Subject:	**Conceptual Development of Aqueduct and Discharge Structure (Final Draft)**
Project feature:	Bethany Reservoir Aqueduct
Prepared for:	California Department of Water Resources (DWR) / Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
Copies to:	File
Date/Version:	December 23, 2021
Reference no.:	EDM_SC_CE_TMO_Conc-Dev-of-Aqueduct-Dis-Structure_000996_V02_FD_20211223

1. Introduction and Purpose

The California Department of Water Resources (DWR) issued a Notice of Preparation (NOP) pursuant to the California Environmental Quality Act (CEQA) on January 15, 2020 (DWR 2020a). The NOP identified a proposed Delta Conveyance Project (Project) to include new intake facilities located along the Sacramento River between Freeport and the confluence of the Sacramento River with Sutter Slough. The new Project conveyance facilities would also include a tunnel to convey water from the new intakes to the existing State Water Project (SWP) Banks Pumping Plant and related pumping and conveyance facilities in the south Delta.

The NOP described Central and Eastern corridor options to convey water from intakes in the north Delta to the SWP and potentially the Central Valley Project (CVP) pumping plants in the south Delta, including the Central Corridor and Eastern Corridor. Each corridor would use the same intakes and the same Southern Forebay, Pumping Plant, and South Delta Conveyance Facilities, and Project alternatives would be sized to convey a range of project design flow rates from 3,000 cfs to 7,500 cfs.

The NOP was circulated to the public, interest groups, and agencies to receive comments. The comments were summarized in a Scoping Report released by DWR in July 2020 (DWR 2020b). Some of the comments were related to concerns about construction of facilities near roadways and communities near Clifton Court Forebay. DWR considered the scoping comments and methods to reduce environmental disturbances at the new Southern Forebay; and therefore, identified the Bethany Reservoir Alternative that would extend from the intakes along the Eastern Corridor to Lower Roberts Island; and then, continue along a tunnel alignment to a new Bethany Reservoir Pumping Plant (BRPP) to be located south of Clifton Court Forebay. The new pumping plant and associated aqueduct would convey the water to a Bethany Reservoir Discharge Structure along the rim of the existing SWP Bethany Reservoir. The BRPP, surge basin, aqueduct, and Bethany Reservoir Discharge Structure are referred to as the Bethany Complex.

The purpose of the Technical Memorandum (TM) is to summarize design concepts and considerations, anticipated construction methodology and sequencing, and operation and maintenance requirements for the Bethany Reservoir Aqueduct (aqueduct) portion of the Delta Conveyance Project (DCP), which would operate between the Bethany Reservoir Pumping Plant (BRPP) and the Bethany Reservoir Discharge Structure at the reservoir, and potentially for an additional aqueduct between the BRPP and the CVP Delta-Mendota Canal (DMC).

1.1 Background and Overview

The overall DCP – Bethany Reservoir Alternative would receive water from the Sacramento River and deliver it through deep tunnels to the new BRPP and surge basin just south of Clifton Court Forebay and Byron Highway. The BRPP would then lift the water to a hydraulic gradeline (HGL) sufficient for delivery of Project flows to Bethany Reservoir downstream of Banks Pumping Plant. That delivery would be accomplished through an aqueduct consisting of two to four parallel 180-inch diameter welded steel pipelines. The BRPP would include provisions to potentially also supply the federal Delta-Mendota Canal (DMC) just upstream of the existing Jones Pumping Plant, through a single 180-inch diameter welded steel pipeline.

Figure 1 is a schematic of the Bethany Reservoir Alternative, beginning at the Lower Roberts Shaft on the Eastern Corridor Option. The Aqueduct and Discharge Structure portions are identified on Figure 2 and serve as the basis for the remainder of this TM.

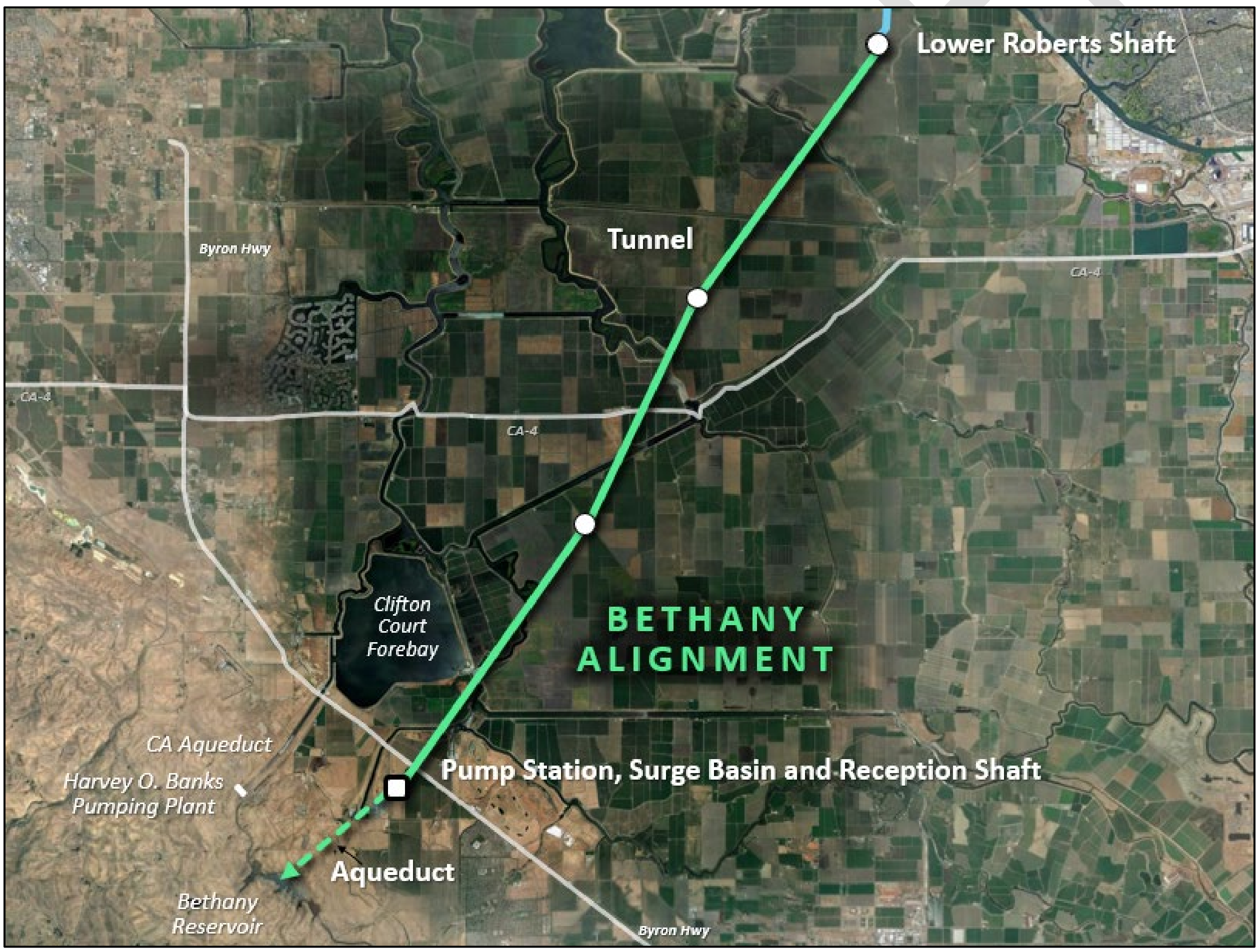


Figure 1. Delta Conveyance Project, Bethany Reservoir Alternative Schematic, South of Lower Roberts Shaft

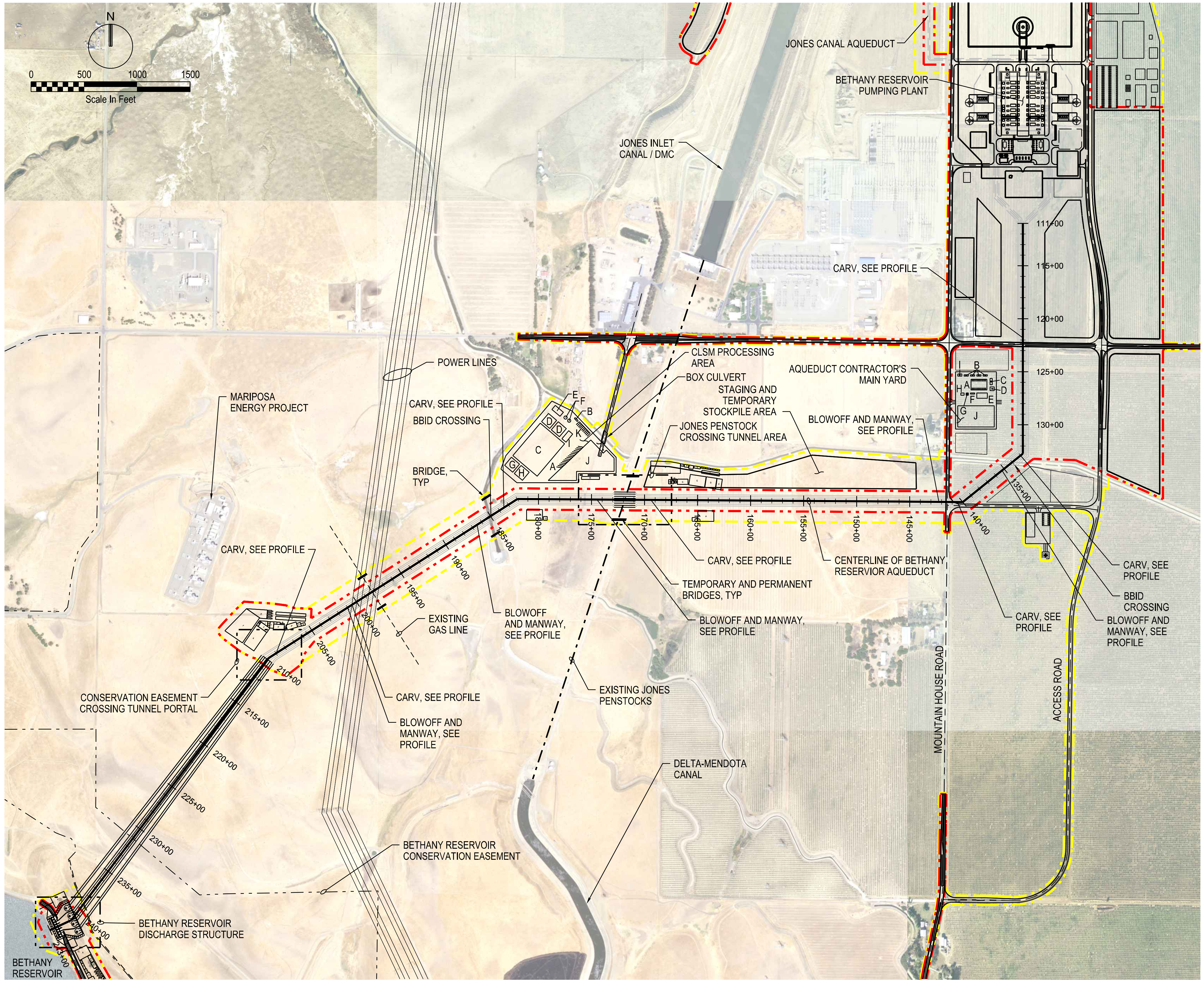


FIGURE 2:
BETHANY RESERVOIR AQUEDUCT AND DISCHARGE STRUCTURE - PLAN AND HORIZONTAL ALIGNMENT

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

1.2 Aqueduct System Capacity and Hydraulics

The DCP's maximum design diversion capacity from the Sacramento River to BRPP, Bethany Reservoir, or the DMC has not been selected. However, a range of project design capacities from 3,000 to 7,500 cubic feet per second (cfs) has been established by the DCO and this range determines the number of pipelines that make up the Bethany Reservoir Aqueduct, as follows:

- 3,000 cfs: Two 180-inch diameter pipelines from the BRPP to Bethany Reservoir, and no pipeline from the BRPP to the DMC
- 4,500 cfs: Three 180-inch diameter pipelines from the BRPP to Bethany Reservoir, and no pipeline from the BRPP to the DMC
- 6,000 cfs: Four 180-inch diameter pipelines from the BRPP to Bethany Reservoir, and no pipeline from the BRPP to the DMC
- 7,500 cfs: Four 180-inch diameter pipelines from the BRPP to Bethany Reservoir, and a single 180-inch diameter pipeline from the BRPP to the DMC

Each pipeline would carry up to 1,500 cfs and would operate at working pressures up to about 100 psi and transient pressures under surge conditions of up to about 180 psi. More details on the hydraulics of the system are provided in a separate TM, Hydraulic Analysis of Delta Conveyance Options – Bethany Reservoir Alternative (DCA 2021b).

2. Aqueduct System Configuration

For the purposes of this TM, the aqueduct system would comprise the following components, generally listed in direction of flow.

BRPP to Bethany Reservoir

- Aqueduct pipelines and appurtenances
- Permanent patrol road along aqueduct
- Aqueduct tunnels, including portals and shafts (to carry portions of the pipelines under surface features that cannot be disturbed)
- Bethany Reservoir Discharge Structure

Optional Extension to CVP DMC (7,500 cfs capacity option only)

- Aqueduct pipeline and appurtenances
- Jones Outlet Structure
- Delta-Mendota Canal Control Structure

Each of these facilites is further described in the following subsections.

2.1 Bethany Reservoir Pumping Plant to Bethany Reservoir

2.1.1 Aqueduct Pipelines and Appurtenances

The aqueduct from the BRPP to Bethany Reservoir would begin where multiple discharge pipelines emerge from both sides of the BRPP and converge into a parallel alignment. Following the horizontal alignment shown in Figure 2, the aqueduct would cross under the following surface features, in the direction of flow:

- Kelso Road
- Byron-Bethany Irrigation District (BBID) canal
- Mountain House Road
- The CVP Jones Pumping Plant penstocks
- BBID canal
- A pair of petroleum pipelines (26-inch and 36-inch diameter)
- The Bethany Reservoir Conservation Easement
- A 16-inch petroleum pipeline
- California Aqueduct Bikeway (SWP access road)

Figure 3 illustrates the aqueduct profile between the BRPP and Bethany Reservoir.

The aqueduct would consist of 2 to 4 welded steel pipelines, 180-inches in diameter, with the number varying based on project capacity option as described in Section 1.2. The pipelines would be constructed 30 feet on center, with pipe inverts set at a depth of 0.7 times the diameter (0.7D, or 10.5 feet in this case) below original ground in all reaches not affected by the undercrossings listed above. The portion of the pipe trench below original ground would be backfilled with Controlled Low Strength Material (CLSM). CLSM is a low strength mixture of cement, on-site excavated soil, and water. The exposed portion of the pipes would be backfilled by mounding fill over the top of the pipes using compacted soil to a depth of 0.7 (10.5 feet) above original ground or about 6 feet over the top of pipe. The 0.7 times the diameter bury depth was established to ensure suitable structural support for the pipeline from the CLSM pipe zone material. Similarly, the separation by one diameter between each parallel pipeline would provide appropriate width for CLSM structural support.

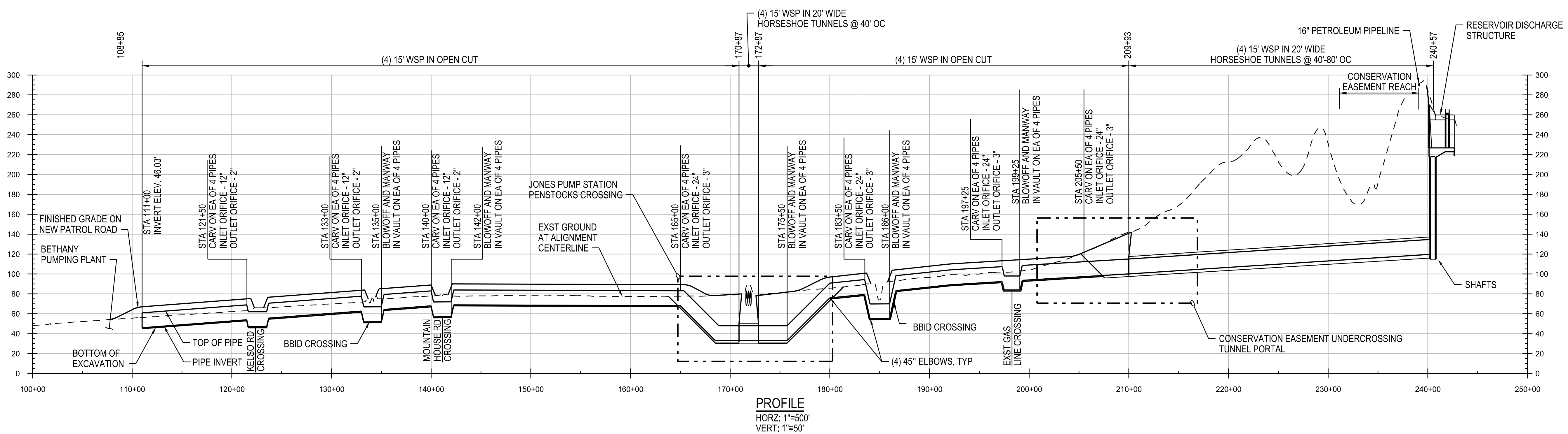


FIGURE 3 :
AQUEDUCT PROFILE BETWEEN BRPP
AND BETHANY RESERVOIR

DCA
DELTA CONVEYANCE DESIGN
& CONSTRUCTION AUTHORITY

An illustration of the typical finished pipeline trench for four parallel pipelines is depicted in Figure 4 below.

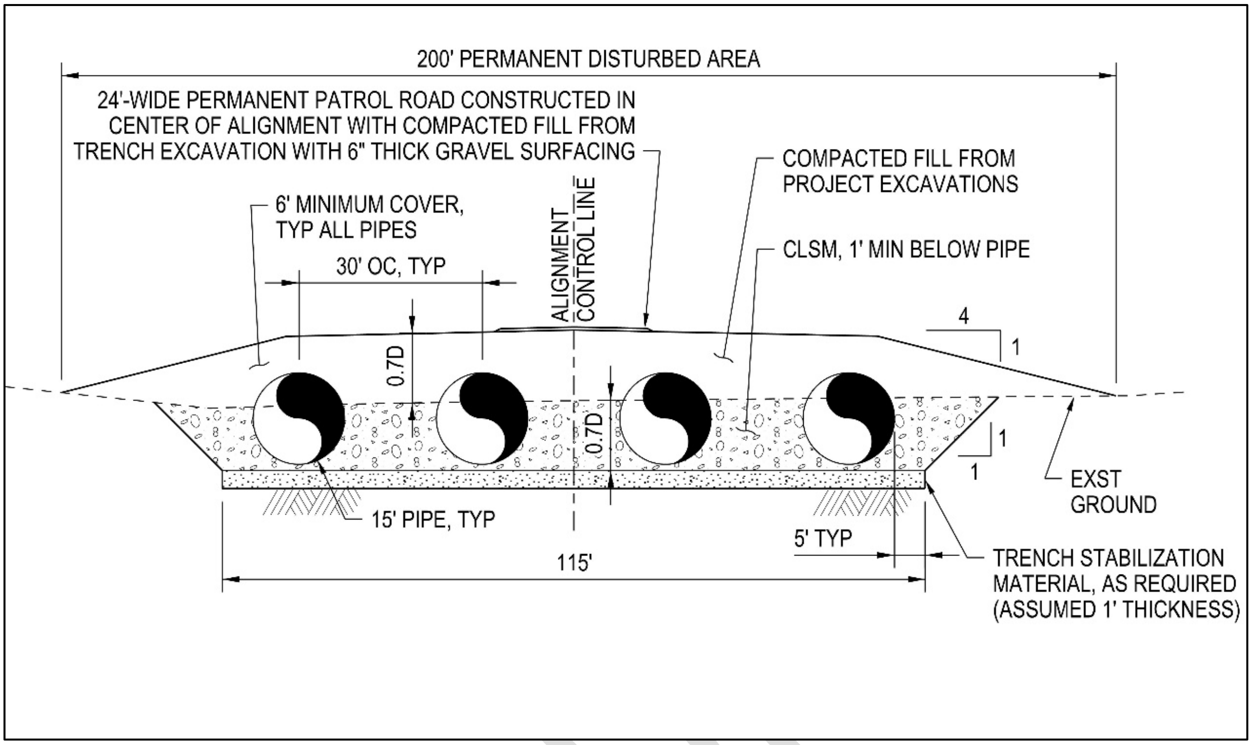


Figure 4. Typical Pipeline Trench between BRPP and Bethany Reservoir

A preliminary analysis was conducted in accordance with AWWA M11 to determine the conceptual steel cylinder thickness for the pipelines. The analysis considered handling, buckling, internal pressure, and deflection. The analysis suggested that a thickness of 0.750 inches would be sufficient, based on the following:

- Operating and surge pressures of 100 psi and 180 psi, respectively
- E' modulus of soil reaction of 3,000 psi (based on CLSM backfill to 0.7D on the pipe)
- Allowable design stress (50% of minimum yield point) of 18 to 21 ksi, assuming 36 to 42 ksi yield steel (to be determined during final design).
- Cover material density of 120 lb/cubic foot
- AASHTO live load of 32,000 lbs for an HS-20 Single Truck
- Allowable deflection for lining/coating not to exceed 2.25 percent

While the pipe is not expected to operate under vacuum conditions, at a thickness of 0.750 inch it would withstand a full vacuum without buckling (including a 2:1 safety factor) for the conceptual design configuration depicted on the engineering concept drawings. It is anticipated that the pipelines would be internally lined with field-applied cement mortar and externally coated with polyethylene tape or polyurethane, and that corrosion would be further controlled with an impressed-current cathodic protection system with air-cooled or oil-cooled rectifiers installed at the pumping plant site.

The aqueduct would include pipeline appurtenances such as air and vacuum valves, access manways, and pipelines drains (blowoffs), as follows:

- Combination air and vacuum valves (CARVs) would be located at each high point in the alignment, especially at many of the undercrossings where the pipe would dive down to go under surface features. CARVs would release accumulating air (through smaller outlet orifices) and help mitigate surge and vacuum conditions (through larger inlet orifices).
- One additional larger CARV would be provided just prior to the tunnel portal, upstream of the by the Conservation Easement, to further facilitate surge mitigation.
- 30- to 36-inch access manways would be provided as part of the CARV facilities described above to provide for entry into the pipelines for inspection and maintenance.
- Blow-offs in vaults would be provided at each low point (same undercrossings listed above) for occasional draining of the low spots along the pipelines for maintenance.

Figure 5 depicts a typical CARV/Manway configuration.

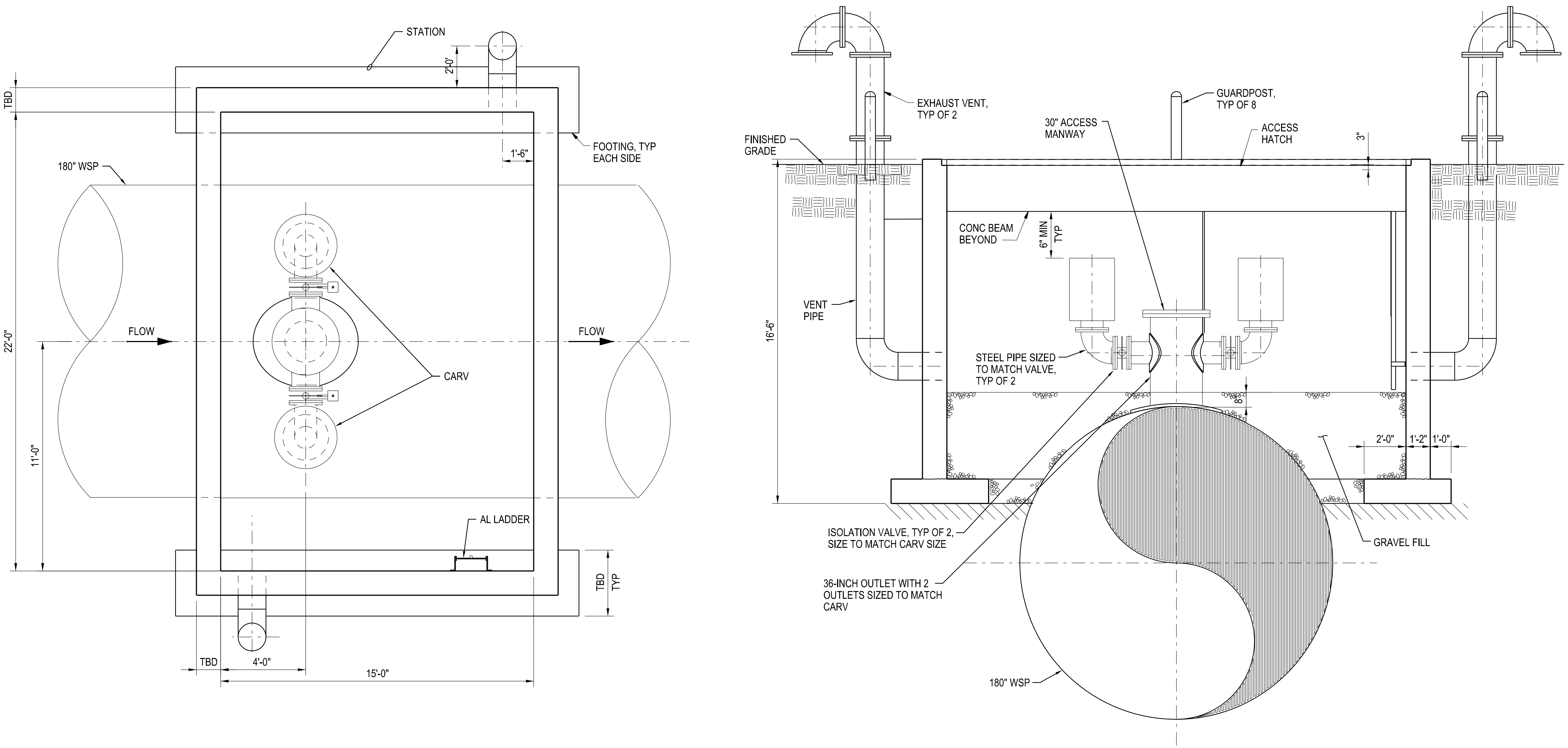


FIGURE 5 :
TYPICAL CARV/MANWAY PLAN AND SECTION

2.1.2 Patrol Road

As depicted in Figure 4, a 24-foot-wide gravel patrol road would be constructed over the pipe trench on compacted fill. The road would provide permanent access to the aqueduct system for operation and maintenance activities. Although generally centered over the pipelines and within the 200-foot-wide permanent easement, the road would veer off this alignment at many of the various undercrossings listed above. In these locations, new permanent bridges would be installed (at petroleum line, penstock, and canal crossings) or existing roads would be used (road crossings) for continuity of the patrol road, with "shoefly" or similar alignment variations on a case-by-case basis. The patrol road would end at the upstream portal to the aqueduct tunnel that extends beneath the Bethany Reservoir Conservation Easement. No surface features would be provided, or required, above this aqueduct tunnel.

Access to the Bethany Reservoir Discharge Structure would use existing roads to the reservoir plus one new road south of the easement used for heavy construction equipment access during construction.

2.1.3 Tunnels

The following two reaches of the aqueduct would be constructed utilizing tunnel excavation methods, because open trenching and surface disturbance would be impractical and/or not permitted:

- Jones Penstock Crossing – At this location, three existing 180-inch diameter steel pipes carry water from the CVP Jones Pumping Plant to the upper section of the Delta-Mendota Canal. The new DCP aqueduct pipelines would cross underneath the existing pipes inside 200-foot-long tunnels, one for each pipeline, with a clearance of approximately one to two tunnel diameters (to be determined during final design, drawings show one diameter of clearance).
- Bethany Reservoir Conservation Easement – Surface disturbance would not be allowed through this easement due to the terms and conditions used to establish it. Further, the terrain adjacent to the easement would require extremely deep and costly excavations for open trenching or if installed on the surface as the remaining of the aqueduct, the pipe(s) would have to be installed in a steep and challenging terrain. Therefore, each aqueduct pipeline would be installed within a separate tunnel, that would be approximately 3,000 feet in length each. Also, the 16-inch petroleum pipeline listed above would be crossed some 140 feet below within this tunneled reach which will not have an impact of the petroleum pipeline.

Figure 3 shows these two tunneled reaches in profile along the aqueduct alignment. In each case, the 15-foot (180 inch) diameter pipelines would be installed inside tunnels approximately 20 feet in diameter. The design is based on installing the pipelines through the tunnels, rather than using pressure tunnels, since the high operational and surge pressure would require a robust, expensive, and potentially infeasible tunnel lining system that could leak over time.

Figure 6 illustrates two ground support concepts for the tunnels that vary based on ground conditions. The configuration would be refined during final design based on data from subsurface explorations such as rock strength and quality.

For both tunnel locations, cuts would be required to establish tunnel portals at ends of the tunnel. Tunnel portals are large excavated areas at the ends of the tunnel and are used to support excavation operations, manage excavated material, allow ingress and egress into the tunnel, and allow the pipelines to be installed in the tunnels. Tunnel portals are generally backfilled after construction.

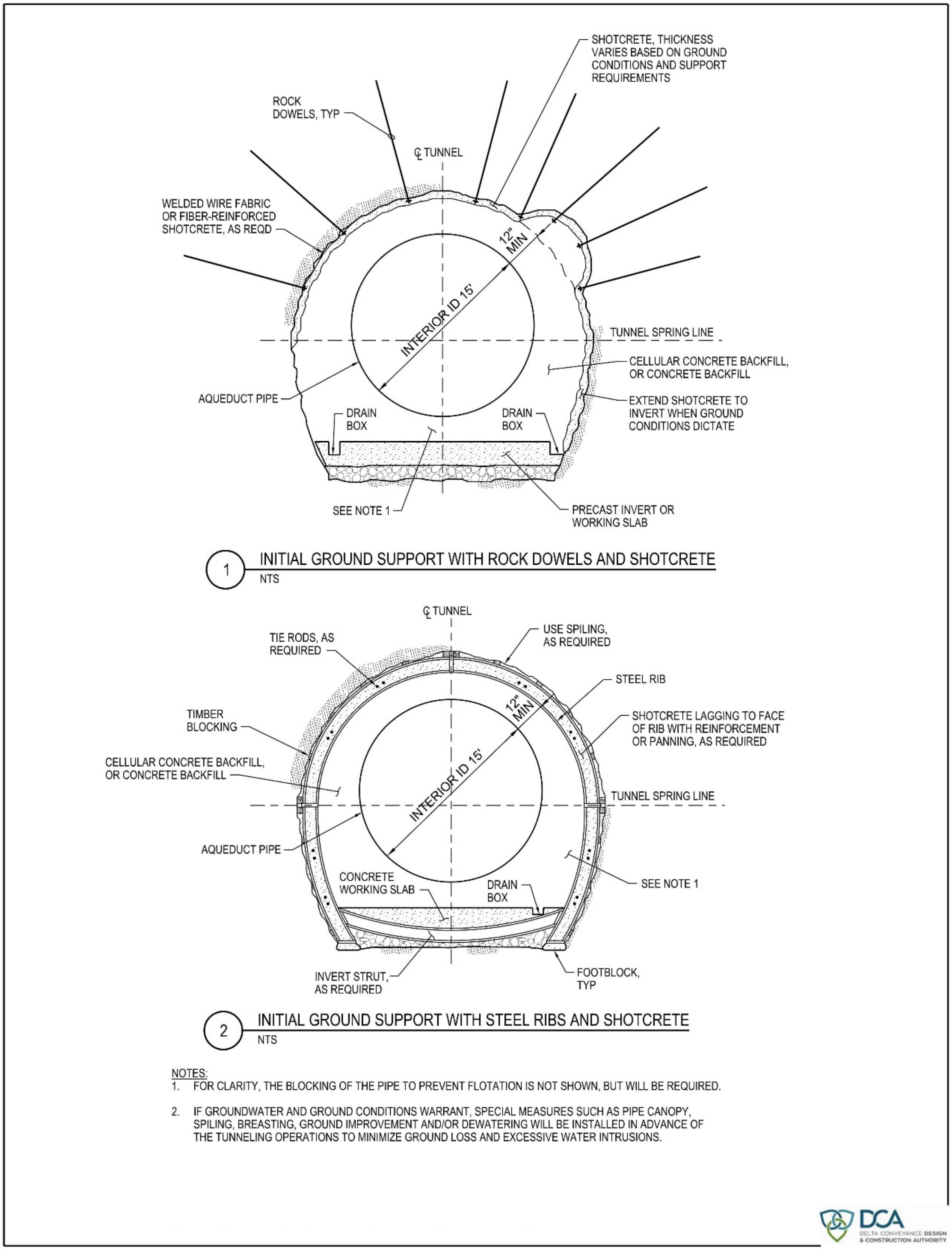


Figure 6. Potential Aqueduct Tunnel Configurations

The 180-inch diameter pipelines housed in the tunnels would be welded in place and the annular space between the tunnel walls and the pipelines would be backfilled with grout typically called Low Density Cellular Concrete (LDCC). This LDCC is grout (cement and water) with foaming agent to yield an approximate density of 80 pounds per cubic foot, however once set it has sufficient strength to adequately keep the pipe in place.

The tunnels for the Jones Penstock Crossing would be excavated 40 feet on center (i.e. parallel) over their entire length and have an excavated portal on each end.

The Conservation Easement Crossing tunnels would also be spaced at 40 feet on center on the upstream end and excavation would commence at an excavated portal located at approximate Station 210+00 on the aqueduct alignment. This location is approximately 0.4 miles north and east of the conservation easement boundary because the topography and tunnel depth are better suited to a portal at this location. In lieu of a portal, these tunnels would terminate on the downstream end in 55-foot diameter deep shafts (one for each tunnel). The tunnels and shafts would be constructed at a spacing of 80 feet on center. Therefore, the tunnels would gradually diverge from each other over their length. The shafts would extend up into the Bethany Reservoir Discharge Structure just beyond the boundary of the easement. The 180-inch diameter pipelines housed in the shafts would be welded in place and connect to pipe installed in the tunnels with 90-degree bends at the bottom of the shafts. The pipes would terminate at the bottom of the concrete channel in the discharge structure that connects to the Bethany Reservoir (see Section 2.1.4). The annular space between the shaft walls and the pipeline would be backfilled with CLSM and concrete up to the Bethany Reservoir Discharge Structure floor.

2.1.4 Bethany Reservoir Discharge Structure

2.1.4.1 Structure Location

The Bethany Reservoir Discharge Structure would be a large concrete structure connecting the aqueduct system to the reservoir. It would be located on a relatively narrow strip of land between the conservation easement and the edge of the reservoir. Site selection for the structure was based on two primary factors:

1) Terrain – A suitable location would be of sufficient size (say 2.5 to 3 acres), on reasonably flat ground that is above the reservoir water levels, and not adjacent to sections of the reservoir rim formed by dams. Approximately one-third of the north and east side of the reservoir are formed by dams or embankments. It is not desirable (nor is it likely to be permittable) to connect to the reservoir through these structures.
2) Water Quality in the Reservoir – For reasonable mixing and circulation of the reservoir, it would be desirable to locate the discharge as close to its “upstream” end as possible (i.e. at the existing Banks Pumping Plant discharge). Otherwise, if water from the new conveyance system was discharged near the downstream end of the reservoir in a future condition with reduced or eliminated contributions from the Banks facility, upstream portions of the reservoir could have less flow-through and possibly create water quality issues.

The site that was ultimately selected is at the approximate mid-point of the reservoir. This location is the upstream-most portion of the reservoir not rimmed by a dam section, and a mid-point discharge was assumed to be sufficient for mixing and circulation. The terrain is suitably above the water level and most of it is relatively flat. However, a portion of the site (0.5 to 1 acre) is on steep, hilly terrain and would require grading to build the structure. A 10-foot wide buffer would be left between the conservation easement and site disturbance, including the required grading.

2.1.4.2 Structure Configuration

The structure would be divided into a number of separate channels equal to the number of aqueduct pipelines described above. The discharge structure width at the location the 55-foot diameter shafts enter from below would be dictated by the required 80-foot center-to-center spacing of the shafts. From the shafts to the reservoir, these separate channels would gradually narrow to approximately half of their original width and be divided into two subchannels each. The subchannel width of 21 feet would be sufficient to keep flow velocity below 2 feet per second for a full reservoir at water surface elevation of 245, or 3.25 feet per second for a low reservoir level at water surface elevation of 238 feet. The channels would be flat from the shafts to the reservoir bank at an elevation (227.0 - nominally selected to match the floor of DWR's existing discharge structure from the Banks Pumping Plant at the northwest corner of the reservoir). With the reservoir water surface operating between elevations of about 238 and 245, depth of water in the channels would vary from 11 to 18 feet.

Structure side walls would rise to elevation 260.0 feet for grade conformance and walls dividing the channels to 255.0 feet, providing significant freeboard over the maximum water level of 245. The height of the outer walls and external soil load would require the structure to include concrete counterforts around the perimeter. The counterforts along the back wall would be founded, in part, on the backfilled shafts.

Near the reservoir, the structure would be crossed by an existing road (the California Aqueduct Bikeway), so a 32-foot wide bridge would span the structure and the discharge channels. To provide isolation of the aqueduct system from the reservoir, each 21-foot wide subchannel would have the following:

- Radial (or Tainter) gates 21 feet wide and 18-20 feet high, facing the reservoir.
- Two rows of stoplog guides, one on each side of the radial gate, to isolate the gate for maintenance. These stoplogs could also be used to isolate the aqueduct from the reservoir.

Radial gates would be held completely out of the water during aqueduct system operation, and the position of the gates would be controlled by hoists situated mid-span on concrete beams spanning each channel. Access to the hoists would be provided by a 12-foot wide maintenance bridge next to the beam supporting the hoists. Trunnions on the other end of the gates would be mounted above high water level on beams forming part of the bridge structure. A standby engine generator would be located at the site for emergency operation of the gates in the event of a power failure.

Stoplogs would be large aluminum or steel stackable panels designed to span the 21-foot width and the hydraulic load under full reservoir head. The bikeway bridge would include openings situated above the upstream-most stoplog slot for stoplog installation/removal, with the openings typically covered with traffic-rated hatches. Downstream stoplogs would be immediately adjacent to the maintenance bridge, on the opposite side of the hoists. It is expected that these stoplogs would be installed and removed by a crane parked on either side of the overall structure, but personnel could assist from the maintenance bridge as needed. This will be discussed further in Section 4.

The concrete floor of the discharge structure would end near the reservoir bank, and a layer of large riprap would be placed beyond the structure to help stabilize and protect the bank and bed of the reservoir from turbulence that may be generated as the water is discharged. At the design discharge velocity, turbulence and erosive forces are expected to be minor, and flow velocity should dissipate quickly in the lake conditions.

Figures 7 and 8 depict the design concept for the Discharge Structure.

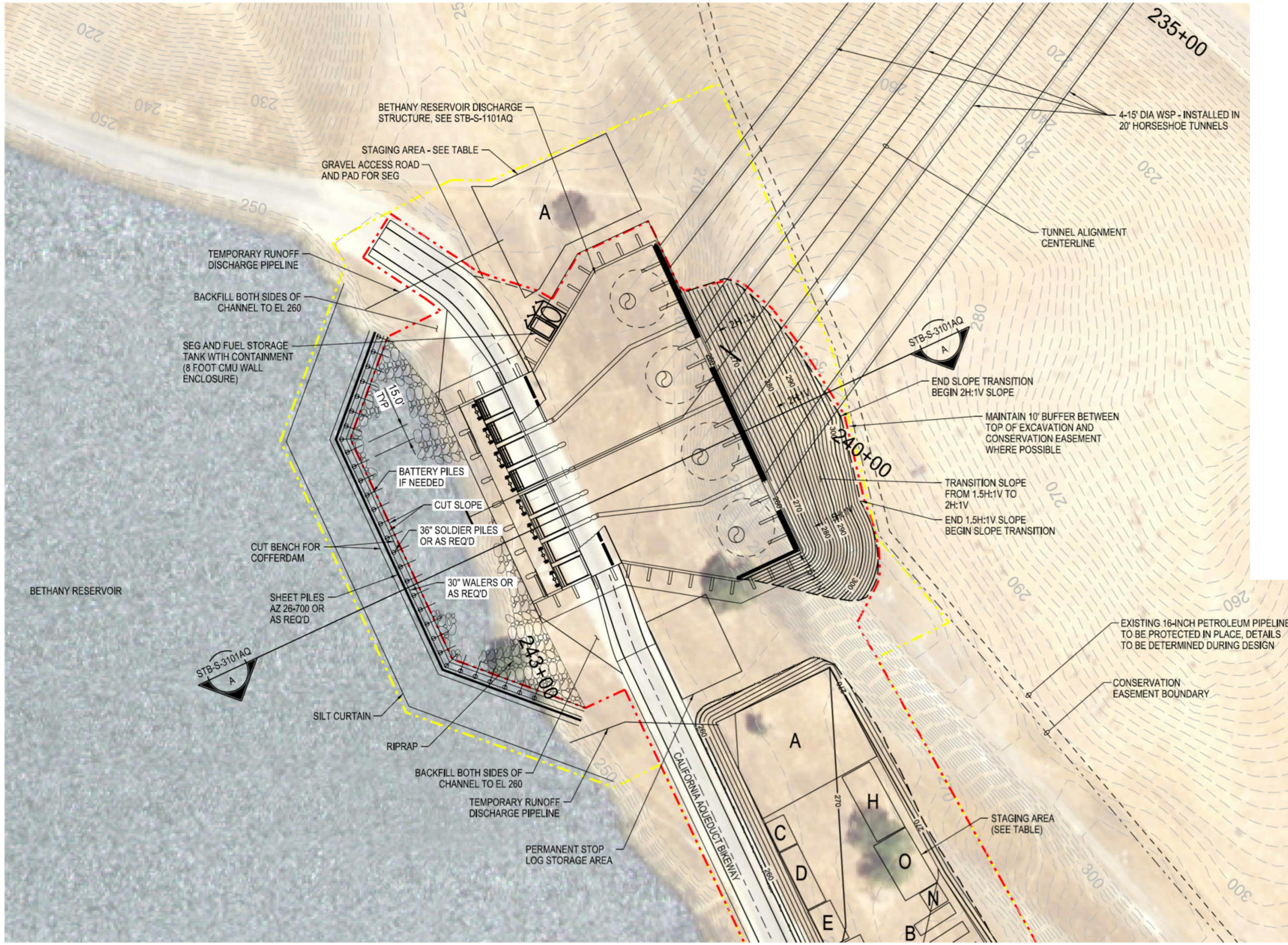


FIGURE 7 :
BETHANY RESERVOIR DISCHARGE STRUCTURE - SITE PLAN AND GRADING

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

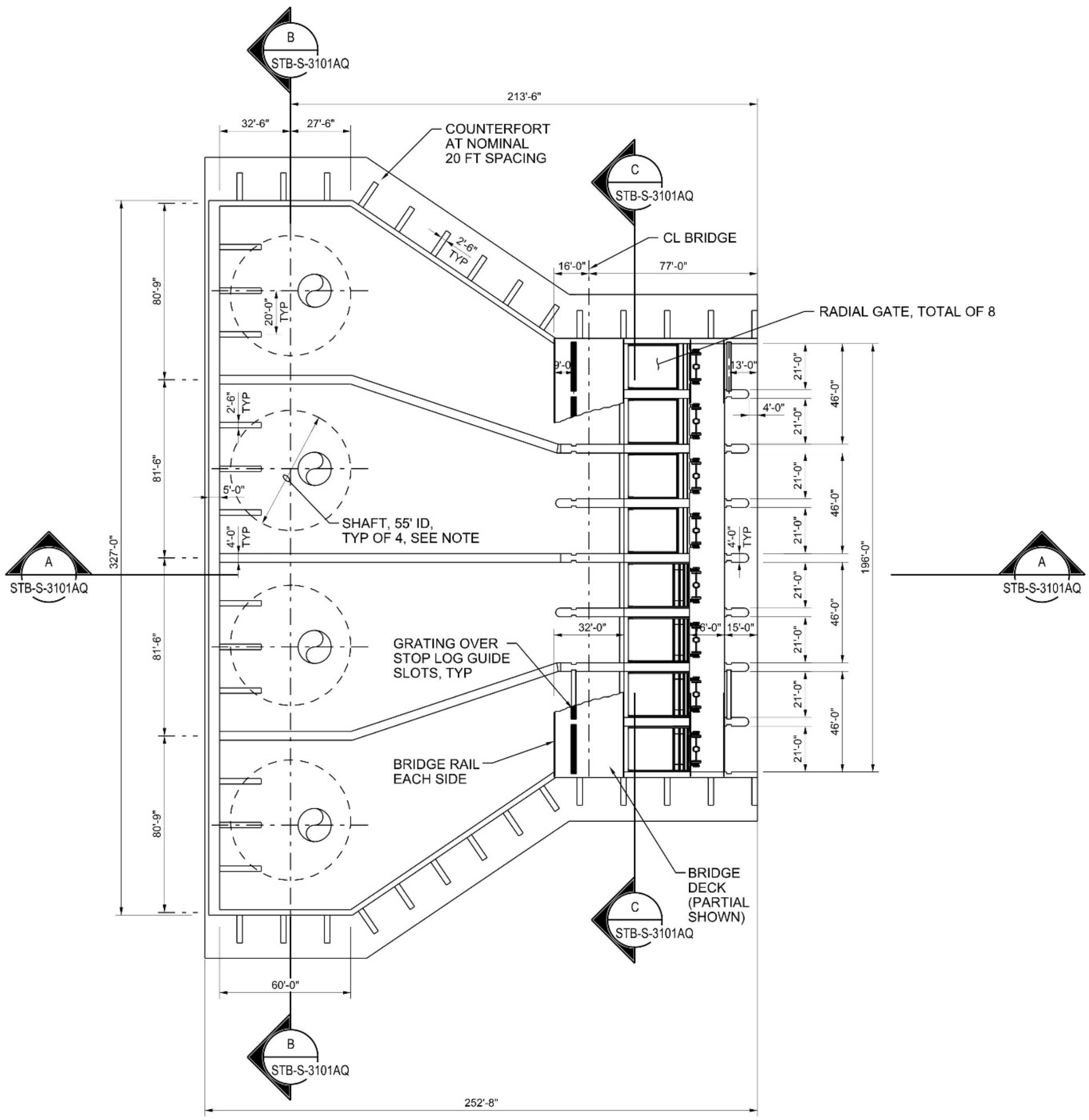


Figure 8. Bethany Reservoir Discharge Structure – Structural Plan

2.2 Optional Extension to CVP Facilities

2.2.1 Aqueduct Pipelines and Appurtenances (BRPP to DMC)

The Jones Canal Aqueduct route is from the BRPP to the DMC and is shown in Figure 9. The route generally heads west and north from the BRPP along Mountain House Road, under the large overhead power transmission lines, and extends to the eastern bank of the DMC (a.k.a. Jones Inlet Canal) approximately ¾ mile upstream of the Jones Pumping Plant. This pipeline would only be part of the Bethany Reservoir Alternative for the 7,500 cfs design flow option, and would be a single 180-inch diameter welded steel pipeline with the same lining, coating, and cathodic protection system described for the aqueduct to Bethany Reservoir in Section 2.1.1. It would be installed entirely in cut with an average of 20 feet of cover. The pipe is deeper than the main aqueduct pipelines to allow it to stay full of water under all operating conditions. Figure 10 shows the pipeline profile between the BRPP and the DMC, and Figure 11 shows the typical pipeline trench.

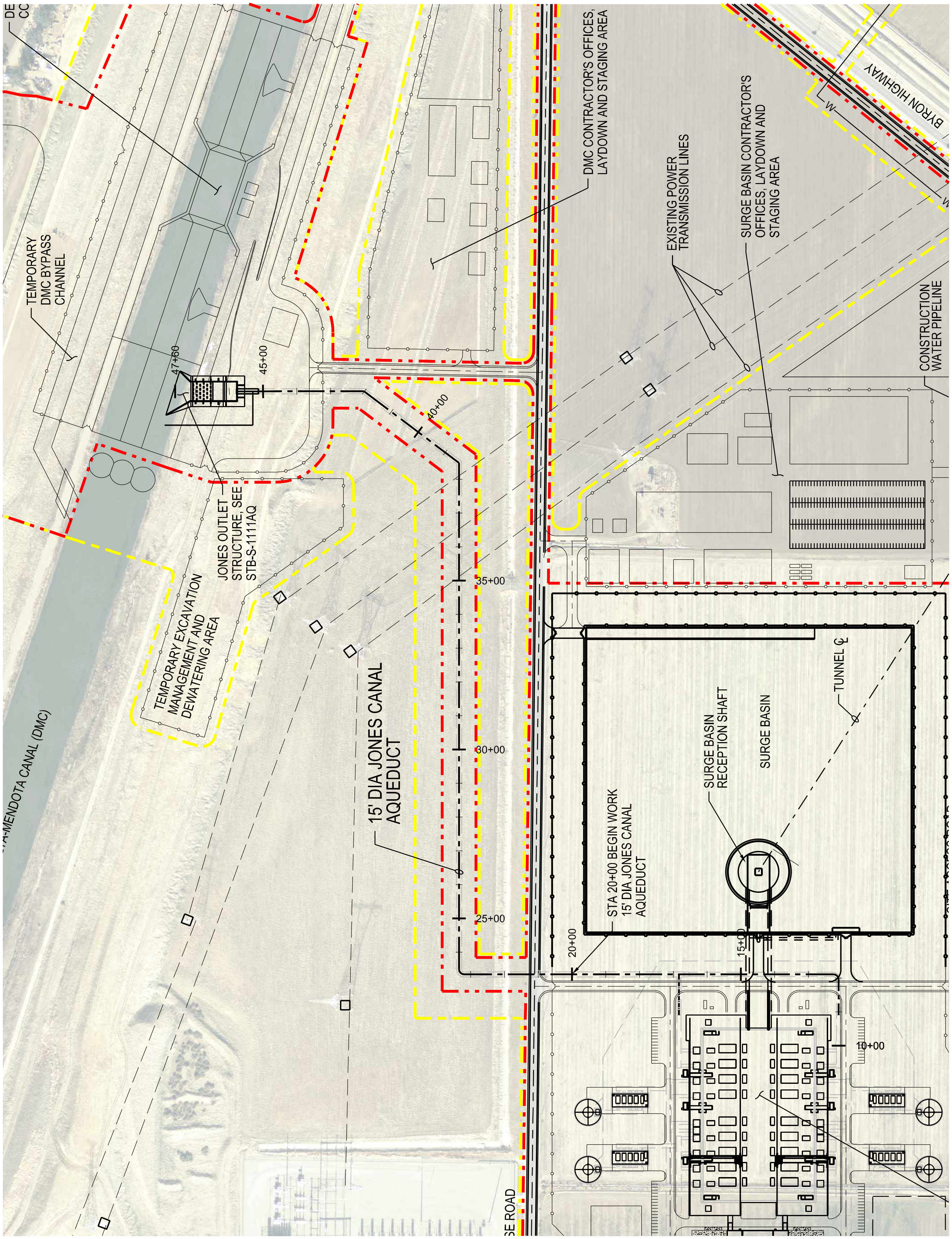


FIGURE 9 :
AQUEDUCT ROUTE FROM BRPP TO DMC

DCA DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

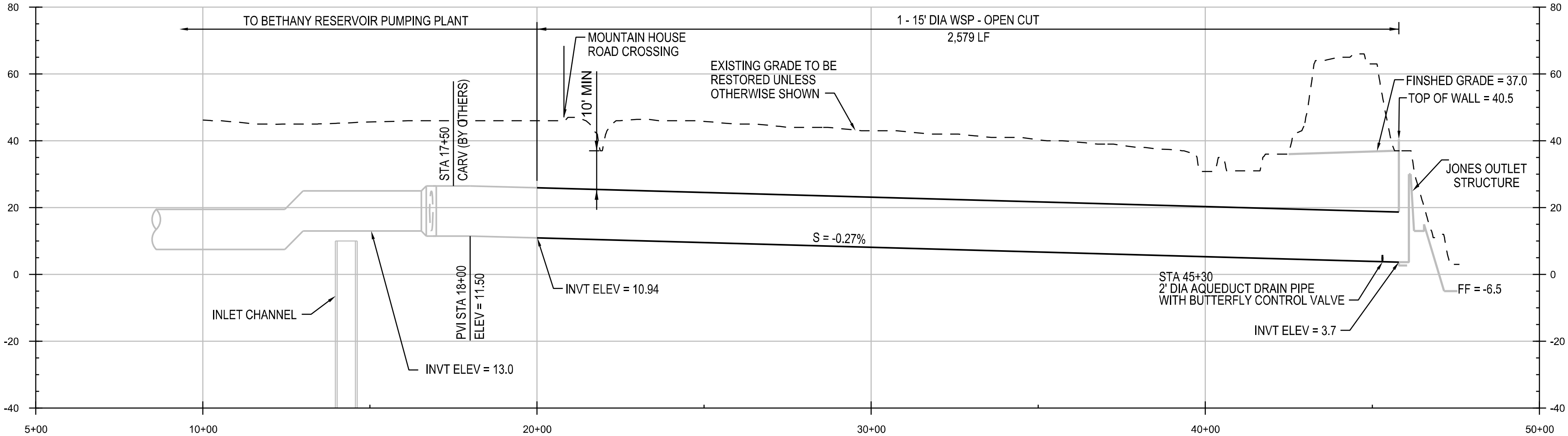


FIGURE 10 :
AQUEDUCT PROFILE BETWEEN BRPP AND DMC

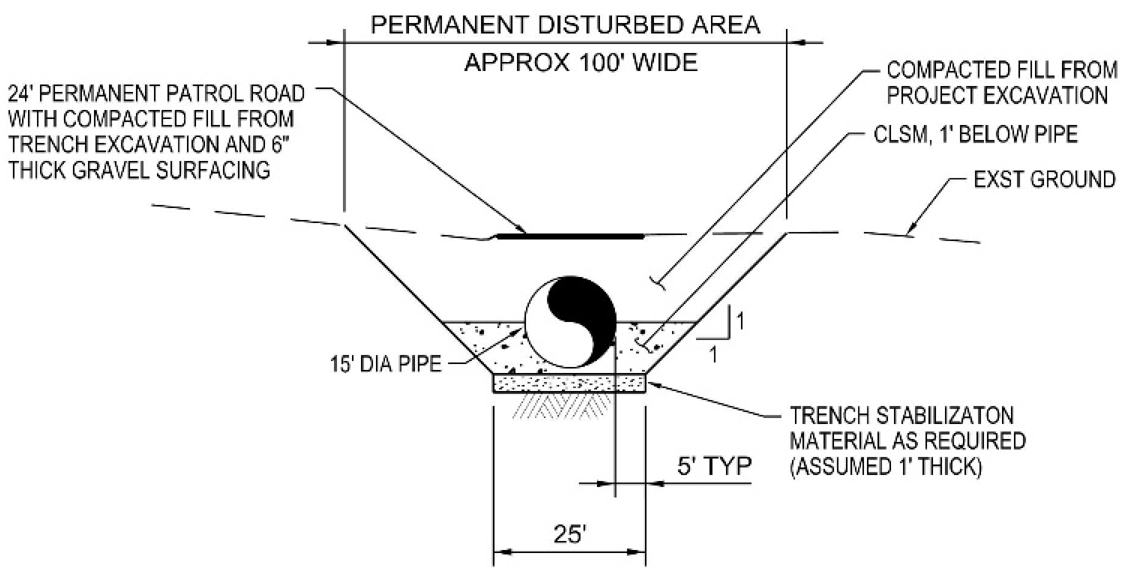


Figure 11. Typical Pipeline Trench between BRPP and DMC

This Jones Canal Aqueduct would not require CARV's or access manways because of its relatively short length (less than 3,000 feet) and because of the configuration of the vertical alignment. The final location of manways would be determined during design after consultation with in-place lining contractors and SWP/CVP operations staff. However, it should be noted that within the limits of the BRPP (upstream of the point designated on the engineering concept drawings as the start of the Jones Canal Aqueduct) a CARV would be installed at the location where the pipeline reaches its high point.

To facilitate draining of the pipeline, as may be needed for maintenance, a drain feature would be provided as part of the Jones Outlet Structure (described in Section 2.2.2) to allow at least part of the water to flow by gravity into the DMC. Water in the pipeline below the water surface elevation (WSE) of the DMC would need to be pumped out, but this could be accomplished from within the discharge basin portion of the structure and would not require an additional facility.

2.2.2 Jones Outlet Structure

The Jones Outlet Structure would be a baffled apron drop structure on the easterly bank of the DMC and situated on the end of the proposed Jones Canal Aqueduct, as shown in Figure 9. This structure would serve two purposes:

- Controlling the water surface elevation in the pipeline coming from the BRPP such that the pipe flows full under all flow conditions.
- Dissipating energy as the flow from the pipeline discharges to the DMC.

The structure would consist of two elements:

1) A rectangular discharge basin 55 feet wide, and 30 feet long at the terminus of the pipeline near the easterly bank of the DMC, with a weir at elevation 30.0 on the downstream side. The weir elevation would ensure that the pipe would always be in a pressurized condition all the way back to the pumping plant, even at the lowest flow rates.

2) Just beyond the weir, a 55-foot wide baffled apron drop (or baffled chute) integral to the bank of the DMC. This portion of the structure would descend at a 3:1 (horizontal to vertical) slope and the flow surface (apron) would be interrupted with staggered rows of 6-foot wide and 4-foot high baffle blocks 6 feet apart across the apron and 8 feet apart in the direction of flow. These blocks would serve to dissipate energy as the water descends to the canal. Wingwalls at the bottom of the structure would help spread the flow as it enters the DMC.

Figure 12 illustrates a plan and section of the structure. It should also be noted that the proposed new articulated concrete mat lining of the DMC in conjunction with the DMC Control Structure (Section 2.2.3) would be extended approximately 280 feet to integrate with the outlet structure's wingwalls and armor the canal floor and banks against the remaining energy from the spilling flow.

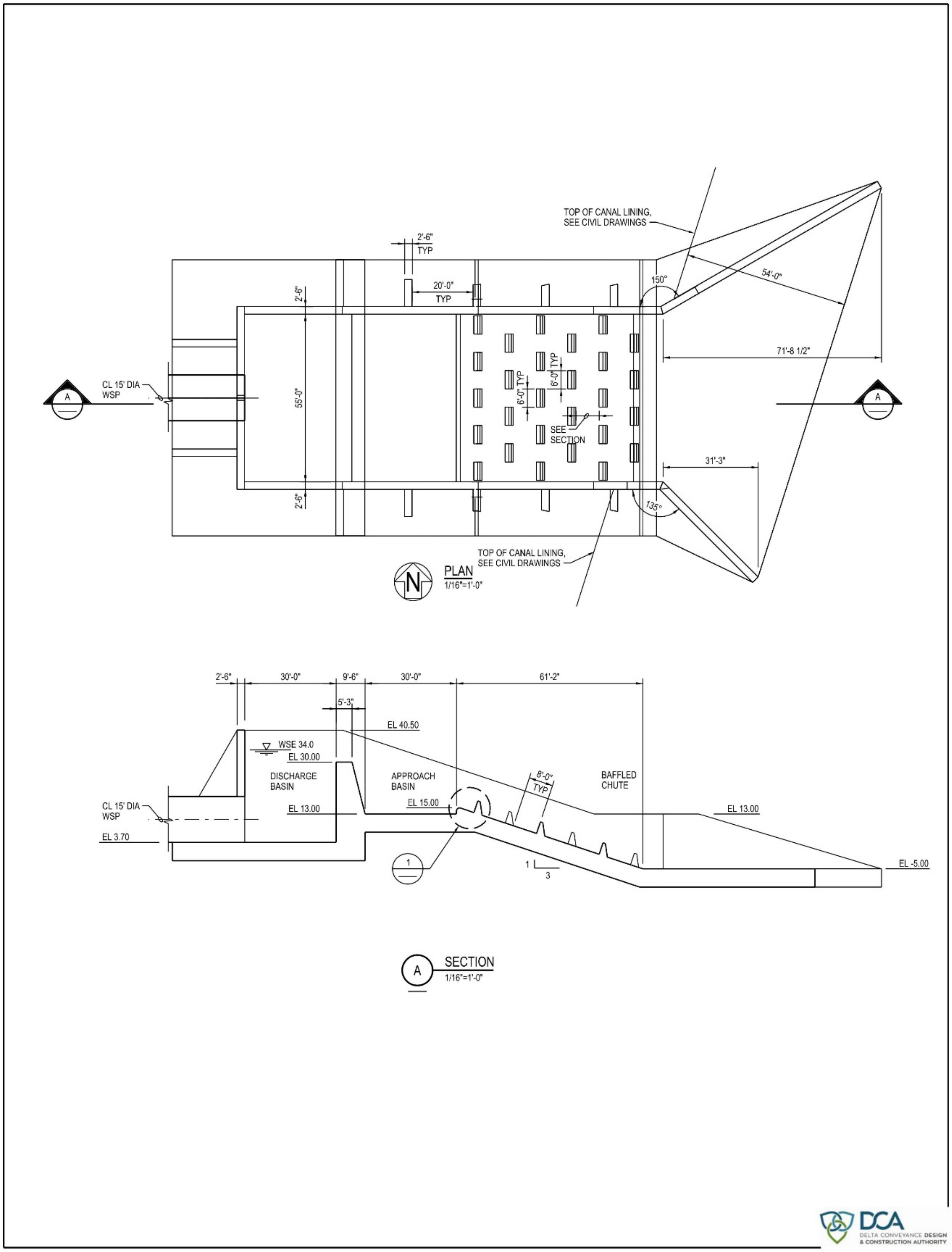


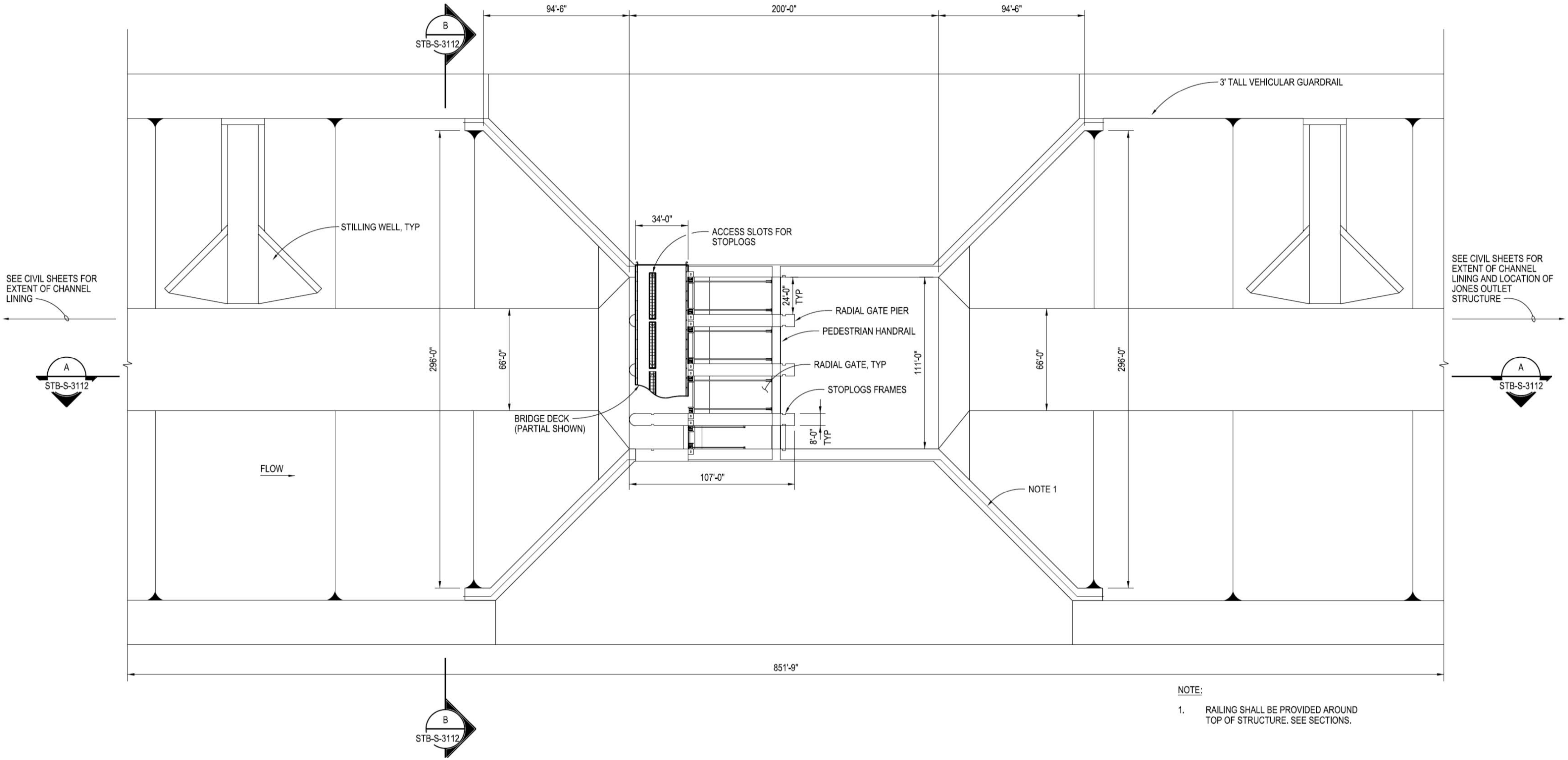
Figure 12. Jones Outlet Structure

2.2.3 Delta-Mendota Canal Control Structure

The DMC Control Structure would be positioned in the DMC, just upstream of the Jones Outlet Structure, with the purpose of working in tandem with deliveries from the BRPP to deliver water to the Jones Pumping Plant (see Figure 9). The DMC Control Structure would control flows in the DMC from Old River, while the BRPP would control flows from the DCP, all flowing to the Jones Pumping Plant.

The main component of the DMC Control Structure would be a series of radial gates that would control upstream flow. Three large gates (24-feet wide and 37-feet high) would control the bulk of the flow in the canal, and a smaller gate (15-feet wide and 19-feet high) would be provided for flow trimming. The smaller gate could also be designed as a sluice gate for the final configuration. The final number and type of gates would be determined during final design. Vertical stoplog slots in the piers, upstream and dowstream of the gates, would be provided for isolation of individual gate bays. Stilling wells would be located upstream and downstream of the gate structure for monitoring flow levels and setting gate openings. The entrance and exit of the structure includes concrete transition sections leading from the existing canal trapezoidal section to the vertical section through the gates. Articulated concrete mats would be placed in the DMC downstream of the structure and through the confluence area with the Jones Outlet Structure to limit erosion in an area of possible turbulence due to mingling flows.

Figures 13 and 14 depict the configuration of this structure.

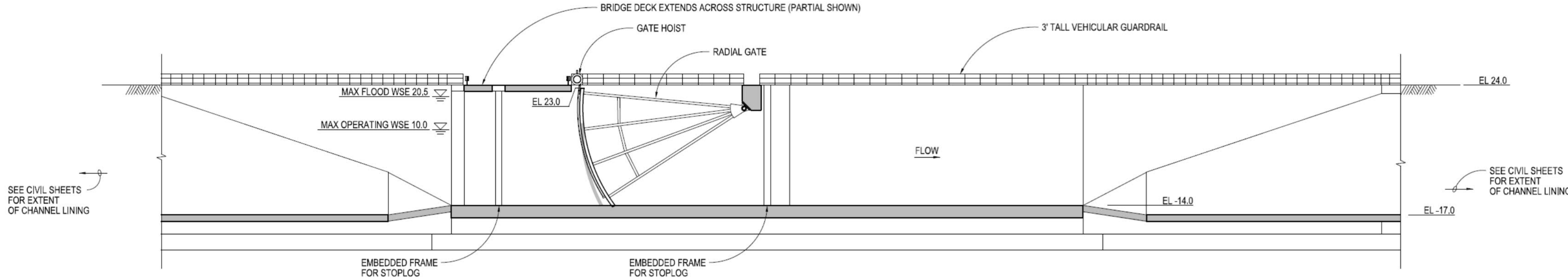


NOTE:

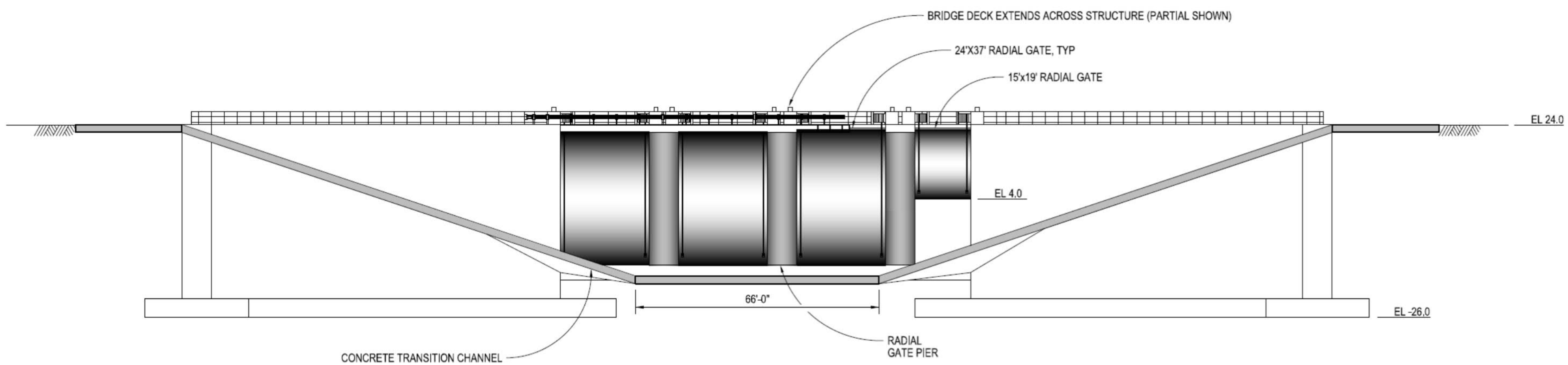
1. RAILING SHALL BE PROVIDED AROUND TOP OF STRUCTURE. SEE SECTIONS.

FIGURE 13 :
DELTA-MENDOTA CANAL CONTROL STRUCTURE - PLAN

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY



A SECTION
1/16"=1'-0"
STB-S-1112AQ



B SECTION
1/16"=1'-0"
STB-S-1112AQ

FIGURE 14 :
DELTA-MENDOTA CANAL CONTROL
STRUCTURE - SECTIONS

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

3. Anticipated Construction Methodology and Sequencing

This section describes anticipated methodology and sequencing of construction, including earthwork, tunneling, staging, cofferdamming and dewatering, pipeline and structure installation, backfill, and demobilization. Material will be presented separately according to the three primary construction locations for the Aqueduct system (aqueduct pipelines, Bethany Reservoir Discharge Structure, and Jones Outlet/DMC Control Structure).

3.1 Aqueduct Pipeline Construction

The aqueduct pipelines would mostly be constructed by open cut and backfill methods. However, two tunnels within the aqueduct reach would be needed to carry the pipelines under an existing surface feature and a conservation easement (as described in Section 2.1.3). The material below describes construction methodology and sequencing separately for the open cut and tunneled reaches.

3.1.1 Open-Trenched Reaches

Just under 10,000 lineal feet (LF) of each aqueduct pipeline from the BRPP to Bethany Reservoir would be constructed using open cut ("cut-cover") methods. From the BRPP to the DMC, the total length of the installed pipeline would be just under 2,600 LF and all of it would be constructed using open cut ("cut-cover") methods.

3.1.1.1 Construction Area and Temporary Limits of Disturbance (LOD)

For the 6,000 cfs and 7,500 cfs capacity options (four parallel aqueduct pipelines), the aqueduct construction corridor (temporary LOD) in the open cut sections of BRPP-to-Bethany Reservoir reach would be 400 feet wide. This width was established based on the following:

- Trench width 115 feet wide at the bottom, to accommodate 4 pipes at 180-inches in diameter and 30 feet on center
- Trench excavated to a depth of about 0.7 times pipe diameter (0.7D), plus 1 foot for pipe bedding and another 1 foot or more for trench stabilization material, where needed
- Trench side slopes 1:1 (assumed, actual slope would be as required for OSHA conformance and contractor's trench safety means and methods)
- A work area 20 feet in width on each side of trench excavation
- An 80-foot-wide strip on each side of trench, beyond the 20-foot wide work area, allocated to serve as a staging area, primarily for temporary storage of excavated material and pipe segments not yet installed in the trench
- Adjacent to the 80-foot-wide staging area, an additional 20-foot wide strip allocated on each side of the trench to serve as a temporary access road for construction travel along the edges of the aqueduct corridor

Figure 15 illustrates the construction condition for open cut aqueduct installation. The 400-foot temporary LOD width would be reduced by 30 feet for a three-pipe trench (4,500 cfs capacity option) and by 60 feet for a two-pipe trench (3,000 cfs capacity option).

For the single pipe trench required for BRPP-to-DMC pipeline (7,500 cfs capacity option), the temporary LOD width would be 180 feet, with a much deeper trench but staging and work areas only on one side (see Figure 16).

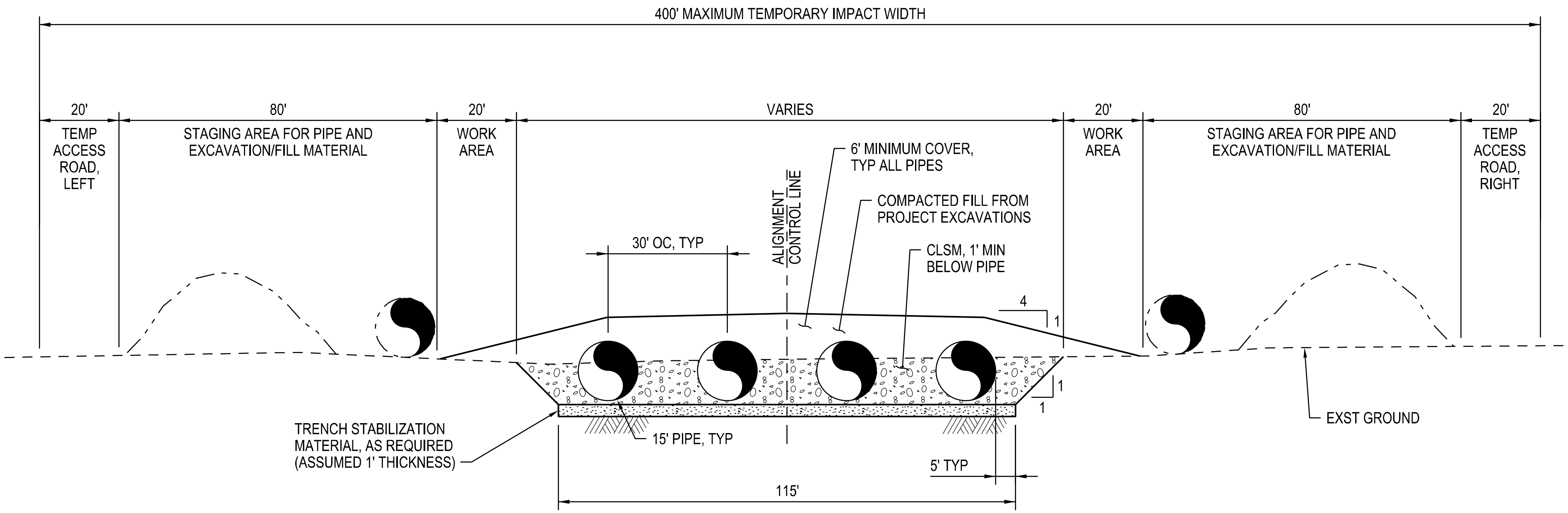


FIGURE 15 :
TYPICAL CONSTRUCTION CONDITION FOR AQUEDUCT INSTALLATION - BRPP TO BETHANY RESERVOIR

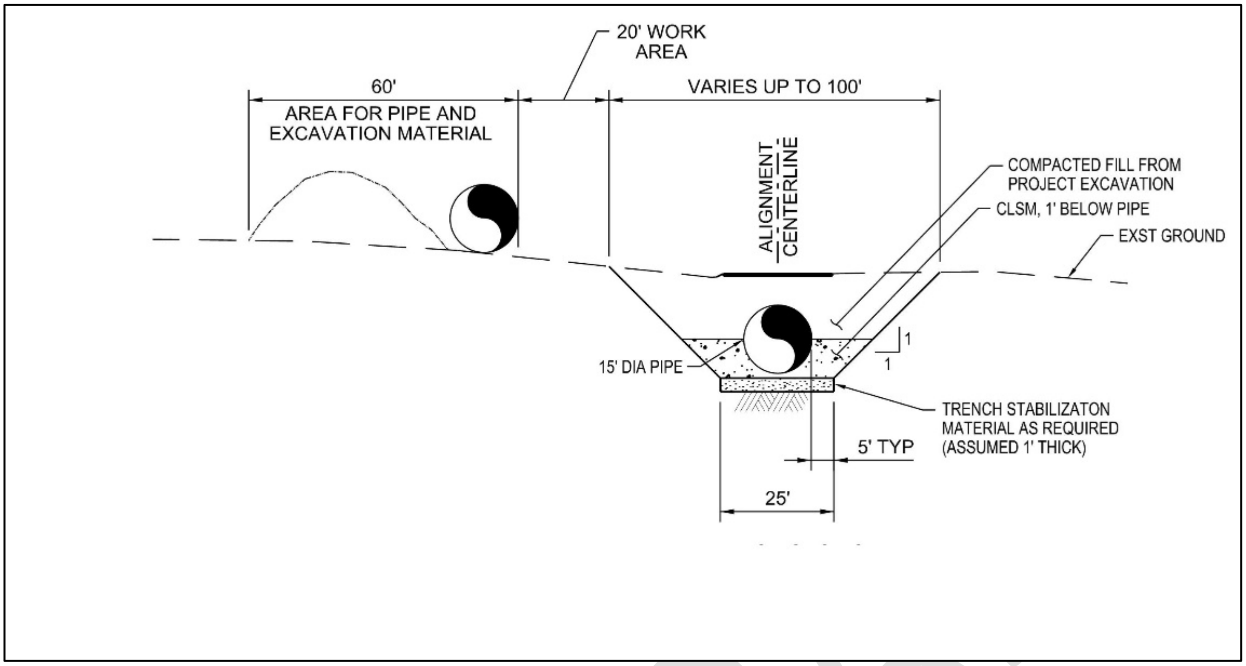


Figure 16. Typical Construction Condition for Aqueduct Installation – BRPP to DMC

In specific reaches, the available work area would extend beyond the 400-foot width. Specifically, between the BRPP and the second crossing of the BBID canal (approximate STA 185+00), the work area west and north of the aqueduct will extend to Mountain House Road and to the BBID canal to provide space for batch plants and other contractor facilities and to utilize space otherwise isolated between the canal and the pipeline construction work. It is generally expected that this additional width would be used for soil stockpiles as part of the overall management of excavated materials for the Bethany Alternative. For additional information, see separate TM, Soil Balance and Reusable Tunnel Material Supplement – Bethany Reservoir Alternative (DCA 2021a) and Section 3.1.1.7 below.

Between the BBID Canal and the existing powerline (approximate stations 185+00 to 200+00), the work area would be reduced as much as possible to help avoid impacts to vernal pools and wetlands. It is expected that about 80-100 feet of work area width reduction could be achieved in this area. The actual amount depends on the actual limits of the vernal pools and wetlands and final pipeline profile. The work area reduction is not shown on the engineering concept drawings, but would be defined during design.

3.1.1.2 Logistics within Pipeline Construction Corridor

As described in Section 3.1.1.1, a portion of the construction corridor would be allocated to vehicle travel and equipment transport on each side of the trench for most of the length of the BRPP to Bethany Reservoir reach, and on one side of the trench for the BRPP to DMC reach. At crossings of the two BBID canals, the Jones Penstocks, and the existing petroleum line, temporary bridges would be installed near the edge of the temporary LOD in general alignment with these temporary access roads on both sides of the trench.

Additionally, as the pipelines are advanced and backfilled and the permanent patrol road (see Section 2.1.2) is constructed on top of the trench, it would provide a secondary means for travel within the corridor. Bridges would be constructed to support the permanent access road at most of the same locations where bridges would be required during construction.

3.1.1.3 Main Contractor's Yard

The contractor's main yard for aqueduct construction would be located at the southwest corner of the intersection of Kelso Road and Mountain House Road (see Figure 2). This parcel of land is relatively flat and wouldn't require significant grading for this purpose. It is anticipated that a yard of about 5 acres would be established to provide space for construction trailers, employee parking, maintenance shop, tool and equipment storage, fuel storage and containment, water tanks, and miscellaneous material storage. Most of the pipe and backfill material for aqueduct construction would be stored at other locations (see Sections 3.1.1.1 and 3.1.1.4).

3.1.1.4 CLSM Processing Area

Aqueduct construction would require from 160,000 to 330,000 cubic yards of CLSM backfill, depending on which flow option is selected. A CLSM processing area would be established at the approximate mid-point of the aqueduct, in a roughly 13-acre triangular area bounded by two BBID canals and the aqueduct alignment (see Figure 2). The area would include two CLSM batch plants that will mix soils excavated from the pipeline trench with cement, fly ash (potentially), and water to generate CLSM (note that for the 3,000 cfs case, only one batch plant would be needed). Other facilities at this site would include offices, a soils storage area, cement/fly ash storage silos, water tanks, a steel building for miscellaneous material storage, an area for conveying and loading equipment, and parking spaces for Redi-Mix trucks and employees. The area is relatively flat and would not require significant grading.

3.1.1.5 Drainage

Construction work in the aqueduct corridor and the associated trench, work areas, staging areas, access roads, and Contractor's yard would in some locations affect local drainage patterns for stormwater. The Contractor would be required to preserve natural drainage paths through and across the site as needed. Specific drainage features, including culverts and ditches, would be developed during final design to preserve drain flow across the top of the backfilled aqueduct. Construction contractors would be required to collect, treat, and discharge stormwater on the work areas in accordance with an approved Stormwater Pollution Protection Plan (SWPPP) and construction phase permits.

3.1.1.6 Special Measures at Special Crossings

Open-trenched crossings of BBID canals, the petroleum lines, roads, and powerlines would require special design and construction measures, including support and safety systems to protect the existing facilities and workers during construction and operations.

It is anticipated that the BBID canals would be crossed outside the irrigation season and pipelines would be concrete encased beneath the canals. Working outside the irrigation season would allow the canals to be disturbed and replaced in kind, possibly with canal lining improvements and possibly requiring bypass pumping from small off-season flows in the canal. Details of BBID canal crossings are subject to coordination with BBID and would require additional design development during the design phase.

The petroleum lines would need to be kept in continuous service and would be carefully supported and protected in-place throughout aqueduct construction. Details of the petroleum line crossings are subject to coordination with the utility owner and would require additional design development during the design phase.

Road crossings would take several days to weeks each and would require temporary bypasses for traffic, traffic control, and potential restrictions on work hours. Details of road crossings are subject to coordination with the county, conformance with associate permits. and would require additional design development during the design phase.

Work under powerlines would require excavation offsets from tower foundations and special grounding of pipe and equipment. Details of powerline crossings are subject to coordination with the utility owner and would require additional design development during the design phase.

3.1.1.7 Excavation and Soil Handling

Material excavated from the pipeline trench would range from 305,000 – 640,000 cubic yards (depending on which flow option is selected). This excavated material would have four possible temporary destinations:

- Sidecast to the staging areas adjacent to the trench, as shown on Figures 16 and 17, for later reuse as backfill
- Transported to the CLSM processing area for use in generating CLSM for backfill
- Transported to other stockpile areas for temporary or permanent storage

Most of the excavated material would be reused either as part of CLSM backfill along the pipelines, or as part of mounding and patrol road backfill over the pipelines. It is expected that only 10-20 percent of the excavated material would remain to be hauled to stockpile areas for other project uses or permanent storage.

Additional information and more comprehensive discussion about soil handling is provided in a separate TM, Soil Balance and Reusable Tunnel Material Supplement – Bethany Reservoir Alternative (DCA 2021a).

3.1.1.8 Dewatering

Prior to pipeline installation, portions of the excavated trench may need to be dewatered to allow for proper placement of bedding and backfill materials. At this conceptual stage of design, little information is available as to the existing groundwater table or the volume of water that would be involved, so the type of dewatering system to be used along the aqueduct corridor would need to be evaluated during final design. However, it is expected that pipeline construction would use sumping for shallower trench's and well points and sumping for deeper trenches (typically at the crossings).

Water removed from the trench by sumping would be pumped to the surface, treated, and either reused for construction water needs or land applied within the aqueduct construction area (subject to applicable permits). Water collected in well points could also be used for dust mitigation, CLSM production, or (if permitted) discharged to BBID canals nearby.

3.1.1.9 Pipe Delivery, Staging, and Installation

As shown in Figures 15 and 16, it is anticipated that individual pieces of pipe (about 30-40 feet in length) would be delivered directly from the plant to the aqueduct corridor, cradled, and strung out adjacent to the trench. From there, they would be lifted directly into the trench by large cranes in the work area between the pipe and trench. It is anticipated that during a typical workday, up to about four pieces could be installed and welded. This means that for a four-pipe trench, the aqueduct would advance by one piece of pipe (about 30-40 feet) per day. Other activities, including the excavation and backfill, would be expected to advance at about the same rate, before and after pipe installation.

Installation of pipe inside tunneled segments is covered in Section 3.1.2.

3.1.1.10 Leakage Testing

Since the pipelines are planned as welded joint welded steel pipe, no leakage would be allowed from the completed pipeline system. All pipe (including pipe installed by open cut methods or installed in the aqueduct tunnels) would be pressure tested at a pressure about 25 percent greater than the maximum operational working pressure. No leakage would be allowed. Note that such a requirement is common in the industry and readily achievable.

3.1.2 Aqueduct Tunnel Construction

Tunnels will be required for installation of the aqueduct under the Jones Penstocks and under the Bethany Reservoir Conservation Easement, as described in Section 2.1.3. These reaches total just over 3,000 feet, and each parallel pipeline would have its own separate tunnel, meaning that a total of about 6,000 to 12,000 feet of tunnel would be excavated (depending on which project design capacity is selected).

3.1.2.1 Tunneling Contractor's Temporary Facilities

For each tunnel reach, 4-5 acre temporary yards would be established at the portal areas for the tunneling contractor's mobile cranes, shops and offices, parking, material laydown and erection areas, equipment staging, tunnel ventilation system housing, temporary electrical substation, portable sanitary facilities, and storage for topsoil stripping. The area at the Jones Penstock tunnel site is relatively flat adjacent to the excavated portal area and wouldn't require significant grading for these purposes (see Figure 17). The area adjacent to the portal excavation for the Conservation Easement tunnel is on a hillside and would need significant grading (mostly excavation, see Figure 18). It is anticipated that the temporary yard graded for the Conservation Easement portal would be left in the "as graded" condition upon completion of the work and not backfilled to original grade. Some sculpted backfills could be placed for aesthetic reasons, if desired.

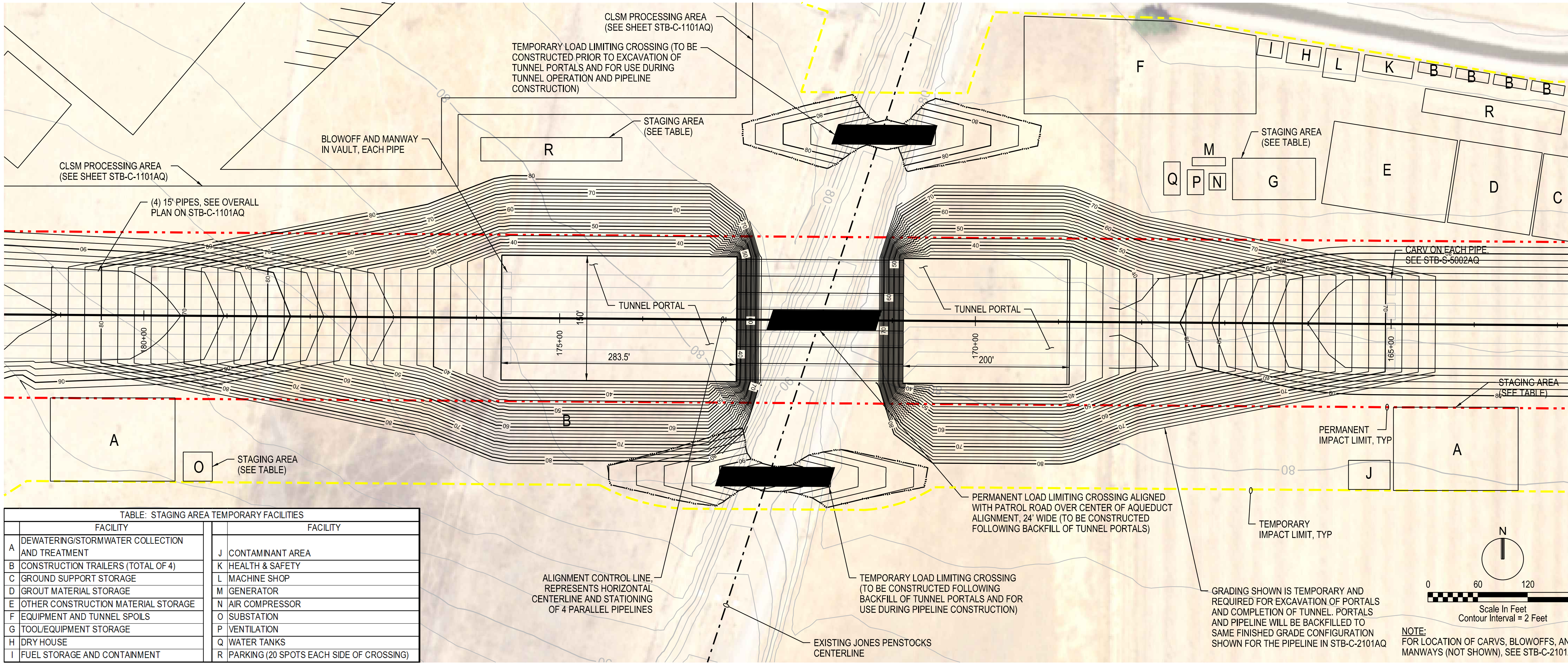


TABLE: STAGING AREA TEMPORARY FACILITIES

	FACILITY		FACILITY
A	DEWATERING/STORMWATER COLLECTION AND TREATMENT	J	CONTAMINANT AREA
B	CONSTRUCTION TRAILERS (TOTAL OF 4)	K	HEALTH & SAFETY
C	GROUND SUPPORT STORAGE	L	MACHINE SHOP
D	GROUT MATERIAL STORAGE	M	GENERATOR
E	OTHER CONSTRUCTION MATERIAL STORAGE	N	AIR COMPRESSOR
F	EQUIPMENT AND TUNNEL SPOILS	O	SUBSTATION
G	TOOL/EQUIPMENT STORAGE	P	VENTILATION
H	DRY HOUSE	Q	WATER TANKS
I	FUEL STORAGE AND CONTAINMENT	R	PARKING (20 SPOTS EACH SIDE OF CROSSING)

FIGURE 17 :
JONES PENSTOCK TUNNEL PORTAL AND TEMPORARY FACILITY YARD

DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

TABLE: STAGING AREA TEMPORARY FACILITIES	
	FACILITY
A	DEWATERING/STORMWATER COLLECTION AND TREATMENT
B	CONSTRUCTION TRAILERS
C	GROUND SUPPORT STORAGE
D	GROUT MATERIAL STORAGE
E	OTHER CONSTRUCTION MATERIAL STORAGE
F	EQUIPMENT AND TUNNEL SPOILS
G	TOOL/EQUIPMENT STORAGE
H	DRY HOUSE
I	FUEL STORAGE AND CONTAINMENT
J	CONTAMINANT AREA
K	HEALTH & SAFETY
L	MACHINE SHOP
M	GENERATOR
N	AIR COMPRESSOR
O	SUBSTATION
P	VENTILATION
Q	WATER TANKS
R	PARKING

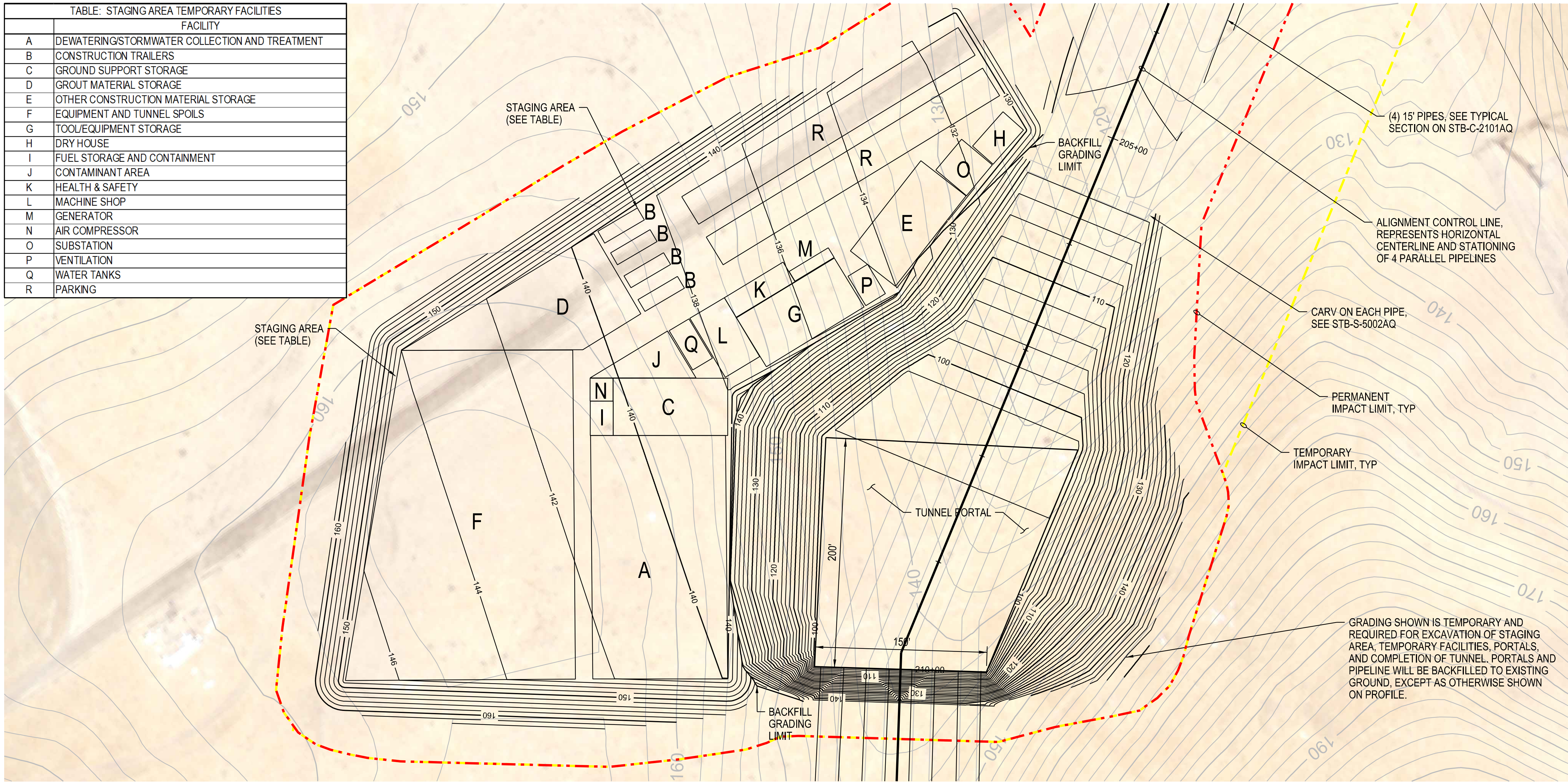


FIGURE 18 :
CONSERVATION EASEMENT TUNNEL LAUNCH PORTAL AND TEMPORARY FACILITY YARD

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

3.1.2.2 Portals – Excavation and Soil Handling

At each tunnel, a temporary portal would be excavated to create a work area for the tunneling equipment. Portals would be about 200 feet long, 150 feet wide, and 25 to 40 feet deep. The 150-foot width for the four-tunnel option would be reduced for three- and two-tunnel options.

Portal excavation (total of three portals) would range from 300,000 – 625,000 cubic yards (depending on which flow option is selected and the associated number of pipelines/tunnels). Material removed from the portals would be placed in nearby temporary stockpiles (in staging and pipeline alignment areas) if it is required to backfill the portal and pipe trench area. Excess excavated material that would not be replaced in the areas would be hauled to the permanent stockpile areas.

3.1.2.3 Anticipated Tunneling Method

Refer to a separate TM, Supplementary Tunnel Information – Bethany Reservoir Alternative (DCA 2021c) for anticipated shaft and tunnel excavation methods and details.

Material removed from the tunnels would be combined with portal material and handled as part of the overall soil handling strategy described above and in a separate TM, Soil Balance and Reusable Tunnel Material Supplement – Bethany Reservoir Alternative (DCA 2021a).

3.1.2.4 Tunnel Sequencing Relative to Connected Work Sequencing

Excavation of the portals and tunnels would be expected to be completed well in advance of nearby open-trench pipeline construction, and as such would be among the first work activities initiated for the aqueduct system. This sequencing supports continuous installation and testing of the steel pipe with delays for portions of the work. The excavation of the 55-foot diameter shafts at the Bethany Reservoir Discharge Structure would be initiated at the same time. These shafts could be completed before the Conservation Easement tunnels are completed, or alternatively the tunnels could be completed first.

3.1.2.5 Tunnel Pipeline Installation

It is anticipated that after the tunnels are completed, individual pipe pieces would be transported into position within the tunnel utilizing a specialized pipe carrier. Then the pipe would be supported in place and welded to the adjacent piece of pipe. Following leakage testing (see Section 3.1.1.11) and appropriate blocking to prevent floatation, the annular space between the tunnel wall and the pipe would be filled with grout (LDCC). Then, pieces pipe would be installed on the portal floor on each side of the tunnel, welded, and backfilled similar to open cut pipe including restoring the portal areas to original and required grades, as applicable.

3.2 Bethany Reservoir Discharge Structure

3.2.1 Sequencing of the Work

Due to the terrain, limited space, and multiple phases and types of construction work, the Bethany Reservoir Discharge Structure would be a congested construction site requiring compact work areas and efficient supply logistics. The sequence of construction is anticipated to be as follows:

- Initial grading of the site and shoring near tunnel outlet shafts
- Setting up shaft contractor's temporary facilities

- Pre-excavation grouting and/or curtain grouting at the shafts.
- Excavating the shafts
- Completion of tunnels under Conservation Easement into the shafts
- Placement of pipe inside tunnel
- Installing and backfilling pipe and fittings in the shafts
- Cofferdamming and dewatering (would be concurrent to work above such that this activity is complete about the same time as backfilling the pipe in the shafts)
- Conducting grouting in the rock matrix beneath the site to minimize water inflow into the excavation from Bethany Reservoir
- Additional excavation and grading between shafts and reservoir (now protected by a cofferdam)
- Forming and pouring the structure
- Installing gates and other features
- Placing riprap
- Backfilling the structure
- Complete electrical/mechanical/SCADA work
- Commissioning and demobilizing

These steps would not in all cases run as “finish-to-start”, because the site would be large enough to allow (for example) grading work to continue in some other areas while the shafts are being excavated. Further, it is expected that the work will involve two to four separate and distinct construction crews (and possibly separate contractors) that specialize in earthwork, shaft excavation, cofferdamming/in-water work, and structure construction. The subsections below (3.2.1.1. through 3.2.1.10) provide additional discussion of construction considerations and anticipated methodology.

3.2.1.1 Initial Grading of the Site and Shoring Near Shafts

The terrain associated with this structure varies considerably in elevation and would require significant grading to create workspace for excavating the shafts, forming and pouring concrete, and establish the contractor’s yard. This grading would need to accommodate a 10-foot wide buffer left between the conservation easement and site disturbance. However, it is anticipated that only portions of the grading needed to develop the work area and begin shaft excavation would be completed initially. Because the shaft pad and the overall structure would be 25-30 feet below reservoir level, it is assumed that most of the ground adjacent to the reservoir would be left unchanged to serve as a “plug” during the 12-18 months of shaft excavation.

The finished floor of the structure itself would be at elevation 227.0. Accounting for the thickness of the slab, the area would need to be excavated down to elevations ranging from 217 to 222, whereas the terrain varies from elevation 250 to over 300 feet. Because of the nearby conservation easement and buffer noted above, the excavation could not be sloped or laid back for portions of the site. The eastern edge of the structure, adjacent to the shafts, and particularly the southeast corner, would need to be shored to address roughly half of this vertical difference. Above elevation 260, the slope could be laid back at 1.5:1 or 2:1 while still providing the required buffer. This sloped area would be a permanent feature, as shown in Figure 7. Other portions of the structure's perimeter would have finished walls roughly at existing grade, so the initial grading for this deep excavation would be backfilled against these walls.

Note that geotechnical information at this site had not been collected prior to the preparation of this TM. As such, it may be possible that the presence of rock could simplify shoring and slope requirements.

The area allocated for the contractor's yard is similarly on uneven terrain and would require significant grading to create an area for the facilities to be described in the next section. This would include cutting a sidehill road to provide more than one means of ingress/egress into this long and narrow area. It is anticipated that this grading work (as shown in Figure 19) would be left generally as shown and not regraded to original conditions. Some sculpted backfills could be placed for aesthetic reasons, if desired.

FIGURE 19 :
TYPICAL CONSTRUCTION CONDITION FOR AQUEDUCT INSTALLATION - BRPP TO BETHANY RESERVOIR

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

3.2.1.2 Contractor's Temporary Facilities

As described in Section 3.2.1, the site would likely require multiple contractors (or subcontractors) with multiple specialties. It is expected that after initial grading work and shoring the hillside on the east/southeast edge of the structure, the primary activity onsite would be excavation of the 55-foot diameter shafts. This work would be expected to take 1 to 1.5 years to complete, during which time the shaft contractor would occupy most/all of the area allocated for temporary facilities, including:

- Offices
- Health and safety and quality building
- Equipment storage buildings (including ventilation equipment storage)
- Shaft ventilation fan housing
- Maintenance shops
- Grout material storage
- Ground support storage
- Shaft spoils storage
- Water tank
- Air compressor
- Standby engine generator
- Vehicle parking
- Electrical substation

Following completion of the shafts and the shaft contractor leaves the site, the area allocated for temporary facilities would likely be re-purposed for materials and equipment associated with additional earthwork, cofferdamming, and concrete structures. Some of the facilities brought in by the shaft contractor could remain, and the site would be expected to include the following:

- Offices
- Dry house
- Health and safety and quality building
- Construction material storage
- Excavated material temporary storage/staging
- General tool equipment storage
- Fuel storage and containment
- Concrete washdown
- Contaminant area
- Water treatment/discharge facilities
- Construction and dust suppression water storage
- Air Compressor
- Vehicle parking
- Electrical substation

3.2.1.3 Excavating the Shafts

Given the proximity of the shafts to the reservoir, there is the potential for large water inflows if open joints are present within the rock mass. To minimize the potential for large water inflows, pre-excavation grouting and/or curtain grouting could be performed at the shaft. Such grouting programs are conducted from the surface at the periphery of the shaft prior to shaft excavation.

It is anticipated that the shafts would be excavated with roadheader equipment. Vertical shafts would be excavated to a bottom elevation of 115.0, a total depth of about 112 feet with a finished surface elevation of about 227.0. However, because the ground would be graded to a surface of about 217 to account for slab thickness, the actual shaft depth to achieve with the roadheader would be about 102 feet. The material removed could be placed temporarily at the nearby facilities yard, or hauled directly to the stockpile areas described in a separate see TM, Soil Balance and Reusable Tunnel Material Supplement – Bethany Reservoir Alternative (DCA 2021a).

3.2.1.4 Completion of Tunnels under Conservation Easement and Placement of Pipe inside Tunnel

As described in Section 3.1.2.4, the tunnels under the Conservation Easement could be completed before or after the shafts have been excavated. Following completion of the shafts and the tunnels, the pipeline through the tunnels would be installed, welded, and leakage tested. Grouting of the annular space could be completed to within a short distance of the shafts, or postponed until the pipelines are placed and welded within the shafts.

3.2.1.5 Installation and Backfill of Pipe in the Shafts

The 180-inch diameter 90-degree bends would be lowered into the shafts and welded to the pipelines at or near the ends of the tunnels. A robust temporary system would need to be designed and installed by the Contractor to install the bend and support them during welding, and during installation of the adjoining straight 180-inch diameter pipe segments running up to the top of the shafts. Once the bends and straight segments are installed and welded, leakage testing would be completed and then the annular space would be filled with concrete (near the bottom) and CLSM. This CLSM would form the subgrade for portions of the main structure slab, and for parts of each counterfort on the high back wall of the structure.

3.2.1.6 Cofferdamming and Dewatering

With shaft work complete and construction shifting to the large concrete structure, the next step would be to construct a cofferdam in Bethany Reservoir. All of the concrete work would be on shore, but portions would be 25 to 30 feet below the reservoir's water surface. Riprap designated to be placed beyond the end of the structure would also be in an otherwise-inundated area. For both these reasons, a cofferdam would be needed to isolate the work from the reservoir and provide a dry work area.

It is envisioned that the cofferdam would consist of sheet piles attached to a series of drilled piles and walers. Circular piles would be drilled into the lake bottom on a predetermined spacing. Sheet piles would then be installed between the circular piles. To minimize vibration at this site within 200-300 feet of a section of dam forming the reservoir bank, the sheet pile would likely not be driven, but rather vibrated into place or pre-excavated into soft rock and backfilled with tremie concrete to help form a water seal at the bottom. Supports would be installed on the dry side of the cofferdam and supported against the lake bottom. The cofferdam and all components would be removed at the completion of the work. If portions of the cofferdam cannot be pulled up from the lake bottom, they would be cut off below grade by divers and any remaining portions covered with small riprap material.

Up to 50 feet beyond the cofferdam (further into the reservoir), a silt curtain would be installed to help contain turbidity from construction activity. The silt curtain would be anchored on the shore and held in place within the reservoir by temporary anchor weights.

On the dry side of the cofferdam, a dewatering system of trenches, pumps, and well points would be required to capture leakage and/or water "subbing" up through the reservoir bottom material and pipe it to shore for treatment and discharge back to the reservoir outside the silt curtain.

3.2.1.7 Additional Excavation and Grading

With the cofferdam and dewatering facilities in place, the remainder of the excavation could occur between the shafts and the edge of the reservoir. Portions of the material removed from the site would be retained in the nearby construction yard for later backfilling, but the remainder would be hauled directly to the stockpile areas described in a separate TM, Soil Balance and Reusable Tunnel Material Supplement – Bethany Reservoir Alternative (DCA 2021a).

It is anticipated that portions of the deep excavation not bounded by the Conservation Easement would be sloped back rather than shored. However, the contractor's access to various parts of the site could be changed and would be developed further during design.

3.2.1.8 Forming and Pouring the Structure

The structure would involve placement of 15,000 to 29,000 cubic yards of concrete, depending on the design flow rate selected. The structure would be relatively complex because of its shape and combination of multiple slab thickness, interior and exterior walls, counterforts on three sides, piers, stoplog slots, gate features, and bridge decking.

3.2.1.9 Riprap

Riprap as described above would be placed in the area between the end of the structure and the cofferdam. This would be a relatively simple operation on a combination of flat, excavated ground and the sloping reservoir bed. Generally, the riprap would be placed on top of existing grade except for a transition area at the end of the structure. It would also be keyed into the native material at the toe along the cofferdam. The size of the rip rap would be determined during the design phase of the project.

3.2.1.10 Backfill and Demobilization

After placing the riprap and adequate time to cure the concrete, the structure would be backfilled, and the dewatering systems would be removed. At that time, the cofferdam and silt curtain would be removed from the reservoir. The piles and walers would be disassembled and it is expected that most of the structure could be removed with ease, but portions drilled and tremied into the reservoir bed may need to be cut off just below the original ground surface using divers.

3.2.2 Logistics

The terrain would make access around the site during construction challenging in some areas. The large and deep excavation for the structure, the Conservation Easement, and Bethany Reservoir would limit available space for roads and entry points for materials and equipment. Access to the site for most construction loads and deliveries would be from the south along a new access road to the reservoir starting on Mountain House Road south of the Conservation Easement. The existing California Aqueduct Bikeway would be widened for construction traffic from a location near the south end of the reservoir up to the structure site. Smaller vehicle access could also access the site from the north via Christensen Road, through the fishing access park, and over one of the perimeter dams to the site.

Though not shown in Figures 7 and 19, the contractor would likely need to install temporary bridges, ramps, additional shoring, or other means for his access around and through the site. It is anticipated that the California Aqueduct Bikeway would be closed to public use throughout the work.

The long and narrow area allocated for the contractor's temporary facilities could be accessed in two locations and would be directly connected to the construction site, but as described in Section 3.2.1.1, this area would be graded to make the area suitable for buildings and equipment. The contractor would therefore need to construct ramps and carefully plan the layout of facilities to make the best use of the space and optimize ingress and egress.

3.2.3 Temporary Limits of Disturbance (LOD)

The temporary LOD for the Bethany Reservoir Discharge Structure site are shown in Figure 19. Rather than being established based on a specific width or offset distance, they generally encompass the area needed to complete temporary and permanent grading, provide construction access to all areas, allocate space for temporary facilities, and enclose the silt curtain in the reservoir.

3.2.4 Drainage

Construction work for the discharge structure, and even for the contractor's yard, would affect local drainage patterns for stormwater. The Contractor would be required to collect, treat, and discharge stormwater in accordance with an approved SWPPP and applicable permits. Finished site grading would allow existing drainage patterns to be maintained after construction.

3.3 Jones Outlet and DMC Control Structures

For the project design capacity of 7,500 cfs, the Jones Outlet and DMC Control Structures would be required as described below.

3.3.1 Sequencing of the Work

Work at this site would need to follow a specific order because of access challenges and the need to keep the DMC in continuous service. The anticipated sequence is as follows, with more detail on each step in the ensuing sections:

- Setting up construction yard
- Initial grading on the west bank of the DMC (down to elevation 15.0) to begin work on the temporary canal bypass, including grading to construct a ramp from the bypass area to the adjacent field where the material would be stockpiled
- Installing temporary bridge over the DMC
- Driving sheetpile to form each side of the temporary bypass channel
- Install temporary bridges over each end of bypass channel
- Excavating material from between the rows of sheetpile, and installing internal supports, down to elevation -17.0 to form bypass
- Place erosion protection on the bottom of the bypass channel (tremie concrete, riprap, or articulated concrete mats, to be determined during design)
- Removing dirt "plug" on each end of bypass channel to begin bypass flow
- Install cofferdams in DMC, each end DMC Control Structure footprint

- Complete remainder of earthwork as needed to form structures
- Form and place concrete (DMC Control Structure and Jones Outlet Structure, with the latter needing to be coordinated with construction of aqueduct pipeline)
- Install gates and other mechanical/electrical/SCADA equipment for structures
- Backfill structures, remove cofferdams, and fill bypass

Additional details for each step are provided in the sections below.

3.3.2 Construction Area and Temporary Limits of Disturbance

These two structures would be part of the same contiguous construction area immediately adjacent to the BRPP site and on the west side of Mountain House Road. The WAPA Tracy Substation is nearby to the south and major power transmission lines and towers feeding the substation from an eastern boundary to the construction area, as does Byron Highway to the north. The overall construction area and LODs are shown on Figure 20.

The contractor's temporary facilities for this portion of the project are anticipated to be as follows:

- Offices
- Health and safety and quality building
- Machine and maintenance shop
- Shipping and receiving building
- Material staging and storage area
- Equipment storage
- Fueling area and hazardous materials storage
- Leachfield
- Temporary stockpile management and dewatering area
- Vehicle parking
- Electrical substation

The area allocated for these temporary facilities is relatively flat and significant grading would only be required where these areas encroach on the original excavation waste piles along the canal.

3.3.3 Logistics and Access

Two means of access to this site are envisioned: 1) Primary - from Mountain House Road, and 2) Secondary - off Byron Highway. The Byron Highway access would be on the west bank of the DMC and would be very limited due to commonly heavy traffic conditions on Byron Highway. It is expected that this secondary access would only be available under traffic control conditions, potentially only at night, and only to mobilize/demobilize heavy equipment and materials to the west side of DMC when the temporary bridges over the DMC and over the canal bypass are not unavailable or are impractical.

As shown in Figure 20, two ramps would need to be excavated to facilitate the contractor's access to the construction area and permanent stockpile area:

- A ramp with retaining walls on both sides between the upper (elevation 37.0) and lower (elevation 13.0) access roads on the eastern bank of the DMC.
- A ramp from the temporary canal bypass area (elevation 15.0) to the adjacent field (elevation 32.0) near the permanent stockpile area.

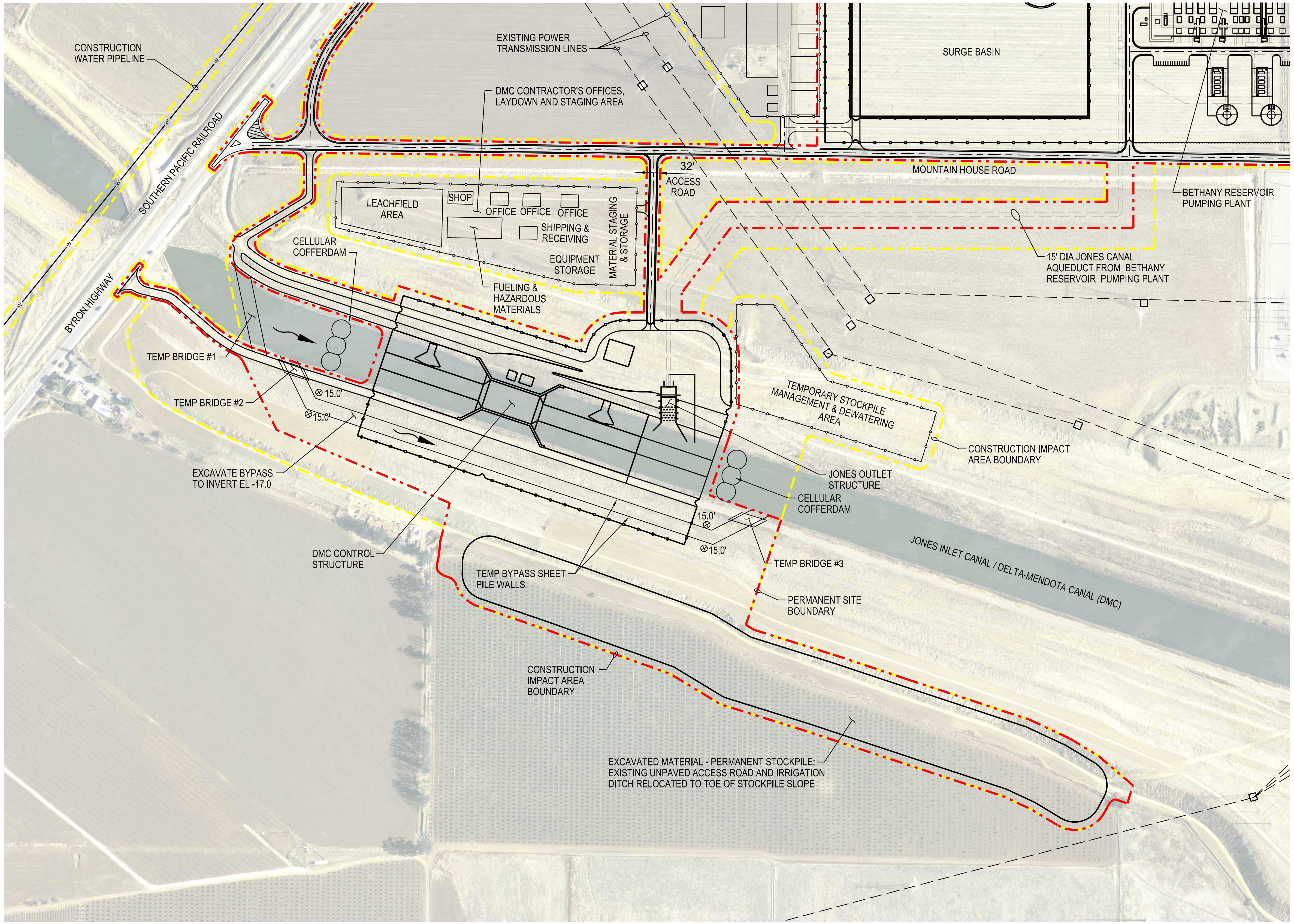


FIGURE 20 :
CONSTRUCTION AREA AND LIMITS OF DISTURBANCE FOR THE JONES OUTLET AND THE DMC CONTROL STRUCTURES

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

It is expected that both these ramps would remain in place permanently.

Because the DMC is a CVP facility in continuous service, it is anticipated that the contractor would need to provide some prearranged level of access to CVP personnel and equipment to and through the site on both sides of the canal.

3.3.4 Cofferdamming, Dewatering, and Temporary Bypass

Construction of the Jones Outlet, and especially the DMC Control Structure, would require construction of a temporary bypass and cofferdams in the DMC. The bypass would need to provide continuous flow of up to 4,600 cfs, and it is anticipated that it would be constructed by installing parallel rows of sheetpile, about 50 to 80 feet apart, with the soil between removed down to elevation -17 feet for a total flow depth of about 17 to 27 feet, depending on Old River levels. The end of the bypass would be flared a small amount to reduce entrance and exit velocity. For a total bypass length of about 2,000 feet, this configuration would result in headloss through the bypass of less than 1 foot (including entrance and exit losses).

The bypass would require temporary bridges over both ends to maintain through traffic for construction and for monitoring of the canal between the Byron Highway and the Jones Pumping Plant. Once the bridges are in place and the bypass is flowing, cofferdams would need to be installed in the DMC just upstream and just downstream of the construction footprint for the DMC Control Structure and Jones Outlet. It is anticipated that cellular sheetpile cofferdams would be used, but other systems may be considered by the contractor. The cofferdams would need to accommodate of hydraulic head of up to 40 feet, accounting for the typical water high surface elevation in the canal (elevation 10 feet) and the bottom of the control structure excavations (elevation -28 to -30 feet).

Once the cofferdams are in place, the construction area would be dewatered to the bottom of the excavation. It is assumed that the dewatering system would consist of sumps and well points, with water pumped out of the excavation and collected in the dewatering area. There it would be treated and discharged to the DMC downstream of the site.

3.3.5 Excavation and Soil Handling

The Jones Outlet/DMC Control Structure site would involve removal of approximately 850,000 cubic yards of soil, with less than 25 percent of that material destined to be used as backfill at the site. Stockpile areas would be available on both sides of the canal to prevent the need for transporting these large volumes over the temporary bridges, and the general plan for soil handling would be as follows:

- Material removed on the west side of the DMC would be transported to the permanent stockpile area at the edge of the field south and west of the site, placed against the embankment at the edge of this field bordering the west DMC canal bank. This material would total slightly over 500,000 cubic yards, and most of it would remain permanently at this stockpile, with the exception of approximately 120,000 cubic yards that would ultimately be returned to fill the bypass when construction is complete.
- Material removed for the Jones Outlet Structure and on the eastern side of the DMC would be transported either to the temporary stockpile area at the southeast corner of the site, or to other permanent stockpile areas for the project adjacent to the BRPP. Only a small portion would need to be used as backfill for the new structure.

Figure 20 above shows the locations of the nearby stockpile areas. It should be noted that for the permanent stockpile area, an existing road and irrigation ditch would need to be relocated to maintain the current function of the field. For this and other aspects of soil handling, see TM, Soil Balance and Reusable Tunnel Material Supplement – Bethany Reservoir Alternative (DCA 2021a).

3.3.6 Concrete Structures

The two structures would involve placement of slightly over 50,000 cubic yards of concrete, with the majority associated with the DMC Control Structure. The structures would be relatively complex because of their shapes and combination of multiple slab thickness, sloped floors and canal lining, piers and stoplog slots, gate provisions, and bridge decking. As noted in Section 3.3.1, the Jones Outlet structure would need to be coordinated with construction of the 180-inch diameter aqueduct pipeline approaching from the east since it penetrates the discharge basin portion of the structure.

The slab at the bottom of the Jones Outlet Structure baffled apron drop would be integrated with canal lining downstream of the DMC Control Structure, so these construction elements would need to be appropriately coordinated.

After concrete has cured adequately, the radial gates and other mechanical/electrical equipment for DMC Control Structure would be installed, as well as the bridge and handrails.

3.3.7 Backfill and Demobilization

After all the concrete, mechanical, and electrical work is complete, the structure would be backfilled with material from the two nearby stockpiles. Then the two cofferdams in the DMC would be removed. The downstream cofferdam would be breached first, to allow backflooding of the structure. Then the both cofferdams would be removed.

With the DMC now flowing through the new structure, the bypass would need to blocked off at each end (likely with temporary sheetpile) and dewatered to allow removal of supports plus filling and compaction of the backfill material. Once the channel is filled, the sidewall sheet pile, and the temporary sheetpile or other means previously installed to block off the bypass, would be removed. It is expected that bank stabilization measures, in the form of riprap or articulated concrete mats, would be placed on the canal bank at both ends of the bypass. This would be accomplished within the dewatered area prior to removal of sheet piles. Temporary bridges over the bypass would also be removed.

3.3.8 Drainage

Construction work on the structures, access roads, and Contractor's yard would in some locations have a minor effect on local drainage patterns for stormwater. The Contractor would be required to preserve natural drainage paths through and across the site as needed, and to collect, treat, and discharge stormwater in accordance with an approved SWPPP and applicable permits. Finished grades would largely preserve the existing drainage patterns at the site. Minor redirection of some drainage would be provided in areas with drainage pattern changes.

4. Operation and Maintenance Requirements

4.1 System Operation

4.1.1 Filling

The aqueduct system would be filled by pumping from the BRPP into each aqueduct pipeline using a single pump at its lowest speed. Prior to filling, crews would need to ensure that all personnel and equipment are out of the pipe, all manways are closed, valves at blowoffs are closed, CARVs are open and functional, gates at the Bethany Reservoir Discharge Structure are fully open, and (for the project design capacity of 7,500 cfs) the control system for the DMC Control Structure is functional and ready to operate gates for the desired flow split between the CVP Old River diversion and the BRPP supply.

During start up, the fluid velocity within the system should be limited to that generated by one pump at minimum flow (assumed to be about 250 cfs or 1.4 feet per second) while filling or until all air has been flushed out and the pressure brought up to operating conditions. At the beginning of filling, it is assumed that the water level at the discharging side of the BRPP pumps would be essentially at the wet well water level. Since the initial pumping head is low, control valves on the discharging pipes would be used to throttle the flow so the pumps could be operated within acceptable ranges.

4.1.2 Draining

Should the system need to be drained for maintenance or repairs in the aqueduct pipelines or portions of the BRPP, the following steps would need to be taken:

- Shut off the pumps at the BRPP.
- Close the radial gates at the Bethany Reservoir Discharge Structure (also install stoplogs on one or both side of the gates depending on whether work is needed inside the pipelines or on the gates or channels between the stoplogs.
- Operate dewatering flow control facility within the BRPP to allow water to be drained back into the pumping plant wet well.
- Open valves at blowoffs to allow sections of pipe that do not drain by gravity at the BRPP to be pumped out, as applicable. This step is not needed unless work is required at that location or movement of people or air is needed. To drain, drop in portable pumps at the blowoffs, and discharge the water to the nearest gravity-draining portion of the aqueduct through temporarily-opened manways (or, discharge to a nearby water course following permitted practices).

4.1.3 CARVs

The combination air and vacuum valves as described in Section 2.1.1 would work automatically to release accumulating air (from outlet orifices) and help mitigate surge and vacuum conditions (through inlet orifices). The isolation valves would be set in the open position. The CARVs are a duplex, fully-redundant design, so one valve could be removed for servicing. At least one valve would need to be in place and operable at all times.

4.1.4 Emergency Shutdown/Isolation (Discharge Structure)

Should a pipe break or other circumstance occur that requires an immediate aqueduct system shutdown, the radial gates at the Bethany Reservoir Discharge Structure would close. Some closures related to loss of pressure would be automatic, preventing the reservoir from draining back through aqueduct. Other closures could be initiated by the system operators from the applicable operations control center, the BRPP, or locally. The control system for the gates would be set such that if any pipeline shows an unexpected pressure drop, all gates for that pipeline would be signaled to close. It is expected that the gates would be fully closed within 5 to 20 minutes. Due to the critical control nature of this facility, a standby engine generator would be provided for backup power in case of a power outage.

4.1.5 Jones Outlet Discharge

The Jones Outlet structure would be a flow-through facility with no operational control and would have no control systems, but may include water level instrumentation. There would, therefore, be no action needed for operation of the facility.

4.1.6 DMC Control Structure

The Delta-Mendota Canal Control Structure would work in tandem with the Jones Control Structure to deliver water to the Jones Pumping Plant. The flow scenarios would include delivery only from the DCP via the BRPP and the Jones Canal Aqueduct, delivery only through the existing CVP facilities, or a combination of both. Radial gates would control upstream flow from Old River into the DMC. Three large gates would control the bulk of the flow in the canal, and a smaller gate would be provided for flow trimming. It is expeced that the BRPP would maintain a flow set point defined by CVP operations staff. The DMC Control Structure would maintain a constant downstream water level and that way wahtever flow is pumped by the Jones PP would be easily fed into the system by the two sources working in tandem.

Due to the critical control nature of this facility, a standby engine generator would be provided for backup power for the gates in case of a power outage. Stilling wells would be provided both upstream and downstream of the gates to monitor water surface levels. These levels would be used with the gate rating curves to establish the flow through the gates. The gates would be controlled with electric hoist operators.

4.2 System Maintenance

Elements of the aqueduct system would vary greatly in terms of the types and frequency of required maintenance. The primary elements requiring maintenance and brief descriptions of the maintenance actions are described below.

4.2.1 Pipelines

Corrosion protection for the pipelines will be provided by the cathodic impressed-current cathodic protection system with air-cooled or oil-cooled rectifiers as described in Section 2.1.1. Maintenance of the CP system would consist of the following:

- Inspect the electrical performance of rectifiers and sacrificial anodes or impressed current anode outputs. This typically is performed monthly.
- Make repairs as needed from monthly inspections.
- Corrosion test stations or test points (accessible aboveground appurtenances such as riser or accessible valve in vault), as well as, any aboveground anode junction boxes with anode wires are checked annually.

All data would be stored as a system of record for the life of the CP system. Inspections, troubleshooting and repairs would be performed by a corrosion engineer.

The pipeline's cement mortar lining would need to be inspected after about 1 year of operation and then every 2 to 3 years by accessing the pipeline though the manways. Visual inspections would typically be performed. Magnetic flux leakage (MFL) testing may be warranted as the system ages. Field repairs of any problem areas found would need to be made immediately to protect pipeline integrity.

Equipment at the CARV's and blowoffs would also need to be tested annually for proper function, leakage, or other operational issues. Valves would need to be exercised as part of this process.

4.2.2 Patrol Roads

Patrol roads along the aqueduct would need intermittent maintenance to maintain a good driving surface. Grading and recompaction of the gravel surface could be needed at least annually, and rutting and potholes from rain and runoff after larger storms could require intermittent or spot repairs several times each year.

4.2.3 Bethany Reservoir Discharge Structure

Maintenance activities at this structure would mostly consist of cleaning the channels of any accumulated debris or sediment, and cleaning, lubricating, and inspecting the radial gates including hoists and related mechanisms. Radial gate corrosion protection anodes would be inspected annually and replaced as needed. Work on the gate hoists could occur at any time since they would be above the water level, but work on the trunions or debris/sediment cleaning would require isolation of a given channel using the gates and stoplogs. Stoplogs would be stored on the site for use as needed. It is anticipated that when isolation is needed, a mobile crane would be brought to the site to lift the hatches (upstream row of stoplogs only) and install the stoplogs. The isolated bay(s) could then be pumped out for maintenance or repairs. The on-site standby engine generator would be tested for proper operation monthly.

Upstream of the stoplogs, in the section between the bridge and the vertical shafts, any given channel could only be dewatered for cleaning if the associated pipeline and pump back at the BPRR were shut off and partially drained. However, very little debris or sediment is expected to collect in these portions of the structure because of the constant flow of water and the relatively clean water source.

4.2.4 Jones Outlet Structure

The Jones Outlet Structure would need to be inspected annually in terms of concrete condition. The discharge basin where the aqueduct pipeline enters the structure could collect sediment and debris and would likewise need to be inspected at least annually. Both the discharge basin and the entire aqueduct from BRPP could be drained partially by gravity using the drainage system shown on Figures 10 and 13. The degree of gravity drainage would be controlled by the elevation of water in the DMC, which most of the time would be lower than the floor of the discharge basin and the invert of the approaching pipe. Therefore, in most cases it is anticipated that gravity draining would be sufficient for inspections.

4.2.5 DMC Control Structure

Maintenance activities at this structure would mostly consist of cleaning the channels of any accumulated debris or sediment, and cleaning and lubricating the radial gate hoists and related mechanisms. Radial gate corrosion protection anodes would be inspected annually and replaced as needed. Work on the gate hoists could occur at any time since they would be above the water level, but work on the trunions or debris/sediment cleaning would require isolation of a given channel using the gates and stoplogs. Stoplogs would be stored on the site for use as needed. It is anticipated that when isolation is needed, a mobile crane would be brought to the site to lift the hatches (upstream row of stoplogs only) and install the stoplogs. The isolated bay(s) could then be pumped out for maintenance or repairs.

Stilling wells and level sensors would need to be checked at least annually to ensure that proper readings are being transmitted to the control system. The on-site standby engine generator would be tested for proper operation monthly.

5. References

California Department of Water Resources (DWR). 2020a. Notice of Preparation of Environmental Impact Report for the Delta Conveyance Project.

California Department of Water Resources (DWR). 2020b. Delta Conveyance Project Scoping Summary Report.

Delta Conveyance Design and Construction Authority (DCA). 2021a. *Soil Balance and Reusable Tunnel Material Supplement – Bethany Reservoir Alternative*. Final Draft.

Delta Conveyance Design and Construction Authority (DCA). 2021b. *Hydraulic Analysis of Delta Conveyance Options – Bethany Reservoir Alternative*. Final Draft

Delta Conveyance Design and Construction Authority (DCA). 2021c. *Supplementary Tunnel Information - Bethany Reservoir Alternative*. Final Draft.

6. Document History and Quality Assurance

Reviewers listed have completed an internal quality review check and approval process for deliverable documents that is consistent with procedures and directives identified by the Engineering Design Manager and the DCA.

Approval Names and Roles			
Prepared by	**Internal Quality Control review by**	**Consistency review by**	**Approved for submission by**
Ron Fehringer / EDM Bethany Aqueduct Lead	Phil Ryan / EDM Design Manager	Gwen Buchholz / DCA Environmental Consultant	Terry Krause / EDM Project Manager

This interim document is considered preliminary and was prepared under the responsible charge of Ronald James Fehringer, California Professional Engineering License C51483.