transmission lines to the onsite switchyard from Bonneville Power Administration or Pacificorp. The exact supply voltage and source of the power must be reviewed with the power supplier and is not yet known.

Incoming power would be connected to two 36 megavolt-amperes (MVA) transformers (nominal conceptual size) with appurtenant switching, power measurement, and protective devices. Each transformer string would be located in a 100-foot-long by 100-foot-wide fenced switchyard adjacent to the electrical room at the pump building. No control building was assumed to be needed since the electrical room is close by and space is available for nominal control panels.

Transformer strings would be sized for the full Naches area project loads (that is, all pump station and flow control facilities). Transformers would reduce supply voltage to 13.8-kilovoltstation utilization voltage. Each string would be connected via underground duct banks to opposite ends of a main-tie-main switchgear line-up in the electrical room. Normally, both transformers would be in operation, and the switchgear tie breaker would be open. In the event of equipment failure on one transformer string, the full station can be run from a single side by opening the associated main breaker and closing the tie breaker.

The switchgear is assumed to feed a reduced voltage starter for each pump. It would also feed associated MCCs for other facility loads. Step down transformers would be provided at the electrical and control building as needed for 480 volt (V) and 110/220V loads. Power would be distributed to MCCs and smaller panels at the pump station and flow control station, as determined during detailed electrical design.

The total facility connected load is expected to be about 31 kilowatts (kW). However, peak load would probably not exceed 29 kW, since the primary load is for pumping and the actual peak load on the pump motors is lower than the nameplate load of 4,500 horsepower (depending on actual pump efficiency). The pump motors account for 40,500 hp (or about 30.3 kW) of connected load. None of the other facilities or appurtenant features have significant electrical load, so a total connected load of about 31 kW is expected.

Site Development

The entire site around the pump station and pipeline facilities would be graded for vehicular access around all sides of each facility, including a traffic flow path onto and across the access deck at the canal intake. Traffic currently using the existing canal patrol road would continue to use the same route, except it would travel across the access area on the top of the wet well. Pavement is planned for the main access roads and the main access around the buildings and between the pump building and the switchyard. Employee parking has not been sited, but suitable space is available at several locations adjacent to the main buildings and switchyard. Sidewalks and door stoops would be provided for the pump building as well as for the electrical and control building.

The site would be graded for drainage to existing drainage ways (assumed to be at Highway 12). A detention basin may need to be provided to limit runoff flow rates, but ample space exists for this feature, if needed, at the site. Culverts would be provided, as needed, to route drainage to the applicable outlet or detention basin.

The entire perimeter of the site would be fenced. At the north side, the fence would align with the pump building so access along the existing canal patrol road is not impeded. Gates would be provided for two entry points on Highway 12 and two access points to the access deck at the existing canal (one on each side of the pump building).

Miscellaneous site features, like protective guard posts, site lighting, and security features, are included in cost allowances, but have not been specifically detailed at this time.

Pump Station Operational Concept

The operational concept for the pump station is fairly simple since variable speed drives and throttling are not included. In general, operations staff or the control system would need to select the correct number of pumps for the desired flow and head conditions. Level information from FCR would be transmitted to the pump station (and operations center if remote from pump station). Operators would monitor the demand and select the number of pumps that give the flow rate closest to the demand. This feature can also be automated. Once the number of pumps has been selected, an operating water level band in FCR would be used to stage pumps on and off. As FCR fills to the top of the band, a pump would be stopped. As it empties to the bottom of the band, a pump would be started. The final design of this control scheme will need to take into account a limited number of starts per day for the pumps. However, it appears that the FCR has ample available operation storage in the upper 5 or 6 feet to easily accommodate this pumping scheme.

4.3 Main Transmission Pipeline

The main conveyance pipeline is proposed to be 96 inches in diameter, nominally sized to limit velocity to less than 8 feet per second, at the maximum flow rate of 370 cfs. It is expected to be a cement mortar lined and coated welded steel pipe, generally in accordance with American Water Works Association's guideline C200. A nominal wall thickness of 0.625 inch was assumed for this analysis, at lower elevations near the river, as required for pressure and loading conditions.

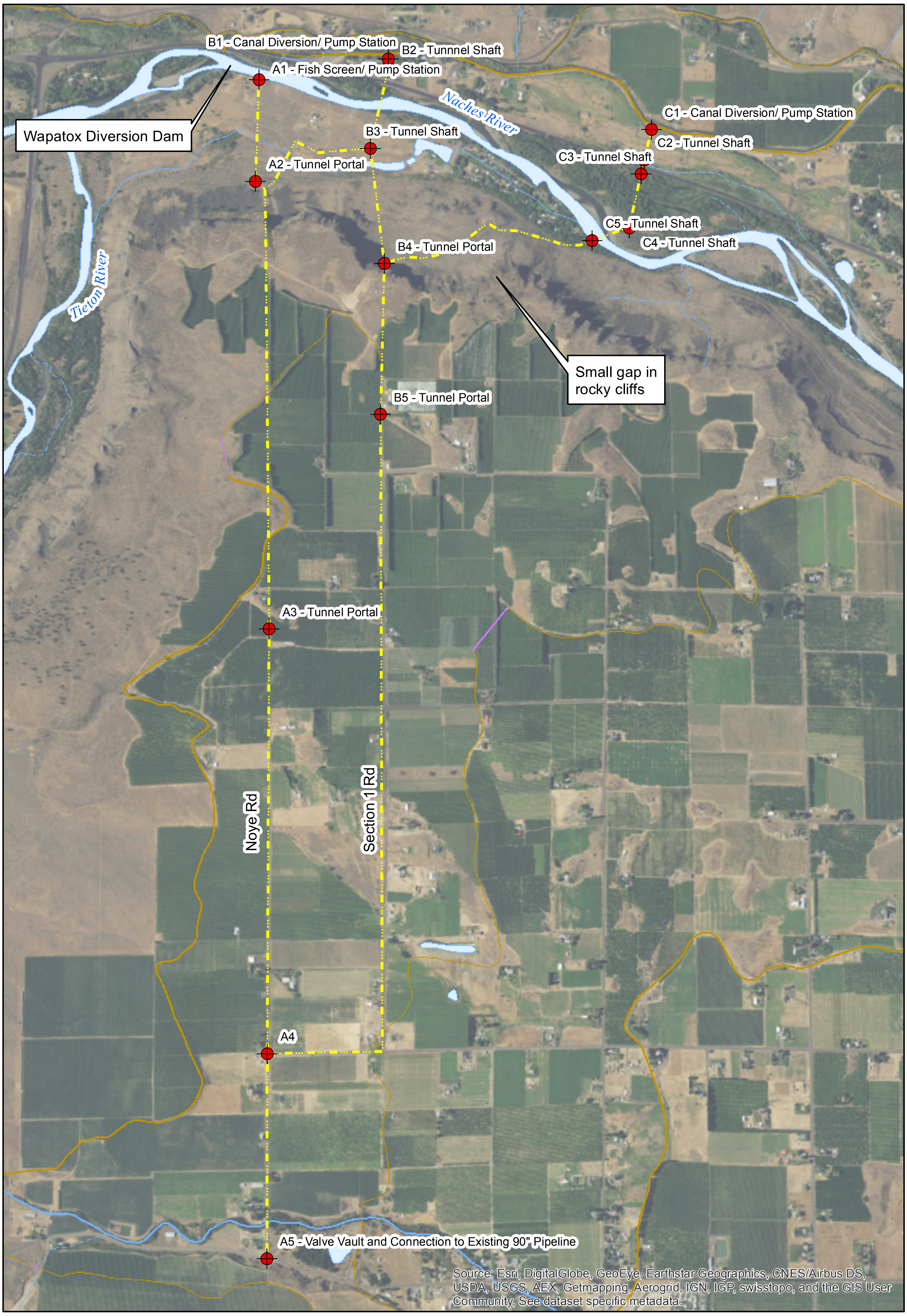
CH2M evaluated multiple horizontal alignments for the pipeline based on field observation of the topography, land use, and property parcels, and in coordination with the location of the pump station. Figure 4-4 illustrates three alternate alignments, summarized in Table 4-4.

Table 4-4. Pipeline Alignment Alternatives

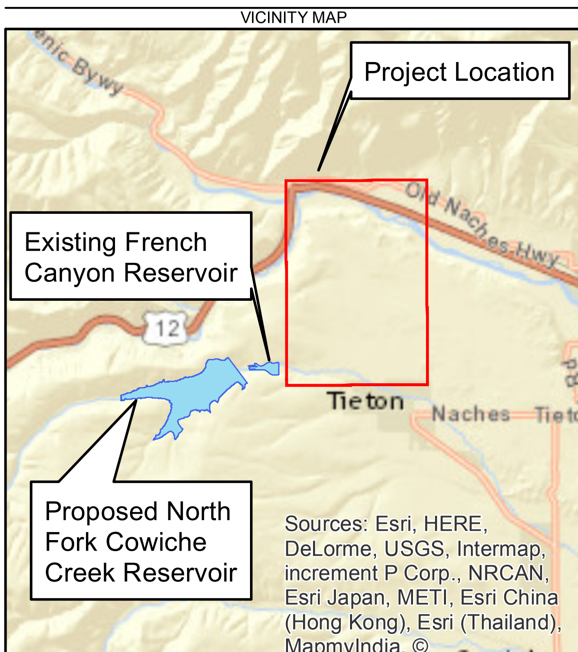
Alternative	Advantages	Disadvantages
A	• This site offers the shortest and straightest route. • Crossings of Highway 12 and the Naches River are avoided. • Potentially unstable ground at the base of the cliffs is avoided.	• Would require a new intake and fish screen on the south side of the river, likely difficult to permit. • New intake facilities are likely in the floodplain.
B	• This site takes advantage of existing intake and fish screen on the north side of the river. • Section 1 Road may have more usable right-of-way for construction versus Noye Road.	• Construction at the base of the cliffs may be on unstable slopes. • Crossing of Highway 12 and the Naches River would be required. • This is a somewhat longer route versus Alternative A.
C	• This site takes advantage of existing intake and fish screen on the north side of the river. • Section 1 Road may have usable right-of-way for construction versus Noye Road.	• Construction at the base of the cliffs may be on unstable slopes. • Crossing of Highway 12 and the Naches River is required. • This is a much longer route versus Alternatives A or B.

After considering the merits of each alternative, CH2M developed a hybrid that uses Alternative B from the pump station to “Node B3” on Figure 4-4, just south of the river crossing, then crosses over to Alignment A for the remainder of the route to the existing 90-inch YTID pipeline connection.

The resulting pipeline would extend a total of about 15,300 linear feet (LF) or just under 3 miles. Refer to Exhibits 1, 5, and 6 in Appendix A. The pipeline would start at the downstream end of the pump discharge header buried beneath the floor of the pump building, cross under Highway 12 and over the Naches River, pass through the flow control station and flow metering structure, and then enter a tunnel at the base of the 500-foot-high cliffs paralleling the river. The pipeline would exit the tunnel about 4,600 LF to the south in an orchard area and in line with Noye Road. For the final 7,800 LF of its length, the pipeline would follow Noye Road and ends at a new valve vault that would be installed on the existing 90-inch pipeline, with 90-inch butterfly valves, and a large vault approximately 42 feet long and 40 feet wide (see Exhibit 7 in Appendix A). The pipeline would provide bi-directional flow capability to allow for both supplying the YTID system (with or without NFCCR) and returning water to the Naches River. Figures 4-5 and 4-6 provide a view of the pipeline corridor on the plateau about the cliffs.



VICINITY MAP



LEGEND

- Pipeline Alignment Points
- Pipeline Alignment Alternatives

NHD Named Rivers

- Pipeline
- Stream / Perennial
- Intermittent / Ephemeral
- Canal, Ditch

Notes:
1. Area of interest subject to change.
2. Washington State High Resolution National Hydrography Dataset (NHD). GIS Data. Available at https://fortress.wa.gov/ecy/ecyprodgislb/arcgis/services. Accessed December 21, 2016.

N

0 625 1,250
Feet

FIGURE 4-4
Intake, Pump Station, and Alignment Alternatives for Diversion Relocation to Wapatox Diversion Dam

UNK \\BOIFPP01\PROJ\YAKIMATIETONIRRIGATI\470080\NORTH FORK COWICHE CREEK RESERVOIR\GIS\MAPFILES\WAPATOX\FIGURE_4-4_WAPATOX_ALIGN_ALTERNATIVES.MXD DS031304

ch2m.

Figure 4-5. Pipeline Route Looking North Along Noye Road from French Road

Figure 4-6. Pipeline Route Looking North from the North End of Noye Road

The pipeline is expected to be excavated (open trench) into the native soil and rock for approximately 19 percent of the alignment, in pavement (open trench) across Highway 12 and along Noye Road (48 percent of the alignment), in a tunnel for 31 percent of the alignment, and on a new bridge across the Naches River. For open trenched sections, a typical cover depth of 5 feet is assumed and a sand-cement slurry is assumed for the pipe zone, with native materials and a road structural section, as applicable, above the pipe zone. More information on pipeline construction in the tunnel section, and on the bridge, is provided in subsequent parts of Section 4. Exhibits 5 and 6 in Appendix A show the plan and profile for the pipeline and tunnel.

Corrosion control for the pipeline will be evaluated in greater detail during final design. Cathodic protection as well as applicable linings and coating will be evaluated.

Appurtenant features for the pipeline are expected to be contained within other structures. As such, the only appurtenant features along the pipeline will be buried access manways every 1,000 LF and air valves at high points.

4.3.1 Highway 12 Crossing

Between the pump station and the river, the pipeline route crosses Highway 12. In many cases, state highway crossings are required by the permitting process to be completed by bore-and-jack or microtunneling, rather than open-trench construction. For the Highway 12 crossing, there is considerable uncertainty about the feasibility of trenchless construction due to groundwater and the likely presence of boulders and cobbles (given its proximity to the river). These factors, along with the relatively light traffic for a state highway, led to an assumption for this study that an open-trench pipeline crossing of Highway 12 could be permitted based on nighttime construction and/or providing an appropriate shoofly bypass for traffic. Figure 4-7 is a photo of the Highway 12 corridor just west of the proposed pipeline crossing.

Figure 4-7. Highway 12, Looking West

4.3.2 Naches River Crossing

Pipeline crossings of rivers may be open-trenched, microtunneled, or via a bridge. The feasibility of each depends on local conditions, such as geology and river morphology, and on the requirements of applicable permits. As noted in the discussion above about the Highway 12 crossing, there is considerable risk for tunneling methods based on the likely presence of boulders and cobble. Open-trenching could be accomplished but would require expensive coffer damming and dewatering, and would likely be the most challenging method to permit because of potential fisheries impacts. Bridge crossings can also be costly and difficult to permit; but, for this project, a bridge crossing is needed for other purposes, specifically for construction access to the south side of the river and for long-term operation and maintenance access to the Naches River discharge facilities. Therefore, it was assumed for this study that a dual-purpose bridge would be constructed to provide a pipe crossing and construction and long-term vehicular access.

It should be noted that while there is an existing bridge about 1,000 feet downstream that provides access to some homes on the south side of the river, this bridge is not suitable for heavy construction vehicles or long term access and maintenance, so it has not been considered a part of the project. The existing bridge could be removed, if desired.

4.3.2.1 Proposed Bridge Description and Influences

The proposed bridge would be approximately 309 feet long over the Naches River and would provide a 14-foot-wide vehicle lane and carry the new 96-inch-diameter pipeline (refer to Exhibit 8 in Appendix A). The bridge would consist of three spans with two interior piers. Each span would consist of five precast, prestressed concrete deck bulb tee girders that span 100 feet. The girders would be seated on cast-in-place concrete interior piers and abutments. The interior piers would likely consist of a concrete pier cap fixed to a single concrete column, which would be supported by an enlarged concrete drilled shaft foundation. Each concrete abutment would also be supported by a single enlarged concrete drilled shaft foundation. During final design, other span configurations, precast concrete supports and driven pile foundations would be considered to simplify in-river construction and cost.

4.3.2.2 Influences

Highway 12 and the Lake Naches Road are approximately 8 to 10 feet above, and in close proximity, to the Naches River and will influence span lengths and bridge type. Accommodating flood flows and providing a reasonable profile across the bridge may be somewhat of a tradeoff.

Typically, a bridge profile is selected to clear the 100-year flood event and to provide a minimum of 2 feet of freeboard above the 50-year flood event. If the bridge is set too high, then the approach roadway grades could become too steep for vehicles or the approach roadways will need to be raised and lengthened, adding cost and potentially impacting adjacent properties. Since the flood event water surface elevations are currently unknown, the shallowest bridge depth coupled with the most efficient span configuration has been assumed.

The bridge depth and span length are directly proportional and must be balanced with the flood event water surface elevations, approach roadway grades, and overall bridge cost. The American Association of State Highway and Transportation Officials’ LRFD bridge design specifications recommend the bridge depth to be no less than 0.045 time the span length for precast concrete girders with simply-supported spans to limit live load deflections and vibrations due to vehicle traffic. However, the access bridge will only be used by construction and maintenance vehicles (not open to public traffic) and a shallower bridge depth based on strength rather than deflection (approximately 0.033L) may be more appropriate.

In determining the span configuration, the bridge depth and number/location of interior piers are key factors. With longer spans, fewer interior piers are required, thus minimizing the potential for debris collection, reducing impacts to the river during construction, and lowering the overall bridge cost. However, with fewer piers, the bridge depth increases and along with potential impacts to approach roadway grades. Given the width of the river at this location, the bridge will require at least one pier to be installed in the river. All in-river activities will require permits from the regulatory agencies involved and could dictate which type of pier foundations can be used.

The span lengths described above result in only one of the interior piers to be placed within the main channel of the Naches River, while the other interior pier will be located on the edge of the northern bank and out of the normal flow. Environmental restrictions and constraints of the riparian area on the northern bank would require consultation and/or permitting with Yakima County, Ecology, and WDFW. It appears this area could potentially be overtopped during high river flows; it was decided to span the area as much as possible. A shorter bridge would require significant approach embankment within the channel reducing the water opening under the bridge and potentially creating unacceptable backwater effects upstream of the bridge.

Precast concrete beams are assumed to eliminate the use of falsework placed in the river and wooded area. Furthermore, precast, prestressed concrete deck bulb tee girders include the bridge deck on the girders, and eliminate the need for forming a cast-in-place concrete deck in the field. Once the girders are set in place and connected together, the bridge will be ready for use.

4.3.2.3 Pipeline

At each end of the bridge, a pair of nominally 45-degree vertical bends will be used for the transition from buried to above-ground pipe. Ring girders will be required along the pipe to provide sufficient stiffness. An air valve will be needed at one end of the bridge, because the pipe elevated on the bridge will represent a local high point where air will collect in the pipeline. At one end of the bridge, an expansion joint will be needed to accommodate thermal expansion and contraction.

4.3.3 Tunnel

A tunnel will be constructed to ascend the steep cliffs from the Naches River floodplain to the plateau above the floodplain. An entry point was selected along the pipeline alignment at the base of the cliffs, as shown in Figure 4-8.

Figure 4-8. Photo of Tunnel Portal Area at the Base of the Cliffs

During the site visit, the team noted one area of the cliffs approximately 0.5 mile to the east, where the rocky cliffs actually discontinue over a small area in lieu of very steep earth slopes (approximately 60 percent); this area may be suitable for a combination of open trenching and above-ground construction. However, given the complexity of construction on these slopes and uncertainty regarding slope stability, it was assumed that tunneling was more feasible and the layout was developed accordingly.

4.3.3.1 Main Beam Gripper Tunnel Boring Machine

This project requires a 96-inch-diameter pipeline with up to 300 pounds per square inch of pressure in the reach near the river and the base of the cliffs. It was assumed for this analysis that the tunnel would employ a two-stage process: 1) mining a tunnel, and 2) installing and grouting a 96-inch-diameter steel pipeline inside the tunnel. A tunnel with a 120-inch-diameter was determined to be appropriate for pipeline installation and a “main beam gripper” tunnel boring machine (TBM) would provide a suitable means of mining the tunnel for this application.

A main beam gripper TBM has a rotating cutterhead that matches the diameter of the tunnel (refer to Figures 4-9, 4-10, and 4-11). The cutterhead holds disc cutters (ranging from 11 to 20 inches in diameter), which are positioned for optimal boring of the given rock type. As the cutterhead turns, hydraulic propel cylinders push the cutters into the rock. The transfer of this high thrust through the rolling disc cutters creates fractures in the rock causing chips to break away from the tunnel face. The floating gripper system pushes on the sidewalls and is locked in place while the propel cylinders extend, allowing the main beam to advance the TBM. The machine can be continuously steered while gripper shoes push on the sidewalls to react the machine's forward thrust. Buckets in the rotating cutterhead scoop up and deposit the rock chips on to a belt conveyor inside the main beam. The rock chips are then transferred to the rear of the machine for removal from the tunnel. At the end of a stroke the rear legs of the machine are lowered, the grippers and propel cylinders are retracted. The retraction of the propel cylinders repositions the gripper assembly for the next boring cycle. The grippers are extended, the rear legs lifted, and boring begins again.

A main beam gripper TBM open design allows quick access directly behind the cutterhead for the installation of rock support (rock bolts, steel mesh, ring beams, and shotcrete) when constructing unlined tunnels. The main beam gripper TBM are suitable for competent to slightly fractured rock in diameters from 10 to 50 feet.

The main beam gripper TBM can install tunnels inclined as much as 17 degrees before the spoil (chips 4 inches or smaller) begins to tumble down the conveyor belt. There have been projects completed in the Alps up to 45 degrees; however, subsurface conditions would have to be carefully studied before considering an installation greater than 17 degrees. For the Wapatox tunnel, the initial profile is based on a 5.7-degree (or 10 percent) slope.

Figure 4-9. Main Beam Gripper TBM Cutting Head (10 foot diameter)

Figure 4-10. Main Beam Gripper TBM with Trailing Gear

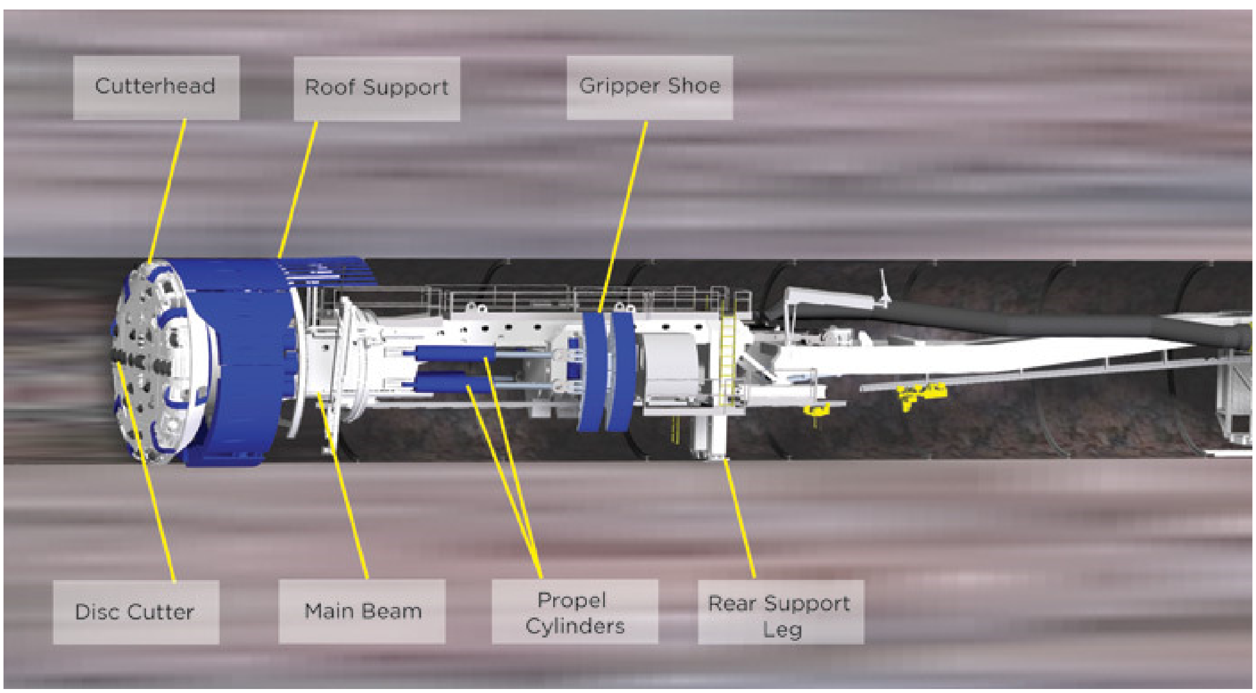


Figure 4-11. Major Components of the Main Beam Gripper TBM

4.3.3.2 Shaft and Starter Tunnel Considerations

Shaft requirements for recovery of this type of TBM range between 22 and 30 feet. The minimum workspace area for this type of operation is 2 to 5 acres. Consideration is given to the required maintenance support structures, equipment storage, and muck disposal when determining the workspace requirements. Location of the lay down areas will also require a detailed assessment of site access for delivery and removal of construction material to and from the site.

A starter tunnel with a larger diameter of approximately 18 to 20 feet will be required to assemble the TBM and trailing gear prior to TBM operation. The starter tunnel will likely be approximately 200 feet in horizontal length, installed flat (no slope) and providing enough room to curve the TBM to the ultimate 10 percent slope. A feasible option in constructing the starter tunnel is by using drill and blast methods. Initial support of the starter tunnel will require the use of rockbolts, mesh, straps and/or shotcrete. Pre-excavation probing and grouting may also be required if water bearing joints are encountered.

4.3.3.3 Power Requirements

TBM excavation using this type of machine requires approximately 1,800hp motors on the cutter head, 200 hp for hydraulics and miscellaneous and 300 hp for the backup equipment. The total power requirement for the TBM is estimated at about 2,300 kilovolt amperes (kVA). An additional 500 kVA is required for tunnel ventilation, pumping, and other surface facilities. Therefore, the total requirement for tunneling operations is approximately 2,800 kVA.

4.3.3.4 Initial Rock Support

As the tunnel advances, deformation in the rock starts taking place about .5 tunnel diameter ahead of the advancing face and reaches a maximum at about 1.5 tunnel diameters behind the face. In order to minimize deformation and maximize rock mass stability, initial support is installed as close to the heading as practical. With a main beam gripper TBM, rock bolts can be installed within shield fingers at a distance of approximately 20 to 25 feet behind the heading and following each stroke/advance of the TBM.

Initial support might include a pattern of five 6-foot-long rockbolts in the crown, 4 feet in plane spacing, and 5 to 7-foot longitudinal spacing. Local segments with poorer rock quality (perhaps 20 percent of the tunnel) may require additional support consisting of pattern rock support with shotcrete, wire mesh, and/or straps. The supplemental support is typically installed just beyond the tail of the shield. The TBM should have capability for pre-excavation probing and grouting to both strengthen the rock and reduce rock mass permeability within localized zones of poorer rock quality.

4.3.3.5 Receiving Shaft

At the end of the tunnel, a shorter (horizontal) length shaft is needed to terminate the mining operation, install the pipeline, and construct pipeline fittings as needed to transition to open trench construction. The receiving shaft can be in excess of 100 or 200 feet in depth, but for the Wapatox project the profile has been based on a shaft of about 70 feet in depth.

4.3.3.6 Pipeline Installation

Once the tunnel is complete, the 96-inch welded steel pipe will be installed. It is anticipated that the contractor will conduct this operation from the receiving shaft (to take advantage of the slope of the tunnel and pipe) and use a rail and cable system to advance each pipe segment to the bottom of tunnel and weld it to the previous segment. A grout pipe will also be advanced through the tunnel and, when all pipe is installed, the annular space left between the 120-inch-diameter tunnel and the 96-inch-diameter pipe will be grouted.

4.4 Naches River Discharge Facilities

The proposed Wapatox project includes facilities to return flows from FCR (and potentially NFCCR) to the Naches River using the proposed project facilities in the reverse direction. The river discharge facilities would be used in situations where it is desirable for river flow augmentation, or for other downriver water users. These situations may be associated with development of the NFCCR, dual use with the existing YTID Tieton Canal, or other operating scenarios. These facilities have been developed as part of this analysis to demonstrate their configuration and identify their cost. If they are not required by the final selected project, then they could be replaced with smaller pipeline draining facilities at a significantly lower cost.

The river discharge facilities were conceptually developed to return up to 370 cfs to the Naches River. Two main components are included as follows:

- Flow control station
- Baffled apron drop outlet structure

Each component is described in this section.

4.4.1 Flow Control Station

Exhibits 9 and 10 in Appendix A illustrate the proposed flow control station (FCS) used for returning flow to the Naches River. The FCS is designed to dissipate the energy associated with conveying between 70 and 345 cfs into the Naches River.

The flow control station is a large concrete vault structure containing three flow control valves required for flow regulation. The structure is assumed to have a fully removable aluminum cover (insulated) to minimize the depth and associated cost of the facility. This approach eliminates the need for a bridge crane, but requires that a portable crane be used to install/remove equipment. Since these valves are not expected to require frequent removal and/or replacement, the removable cover system was included.

Flow control will be accomplished using three flow control trains, each using a 36-inch flow control valve. The flow control valves are shown on the drawings as sleeve valves with a downstream fixed energy dissipater. The additional energy dissipater is required because of the high driving head from FCR. Plunger valves may provide the same service as sleeve valves and may be slightly shorter and slightly lower cost. Each flow control train also includes a 48-inch isolation butterfly valve on the upstream end and a 36-inch isolation ball valve on the downstream end. Since the flow control valves result in turbulent flow at their discharge end, the full port ball valve is recommended on the downstream side. The upstream side connects to the main transmission pipeline and the downstream side connects to dedicated river outlet discharge pipeline that leads to the baffled apron drop outlet structure.

A variety of instruments will be provided to monitor valve position and pressure in the flow control station. A PLC will be located at the flow control station to provide control logic required to modulate the flow control valves. The PLC will modulate the valves to provide a constant flow rate (operator selected) from FCR to the river. The control system will use the flow rate signal from the flow measurement structure as a control parameter.

4.4.2 Baffled Apron Drop Outlet Structure

A baffled apron drop structure is included downstream of the FCS to dissipate the remainder of the energy and discharge flow into the river in a controlled manner. The structure also provides a vertical and velocity barrier to prevent fish from being attracted to (or entering) the discharge structure, as would be required by the applicable resource agencies.

Commonly known as a USBR Type IX Baffled Apron, the structure consists of a steep concrete ramp with alternating rows of piers (or baffle blocks) that absorb energy as the water descends toward the river. Training walls on each side contain the flow, and the structure's width is based on a target range of 20-60 cfs per foot of width. Initial layout for the Wapatox project was based on 20 cfs per foot of width, providing a more conservative design and what the literature describes as "relatively mild conditions". Other design parameters including entrance velocity of water approaching the chute, depth of water in the approach channel, and pier height and width are a function of critical depth for the design flow rate. Table 4-5 summarizes the key design parameters used for this analysis.

Table 4-5. Baffled Apron Design Parameters

Parameter	Design Value
Rate of Flow (cfs)	Up to 345
Design Unit Discharge (cfs)	20
Width (ft)	> 17.25 (used 20 feet)
Ideal Entrance Velocity (ft/sec)	< 3.6
Pier Height (ft)	1.9
Pier Width (ft)	2.8
Training Wall Height (ft)	> 5.6

A concrete structure is included to direct flow from the FCS discharge pipe, over a weir and through a convergence to the baffled apron drop. The inlet chamber includes baffle columns to facilitate uniform flow over the weir and the baffle drop spreads the flow out to minimize the impact of the return flow on the flow regime in the river. The structure is depicted in Exhibit 11 in Appendix A.

It is expected that this structure will be constructed inside a sheet piled cofferdam. The sheet piles will also serve as long-term scour/undermining protection for the foundation of the structure. The top of inlet chamber is raised above the surrounding grade and equipped with a handrail and grating for safety and to minimize the impact of flooding on the structure.

4.5 Flow Measurement Structure

A flow measurement structure is proposed to facilitate operating the WCPS and the Naches River discharge facilities. The flow measurement structure will be placed along the main conveyance pipeline a suitable distance downstream (toward FCR) of the flow control station to facilitate measuring flow in a straight pipe.

A multi-path ultrasonic flowmeter was assumed for this application since it is relatively accurate and allows flow measurement in either direction. Reasonable flow accuracy, assumed to be 2 percent (or better) is expected to be needed since this would be the meter that records YTID's diversions and return flows, as applicable. Other meter types could be considered during detailed design providing 2 percent or greater accuracy is maintained.

The flow measurement structure is a concrete vault structure containing the metering equipment. The vault will be fairly wide (about 20 to 30 feet), depending on meter characteristics. It must be wide enough to accommodate installation and removal of the ultrasonic probes. The structure is assumed to have a concrete cover since the ultrasonic meter components are small and can be removed through a roof hatch. It is expected that the flow signals will be communicated to the network via the PLC at the flow control station for control purposes, flow and volume documentation, and operator information.

Project Operations

5.1 Available Water Supply

The available water supply for this project is dependent on several factors, including but not limited to Rimrock Reservoir and Bumping Reservoir operations, instream flow requirements, hydrology, and watershed yield.

5.1.1 Rimrock and Bumping Reservoirs Storage and Operations

The data available for Rimrock and Bumping Reservoirs show that, in most years, the reservoirs fill to capacity, usually reaching full pool between late May and early July. By early springtime, the USBR (which operates releases from the reservoirs) has a relatively accurate assessment of the available snowpack in the watershed above the reservoirs, and excess water is released from the reservoirs in order to make room for spring runoff, snowmelt, and flood control storage. Water releases from Rimrock and Bumping Reservoirs will often occur early in the spring, before the water is needed for irrigation purposes. Spring releases from Rimrock, which is the larger of the two reservoirs and is located on the Tieton River drainage, constitute the majority of the available water supply for the proposed Wapatox Diversion and NFCCR. (USBR, 2011)

The date when the USBR begins releasing water from reservoirs to meet irrigation demands is known as the storage control date. Historically, storage control occurs on June 24. After the storage control date, the USBR releases only the amount of water required to meet agricultural and instream flow demands downstream. This study assumes that any water released from Rimrock to the Tieton River (or Bumping Reservoir to Bumping River and eventually the Naches River), prior to the storage control date and in excess of minimum instream flow requirements, currently flows downstream into the Yakima and Columbia Rivers and eventually to the sea. This volume of water is assumed to be available to the YTID and the NFCCR for storage and later use.

5.1.2 Instream Target Flow

Instream flow targets relevant to this project consist of several components. With some minor exceptions, current minimum instream flow targets in the Tieton River below YTID's point of diversion must meet or exceed 75, 100, and 120 cfs in dry, normal, and wet years, respectively. In addition, there are also minimum target flow requirements of 450 cfs or the natural flow (whichever is less) at the stream gage located on the Naches River near Naches (NACW gage), which is downstream of the confluence of the Tieton and Naches Rivers, and is the stream flow gage located closest to the Wapatox Diversion. In addition to these target flows, there is a volume that is typically released from Rimrock Reservoir in the April and May timeframe that passes downstream in the form of a pulse flow. This experimental pulse flow is largely intended to mirror the timing and general magnitude change of unregulated flow, and assist with the out-migration of salmonids. It is dependent on estimates of total water supply available (TWSA) and other factors that influence the Yakima Project operations. TWSA is the total water supply available for the Yakima River Basin above the USGS gage at Parker, located below Union Gap and the Sunnyside Diversion Dam), for the period April through September, expressed in a mathematical formula, reading as follows:

April 1 through July 31 forecast of runoff

\+ August 1 through September 30 projected runoff

+ April 1 reservoir storage contents in the five major reservoirs that serve the Yakima River Basin

+ Usable return flow upstream from Parker gage

= TWSA

The total demand to be placed against this TWSA for irrigation, regulation, and flows passing Parker gage averages 2.7 million acre-feet in a normal year. (USBR, 2011)

It is noted that, prior to 2011, instream target flows were lower than those currently established. For the purposes of this feasibility study, availability of flow for the proposed Wapatox Project is principally based on maintaining either 450 cfs or the natural flow (whichever is less) at the NACW gage located on the Naches River near Naches. Other instream flow requirements are highly dependent on operations and major reservoir releases throughout the Yakima River Basin, and these requirements can be addressed during subsequent studies or design phases of the project.

5.1.3 Hydrology and Watershed Yield

A complete and thorough hydrologic analysis, to determine potential watershed yield and inflows into Rimrock Reservoir, Bumping Reservoir, and the Naches River at the Wapatox Diversion, is complex and beyond the scope of this feasibility study. Generally speaking, however, historical flow released from Rimrock to the Tieton River usually exceeds the combination of instream flow requirements and downstream agricultural demands. In other words, water is intentionally spilled because the inflow exceeds the Rimrock storage capacity in most water years, indicating that there is sufficient water available for diversion and use in the YTID system and storage in the NFCCR. Estimates of the available water supply for the proposed Wapatox Diversion are presented in Section 5.3.

5.2 Water Demand and Water Use

In 2013, CH2M completed a study to evaluate alternatives to address the YTID Tieton Canal. The study included rehabilitation alternatives and cost estimates (CH2M, 2013). In order to achieve YTID's long-term goals for a reliable water supply and flexibility to support other water users, the preferred project alternative identified in that study consisted of expanding the canal capacity to 370 cfs. A canal capacity of 370 cfs would provide sufficient capacity to accommodate both YTID's peak demand (345 cfs) and the peak demand for the Cowiche Creek Water Users (25 cfs).

The Wapatox alternative would effectively replace the canal system evaluated in the prior study. For the purposes of this feasibility study, it was assumed that demands would increase to a peak of 370 cfs, would be met by the new pump station and pipeline system, would also be agricultural in nature, and would follow the general timing and demand pattern of the existing demand curve shown previously in Section 3 (refer to Figure 3-4).

5.3 Typical Project Operations and Project Yield

Typical project operations and annual project yield for the Wapatox Project depend on available water in the Naches River, timing of deliveries to YTID customers and potentially to other area water users, and whether or not the NFCCR is also constructed. For this study, CH2M evaluated project operations for two potential scenarios:

5.3.1 Scenario 1: 370 cfs Maximum River Diversion Rate, NFCCR Not Included

Water is pumped at whatever rate is needed to meet YTID demands (peak demand of 345 cfs), with an additional capacity of 25 cfs for others (that is, AID and Cowiche Creek Water Users Association [CCWUA]) that may have water wheeled to them (370 cfs total peak capacity). Water would be diverted only during the current irrigation season (assumed April 1 to October 31 for the purposes of this study) and minimum instream flows discussed previously would be maintained. CH2M's spreadsheet water model also implements an assumed storage control date of June 24, meaning that every year from June 24 to October 31, the diversions at Wapatox are limited to YTID historical demands.

Based on the operating scenario described, estimates of water available for diversion to YTID were compared to actual historical water deliveries to FCR for the same time period in order to determine the availability of water for the project as a whole. Table 5-1 shows the historical demand, water volume available for diversion at Wapatox, and the maximum feasible annual diversion (in acre-feet) for this scenario by year. Minimum, maximum, and average water volumes are also given for the same time period. The table shows that, given the constraints and assumptions described, enough water is available in the Naches River to satisfy YTID's full water right of 96,611 acre-feet in all but one of the past 16 years. In 2001, there were extended periods of low flows in the Naches River, and the model limits diversions in order to maintain instream flow requirements. Available flow for all years exceeds historical demands.

Table 5-1. Project Yield for Scenario 1

Year	Historical YTID Delivery to FCR (AF)	Water Available for Diversion at Wapatox (AF)	Maximum Annual Diversion for Wapatox PS (AF)
2016	84,071	112,135	96,611
2015	85,692	110,690	96,611
2014	82,863	112,937	96,611
2013	81,078	113,806	96,611
2012	76,924	114,501	96,611
2011	75,863	114,611	96,611
2010	71,821	111,917	96,611
2009	77,466	110,467	96,611
2008	74,749	110,503	96,611
2007	79,511	112,427	96,611
2006	73,023	114,095	96,611
2005	75,302	103,127	96,611
2004	72,178	108,111	96,611
2003	76,524	113,220	96,611
2002	72,930	110,955	96,611
2001	75,544	87,380	87,380
2000	84,182	117,659	96,611
Minimum	71,821	87,380	87,380
Average	77,631	110,502	96,068
Maximum	85,692	117,659	96,611

Notes:
AF = acre-feet
PS = pumping station

5.3.2 Scenario 2: 345 cfs Maximum River Diversion Rate, NFCCR Included

Water is pumped at a maximum rate of 345 cfs directly to the YTID's distribution system, to the NFCCR for storage, or both depending on supply, YTID demands, and demands of other users (that is, AID and CCWUA) in the basin. Water could be diverted year round as available (for storage) and as needed during the irrigation season. As will be illustrated by the model results shown in Table 5-2, a year-round diversion schedule allows for capturing a significantly larger volume of water that is typically lost to sea, given existing reservoir operations in the basin. This scenario also provides flexibility in the ability to pump to the NFCCR and use that storage during times of peak demands. Minimum instream flows discussed previously would be maintained. CH2M's spreadsheet water model also implements an assumed storage control date of June 24, meaning that every year, from June 24 to October 31, the diversions at Wapatox are limited to YTID historical demands.

Based on the operating scenario described, estimates of water available for diversion to YTID were compared to actual historical water deliveries to FCR for the same time period in order to determine the availability of water for the project as a whole. Table 5-2 shows the historical demand, water volume available for diversion at Wapatox, and the excess water volume available for others (in acre-feet) for this scenario by year. Minimum, maximum, and average water volumes are also given for the same time period. Results are shown for a year-round diversion schedule, as well as the standard irrigation schedule (April 1 through October 31). As the table illustrates, the year-round diversion schedule yields substantially more excess flow available for storage or for basin demands. Available flow for all years for both schedules exceeds historical demands, and a substantial volume of water would be made available to other water users for this scenario.

Table 5-2. Project Yield for Scenario 2

Year	Historic Demand (AF)	Year-Round Diversion Schedule		April 1-October 31 Diversion Schedule	
		Water Available for Diversion at Wapatox (AF)	Excess Available for NFCCR/CCWUA/AID (AF)	Water Available for Diversion at Wapatox (AF)	Excess Available for NFCCR/CCWUA/AID (AF)
2016	84,071	196,755	112,683	119,385	35,314
2015	85,692	206,219	120,527	103,147	17,455
2014	82,863	191,168	108,305	120,923	38,059
2013	81,078	171,610	90,532	102,190	21,112
2012	76,924	199,267	122,342	96,949	20,025
2011	75,863	184,335	108,472	90,766	14,904
2010	71,821	199,321	127,499	102,121	30,299
2009	77,466	177,786	100,320	104,281	26,815
2008	74,749	175,796	101,047	112,367	37,618
2007	79,511	191,088	111,577	95,169	15,658
2006	73,023	202,751	129,727	114,976	41,952
2005	75,302	131,892	56,589	104,222	28,920
2004	72,178	150,831	78,652	114,750	42,571
2003	76,524	160,144	83,620	116,614	40,090
2002	72,930	129,912	56,981	112,857	39,927

Table 5-2. Project Yield for Scenario 2

Year	Historic Demand (AF)	Year-Round Diversion Schedule		April 1-October 31 Diversion Schedule	
		Water Available for Diversion at Wapatox (AF)	Excess Available for NFCCR/CCWUA/AID (AF)	Water Available for Diversion at Wapatox (AF)	Excess Available for NFCCR/CCWUA/AID (AF)
2001	75,544	89,988	14,444	94,483	18,938
2000	84,182	127,136	42,954	102,655	18,473
Minimum	71,821	89,988	14,444	90,766	14,904
Average	77,631	169,765	92,134	106,344	28,714
Maximum	85,692	206,219	129,727	120,923	42,571

Notes:
AF = acre-feet

5.3.3 Modeling Assumptions and Limitations

The results of CH2M's spreadsheet water model are dependent on historical flow records for the Naches and Tieton Rivers, historical YTID diversions, and historical reservoir levels in Rimrock and Bumping reservoirs, which were used as input for the calculations. For the purposes of this feasibility study, flow records from years 2000 to 2016 were used to estimate potential project yield. This approach requires the assumption that reservoir operations within the basin (particularly at Rimrock and Bumping reservoirs) will mimic operations during that same time period. In reality, however, the implementation of additional storage and/or conveyance projects, such as the Wapatox Pump Station and Pipeline or the NFCCR, would result in alterations to USBR's reservoir operations in order to optimize and effectively manage water for users within the Yakima River Basin. Actual project yield will depend on actual (and potentially altered) basin-wide reservoir operations, available storage, and the timing and magnitude of actual user demands in the future.

The approach used in this feasibility study to estimate potential water available for others yielded results on the order of 90,000 to 110,000 AF. This volume far exceeds the capacity of the YTID's storage capacity, as well as the additional potential storage capacity of the NFCCR. This is an indication that there is a substantial amount of water available in the basin that is lost to sea. Even if the Wapatox Project and/or NFCCR are pursued in the future, it may not be feasible to capture the entirety of this volume of water. As mentioned previously, additional study and coordination with USBR's reservoir operations group would be needed to refine the estimates for project yield.

In addition to the assumptions previously discussed, it is noted that CH2M's spreadsheet water model assumes that any reach losses between the existing point of diversion on the Tieton River and new Wapatox Pump Station are negligible; the same daily water volume previously diverted into the existing Tieton Canal is conveyed downstream and available at the Wapatox site. Additionally, the model neglects instream flow requirements for the Tieton River, as the YTID's diversion would no longer be located in that drainage.

Environmental Impacts

6.1 Preliminary Environmental Impacts

A preliminary assessment of environmental impacts was made using available GIS data. Acreages of impacted habitat and species utilization are presented in Table 6-1. Approximately 13.64 acres would be impacted by the proposed diversion, pump station, Naches River Bridge, and pipeline. Agricultural land and associated disturbed areas dominate the project area, although some areas of wildlife habitat and shrub-steppe, cliff/bluff, and shoreline habitats would be affected.

Table 6-1. Summary of Impacts to Priority Habitats and Priority/Federal and State-listed Species

Environmental Resource	Impact Area Footprint (acres)
Total Footprint	13.64
Priority Habitats	
Shrub-steppe	0.53
Cliffs/bluffs	0.33
Shoreline	0.05
Priority/Federal and State-listed Species	
Steelhead	0.14
Bull trout	0.14
Mule deer	1.55
Elk	1.55
Wood duck	1.81
Golden eagle	0.33
Bald eagle	1.81

6.2 Environmental Compliance and Permits

The construction of the proposed project may include funding from state and federals sources. As such, the proposed project would need to comply with the stipulations set forth by various federal and state acts before construction could proceed. A list of these federal and state acts is provided below:

- Clean Water Act (CWA) (33 *U.S. Code* [U.S.C.] §§ 1251-1387)
- National Environmental Policy Act (NEPA) (42 U.S.C. § 4321)
- State Environmental Policy Act (SEPA) (Chapter 43.21C RCW)
- Shoreline Management Act (SMA) (Chapter 90.58 RCW)
- Endangered Species Act (16 U.S.C. §§ 1531-1544)
- Bald and Golden Eagle Protection Act (16 U.S.C. § 668)
- Migratory Bird Treaty Act (MBTA) (16 U.S.C. §§ 703–712)

Initial steps towards compliance with the CWA and SMA would involve a wetland and ordinary high water mark delineation of the project area. This would determine the presence of any potentially jurisdictional wetlands, Waters of the United States, and Shorelines of the State. After the receipt of a preliminary jurisdictional determination from U.S. Army Corps of Engineers (USACE), a Section 401/404 permit application would be filed to allow the discharge of dredged or fill material into jurisdictional wetlands and waters. Necessary permits would be filed with Ecology to allow construction within riparian zones, in compliance with the SMA. Mitigation and avoidance measures would be developed as part of the permitting and design process.

An environmental assessment (EA) would be initiated to ensure compliance with the NEPA. The EA would determine the significance of any impacts from the proposed project and would satisfy requirements of the SEPA. SEPA follows similar protocol as NEPA and permits the issuance of joint documents.

Consultation with the National Marine and Fisheries Service (NMFS) and the Yakama Nation would be recommended to assess any impacts to protected fish downstream of the proposed Naches River diversion.

The EA development and NMFS consultation could begin immediately. A wetland delineation could be performed at any time during the growing season. As the first step in a months-long process of USACE permitting, it is recommended that the delineation occur, once funding for the project is secured. Compliance with the Bald and Golden Eagle Protection Act and the MBTA would require timing construction to avoid nesting periods.

6.2.1 Limitations of this Investigation

This investigation of environmental resources is based on a brief site visit and available online resources. Field biological surveys were not conducted. Formal protocol-level surveys for any threatened or endangered species with potential habitat in the project area would need to be performed at appropriate times for each species (for example, nesting period for birds). A wetland delineation performed during the growing season would be required to accurately assess any impacts to wetlands.

Cost Estimate

7.1 Capital Cost

A Class IV cost estimate, as defined by American Association of Cost Engineers , was developed for the proposed project. The cost estimates presented in this section include capital costs for the Wapatox Project facilities described in this report and depicted on the associated drawings. Costs for power transmission from the source of power to the switchyard at the pump station site are not included at this time. It is assumed that those costs would be the responsibility of the power company and they would be reimbursed as part of their rate structure.

The purpose of this conceptual design phase construction cost estimate (estimate) is to aid strategic planning, project screening, alternative scheme analysis, confirmation of economic and or technical feasibility, and preliminary budgeting for proposed projects. This estimate is prepared based on limited field and design-specific information where the conceptual engineering is less than 15 percent complete. Examples of estimating methods used are equipment and or system process factors, scale-up factors, and parametric techniques. The expected accuracy ranges for this class of estimate are – 15 percent to – 30 percent on the low range side, and + 20 percent to + 50 percent on the high range side.

The costs presented include general conditions and contractor overhead and profit. Also included is a 30 percent contingency for the project facilities. The contingency allowance is intended to account for changes in the project scope and items that have not been defined at the conceptual level of project design. No costs are included for land acquisition, administrative, legal, financing, engineering, construction management, environmental analyses and mitigation, or permitting. Cost are presented in fourth quarter 2016 dollars, and no escalation has been provided.

The overall estimated capital cost for the project is summarized in Table 7-1. More detailed information regarding the cost for the various components is provided in Appendix B. The Naches River return flow facilities are not needed for YTID to simply replace their existing Tieton Canal water supply. These facilities would primarily be required to release flows for potential water sharing partners, especially if the North Fork Cowiche Creek Dam project were implemented. While these costs may be needed, they might not be attributable to YTID’s share in the overall project costs. Therefore, Table 7-1 includes the total project cost with and without the Naches River return flow facilities.

Table 7-1. Summary of Estimated Capital Cost for the Wapatox Project

Facility	Estimated Capital Cost ($1000s)
Wapatox Canal Pump Station	61,554
Main Transmission Pipeline	60,236
Naches River Return Flow Facilities	7,683
Flow Measuring Structure	563
Project Total w/Naches River Return Flow Facilities	**130,036**
Project Total w/o Naches River Return Flow Facilities	**122,353**

7.2 Annual Operations and Maintenance Costs

O&M costs were developed to help estimate the order-of-magnitude for annual operating and overall life cycle cost of the facility.

Typical O&M costs, excluding the cost of power, were established as a percent of the capital cost for each facility, as summarized in Table 7-2. These costs are expected to account for general upkeep, repair and replacement of minor items, and normal efforts required to inspect and monitor the facility as well as keep it in good condition and functional (including such tasks as periodic painting and cleaning, or lubrication). Factors were developed from past project experience and are expected to be conservatively high.

Table 7-2. Operations and Maintenance Cost Factors by Facility

Item	Annual O&M Cost Factor (Percent of Initial Capital Cost)
Wapatox Canal Pump Station	1.0
Main Transmission Pipeline	0.5 pipe and tunnel 1.0 Naches River bridge
Naches River Return Flow Facilities	0.5 flow control station 0.0 outlet structure
Flow Measuring Structure	1.0

Specific estimates are provided for annual power cost assuming $0.05/kW-hour, 80 percent pumping efficiency, 80,000 acre feet per year pumped (17-year average is 76,270 acre feet per year). Also included is a specific operational estimate at 2 full-time equivalent employees for the full year. It is recognized that the facility will not be functional the entire year, but there will be 24-hour operation required for portions of the year by more than one staff member.

Table 7-3 provides a summary of the total estimated annual O&M cost.

Table 7-3. Estimated Annual Operations and Maintenance Cost Summary

Item	Annual O&M ($1000s)
Wapatox Canal Pump Station	616
Main Transmission Pipeline	328
Naches River Return Flow Facilities	27
Flow Measuring Structure	6
Operations (2 full-time equivalent employees)	300
Power	2,963
Total	**4,240**

7.3 Life Cycle Cost

An estimate of life cycle cost was developed to help determine the long-term value of the project relative to the long-term expected yield. The following parameters were used to estimate the life cycle cost:

- Facility Life (assuming good O&M practices are maintained):
  - WCPS:
    - Structure and site (40 percent of facility): 100 years
    - Mechanical Electrical Components (60 percent of facility): 30 years
  - Flow Control Station:
    - Structure and site (40 percent of facility): 100 years
    - Mechanical Electrical Components (60 percent of facility): 40 years
  - Conveyance Pipeline: 100 years
  - Flow Measurement Structure:
    - Structure and site (60 percent of facility): 100 years
    - Mechanical Electrical Components (40 percent of facility): 20 years
- Analysis Period: 100 years
- Discount Rate: 3 percent
- Cost Basis:
  - Capital Costs: 2016 capital costs from Section 7
  - O&M Costs: Table 7-3
  - Replacement Costs: Frequency and percentage of initial capital cost as indicated above

A net present value analysis was conducted using the information described above. The resulting 100-year net present value of the project is $290 million with the Naches River Return Flow Facilities and $279 million without the Naches River Return Flow Facilities.

7.4 Opportunities for Enhancing Project and Reducing Cost

The project facilities described in this report are presented in accordance with the various criteria and design parameters described in each section. The following list includes ideas and opportunities for improving the project, reducing project cost during subsequent design phases, or both. These concepts would result in a slightly different project configuration, without sacrificing fundamental project performance and goals:

- It is recommended that one of the first activities associated with moving the project forward is to conduct a formal facilitated value engineering session. The value engineering session would bring applicable subject-matter experts together to review the conceptual project and suggest ideas that the project team can consider to improve the functionality or reduce the cost of the project.
- As noted above, the Naches River return flow facilities are not needed for YTID to simply replace their existing Tieton Canal water supply. These facilities would primarily be required to release flows for potential water sharing partners, especially if the North Fork Cowiche Creek Dam project were implemented. While these costs may be needed, they might not be attributable to YTID's share in the overall project costs.
- Since the Wapatox Project would provide a significant environmental benefit due to the increased instream flows in the Tieton River and the elimination of an existing diversion, it may be possible to enlist environmental partners to help share in the cost of the facility to make it more affordable to YTID shareholders.
- As noted in this report, the use of a can-mounted pump station configuration, versus the wet well with open-top can configuration for the pump station, could result in lower pump station costs. It is recommended that a more detailed evaluation of the alternative configurations be conducted to better assess whether cost saving can be achieved.

- The power supply switchyard assumes the use of two 36 MVA transformers, where each transformer train is capable of supplying the full station power requirement. The use of dual transformer trains with a small capacity, perhaps 80 to 90 percent of full load should be considered to save cost without sacrificing a substantial portion of the project capacity. Full load is only required for pumping the maximum 370 cfs flow rate when FCR is approaching its full condition.
- Alternative transfer pump station configurations, especially the can-mounted pump alternative and the possibility to use submersible pumps, should be evaluated in detail to determine if they can provide the same functionality at a lower cost than the pump and wet well configuration included in the conceptual design.
- Additional information on soils and geology may provide an opportunity to optimize the slope of the tunnel and the depth of the receiving shaft, which could shorten the tunnel reach and save cost.
- Depending on what is learned from subsurface investigations, there may be an opportunity to ascend part or all of the cliff area with a combination of buried and above-ground pipeline. Alignment Alternatives B and C (as described in Section 4) ascend almost half the cliff height prior to the beginning of the tunnel. Although not specifically shown as an alternative, the gap in the cliffs to the east may offer an opportunity to avoid tunneling all together. However, any of these variations on what was presented may not be feasible depending on hillside slope stability and subsurface conditions.
- As described in Section 2, there may be an opportunity to significantly reduce the size and cost of the pumping and conveyance facilities if the Wapatox project is combined with NFCCR, by reducing the peak flow rates, extending the duration of pumping to 10 or 11 months per year, and taking advantage of new storage in the system. This would require reservoir operations optimization modeling of multiple Yakima River Basin reservoirs and water rights analysis that are beyond the scope of this study.

Conclusions and Recommendations

8.1 Conclusions

8.1.1 Project Costs and Funding

The Class IV construction cost estimate for this project is $130 million to $122 million, with and without the Naches River return flow facilities, respectively. The total cost could be expected to range from about $100 million to $140 million, depending on market conditions. This study also estimates a $4.2 million annual O&M cost, and a 100-year net present value of $290 million to $279 million, with and without the Naches River return flow facilities, respectively.

8.1.2 Engineering Analyses

8.1.2.1 Pump Station

(a) Wapatox Canal Pump Station

The intake will be located on the south bank of the existing Wapatox Canal, about 600 feet downstream from the existing Wapatox fish screen facility. The Wapatox Canal Pump Station will lift water from the existing canal to FCR. It is proposed to be a constant speed, vertical turbine, pumping facility capable of operating at a nominal capacity of 370 cfs under all operating conditions.

Three sites were considered for the pump station: upstream of the existing Wapatox Diversion Dam, downstream of the existing Wapatox Diversion Dam, and on the existing Wapatox Canal. Ultimately, the existing Wapatox Canal location was selected, because it uses an existing diversion and fish screen, is expected to be easier to operate and maintain, and is not expected to be costlier.

Vertical turbine pumps are proposed since horizontal pumps would result in a deeper and costlier facility. Three pumping alternatives were considered: six, seven, and eight duty pumps. Each alternative would include a standby pump. All alternatives are feasible and should be reconsidered during final design. The eight duty pump alternative was selected for this analysis because it provides smaller pumping units and the best compatibility with the flow balancing capacity of FCR.

Three pump station wet well configurations were analyzed, including can-mounted pumps, a conventional wet well, and a wet well with open top cans. The conventional wet well is the most expensive option. Therefore, the can-mounted pump and wet well with open top can alternatives are preferred and should be considered during final design. Site-specific cost details are needed to clearly differentiate between the two alternatives. The wet well with open top can configuration was selected as the basis for the cost estimate for this analysis because it is easier to define at this stage of project development. Also, the wet well with open top can arrangement has generally more favorable non-cost characteristics, so the can-mounted pump configuration would be selected only if it lowers the cost.

A pump building is proposed to provide environmental protection for the pumps, motors, discharge piping, and electrical equipment. The building is about 215 feet long, 56 feet wide, and 50 feet tall. The building walls could be concrete masonry unit or precast concrete panels with a concrete or steel framing system. As part of the pump building, electrical and control rooms are proposed for the project. The electrical room is expected to house the main electrical switchgear, MCCs, reduced-voltage pump starters, low-voltage panel boards, and other related equipment.

Pneumatic air over water surge control tanks with compressed air and applicable accessories were assumed for the conceptual analysis to reserve cost and space on the proposed site. No transient analyses have been conducted, so these facilities will need to be verified during final design.

Various site development and access feature are incorporated into the pump station site to provide a complete and functional facility. Depending on project funding and YTID's preference, other options could be considered during final design.

(b) Power Transmission System

The power supply will include transmission lines to an onsite switchyard. The exact supply voltage and source of the power will be reviewed with the power supplier and is not yet known. Incoming power will be connected to two 36-MVA transformers (nominal conceptual size) with appurtenant switching, power measurement, and protective devices. Each transformer string will be located in a fenced switchyard adjacent to the electrical building.

8.1.2.2 Pipeline

The main conveyance pipeline will be 96 inches in diameter, cement mortar lined and coated welded steel pipe, with a maximum nominal wall thickness of 0.625 inch; it will be approximately 15,300 feet in total length. The pipeline starts at the downstream end of the pump discharge header buried beneath the floor of the pump building, crosses under Highway 12 and over the Naches River on a new bridge, passes through the flow control station and flow metering structure, and then enters a tunnel at the base of the 500-foot-high cliffs paralleling the river. The pipeline exits the tunnel about 4,600 LF to the south in an orchard area and in line with Noye Road. The pipeline follows Noye Road and ends at a new valve vault structure that would be installed on the existing 90-inch YTID pipeline. The pipeline will provide bi-directional flow capability to allow for both supplying the YTID system (with or without NFCCR) and returning water to the Naches River.

It is expected that the pipeline will be excavated (open trench) into the native soil and rock for approximately 19 percent of the alignment, in pavement (open trench) across Highway 12 and along Noye Road (48 percent of the alignment), in a tunnel for 31 percent of the alignment. For open trenched sections, a typical cover depth of 5 feet is assumed and a sand-cement slurry is assumed for the pipe zone, with native materials and a road structural section, as applicable, above the pipe zone.

This study has assumed that the pipeline will crosses Highway 12 with open trenching, rather than by bore-and-jack or microtunneling. The Naches River crossing is assumed to be achieved with a new dual-purpose, bridge that will also be needed for construction and long-term O&M access to the Naches River discharge facilities. The bridge will be approximately 309 feet long, with a 14-foot-wide vehicle lane alongside the 96-inch-diameter pipeline, and 3 100-foot-long spans with 2 interior piers.

The reach of pipeline, which ascends from the base of the cliffs to the plateau, was considered most feasible to be tunneled, employing a two-stage process to mine the tunnel and then install the 96-inch-diameter steel pipeline. A tunnel with a 120-inch-diameter was determined to be appropriate for pipeline installation, and a Main Beam Gripper TBM would provide a suitable means of mining the tunnel for this application. A starter tunnel at the base of the cliff would be about 20 feet in diameter and 200 feet long and flat, to provide enough room to curve the TBM to the 10 percent upward slope for the remainder of the 4,550 LF of 120-inch-diameter tunnel. At the end of the tunnel, a 50-foot-long (horizontal) shaft with about 70 feet of depth is needed to terminate the mining operation, install the pipeline, and construct pipeline fittings as needed to transition to open trench construction. Once the tunnel is complete, the 96-inch-diameter welded steel pipe would be installed by inserting and welding one piece of pipe at a time, then filling the annular space outside the pipe with grout.

8.1.2.3 Naches River Return Flow Facilities

A flow control station and baffled apron drop outlet structure are planned for returned flow from FCR to the Naches River using the Wapatox project facilities. The flow control station will provide the needed head loss to control flows from FCR into the river. The flow control station was conceptualized with three flow control trains, including sleeve valves and associated isolation valves. A variety of instruments will be provided to monitor valve position and pressure in the flow control station. A PLC will be located at the flow control station to provide control logic required to modulate the flow control valves.

Flow will be discharged into a pipeline leading to the baffled apron drop outlet structure. The baffled apron drop structure is a concrete outlet structure intended to allow return flows to discharge into the river in a controlled manner. The hydraulic design of the structure includes drop and velocity management features to minimize fisheries impacts and is assumed to be acceptable to the applicable resource agencies.

8.1.2.4 Flow Measurement Structure

A flow measurement structure is proposed to measure pumping and Naches River return flow rates and volumes. The flow measurement structure will be placed along the main conveyance pipeline a suitable distance downstream of the flow control station (toward FCR) to facilitate measuring flow in a straight pipe. A multi-path ultrasonic flowmeter was assumed for this application, since it is relatively accurate and allows flow measurement in either direction.

8.1.3 Cultural and Environmental Analyses

This feasibility study included a brief assessment of environmental and cultural resources that could potentially be affected by the project, and what actions would need to be taken during future phases of the project to comply with applicable state and federal requirements. The assessment was limited to what could be observed from a review of existing literature and from a brief site visit.

8.1.3.1 Environmental Resources

Several wetlands and surface waters identified by the NWI and NHD are located within the project area. The USFWS ECOS system indicates seven federally listed threatened, endangered, and proposed threatened species (birds, fish, and mammals) that could occur or be potentially impacted by the project. Two listed species, bull trout and steelhead, occur in the project area. Three WDFW priority habitats (shrub-steppe, cliffs/bluffs, and riparian) were identified in the project area. There are no documented occurrences of any WNHP rare plants in the project area. Potential impacts to these priority habitats and priority/federal and state-listed species, in terms of acreages inundated by the diversion, pump station, pipeline and bridge, are tabulated in Section 6.

8.1.3.2 Cultural Resources Summary

The WISAARD database lists six previous cultural resources inventory efforts within 1 mile of the proposed pipeline. All archaeological sites that have been identified within 1 mile of the proposed alternatives are precontact sites, consisting of lithic scatters, rock shelters, and rock cairns, and burials. One site has been evaluated and determined eligible for listing on the NRHP (45YK113). This site, consisting of rock cairns and possible cremation pits, is on the western side of the Tieton River, opposite the proposed project alternatives, and will not be impacted by the project activities. No previously documented historical archaeological sites are located within 1 mile of the proposed alternatives. There are no previously recorded cultural resources or historical properties of any kind intersecting the proposed alternatives.

8.2 Recommendations

8.2.1 Future Engineering Evaluations and Onsite Investigations

To confirm feasibility of the proposed layouts for the pump station, bridge, pipeline, and tunnel and determine if alternatives could offer cost savings, site-specific information is needed. It is recommended that a geotechnical exploration be performed, including the following minimum elements:

1. Place borings along the pipeline alignment (open-trench sections) every 1,000 LF to determine the nature of the materials that would be encountered during construction, location of groundwater, and other key design and construction considerations. This step could optionally include borings also along the alternative alignments described in Section 4.
2. Place at least four borings at the pump stations site and two more immediately adjacent to the river bank at each end of the proposed bridge site.
3. Investigate slope stability at the proposed tunnel portal at the base of the cliffs, and in other locations near the cliffs where open-trench construction or above-ground pipeline construction could be considered in lieu of tunneling (described as alternatives considered in Section 4).
4. Based on the results of geotechnical investigations, note that additional analyses of pipeline/tunnel alignments and the potential to replace some of the tunneling with open-trenching or above-ground pipeline through the cliff section may be warranted.
5. Conduct additional analyses, if deemed appropriate and if NFCCR is still seen as viable, to see if there are opportunities to reduce the size of the pumping and conveyance facilities by reducing the peak flow rates. This would require modeling, optimization, and water rights analysis that was beyond the scope of this study.

8.2.2 Environmental Resources

The construction of the proposed project may include funding from state and federal sources. As such, the proposed project would need to comply with the stipulations set forth by various federal and state acts before construction could proceed. Initial steps towards compliance with the CWA and SMA would involve a wetland and ordinary high water mark delineation of the project area. After the receipt of a preliminary jurisdictional determination from the USACE, a Section 401/404 permit application would be filed to allow the discharge of dredged or fill material into jurisdictional wetlands and waters. Necessary permits would be filed with Ecology to allow construction within riparian zones, in compliance with the SMA. Mitigation and avoidance measures would be developed as part of the permitting and design process.

Should the project continue to advance with anticipation of state/federal funding, an EA should be initiated to ensure compliance with the NEPA. The EA would determine the significance of any impacts from the proposed project, and would satisfy requirements of the SEPA. SEPA follows similar protocol as NEPA, and permits the issuance of joint documents.

Consultation with the NMFS and Yakama Nation would be recommended to assess any impacts to protected fish downstream of the proposed diversion.

The EA development and NMFS consultation could begin immediately. A wetland delineation could be performed at any time during the growing season. As the first step in a months-long process of USACE permitting, it is recommended that the delineation occur once funding for the project is secured.

8.2.3 Cultural Resources

If the proposed Wapatox pipeline is selected for further development, design, or construction, then inventory surveys are recommended within the construction footprint to identify NRHP eligible properties. Although most of the proposed route alternatives are within a disturbed environment along a road through an agricultural area, according to the DAHP predictive model and density of surrounding resources in previously inventoried areas, cultural resource surveys along the northern end of the project are highly likely to result in the identification of additional resources. Future surveys in the project area will require subsurface testing due to the depositional environment on river terraces.

Once the route and associated activities have been well defined within an APE, the exact location of archaeological site 45KY112 needs to be verified. This site was originally mapped in the 1960s and the hand-drawn map puts the site close to the preferred alternative route. If it does intersect the construction footprint/APE then the site form will need to be updated and the site will need to be evaluated for eligibility on the NRHP, unless avoidance is possible.

To determine whether project implementation will result in adverse effects to historic properties as defined by Section 106 of the NHPA, a DOE for the NRHP would need to occur for each of the identified sites within the APE (once it has been defined), including those that may be identified during survey, or previously recorded. Doing so would be a necessary step towards meeting the requirements, as outlined in Section 106 of the NHPA. To assess whether previously undocumented traditional cultural properties are located within the site, consultation with the affected tribes and State Historic Preservation Office should occur.

In addition to cultural resource field investigations, cultural resources monitoring is recommended during excavation and construction within the valley/canyon. This is due to the sensitive nature of the area from proximity of known burials and cremation locations, and the difficulty in identifying such sensitive features within talus slopes.

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Appendix A
Conceptual Design Drawings

EXHIBIT 1
OVERALL SITE PLAN

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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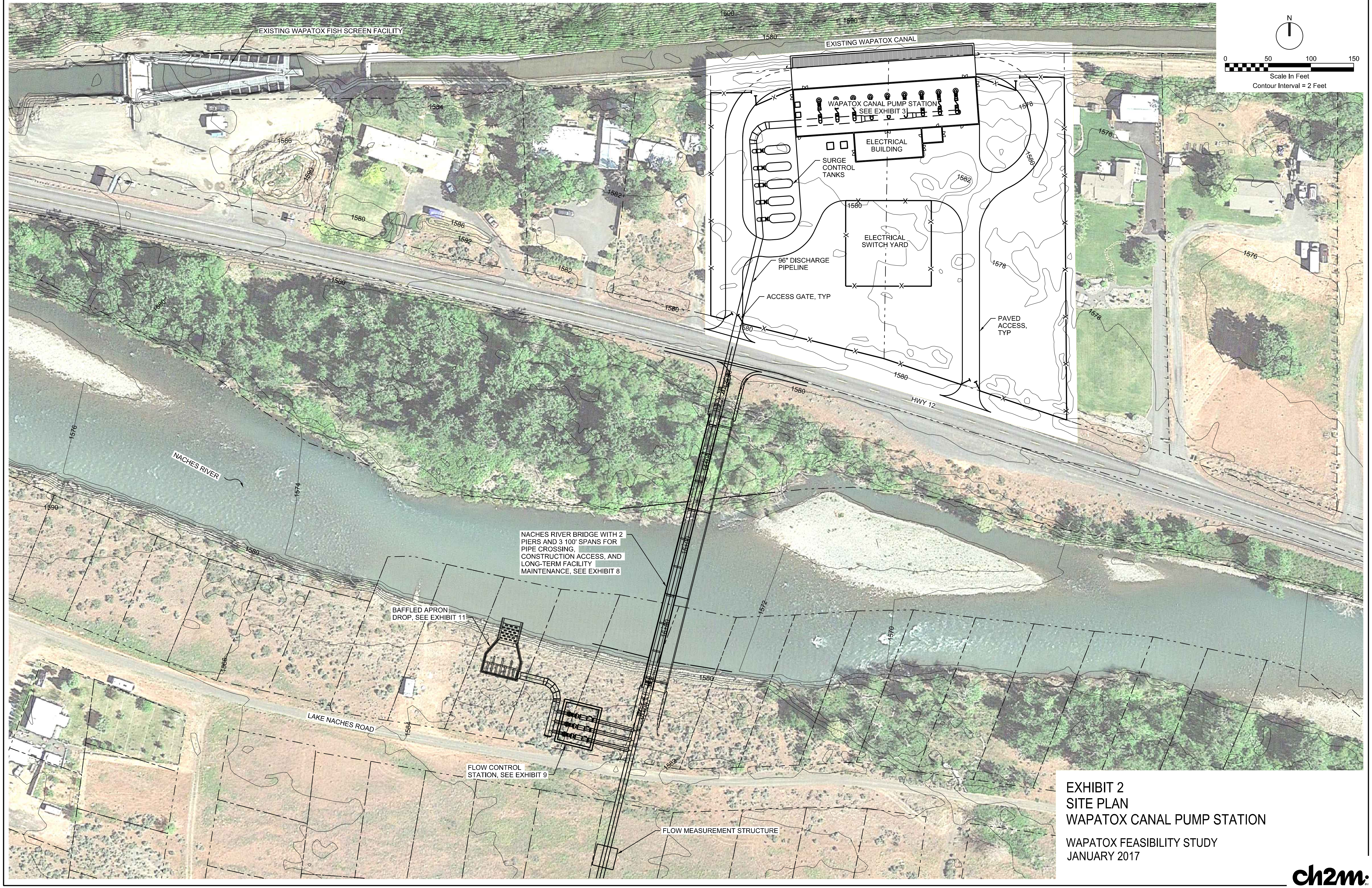

EXHIBIT 2
SITE PLAN
WAPATOX CANAL PUMP STATION

WAPATOX FEASIBILITY STUDY
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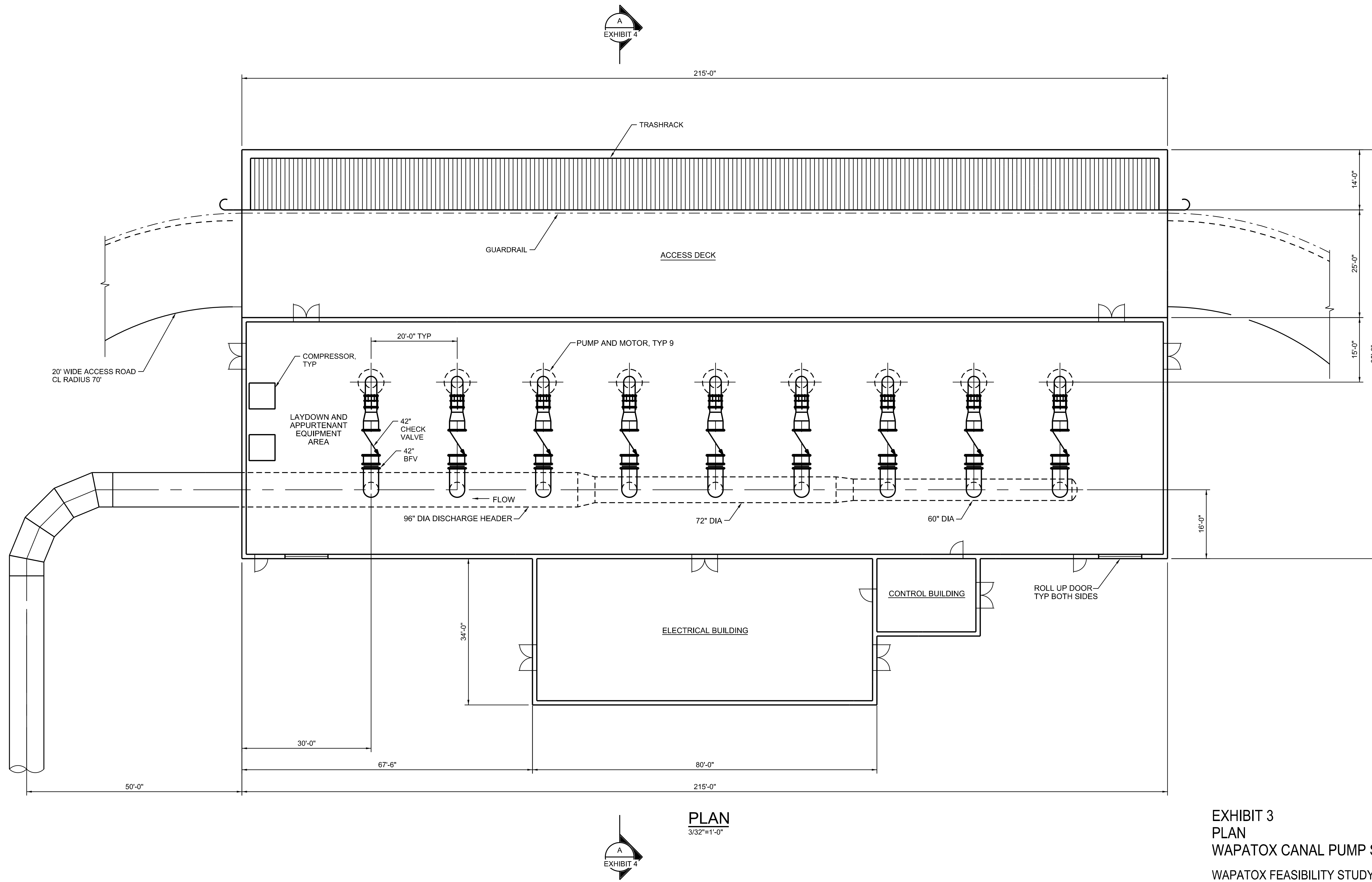

EXHIBIT 3
PLAN
WAPATOX CANAL PUMP STATION

WAPATOX FEASIBILITY STUDY
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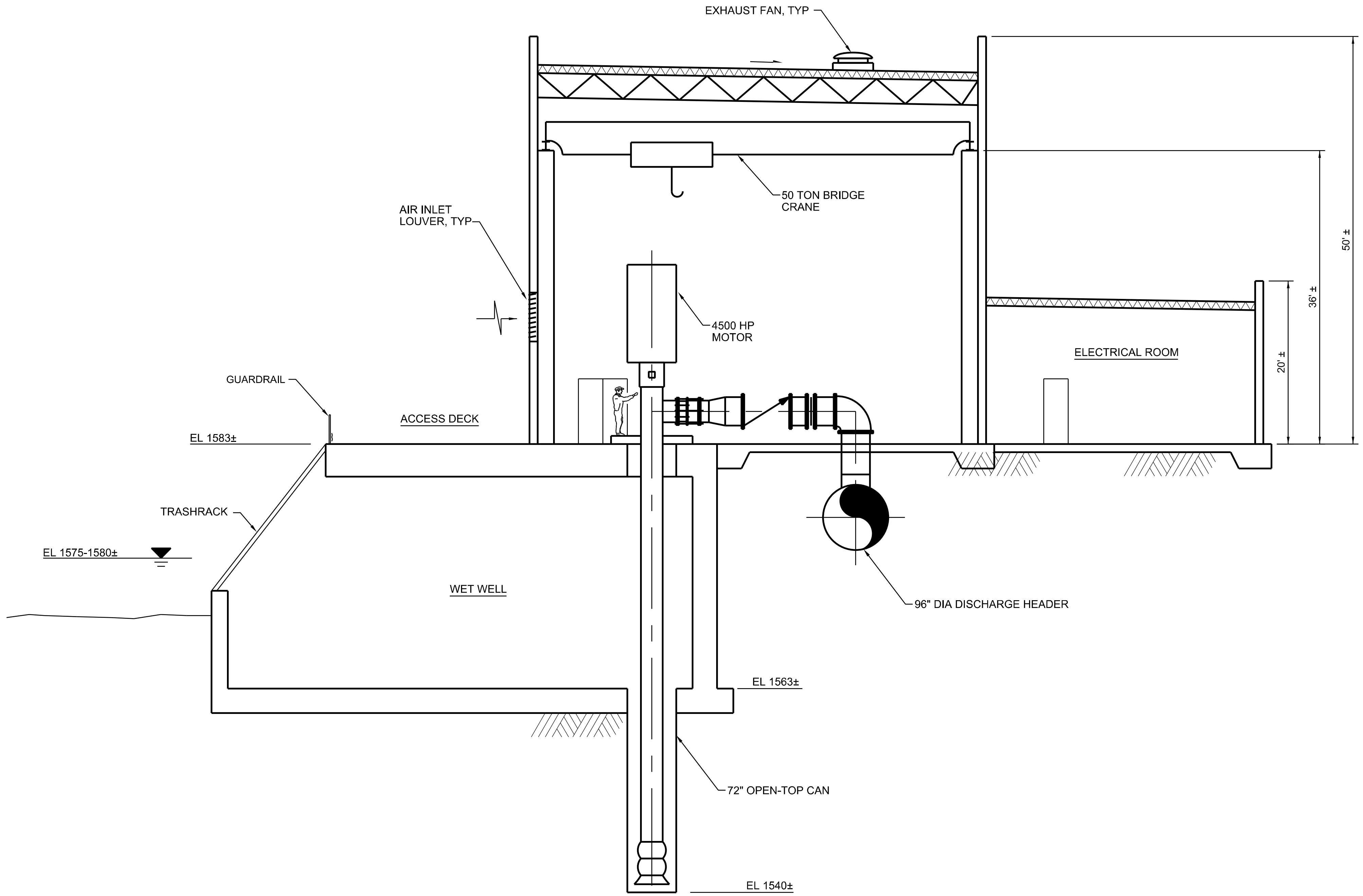

A SECTION
1/8"=1'-0"
EXHIBIT 3

EXHIBIT 4
SECTION
WAPATOX CANAL PUMP STATION

WAPATOX FEASIBILITY STUDY
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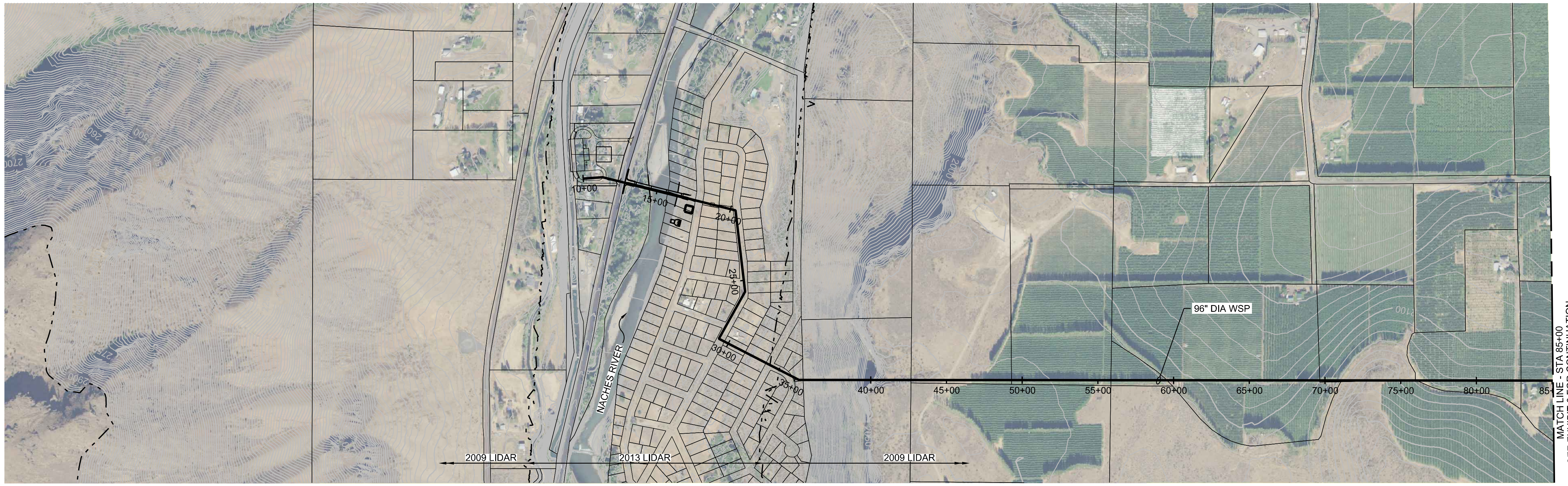
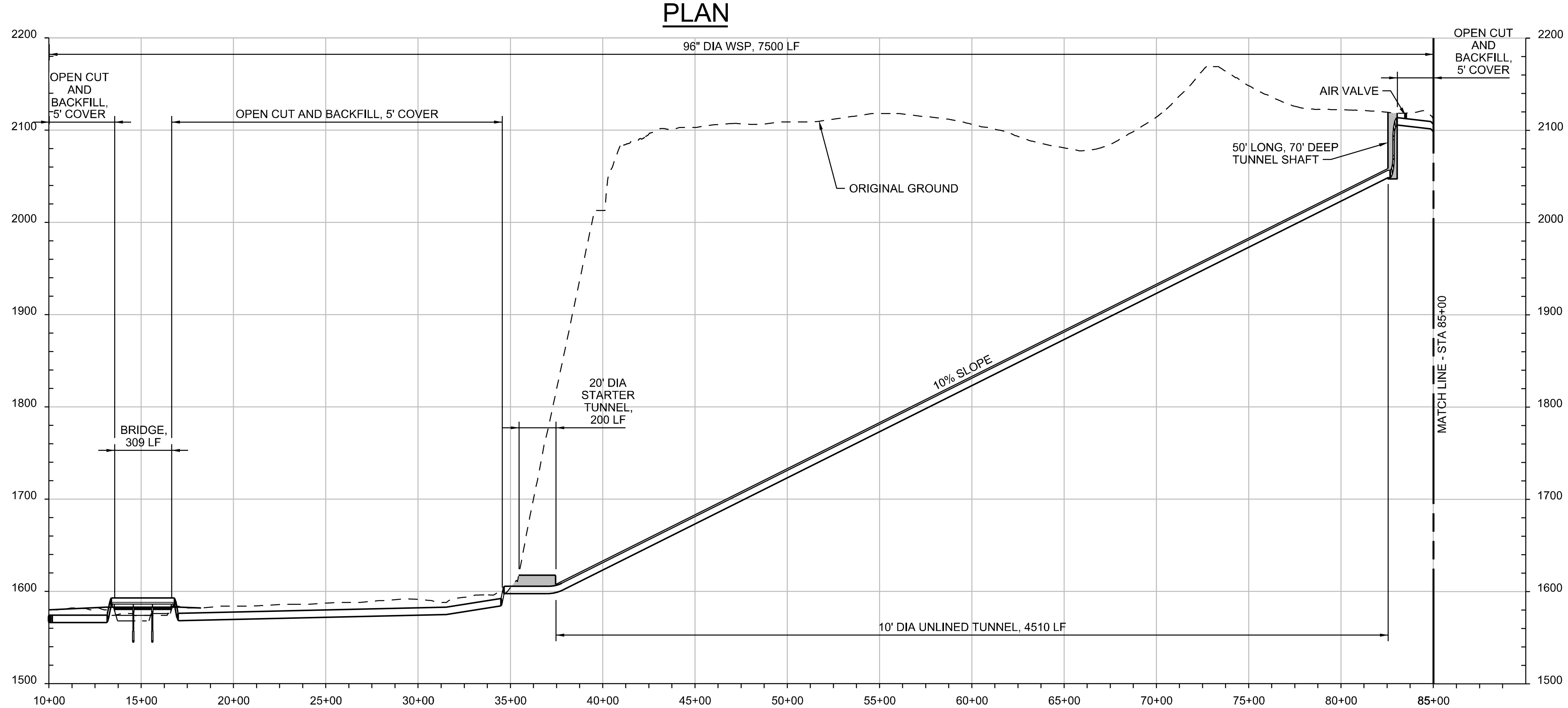


PLAN



PROFILE

HORZ: 1"=400'
VERT: 1"=80'

EXHIBIT 5
PLAN AND PROFILE
PIPELINE AND TUNNEL STA 10+00 TO STA 85+00

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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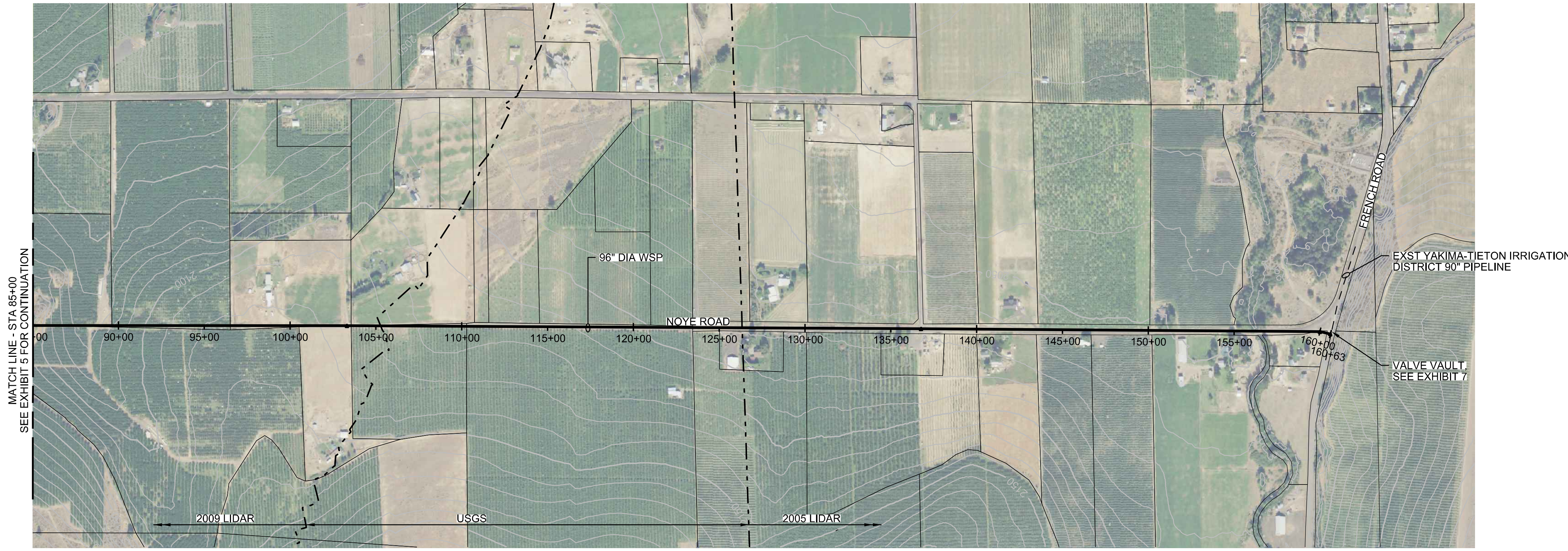
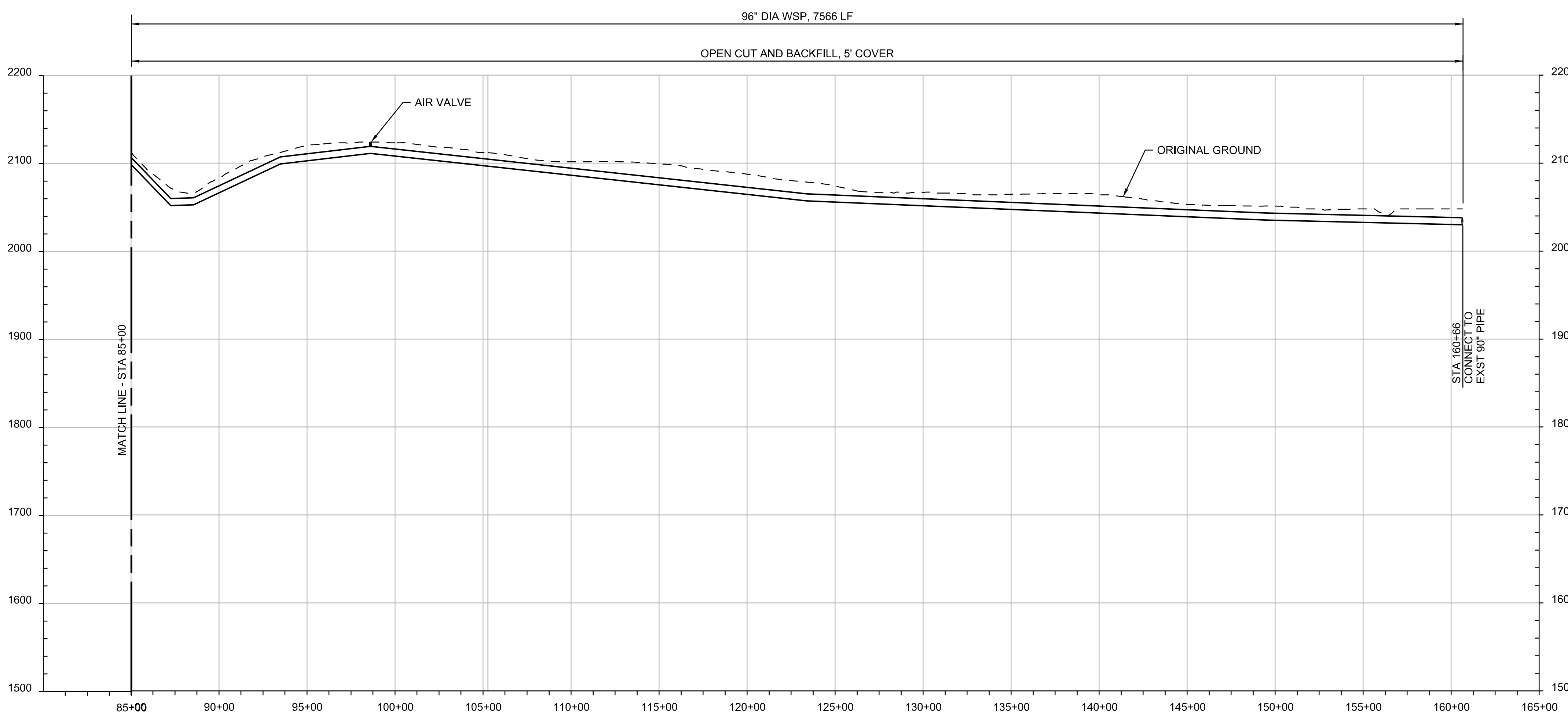


PLAN



PROFILE

HORZ: 1"=400'
VERT: 1"=80'

EXHIBIT 6
PLAN AND PROFILE
PIPE AND TUNNEL STA 85+00 TO STA 160+66

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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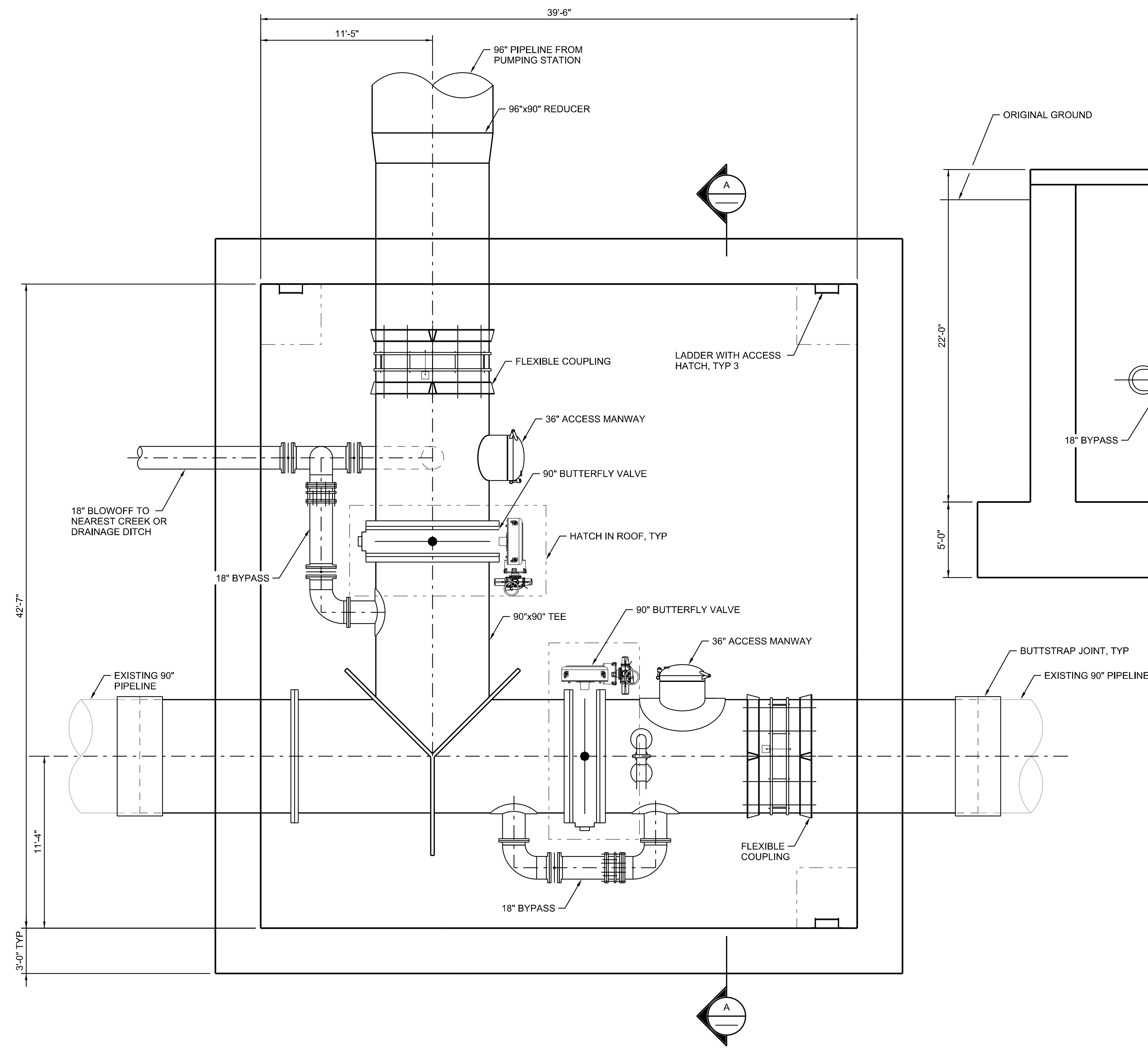
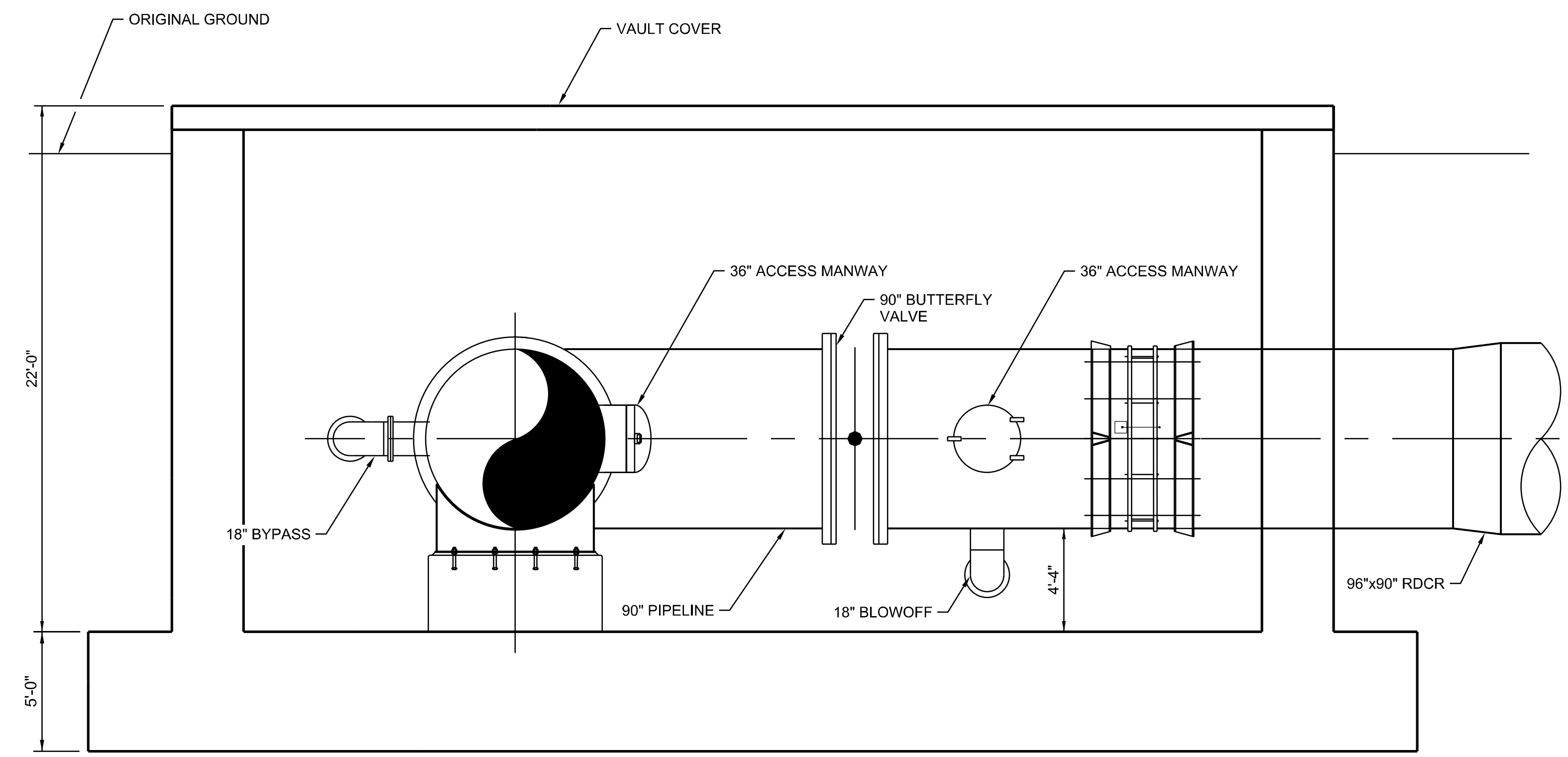


VALVE VAULT AT CONNECTION TO EXISTING 90" PIPELINE

PLAN
1/4"=1'-0"

N



A SECTION
1/4"=1'-0"

EXHIBIT 7
PLAN AND SECTION
VALVE VAULT

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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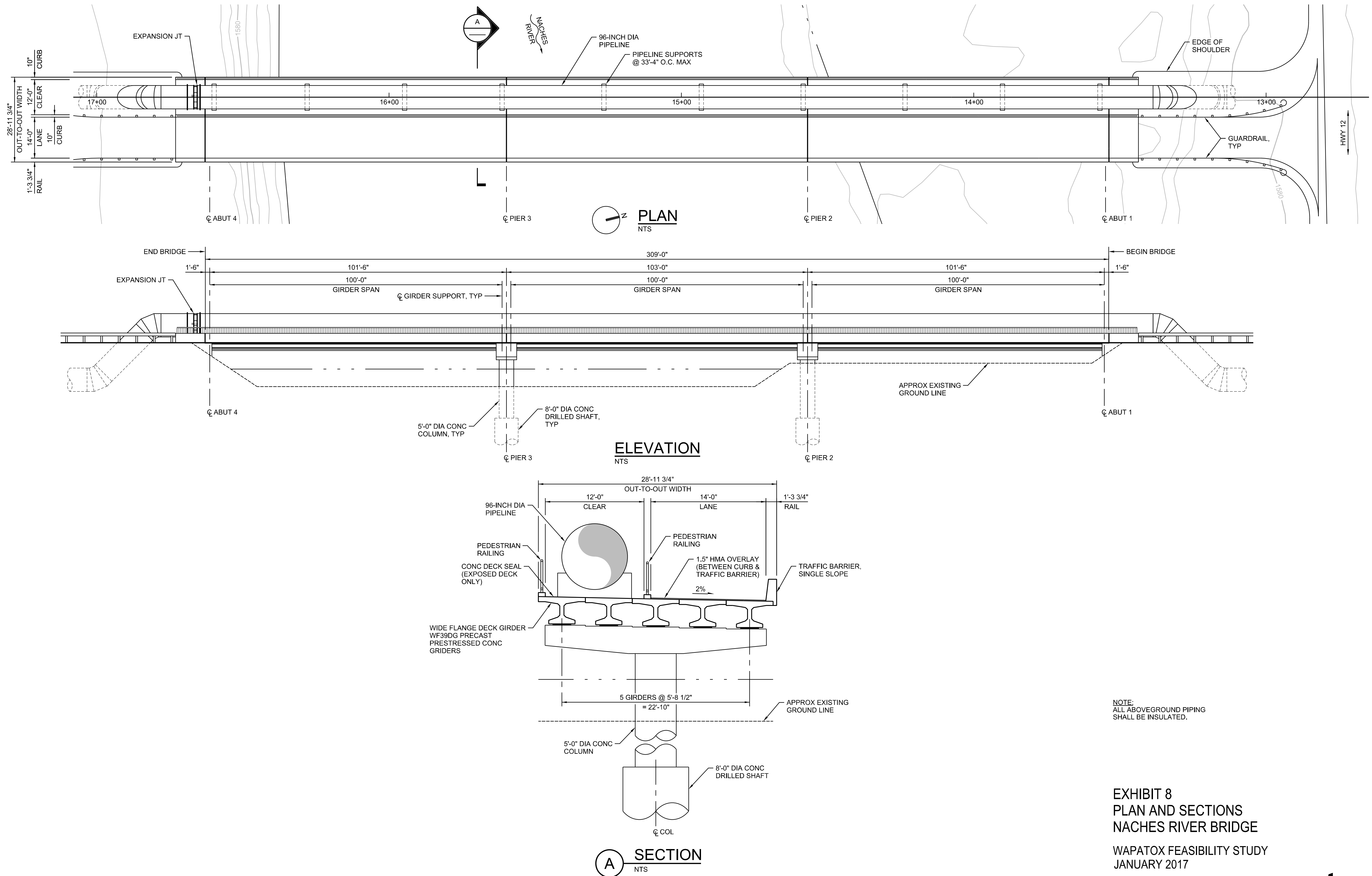

NOTE:
ALL ABOVEGROUND PIPING SHALL BE INSULATED.

EXHIBIT 8
PLAN AND SECTIONS
NACHES RIVER BRIDGE

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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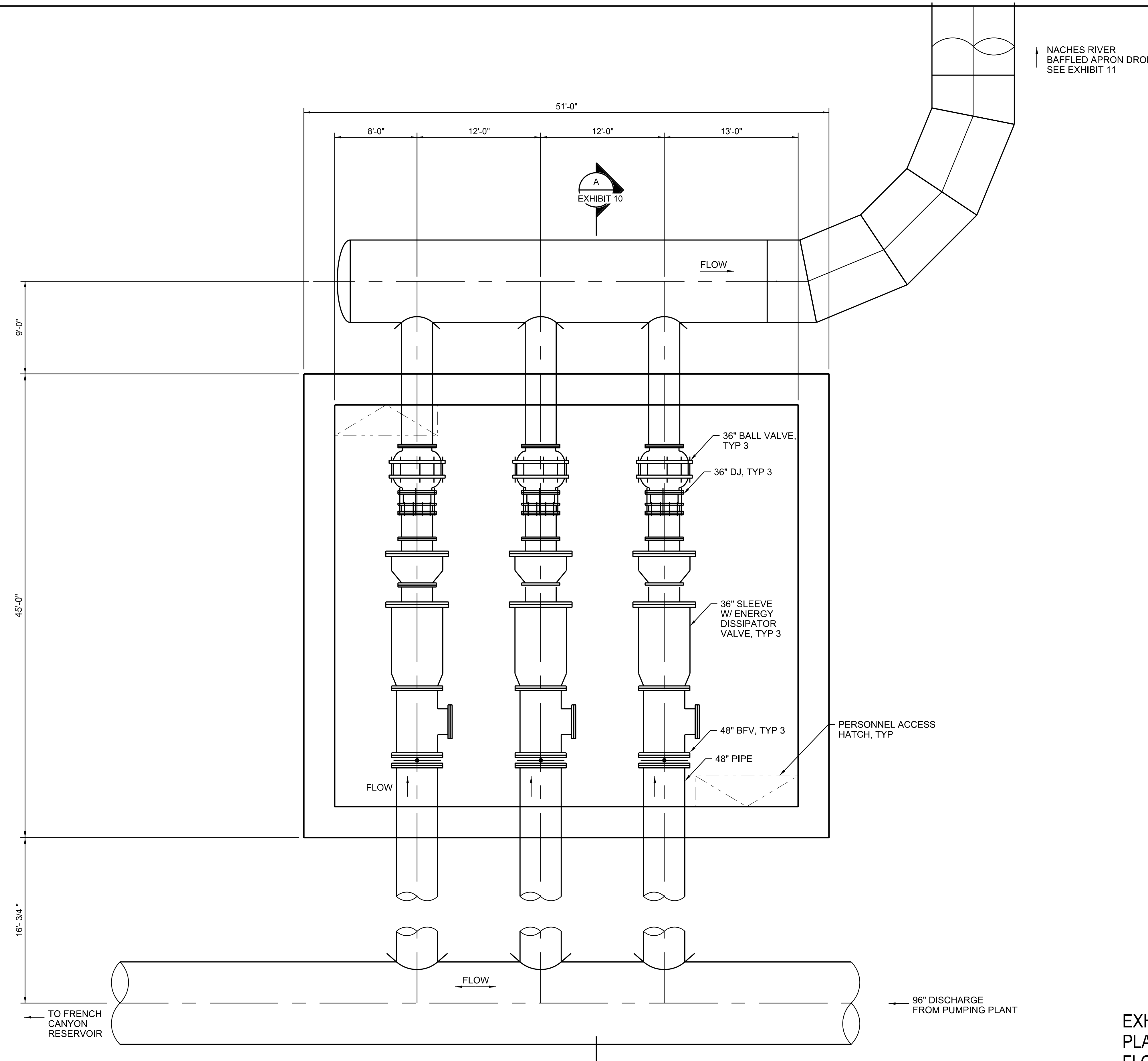

FLOW CONTROL STATION

PLAN

3/32"=1'-0"

EXHIBIT 9
PLAN
FLOW CONTROL STATION

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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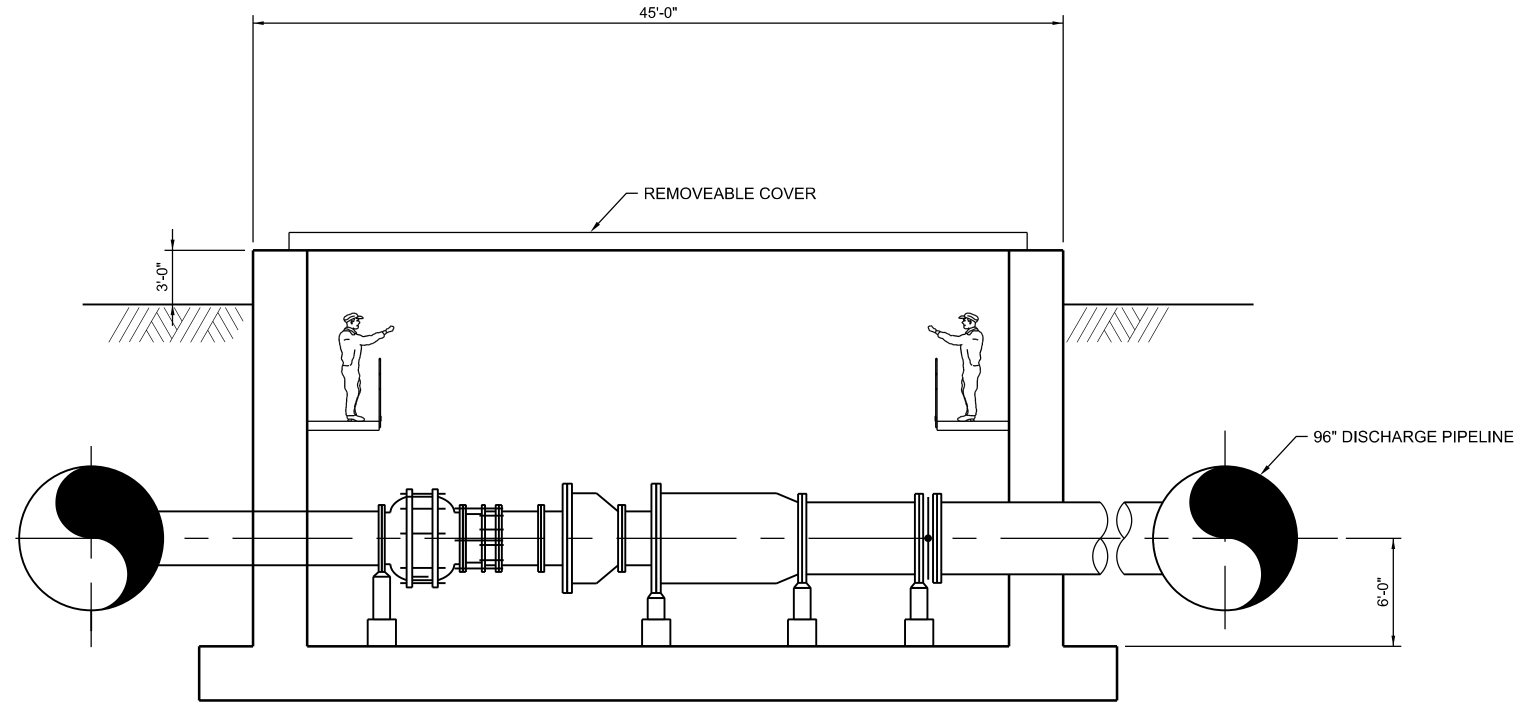

A SECTION
3/32"=1'-0"
EXHIBIT 9

EXHIBIT 10
SECTION
FLOW CONTROL STATION

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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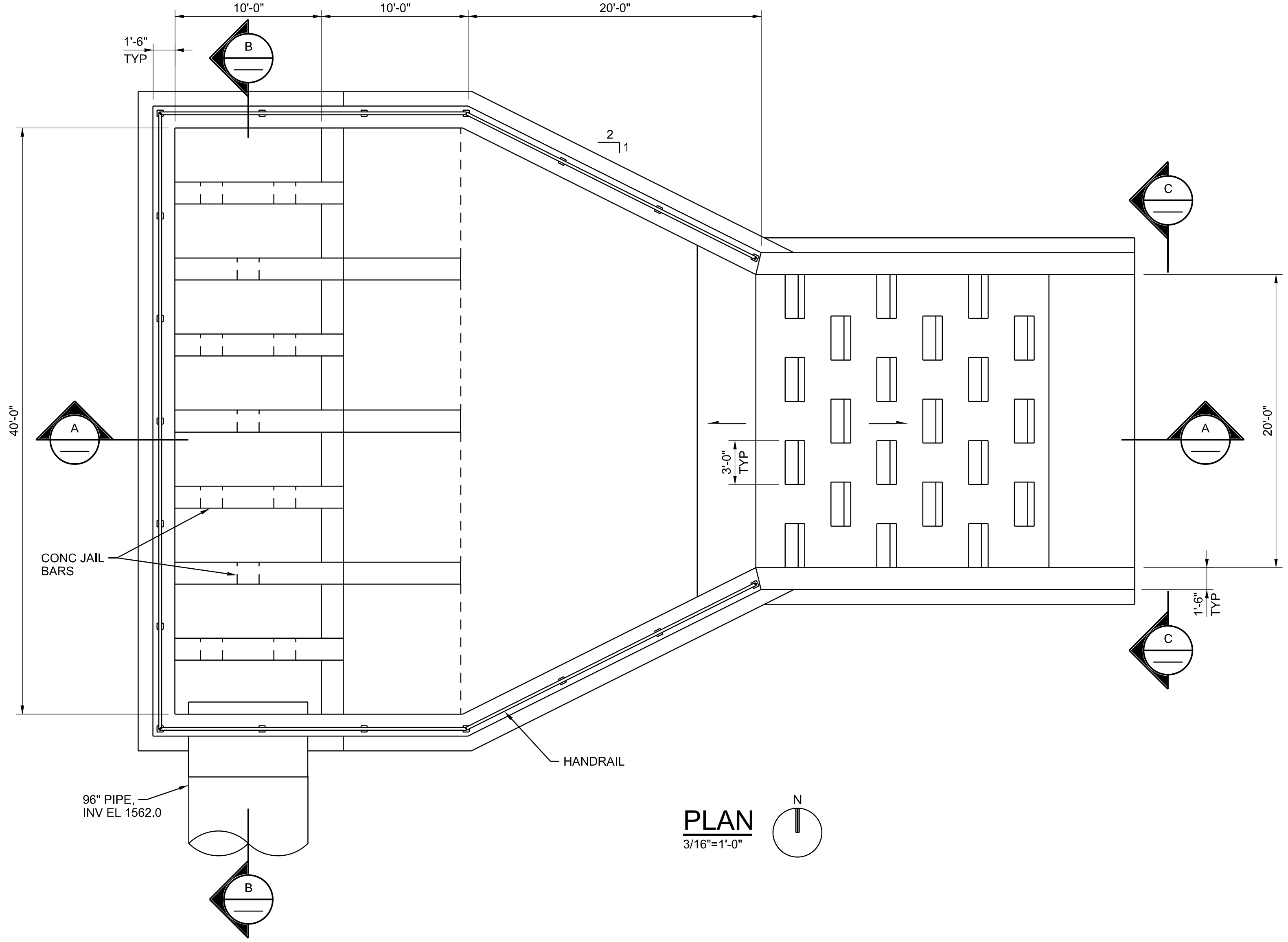

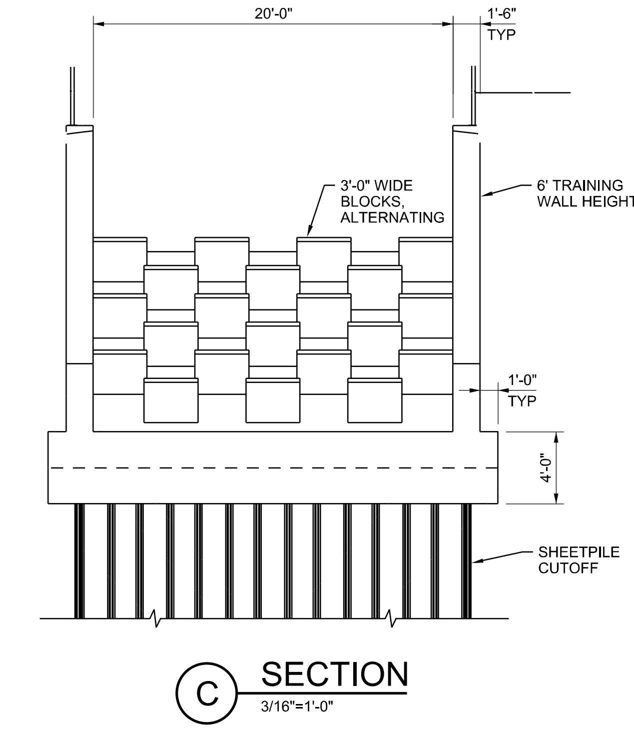

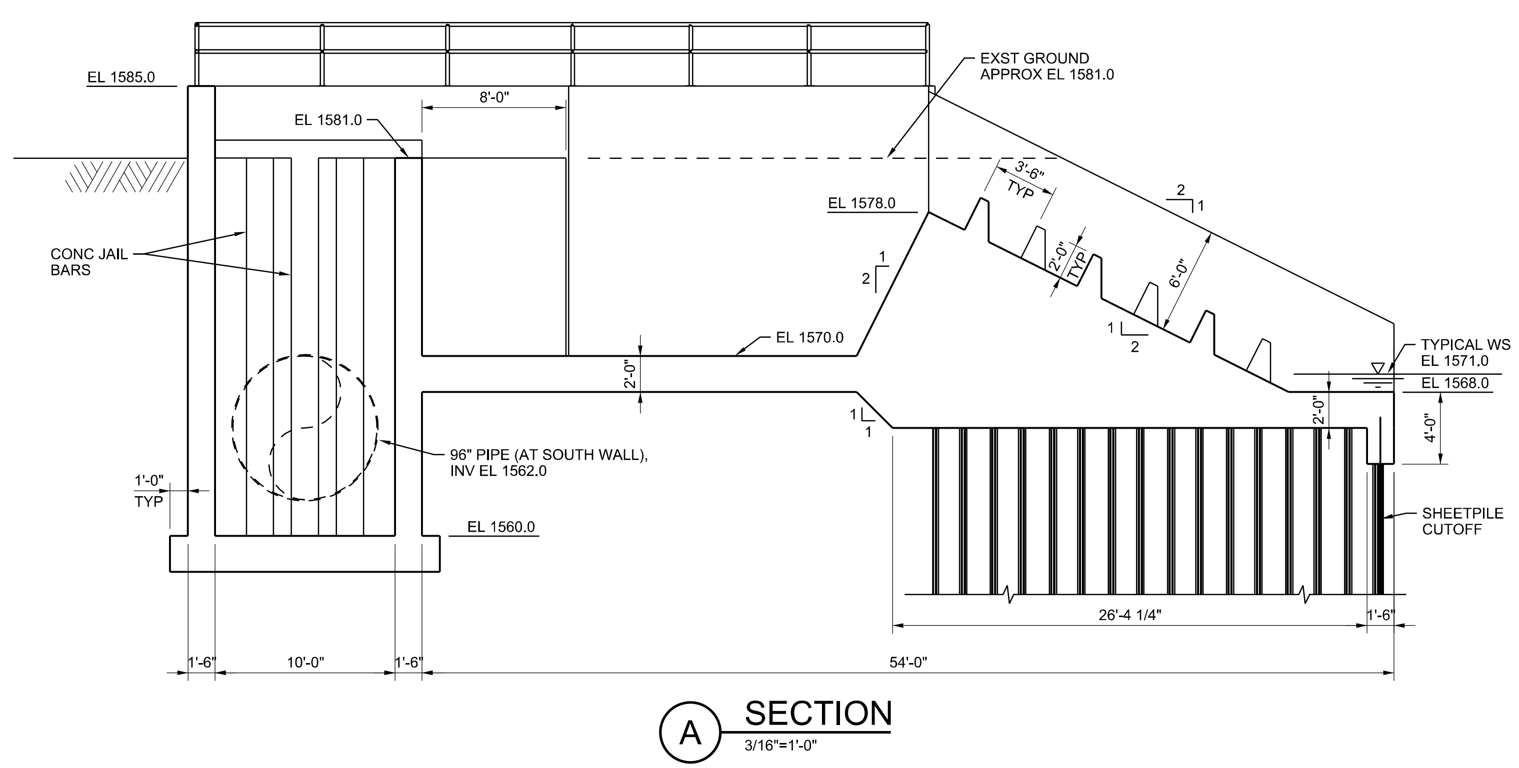

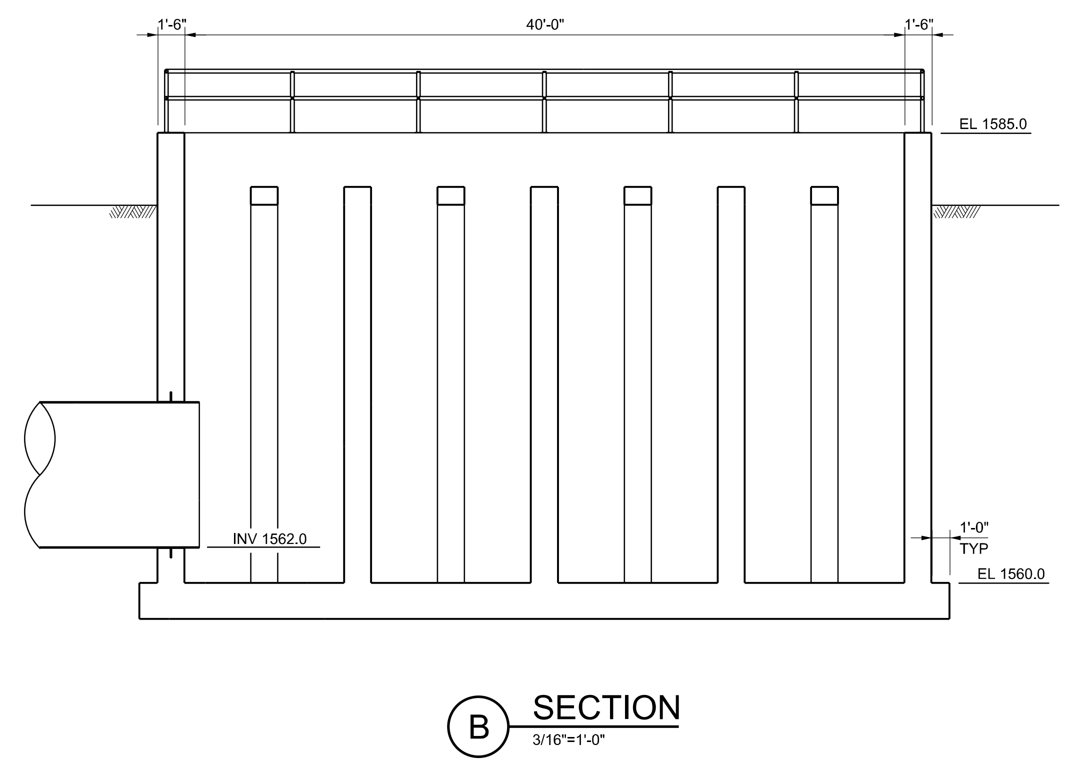

EXHIBIT 11
PLAN AND SECTIONS
BAFFLED APRON DROP

WAPATOX FEASIBILITY STUDY
JANUARY 2017

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Appendix B
Construction Cost Estimates

Wapatox Project

Class 4 Construction Cost Estimate

January, 2017

Facility	2016 Cost	O&M
Apron Drop Structure	$ 2,263,000	$ -
Flow Meter Vault	$ 563,000	$ 5,630
Flow Control Station	$ 5,420,000	$ 27,100
Pump Station	$ 61,554,000	$ 615,540
Main Pipeline	$ 38,739,000	$ 193,695
Naches River Pipe Bridge	$ 5,417,000	$ 54,170
Cliff Tunnel	$ 16,080,000	$ 80,400
	$ 130,036,000	**$ 976,535**

Notes:

1. See individual cost sheets for breakdown
2. Costs include contractor's General Conditions, overhead and profit
3. Costs include 30% contingency
4. No cost included for land acquisition, admin, legal, engingeering, construction management, environmental mitigation, or permitting
5. Cost are 4th qtr 2016, no escalation is included
6. Class 4 cost estimates are based on conceptual designs and limited field information. Probable accuracy of cost estimate is 30% below to 50% above bid price, at the time the estimate was completed.

Wapatox Project

Class 4 Construction Cost Estimate

Baffled Apron Drop Structure

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
General						
	Mobilization	1	LS	$ 50,000	$ 50,000	Approximately 3% of Total
	SWPPP	0	LS	$ 3,000	$ -	Included in Flow Control Station
	SWPPP Best Practices	0	LS	$ 5,000	$ -	Included in Pump Station
	Demobilization	1	LS	$ 35,000	$ 35,000	Approximately 2% of Total
				Subtotal	**$ 85,000**	
Site Work						
	Clearing and Grubbing	0.5	AC	$ 5,000	$ 2,296	
	Dewatering	1.0	LS	$ 30,000	$ 30,000	
	Sheet Pile	12000	SF	$ 50	$ 600,000	
	Tremmie Seal	526	CY	$ 150	$ 78,944	
	Site Grading	741	CY	$ 10	$ 7,410	Assume 1 foot over cleared area
	Gravel Surfacing	1250	SQFT	$ 1.50	$ 1,875	
				Subtotal	**$ 720,525**	
Vault Structural						
	Excavation	2950	CY	$ 25	$ 73,750	Inside Sheets
	Substructure Fill	1061	CY	$ 150	$ 159,167	
	Concrete-Slab	399	CY	$ 750	$ 299,250	
	Concrete-Walls	279	CY	$ 1,000	$ 279,000	
	Concrete-Special	31	CY	$ 1,250	$ 38,750	Columns, beams, baffles
	Hand Rail	1	LS	$ 5,000	$ 5,000	
	Misc Structural	1	LS	$ 75,000	$ 75,000	Allowance
				Subtotal	**$ 929,917**	
Vault Mechnical						
	n/a	0	LS	$ 10,000	$ -	No mechanical
				Subtotal	**$ -**	
Electrical and I&C						
	Misc electrical	1	LS	$ 2,500	$ 2,500	Allowance for conduit, cable, etc
	Misc instrumentation and control	1	LS	$ 3,000	$ 3,000	Allowance for instruments
				Subtotal	**$ 5,500**	

Wapatox Project
Class 4 Construction Cost Estimate
Baffled Apron Drop Structure

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
Totals						
				Subtotal	**$ 1,740,942**	
				Contingency (30%)	$ 522,280	
				Subtotal	**$ 2,263,222**	
				Total Facility Cost	**$ 2,263,000**	

Wapatox Project

Class 4 Construction Cost Estimate

Flow Meter Vault

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
General						
	Mobilization	1	LS	$ 13,000	$ 13,000	Approximately 3% of Total
	Start-up/Testing	1	LS	$ 2,500	$ 2,500	Allowance
	Demobilization	1	LS	$ 8,700	$ 8,700	Approximately 2% of Total
				Subtotal	**$ 24,200**	
Site Work						
	Clearing and Grubbing	0.00	AC	$ 5,000	$ -	Included in FC Station
	Site Grading	0	CY	$ 10	$ -	Included in FC Station
	Gravel Surfacing	0	SQFT	$ 1.5	$ -	Included in FC Station
	Bollards	8	EA	$ 500	$ 4,000	
				Subtotal	**$ 4,000**	
Vault Structural						
	Excavation	1210	CY	$ 17	$ 20,570	
	Backfill	1000	CY	$ 25	$ 25,000	
	Concrete-Slab	40	CY	$ 750	$ 30,000	
	Concrete-Walls	140	CY	$ 1,000	$ 140,000	
	Top Hatch	1	EA	$ 15,000	$ 15,000	
	Removable Roof Panels	290	SF	$ 50	$ 14,500	
	Interior Metals	1	LS	$ 2,500	$ 2,500	Allowance
	Misc Structural	1	LS	$ 5,000	$ 5,000	Allowance
				Subtotal	**$ 252,570**	
Vault Mechnical						
	Ultrasonic Flowmeter	1	EA	$ 100,000	$ 100,000	
	Sump Pump and Piping	1	EA	$ 15,000	$ 15,000	
	HVAC/ducting	1	LS	$ 10,000	$ 10,000	
	Misc Mech	1	LS	$ 5,000	$ 5,000	Allowance at vault
				Subtotal	**$ 130,000**	
Electrical and I&C						
	Site Electrical	1	LS	$ 7,500	$ 7,500	Power/signal run and ground
	110/200V Panel	1	EA	$ 5,000	$ 5,000	

Wapatox Project

Class 4 Construction Cost Estimate

Flow Meter Vault

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
	Vault Wiring	1	LS	$ 2,500	$ 2,500	
	Misc electrical	1	LS	$ 2,500	$ 2,500	Allowance for lighting, conduit, cable, etc
	Misc instrumentation and control	1	LS	$ 5,000	$ 5,000	Allowance for instruments, network switches, wiring, etc
				Subtotal	**$ 22,500**	
Totals						
				Subtotal	**$ 433,270**	
				Contingency (30%)	$ 129,980	
				Subtotal	**$ 563,250**	
				Total Facility Cost	**$ 563,000**	

Wapatox Project

Class 4 Construction Cost Estimate

Flow Control Station

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
General						
	Mobilization	1	LS	$ 125,000	$ 125,000	Approximately 3% of Total
	SWPPP	1	LS	$ 3,000	$ 3,000	
	SWPPP Best Practices	0	LS	$ 5,000	$ -	Included in Pump Station
	Start-up/Testing	1	LS	$ 25,000	$ 15,000	Allowance
	Demobilization	1	LS	$ 85,000	$ 85,000	Approximately 2% of Total
				Subtotal	**$ 228,000**	
Site Work						
	Clearing and Grubbing	0.5	AC	$ 5,000	$ 2,296	
	Dewatering	1.0	LS	$ 30,000	$ 30,000	
	Site Grading	741	CY	$ 10	$ 7,410	Assume 1 foot over cleared area
	Gravel Surfacing	3750	SQFT	$ 1.50	$ 5,625	
	Bollards	6	EA	$ 500	$ 3,000	
				Subtotal	**$ 48,331**	
Vault Structural						
	Excavation	5220	CY	$ 10	$ 52,200	
	Backfill	3310	CY	$ 25	$ 82,750	
	Concrete-Slab	323	CY	$ 750	$ 242,250	
	Concrete-Walls	460	CY	$ 1,000	$ 460,000	
	Top Hatch	2	EA	$ 15,000	$ 30,000	
	Removable Roof Panels	2300	SF	$ 50	$ 115,000	
	Interior Walkways	620	SF	$ 50	$ 31,000	
	Misc Structural	1	LS	$ 75,000	$ 75,000	Allowance
				Subtotal	**$ 1,088,200**	
Vault Mechnical						
	96" Headers	1	LS	$ 375,000	$ 375,000	Not including pipe
	96" Pipe	100	LF	$ 2,440	$ 244,000	Includes allowance for elbow and connection
	48/36" Piping	1	LS	$ 625,000	$ 625,000	
	48" BFV	3	EA	$ 50,000	$ 150,000	
	36" Sleeve/Plunger Valve	3	EA	$ 300,000	$ 900,000	

Wapatox Project

Class 4 Construction Cost Estimate

Flow Control Station

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
	36" Ball Valve	3	EA	$ 110,000	$ 330,000	
	Sump Pump and Piping	1	EA	$ 15,000	$ 15,000	
	HVAC/ducting	1	LS	$ 10,000	$ 10,000	
	Misc Mech	1	LS	$ 10,000	$ 10,000	Allowance at vault
				Subtotal	**$ 2,659,000**	
Electrical and I&C						
	Site Lighting	1	LS	$ 1,000	$ 1,000	Allowance
	Site Electrical	1	LS	$ 50,000	$ 50,000	Power/signal run and ground
	480V Panel	1	EA	$ 15,000	$ 15,000	Panel and Main Disconnect
	110/200V Panel w/XFMR	1	EA	$ 10,000	$ 10,000	
	Vault Wiring	1	LS	$ 30,000	$ 30,000	
	Misc electrical	1	LS	$ 10,000	$ 10,000	Allowance for lighting, conduit, cable, etc
	Misc instrumentation and control	1	LS	$ 30,000	$ 30,000	Allowance for instruments, network switches, wiring, etc
				Subtotal	**$ 146,000**	
Totals						
				Subtotal	**$ 4,169,531**	
				Contingency (30%)	$ 1,250,860	
				Subtotal	**$ 5,420,391**	
				Total Facility Cost	**$ 5,420,000**	

Wapatox Project

Class 4 Construction Cost Estimate

Pump Station

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
General						
	Mobilization	1	LS	$ 1,420,000	$ 1,420,000	Approximately 3% of Total
	SWPPP	1	LS	$ 3,000	$ 3,000	Allowance
	SWPPP Best Practices	1	LS	$ 5,000	$ 5,000	Allowance
	Start-up/Testing	1	LS	$ 150,000	$ 150,000	Allowance
	Demobilization	1	LS	$ 945,000	$ 945,000	Approximately 2% of Total
				Subtotal	**$ 2,523,000**	
Site Work						
	Clearing and Grubbing	3.4	AC	$ 5,000	$ 17,000	
	Perimeter Fence	1300	LF	$ 15	$ 19,500	
	Gates	4	EA	$ 5,000	$ 20,000	
	Dewatering	1	LS	$ 100,000	$ 100,000	
	Sheet Pile	38000	SQFT	$ 50	$ 1,900,000	
	Tremmie Seal	2906	CY	$ 150	$ 435,861	
	Site Grading	10970	CY	$ 10	$ 109,700	Assume 2 feet over entire site
	Site Drainage	1	LS	$ 10,000	$ 10,000	Allowance
	Excavation	23246	CY	$ 25	$ 581,148	Inside sheets
	Backfill	2271	CY	$ 100	$ 227,111	
	Canal Lining	9450	SQFT	$ 25	$ 236,250	
	96" Pipe	300	LF	$ 1,440	$ 432,000	To fence near highway
	Gravel Surfacing	26200	SQFT	$ 1.50	$ 39,300	Switchyard and inside deck access road
	Paved Surfacing (incl AB)	32380	SQFT	$ 5	$ 161,900	
	Site Lighting	1	LS	$ 10,000	$ 10,000	Allowance
	Site Electrical	1	LS	$ 100,000	$ 100,000	
	Bollards	16	EA	$ 500	$ 8,000	
				Subtotal	**$ 4,407,770**	
Surge Control						
	Surge Tanks	5	EA	$ 125,000	$ 625,000	
	Piping	5	EA	$ 40,000	$ 200,000	
	48" BFV	5	EA	$ 50,000	$ 250,000	

Wapatox Project
Class 4 Construction Cost Estimate
Pump Station

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
	Tank Bases	10	EA	$ 12,500	$ 125,000	Concrete saddle bases
	Tank Accessories	5	EA	$ 50,000	$ 250,000	Level chamber, manway, safety, recirc, air in/out, etc
	Compressors and Air Piping	2	EA	$ 100,000	$ 200,000	
	Surge Electrical	1	LS	$ 50,000	$ 50,000	
	Misc instrumentation and control	5	EA	$ 10,000	$ 50,000	
				Subtotal	**$ 1,750,000**	
Pump Station (not including Electrical/Control Rooms)						
	Wet well slab	1743	CY	$ 750	$ 1,307,250	
	Pump room floor	394	CY	$ 750	$ 295,500	
	Wet well walls	1956	CY	$ 1,000	$ 1,956,000	
	Wet well top slab	836	CY	$ 1,000	$ 836,000	
	Exterior PS walls	26900	SQFT	$ 40	$ 1,076,000	Includes finishes
	Roof	12040	SQFT	$ 50	$ 602,000	
	Doors	1	LS	$ 52,500	$ 52,500	Includes all man doors and roll-up doors
	Sidewalks	0	CY	$ 250	$ -	Include in pavement
	Crane support structure	1	LS	$ 250,000	$ 250,000	Allowance
	Misc structural	1	LS	$ 100,000	$ 100,000	Allowance for undefined structural features
	Misc metals	1	LS	$ 50,000	$ 50,000	Allowance-ladders, embeds, wall sleeves, etc.
	Pump Cans	9	EA	$ 160,000	$ 1,440,000	
	Pump bases	9	EA	$ 20,000	$ 180,000	Base, base plate, and bolts
	Trash Rack	1	LS	$ 100,000	$ 100,000	
	Bridge crane	1	LS	$ 100,000	$ 100,000	Includes controls
	Pumps and motors	9	EA	$ 2,000,000	$ 18,000,000	
	Pump discharge piping	9	EA	$ 40,000	$ 360,000	
	Discharge header	1	LS	$ 450,000	$ 450,000	
	Check valves	9	EA	$ 140,000	$ 1,260,000	
	Isolation valves	9	EA	$ 50,000	$ 450,000	
	Exhaust Fans	9	EA	$ 5,000	$ 45,000	Includes control panel
	HVAC ducting	1	LS	$ 50,000	$ 50,000	
	Louvers	9	EA	$ 5,000	$ 45,000	

Wapatox Project

Class 4 Construction Cost Estimate

Pump Station

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
	Misc mechanical	1	LS	$ 100,000	$ 100,000	Allowance for piping etc.
	Misc plumbing	1	LS	$ 25,000	$ 25,000	Allowance for drains/process water
	Lighting	1	LS	$ 100,000	$ 100,000	
	Misc electrical	1	LS	$ 750,000	$ 750,000	Allowance for conduit, cable, etc
	Misc instrumentation and control	1	LS	$ 104,000	$ 104,000	Allowance for instruments, network switches, wiring, etc
				Subtotal	**$ 30,084,250**	
Electrical and Control Room						
	Floor Slab	117	CY	$ 750	$ 87,750	
	Exterior Walls	2560	SQFT	$ 40	$ 102,400	Included finishes
	Roof	2972	SQFT	$ 50	$ 148,600	
	Doors	1	LS	$ 17,500	$ 17,500	Includes all man doors
	Sidewalks	0	CY	$ 250	$ -	Included in pavement
	Misc structural	1	LS	$ 25,000	$ 25,000	Allowance for undefined structural features
	Misc metals	1	LS	$ 10,000	$ 10,000	Allowance-ladders, embeds, wall sleeves, etc.
	Equipment bases	12	CY	$ 400	$ 4,889	
	Main switchgear	1	EA	$ 750,000	$ 750,000	
	RVSS	9	EA	$ 110,000	$ 990,000	
	MCC	2	EA	$ 150,000	$ 300,000	
	480V Panelboard	2	EA	$ 25,000	$ 50,000	
	110/220 Panelboard w/xfmr	4	EA	$ 15,000	$ 60,000	
	HVAC	1	EA	$ 150,000	$ 150,000	Allowance for A/C unit and ducting
	Lighting	1	LS	$ 25,000	$ 25,000	
	Misc electrical	1	LS	$ 250,000	$ 250,000	Allowance for conduit, cable, etc
	Main PLC Panel	1	EA	$ 100,000	$ 100,000	
	Control/SCADA workstation	1	EA	$ 25,000	$ 25,000	Includes desk/chair and computer equipment
	Network/Comms panel/racks	1	EA	$ 50,000	$ 50,000	
	UPS	2	EA	$ 20,000	$ 40,000	
	Fire Detection/Alarm	1	LS	$ 100,000	$ 100,000	
	Security	1	LS	$ 100,000	$ 100,000	
	Misc instrumentation and control	1	LS	$ 150,000	$ 150,000	Allowance for instruments, network interface, wiring, etc

Wapatox Project

Class 4 Construction Cost Estimate

Pump Station

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
				Subtotal	**$ 3,536,139**	
Switchyard						
	Perimeter Fence	400	LF	$ 15	$ 6,000	
	Gate	1	LS	$ 5,000	$ 5,000	
	Control Equipment	1	LS	$ 200,000	$ 200,000	Switch, relays, comms, etc.
	Incoming bus and connections	1	LS	$ 150,000	$ 150,000	
	Air Switch	2	EA	$ 125,000	$ 250,000	
	Metering	2	EA	$ 75,000	$ 150,000	
	Transformer	2	EA	$ 1,800,000	$ 3,600,000	
	Outgoing bus to E bldg	200	LF	$ 750	$ 150,000	
	Equipment bases	54	CY	$ 500	$ 26,963	
	Misc electrical	1	LS	$ 300,000	$ 300,000	Allowance for lighting, conduit, cable, etc
	Misc instrumentation and control	1	LS	$ 150,000	$ 150,000	Allowance for instruments, network interface, wiring, etc
	Containment	1	LS	$ 50,000	$ 50,000	
	Security	1	LS	$ 10,000	$ 10,000	
				Subtotal	**$ 5,047,963**	
Totals						
				Subtotal	**$ 47,349,122**	
				Contingency (30%)	$ 14,204,740	
				Subtotal	**$ 61,553,862**	
				Total Facility Cost	**$ 61,554,000**	

Wapatox Project
Class 4 Construction Cost Estimate
Main Pipeline

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
General						
	Mobilization	1	LS	$ 895,000	$ 895,000	Approximately 3% of Total
	SWPPP	1	LS	$ 50,000	$ 50,000	Allowance
	SWPPP Best Practices	1	LS	$ 5,000	$ 5,000	Allowance
	Start-up/Testing	1	LS	$ 5,000	$ 5,000	Allowance
	Demobilization	1	LS	$ 595,000	$ 595,000	Approximately 2% of Total
				Subtotal	**$ 1,550,000**	
Pipeline and Appurtenances						
	96" Pipe	14970	LF	$ 1,700	$ 25,449,000	Excludes portion on bridge but includes portion in tunnel
	Installation for Portion in Tunnel	0	LS	$ -	$ -	Anticipate using a rail and cable system to advance each pipe piece to bottom of tunnel and weld to previous piece; assume this cost already covered by unit price of pipe installation
	Corrosion Protection	1	LS	$ 250,000	$ 250,000	Allowance
	Air Valves, Blowoffs, and Appurtenances	1	LS	$ 500,000	$ 500,000	
	Manways	10	EA	$ 5,000	$ 50,000	Assumes one every thousand feet of pipe, excluding portions in tunnel or on bridge
	Valve Vault and Valves at Connection to Existing 90" YTID Main Pipeline	1	LS	$ 2,000,000	$ 2,000,000	
				Subtotal	**$ 28,249,000**	
Totals						
				Subtotal	**$ 29,799,000**	
				Contingency (30%)	$ 8,939,700	
				Subtotal	**$ 38,738,700**	
				Total Facility Cost	**$ 38,739,000**	

Wapatox Project

Class 4 Construction Cost Estimate

Naches River Bridge

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
General						
	Mobilization	1	LS	$ 125,000	$ 125,000	Approximately 3% of Total
	SWPPP	1	LS	$ 10,000	$ 10,000	Allowance
	SWPPP Best Practices	1	LS	$ 5,000	$ 5,000	Allowance
	Start-up/Testing	0	LS	$ -	$ -	Allowance
	Demobilization	1	LS	$ 85,000	$ 85,000	Approximately 2% of Total
				Subtotal	**$ 225,000**	
Bridge, Pipe, and Related Site Work						
	Bridge	1	LS	$ 2,647,000	$ 2,647,000	
	Dewatering	1	LS	$ 30,000	$ 30,000	
	Cofferdamming for 2 piers	2	EA	$ 250,000	$ 500,000	Assume sheetpile, each enclosure 30'x15' and using 60'L sheets
	96" Pipe	310	LF	$ 1,500	$ 465,000	Includes pipe crossing accessories
	Expansion Joint on Pipe	1	LS	$ 100,000	$ 100,000	
	Air Valves	2	EA	$ 25,000	$ 50,000	
	Misc Civil	1	LS	$ 100,000	$ 100,000	Road approaches, each side of river
	Misc Electrical	1	LS	$ 50,000	$ 50,000	Allowance for heat tracing
				Subtotal	**$ 3,942,000**	
Totals						
				Subtotal	**$ 4,167,000**	
				Contingency (30%)	$ 1,250,100	
				Subtotal	**$ 5,417,100**	
				Total Facility Cost	**$ 5,417,000**	

Wapatox Project
Class 4 Construction Cost Estimate
Pipeline Tunnel

Facility	Description	Qty	Unit	Unit Price	Extended Total	Comments
General						
	Mobilization	1	LS	$ 370,000	$ 370,000	Approximately 3% of Total
	SWPPP	1	LS	$ 20,000	$ 20,000	Allowance
	SWPPP Best Practices	1	LS	$ 5,000	$ 5,000	Allowance
	Start-up/Testing	1	LS	$ 5,000	$ 5,000	Allowance
	Demobilization	1	LS	$ 250,000	$ 250,000	Approximately 2% of Total
				Subtotal	**$ 650,000**	
Tunnel, Shaft, and Related Site Work						
	Starter Tunnel (20' dia)	200	LF	$ 6,200	$ 1,240,000	
	Main Tunnel (10' dia)	4550	LF	$ 2,100	$ 9,555,000	
	Reception Shaft (50' wide)	80	LF	$ 7,800	$ 624,000	
	96" Pipe	0	LF	$ 1,440	$ -	Pipe costs covered in other elements
	Grouting annual space	4750	LF	$ -	$ -	Assume grouting covered in unit price of pipe installation cost, in other elements
	Site preparation for tunneling at cliff face	1	LS	$ 100,000	$ 100,000	Anticipating disturbance of 2-5 acres
	Misc Civil (access roads, grading, and site restoration at starting and receiving ends)	1	LS	$ 200,000	$ 200,000	Allowance
				Subtotal	**$ 11,719,000**	
Totals						
				Subtotal	**$ 12,369,000**	
				Contingency (30%)	$ 3,710,700	
				Subtotal	**$ 16,079,700**	
				Total Facility Cost	**$ 16,080,000**	