Subject:	**Bethany Reservoir Pumping Plant Facilities and Site Configuration (Final Draft)**
Project feature:	Pumping Plant
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1. Introduction

This Technical Memorandum (TM) describes the purpose and functionality of the main facilities associated with the Bethany Reservoir Pumping Plant (BRPP), which is a primary element within the Delta Conveyance System (project). This TM describes the arrangement of the facilities and supporting infrastructure that constitutes the concept-level site configuration. The facilities and site configuration have been defined and developed in accordance with the information presented in the TM entitled *South Delta Pumping Plant Basis of Conceptual Design Criteria* (DCA. 2021a).

The BRPP facilities would be used to pump raw water from the project's main tunnel into the Bethany Reservoir, or potentially to the Central Valley Project (CVP) C.W. "Bill" Jones (Jones) Pumping Plant approach channel, as well. The BRPP would be situated near, and connected to, the Surge Basin Reception Shaft at the southern end of the project's main tunnel system.

The range of project design capacities of 3,000 to 7,500 cubic feet per second (cfs) was established by the DCO. The BRPP facilities and site configuration have been sized to convey four specific design capacity options of 3,000, 4,500, 6,000 and 7,500 cfs. The size and configuration of the overall BRPP site would depend on the selected project design capacity. The size and number of the below ground structures (dry pit bays, surge basin, and wet well), the above-grade electrical building, and the arrangement of other structures and facilities would change based on the number of pumps required to achieve the selected project design capacity. The engineering concept drawings show the required building dimensions and configurations of the BRPP facilities as they apply to each project design capacity.

The engineering concept drawings show the permanent infrastructure layout associated with the BRPP facilities for all project design capacity options. Engineering concept drawings include the project design capacity option of 7,500 facilities in more detail than other capacity options since this design capacity option represents the largest facility footprint. The following major facilities would be included as part of the BRPP facilities:

- Connection to Surge Basin Reception Shaft.
- BRPP wet well inlet conduit.
- Main tunnel surge basin overflow containment facility.
- BRPP belowground dry pit pump bays and adjoining belowground wet well.
- Above ground canopy structures and rail mounted gantry cranes (over the belowground dry pit pump bays).

- Above-ground surge tanks with connecting belowground check valve vaults.
- Electrical building.
- Heating, ventilation, and air conditioning (HVAC) equipment yard.
- Electrical substation.
- Emergency generator building.
- Equipment storage and maintenance building.
- Buried welded steel discharge pipelines connecting to the Bethany Reservoir Aqueduct for conveying pumped flow to Bethany Reservoir.
- Buried welded steel discharge pipeline connecting to the Jones Pumping Plant Approach Channel Aqueduct for conveying pumped flow to the CVP Jones Pumping Plant Approach Channel (7,500-cfs project design capacity only).
- Site access and interior roads.

1.1 Organization

This TM is organized as follows:

- BRPP Facilities.
- BRPP and Surge Basin Site Plan Configuration.
- References.
- Document History and Quality Assurance.

2. BRPP Facilities

The BRPP would be located at the southern end of the main tunnel system and would include a wet well inlet conduit connection to the Surge Basin Reception Shaft beneath the Surge Basin, pumping plant facility structures, aboveground surge tanks, and welded steel discharge pipelines. The following subsections describe the individual facilities that constitute the BRPP facilities and their use, configuration, and functionality.

2.1 Surge Basin Reception Shaft

The Surge Basin Reception Shaft is the tunnel shaft located at the southern end of the main tunnel system. It would be located within the Surge Basin on the BRPP site. This shaft would initially serve as a tunnel reception shaft during construction for the southern section of the main tunnel. The shaft would be repurposed as the tunnel surge overflow inlet to the surge basin and as the point of connection to the inlet conduit connecting the main tunnel to the pumping plant wet well.

The reception shaft would be open-top for its entire diameter. The shaft would have a bottom elevation of -169.18 feet and would extend vertically to a top elevation of +7.0 feet, matching the finished floor elevation of the Surge Basin structure above the shaft. The shaft would be concrete-lined and have a finished interior diameter of 120 feet, as shown on the engineering concept drawings.

A bridge structure extending from finished site grade out over the top of the shaft would allow access to enter the tunnel or to install temporary (or permanent) vertical submersible pumps within the shaft for dewatering the main tunnel when needed by operations for inspection or maintenance of the tunnel. The bottom elevation of the shaft would be the low point of the main tunnel.

2.2 Surge Basin

The Surge Basin would be located above the main tunnel and Surge Basin Reception Shaft, as shown on the engineering concept drawings. The Surge Basin would be an open top, rectangular, below ground-level structure and would be constructed with diaphragm wall sidewalls and a reinforced concrete floor slab. The top elevation of the diaphragm walls would vary from elevation 46.5 feet on the southern wall to 42.0 feet on the northern wall of the structure to match the exterior finished grade. The interior top of floor slab elevation of 7.0 feet would match the top outlet elevation of the reception shaft. The diaphragm walls would be restrained by two levels of permanent tiebacks at elevations 35.0 and 23.0 feet, spaced 6 feet on center horizontally all around the perimeter of the basin. The basin floor would be a waterproofed structural slab designed to resist hydrostatic uplift pressures using a thickened reinforced slab anchored to drilled shafts. The reinforced floor slab would be 5 feet-thick and resist uplift with the aid of a series of 6-foot diameter drilled reinforced concrete tie-down shafts extending to a bottom elevation of -58.0 feet. Structural details associated with diaphragm wall design and tie backs, as well as the floor slab design and uplift resistance, would be reviewed and considered in greater detail during final design.

The surge basin would contain an access ramp along the northerly edge of the basin that would allow direct access from Mountain House Road located immediately west of the structure. The ramp would be constructed at a six percent grade to facilitate the removal of the tunnel boring machine (TBM), plus construction and operations and maintenance access to the base of the surge basin.

The Surge Basin would include a 180-foot-diameter circular weir wall surrounding the outlet of the vertical reception shaft. The circular weir wall would extend vertically from the top of floor slab (elevation 7.0 feet) to a top of weir elevation of 18.0 feet and would incorporate six gated openings around its circumference. The gated openings would normally be closed while the system was in operation. During a hydraulic transient-surge condition within the main tunnel, water from the tunnel would automatically flow over the circular weir wall and into the Surge Basin. Such a surge event would be the result from an electrical power failure at the BRPP site (or other emergency that would generate a transient-surge condition). The circular weir wall with its gated openings in the closed position would prevent water stored within the Surge Basin from reentering the tunnel. The gated openings would only be opened to drain the Surge Basin back into the tunnel system after the transient-surge event dissipated within the tunnel.

The Surge Basin structure would be designed to contain a maximum water surface elevation (WSE) of 28.2 feet as shown on the engineering concept drawings for the project design flow option of 7,500 cfs. The maximum WSE of 28.2 feet is the Sacramento River 200-year flood level with sea level rise at intake C-E-2 as described in the Engineering Project Report for the Central and Eastern tunnel corridor options (DCA. 2021e). C-E-2 would be constructed for the 7,500 cfs project design capacity option only. The WSE of 28.2 feet would be reached within the Surge Basin structure in the event the control and radial gates are opened in the Sacramento River Intake C-E-2 while the BRPP is not in operation. For the project design capacity options of 3,000, 4,500 and 6,000 cfs, intake C-E-2 would not be constructed, and intake C-E-3 would establish the maximum WSE of 27.3 feet within the Surge Basin structure as 27.3 feet would be the Sacramento River 200-year flood level with sea level rise at intake C-E-3. Under normal steady-state hydraulic operating conditions associated with the project, the control gates and radial gates within the intakes would be modulated to develop sufficient differential head to maintain the WSE within the Surge

Basin structure at an elevation below the structure's top of overflow weir elevation of 18.0 feet for the project design flow capacity options and range of Sacramento River WSEs at each intake.

During normal operations of the BRPP, the Surge Basin would be maintained in a normally empty condition to accommodate overflow volumes associated with transient-surge events. Following a tunnel transient-surge or wet weather event where the free-water surface within the basin was above a predetermined elevation, the BRPP would not be permitted to operate until the basin had been emptied below the predetermined elevation, so sufficient storage was available within the basin for tunnel overflow volumes. The Surge Basin facility would also include permanently installed dewatering pumps to drain water contained within the basin from wet weather events and allow for more flexibility in the timing of restarting the BRPP pumps after a transient event. Pumped water from the surge basin would be discharged into the pipelines leading to Bethany Reservoir.

The Surge Basin containment capacity (between the top of the overflow weir and the basin floor) would be sized to accommodate water that may overflow into the basin during a tunnel transient overflow event. A volumetric safety factor of 1.25 was applied to the containment capacity of the basin shown in the engineering concept drawings (7,500 cfs project design flow option) in case some amount of water was already in the basin during a hydraulic surge event and to allow for variations in surge volume. The surge basin configurations would provide the same volumetric safety factor of 1.25 for all project design capacities options (3,000, 4,500, 6,000 and 7,500 cfs). The final depth, configuration, and volumetric safety factor of the surge basin structure should be further refined during the future design phase.

The Surge Basin would include a bridge structure that spanned from the southern edge of the basin out over the vertical overflow shaft. The top of the bridge deck would be at elevation 46.5 feet and would be aligned directly over the top of the covered wet well inlet conduit. The bridge structure would include a removable panel centered over the reception shaft and a rail-mounted gantry crane that would be used to facilitate access into the tunnel and install submersible pumps and connect discharge piping for dewatering the tunnel. Pumped water would be discharged into the BRPP discharge headers leading into the Bethany Reservoir Aqueduct. The gantry crane rail system would run the entire length of the bridge structure including the laydown area located next to the bridge on the south end of the structure.

2.2.1 Surge Basin Construction Sequence

Construction sequence activities for the Surge Basin would include all aspects of construction for the Surge Basin Reception Shaft and the Surge Basin Structure. Major activities in sequential order include, but are not limited to:

- Construct diaphragm walls for reception shaft from existing grade.
- Excavate interior of shaft. Transport excess excavation to stockpiles. Construct tremie slab at base of shaft and then dewater, followed by installing shaft lining and frame for openings.
- Construct diaphragm walls for inlet conduit walls (in conjunction with construction of pumping plant diaphragm walls), and center wall for inlet conduit bulkhead gate panels. Install drilled tie-down shafts for base slab of inlet conduit with reinforcing steel only be installed in the lower portion of the shaft for connection to the inlet conduit base slab.
- Construct roof slab for inlet conduit (in conjunction with roof slab for pumping plant).

- Construct diaphragm walls (from existing grade) for surge basin concurrent with excavation of inlet conduit (and pumping plant). As shown on the engineering concept drawings, the upper portion of the diaphragm wall for the perimeter of the surge basin will have reinforcing steel while the lower portion will be unreinforced and will primarily be used for seepage cutoff during construction.
- Install dewatering system within the area inside the surge basin, from existing grade.
- Perform top-down excavation within the surge basin concurrent with the inlet conduit excavation. For the surge basin, install tiebacks for surge basin walls as excavation progresses. Remove unreinforced portion of inlet conduit walls as surge basin excavation progresses. Transport excess excavation to stockpiles.
- Form and construct vertical wall on inlet conduit to connect roof slabs and complete surge basin perimeter.
- Install surge basin drilled tie-down shafts for uplift resistance from bottom of surge basin excavation (El. 2 ft).
- Remove shaft wall at connection between shaft and inlet conduit.
- Remove upper portions of the diaphragm walls for the shaft and inlet conduit walls within the surge basin footprint.
- Construct surge basin floor slab to El. 7 ft; connect slab to tie-down shafts.
- Construct permanent access ramp for surge basin.
- Partially construct overflow weir wall, bridge, rail-mounted pump system, and bulkhead gates.
- Retrieve TBM.
- Finish construction of overflow weir wall, bridge, rail-mounted pump system, and bulkhead gates and complete site work.

2.3 BRPP Wet Well Inlet Conduit

The inlet conduit to the BRPP wet well would convey water from the tunnel reception shaft (located within the surge basin) to the pumping plant wet well. The inlet wet well conduit would be approximately 400 feet long, 60 feet wide, with an invert elevation of -100.5 feet. The inlet wet well conduit sidewalls would be of diaphragm wall construction with a reinforced concrete floor slab, up to five intermediate levels of internal support bracing and a reinforced top slab (with top of slab at elevations of 7.0 feet within the surge basin and 47.0 feet between the surge basin and the BRPP wet well), as shown on the engineering concept drawings. The intermediate support bracing would be at elevations -83.25 feet, -72.00 feet, -47.00 feet, -22.00 feet, and -0.50 feet. These intermediate support braces would be provided to support the diaphragm walls during excavation and for permanent structural stability of the conduit since the conduit structure would be constructed from the top down, similar to the pumping plant and wet well structures.

Two sets of isolation bulkhead gates and associated openings and guides would be provided in the inlet wet well conduit at the edge of the Surge Basin, immediately downstream of the vertical reception shaft.

The isolation bulkhead gates would isolate water in the shaft and tunnel from entering the BRPP wet well during times of inspection or maintenance within the conduit or wet well. The bulkhead panel guide structure with removable cover would be located within the wet well inlet conduit along the southern edge of the Surge Basin. The structure would be sized to accommodate two sets of panels (in-series) to provide double isolation for life-safety. At this time, the bulkhead panel storage area would be located in the laydown area near the equipment storage building; however, other storage options could be considered during detailed design. The overhead rail mounted gantry crane located above the Surge Basin bridge structure would be used to install and remove the bulkhead panels.

2.4 BRPP

The BRPP would be a below ground structure with vertical walls of diaphragm wall construction that consisted of dry-pit pump bays housing the pump and motor assemblies, connecting pump control valves, discharge piping, flowmeters and discharge isolation gate valves, and an adjoining rectangular concrete wet well, as shown in the engineering concept drawings. The BRPP structure would include removable panel sections at the ground level slab and openings at each below ground level intermediate floor that permitted the installation and removal of all pumps, motors, valves and discharge piping via rail mounted gantry cranes located above the BRPP's ground level slab. Depending on the design capacity and associated number of pumps, a separate dry pit pump structure would be connected to either one side, or to both sides, of the wet well.

Table 1 provides the BRPP belowground building footprint dimensions and corresponding number of main pumps required based on the project design capacity.

Table 1. BRPP Building Footprint Dimensions by Design Capacity

Design Capacity (cfs)	Combined Width of Wet Well and Dry Pit Structures (feet)	Length of Wet Well and Dry Pit Structures (feet)	No. Of Dry Pit Structures	Total No. of Pumps
3,000	243	548	1	8
4,500	243	683	1	11
6,000	412	503	2	14
7,500	412	601	2	18

The BRPP would have up to five intermediate floors below the ground level slab. The pump-level finished floor would be located at elevation -100.50 feet. The motor-level finished floor elevation would be located at elevation -72.00 feet. Additional intermediate finished floor elevations would be at -88.25 feet, -47.00 feet, -22.00 feet, and -3.00 feet. These additional intermediate floor levels are required to support the diaphragm walls during the excavation of the pump dry pit bays and the adjoining wet well.

The BRPP would include two separate dry-pit pump bays, identified as Pumping Plant A and Pumping Plant B, for facility design flow capacities of 6,000 and 7,500 cfs, respectively. The BRPP would include a single dry-pit pump bay for facility design flow capacities of 3,000 and 4,500 cfs. As shown on the engineering concept drawings, each pump dry-pit bay would include a center divider wall separating each bay into two sections for redundancy against flooding and for life-safety in case of fire. Each section within each dry-pit bay would have up to three enclosed stairwells for emergency egress and a freight elevator to support operations and maintenance activities. Each stairwell and elevator would have access to each intermediate floor level and to the grade-level top slab. Openings have been provided in the above-grade and below-grade level slabs above all pumps and motors, valves, and vertical discharge piping for removal and installation by above grade gantry cranes. All openings in the aboveground-level slab would have removable covers. All openings in each intermediate floor would be enclosed with handrail for fall protection. Locations of all openings are shown on the engineering concept drawings.

The BRPP wet well would be an adjoining structure to the dry-pit pump bays. To provide sufficient net positive suction head to the pumps at the lowest expected wet well operating water surface elevation (WSEL), the finished floor elevation of the wet well would be -100.50 feet, which establishes the vertical location of each main pump's formed suction inlet and the impeller centerline elevation, as shown on the engineering concept drawings. Water would flow from the wet well into each pump through individual formed suction inlets (FSIs).

The main raw water pumps (pumps) would be of the vertical centrifugal end suction type with volutes encased in reinforced concrete, as shown on the engineering concept drawings. The encasement structures would provide access to flanged inspection ports associated with each pump volute. Pump motors would be mounted on a separate motor level floor above each pump. The BRPP wet well would be configured for parallel operation of the pumps. The FSIs for each pump would provide suitable pump suction hydraulics throughout the required flow and head operation range of each pump. The wet well minimum operating depth was established to provide sufficient submergence over each pump FSI at its maximum design flow capacity. The typical centerline spacing between the parallel pumping units would be 45 feet to provide clearance between each pump for maintenance access. The interior length and width of dry pit bay section that housed up to four pumps would be 225.0 feet by 104.5 feet, and 270.0 feet by 104.5 feet for dry pit bay sections that housed up to five pumps.

Each pump would discharge into a 108-inch discharge pipe oriented vertically through the structure. Near the ground surface, the discharge pipes would bend to a generally horizontal configuration. An 84-inch pump control valve (spherical valve) would be placed at the outlet of each pump. A 108-inch gate valve would be placed in each discharge pipe just downstream of the vertical to horizontal pipe bend. Each isolation valve would be housed within the structure near the surface to reduce the deep horizontal footprint of the structure. The discharge piping would then extend to buried discharge headers that wrapped around the BRPP structure and were routed to their points of connection to the Bethany Reservoir Aqueduct and the Jones Pumping Plant Canal Aqueduct, as shown on the engineering concept drawings. Ultrasonic flow meters would be installed on each vertical pump discharge piping system. Flow meters would be accessible at the intermediate floor level at elevation -22.00. Flow meters would be used for individual control of each pump's operating speed and corresponding pumped flow output. Each 108-inch discharge pipe would permit dewatering of the connecting Bethany Reservoir Aqueduct. The current piping configuration would accommodate space for additional control valve stations for regulating the dewatering flow from the Aqueduct into the wet well.

Each discharge header for pumping flow to the Bethany Reservoir would be sized to a finished inside diameter of 180 inches. Each header would connect to four 500-cfs pumps and convey up to a maximum of 1,500 cfs of combined pumped flow. Cross connections from each standby pump's discharge piping would be provided to each header that would enable each header to convey its maximum design flow inf up to two duty pumps were simultaneously out of service.

Each discharge header for pumped flow to the CVP Jones Pumping Plant approach channel (7,500-cfs project design capacity only) would be sized to a finished inside diameter of 144 inches. Each header would connect to two 500-cfs pumps and would convey up to a maximum of 1,000 cfs of combined pumped flow. No cross connection from the standby pump to each header would be required.

2.4.1 BRPP Construction Sequence

Construction sequence activities for the BRPP would include all aspects of construction for the wet well inlet conduit, above and belowground structures, surge tanks and yard piping systems. Major activities in sequential order include, but are not limited to:

- Construct reinforced concrete perimeter diaphragm walls and interior diaphragm columns for the pumping plant dry pits, center wet well structures, and wet well inlet conduit.
- Install dewatering system within area inside diaphragm walls.
- Excavate to sufficient depth to construct roof slab and beams over pumping plant dry pit and wet well structures.
- Perform top-down excavation below roof slab and below and between intermediate floor levels within the structures. Transport excavated material to stockpiles.
- Each intermediate floor would be connected to the diaphragm walls and columns and constructed by repeating the two previous steps listed above.
- Construct foundation slab.
- Construct all interior concrete elements.
- Install mechanical equipment and piping.
- Excavate and dewater for construction of the reinforced concrete mechanical room which includes gate valve gallery. Groundwater cutoff structures to be determined during future design phase.
- Install drilled piers for support of the mechanical room.
- Construct base slab, perimeter walls and all interior elements.
- Remove diaphragm wall sections between the mechanical room and pumping plant dry pit structures.
- Construct roof slab over the gate valve gallery.
- Complete construction of ancillary structures and site work.

2.4.2 Pump Selection

The systems and facilities making up the project would have many individual hydraulic elements that would be connected and interdependent to convey the diversion flows from the Sacramento River Intakes to Bethany Reservoir. Each element would have hydraulic losses that would form the energy gradelines (EGLs) and hydraulic gradelines (HGLs) throughout the entire system. To replicate the interaction of these system components from the Sacramento River intakes to Bethany Reservoir, a hydraulic model was constructed for the project using Innovyze's InfoWorks Integrated Catchment Modeling (ICM) software.

The model and associated hydraulic criteria are described in the TMs entitled *Hydraulic Analysis Criteria* (DCA 2021b) and *Hydraulic Analysis of Delta Conveyance Options – Bethany Reservoir Alternatives* (DCA 2021c).

System head curves were developed using the ICM model for the envelope of expected hydraulic conditions for the project over the full range of each design capacity. The pump suction conditions were established as the result of the hydraulic analysis performed between the intakes and the BRPP wet well. The pump discharge conditions were established as the result of the hydraulic analysis performed between the BRPP and Bethany Reservoir, including the pump discharge piping, the Bethany Reservoir Aqueduct, and the Bethany Reservoir Discharge Structure. Controlling water surfaces are defined in the TM entitled *Hydraulic Analysis Criteria* (DCA 2021b). Pumps would be sized to primarily operate in steady-state conditions within their preferred operating range (POR) for all expected operating scenarios. The pump's POR would be as defined by the American National Standards Institute, Inc., *ANSI/HI Standard 9.6.3, Rotodynamic Pumps – Guideline for Operating Regions* (ANSI 2017).

The system head conditions were evaluated for the high head, design head, normal low head, and extreme low head static heads and associated internal friction factors:

- **The High Head** system head curve (SHC) is the maximum total dynamic head conditions required for operating any combination of pumps. This condition represents the maximum static head conditions, systemwide head losses associated with the highest internal friction factor for the tunnel and the BRPP's discharge pipelines.
- **The Design Head** is the design head conditions whereby the maximum design flow of the project must be achieved with the largest pumping unit out of service. This SHC was developed with the systemwide head losses associated with the highest internal friction factor for the tunnel and the BRPP's discharge pipelines.
- **The Normal Low Head** SHC is the lowest total dynamic head conditions for the pumps under the normal low static head conditions and the SHC was developed with the lowest systemwide head losses associated with the lowest friction factor for the tunnel and the BRPP's discharge pipelines.
- **The Extreme Low Head** SHC is the lowest possible total dynamic head conditions and represents the extreme low static head condition and developed with systemwide head losses associated with the lowest friction factor for the tunnel and BRPP's discharge pipelines.

2.4.2.1 Criteria

The following criteria was used for SHC development.

- Project Design Capacity Range: System head curves (SHCs) were conducted over the full range of project design capacity between 0 cfs and the maximum design capacities of 3,000, 4,500, 6,000 and 7,500 cfs. Table 2 indicates the combination of available intakes for each project design capacity.

Table 2. Proposed Intakes for Range of Project Design Capacities (cfs)

Intake	3,000	4,500	6,000	7,500
C-E-2	Not used	Not used	Not used	1,500
C-E-3	Not used	3,000	3,000	3,000
C-E-5	3,000	1,500	3,000	3,000

- WSELs: Tables 3, 4, 5 and 6 provide the design WSELs for the project design capacity scenarios considered in this analysis. These WSELs establish static head conditions for the analyses. All elevations are based on the North American Vertical Datum of 1988 (NAVD88). To establish the maximum range of system head conditions, the high head and extreme low head Sacramento River WSELs were used over the full range of each project design capacity.

Table 3. Design WSELs for System Head Curves Development for Project Design Capacity of 7,500 cfs

Pump Head Condition	Sacramento River WSEL	Bethany Reservoir WSEL	Wet Well WSEL
High Head	3.80	245.0	-44.7
Design Head	4.66	245.0	-43.8
Normal Low Head	6.01	238	-32.3
Extreme Low Head	28.2	238	-10.1

All values are NAVD88 elevation, in feet

Table 4. Design WSELs for System Head Curves for Project Design Capacity of 6,000 cfs

Pump Head Condition	Sacramento River WSEL	Bethany Reservoir WSEL	Wet Well WSEL
High head	3.72	245.0	-49.3
Design head	4.59	245	-48.4
Normal low head	5.91	238	-35.2
Extreme low head	27.3	238	-13.8

All values are NAVD88 elevation, in feet

Table 5. Design WSELs for System Head Curves Development for Project Design Capacity of 4,500 cfs

Pump Head Condition	Sacramento River WSEL	Bethany Reservoir WSEL	Wet Well WSEL
High head	3.72	245	-62.5
Design head	4.59	245	-61.6
Normal head	5.91	238	-44.9
Extreme low head	27.3	238	-23.5

All values are in feet

Table 6. Design WSELs for System Head Curves Development for Project Design Capacity 3,000 cfs

Pump Head Condition	Sacramento River WSEL	Bethany Reservoir WSEL	Wet Well WSEL
High head	3.6	245	-68.6
Design head	4.5	245	-67.7
Normal low head	5.8	238	-48.8
Extreme low head	26.3	238	-28.3

All values are in feet

- This analysis included the following Standard Roughness Coefficients:
  - Manning's n of 0.016 was used to develop the "high head" and "design head" SHCs and represents the highest friction conditions.
  - Manning's n of 0.014 was used to develop the "low head" and "extreme low head" SHCs and represents the lowest friction conditions.
  - Pipe absolute roughness values of 0.1 millimeter (mm) to 1.5 mm were used to calculate minor friction losses within piping and Aqueduct pipeline systems.

2.4.3 Pump Selection Design Criteria

Vertical, centrifugal end-suction pump designs are considered as the main raw water pump type for this evaluation.

The pump selection process considered several combinations of pump sizes and corresponding operating speed ranges that would primarily maintain each pump within the POR, as defined by the ANSI/HI Standard 9.6.3, throughout the design head conditions between 10 percent and 100 percent of the established design capacity of the BRPP. For example, at a maximum design flow capacity of 6,000 cfs, the BRPP design flow range would be 600 to 6,000 cfs. When pump operating conditions fell outside of the pump's POR, pump performance was required to be well-within the manufacturer's recommended allowable operating range (AOR).

Each candidate pump considered was evaluated within the design conditions defined here. Additional design criteria for the candidate pumps included:

- Capable of achieving minimum flows (10 percent of the maximum project design capacity) at all anticipated wet well levels and operating water surface elevations at the Bethany Reservoir associated the high head conditions with a single pump in operation.
- Capable of achieving maximum flows (100 percent of the maximum design flow capacity) at all anticipated wet well levels and operating water surface elevations at the Bethany Reservoir associated with the design head conditions with the largest pump out of service.
- No unachievable flowrates among operating combinations of pumps within the designated design flow range (10 percent to 100 percent of the maximum design flow capacity).
- Pumps operate primarily within their POR within the envelope of system flow and head conditions.
- Pumps may operate outside their POR but within the manufacturer's defined AOR within the envelope of system flow and head conditions.

2.4.4 Candidate Pump Manufacturer and Performance Requirements

The candidate pump manufacturers consulted during this evaluation were Ebara and Voith. Each candidate manufacturer's pump performance curves were evaluated based on the required envelope of system flow and head conditions as defined here and achieved suitable performance per the selection criteria. For this TM, pump selections obtained by Ebara were used to illustrate the performance requirements for each of the project design capacities.

2.4.4.1 BRPP Project Design Capacity of 7,500 cfs

This project design capacity option involves the evaluation and selection of candidate pumping equipment for two pump discharge zones: (1) 6,000 cfs to Bethany Reservoir and (2) 1,500 cfs to the Jones Pumping Plant Approach Channel.

Figures 1 and 2 show the SHCs developed for the high head and extreme low head SHCs defined in Table 3 that determine the envelope of expected hydraulic conditions associated with the maximum project design capacity of 7,500 cfs for the project plotted against the candidate pump performance curves.

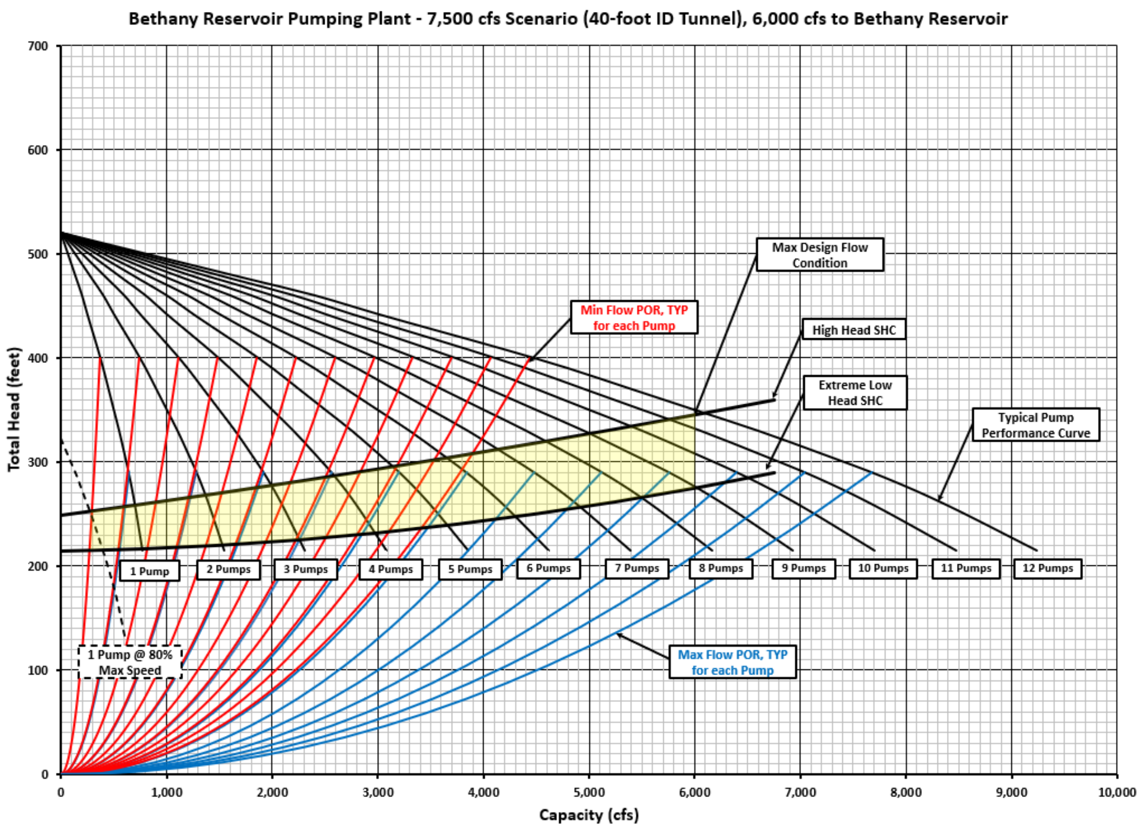


Figure 1. Pump Selection for the BRPP Maximum Design Capacity of 7,500 cfs, 6,000 cfs to Bethany Reservoir

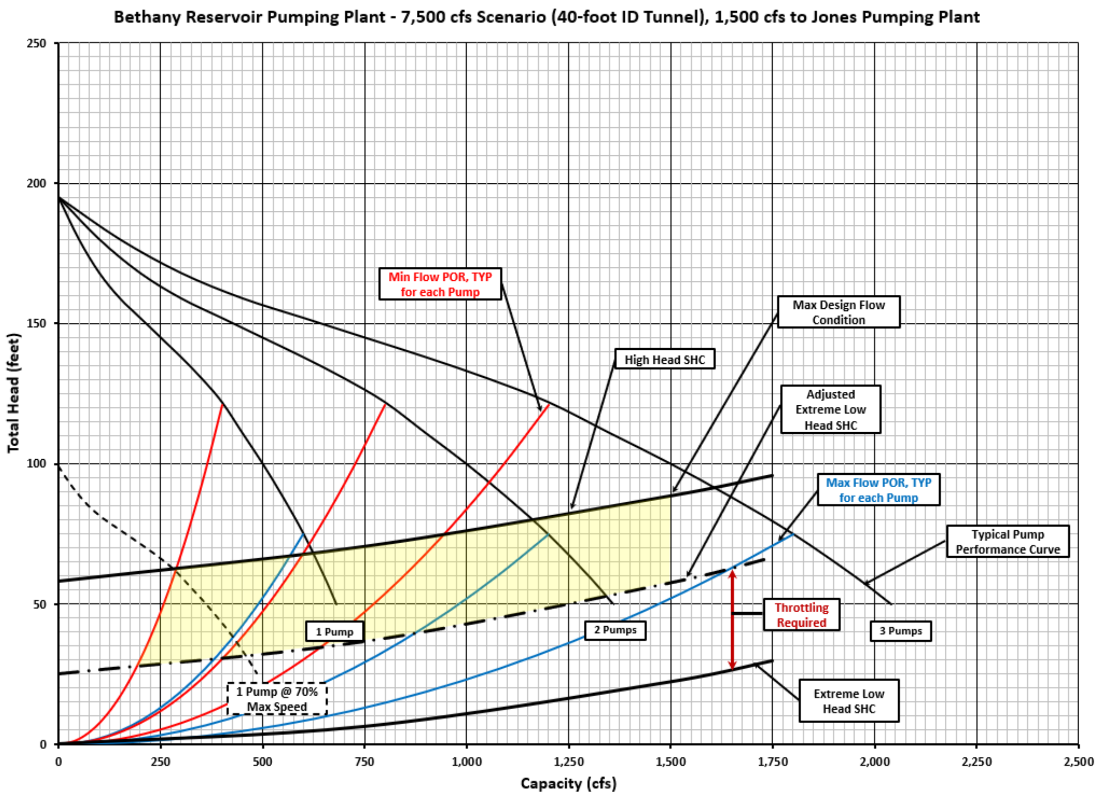


Figure 2. Pump Selection for the BRPP Maximum Design Capacity of 7,500 cfs, 1,500 cfs to Jones Pumping Plant Approach Channel

For the maximum project design capacity of 7,500 cfs, a maximum of 6,000 cfs would be pumped to the Bethany Reservoir (Figure 1) while simultaneously pumping an additional maximum capacity of 1,500 cfs to the Jones Pumping Plant approach channel (Figure 2). Figure 1 shows the SHCs associated with pumped flow (up to 6,000 cfs) to the Bethany Reservoir. The high head SHC on Figure 1 was developed with a constant flow of 1,500 cfs being pumped to the Jones Pumping Plant Approach Channel. The extreme low head SHC shown on Figure 1 was developed with no flow being pumped to the Jones Pumping Plant approach channel.

The high head SHC configured on Figure 2 was developed with a constant flow of 6,000 cfs pumped to the Bethany Reservoir. The extreme low head SHC shown on Figure 2 was developed with no flow being pumped to the Bethany Reservoir. The static head conditions for both the high head and extreme low head SHCs shown on Figure 2 would include a weir (weir crest at elevation 30.00 feet) located in the discharge pipeline outlet structure that maintained full pipe flow within the pipeline. Full pipe flow would be required for suitable hydraulic transient-surge mitigation for the pipeline and would maintain the internal pressures limits within its design limits.

Pumping to Bethany Reservoir

The candidate pump selection identified on Figure 1 is the Ebara, Model 2600X1800VLM (500 cfs at 400 feet) at the maximum operating speed of 400 revolutions per minutes (rpm). Model 2600X1800VLM is a 25,000-horsepower (hp) pump with a design flow capacity of 500 cfs at 350 feet of total dynamic head (TDH). The Model 2600X1800VLM meets the project’s flow and head conditions and this pump type has successful service history for California State water projects of similar head and design flow capacities.

The POR for each pump and for parallel operation of multiple pumps has been plotted on Figure 1. The minimum and maximum flows defining each pump's, or group of pumps', POR are shown with red and blue affinity curves, respectively, and are plotted across the SHCs for the combinations of pumps. The minimum and maximum flow envelope defining the pumps POR along the SHCs for a single pump (at reduced speed) and all pumps operating in parallel (at maximum speed) is shown by the yellow shaded region. The shaded region verifies that all design flows within the envelope of SHCs are well-within the candidate pump's POR.

Figure 1 depicts the envelope of SHCs plotted against the pump performance curves to achieve the maximum project design capacity of 6,000 cfs to the Bethany Reservoir. The maximum TDH condition to pump 6,000 cfs to Bethany Reservoir would be 345 feet. The maximum design flow condition is established with 12 pumps operating in parallel at their maximum rated speeds and within the POR of all pumps in operation.

The minimum flow achieved along the high head SHC with a single pump in operation is 300 cfs. This is determined by the intersection of the lowest flow of the pump's POR (red curve) and the high head SHC. At this condition, the single pump is operating at 80 percent of its maximum rated speed. The minimum flow achieved along the extreme low head SHC with a single pump in operation is slightly less than 300 cfs. At this condition, the single pump is operating at 74 percent of its maximum rated speed. To achieve the minimum flow of 600 cfs (10 percent of the maximum project design capacity to Bethany Reservoir of 6,000 cfs), a single pump operating at a speed of 94 percent of its maximum rated speed is required along the high head SHC. As Figure 1 shows, the candidate pumps are capable of achieving the complete design flow range for the project within each pump's POR and within a reasonable speed range.

To maintain operations within each pump's POR for flows less than the maximum project design capacity of 6,000 cfs along the SHCs, the pumps must operate in parallel at reduced speeds. The number of pumps and corresponding operating speeds can be determined by the intersection of the POR affinity curves with the SHCs. For example, to achieve 3,500 cfs along the high head and extreme low head SHCs shown on Figure 1, six pumps operating in parallel and at reduced speeds would be required to maintain operations within the pumps' combined maximum flow POR.

Based on this candidate pump selection, 12 pumps operating in parallel at maximum speed would be required to achieve the maximum design capacity condition of 6,000 cfs along the high head SHC. Ten of the 12 pumps would be required to be operated with variable-frequency drives. This can be determined by inspecting the POR affinity curves on Figure 1. For a constant-speed pump operation, the envelope of SHCs (high head and extreme low head SHCs) must be within the POR (red and blue affinity curves for the pump) at the maximum pump speed. As Figure 1 shows, this would not occur until 10 pumps were in operation along the extreme low head SHC and 9 pumps were operated at their maximum rated speeds prior to starting the tenth pump. This would require that the constant-speed pump could only be started as the last pump in a 10-pump sequence. This would result in pumped flow capacities of 5,400 cfs along the high head SHC and 6,400 cfs along the extreme low head SHC (which is above the maximum design capacity condition of 6,000 cfs). Based on this candidate pump selection, it is recommended that all pumps dedicated to conveying flows to Bethany Reservoir operate with variable frequency drives.

To ensure operational reliability, 12 duty pumps with two standby pumps (N+2) have been included in the concept design for pumping flow to Bethany Reservoir. Each standby pump has been interconnected into two discharge aqueducts, as shown on the engineering concept drawings. This interconnection will permit the standby pump units to be operated at any time, back up any other pump on the same side of the pumping plant, and help maintain equal run times for all pumps.

Pumping to Jones Pumping Plant Approach Channel

The candidate pump selection identified on Figure 2 for pumping to the Jones Pumping Plant Approach Channel is the Ebara, Model 2600X2000VLYM at the maximum operating speed of 400 rpm. Model 2600X2000VLM is a 7,600-hp pump with a design flow capacity of 500 cfs at 100 feet of TDH.

The POR for each pump and for parallel operations of multiple pumps has been plotted on Figure 2. The minimum and maximum flows defining each pump's, and multiple pumps', POR are shown with red and blue affinity curves, respectively, and are plotted across the SHCs for the combinations of pumps. As Figure 2 shows, the extreme low SHC is below the pump performance envelope developed by the POR for all pump combinations of parallel operations. As previously stated, the extreme low SHC for this scenario only includes flow being pumped to the Jones Pumping Plant Approach Channel and no flow being pumped to Bethany Reservoir. As such, very little head loss is developed within the 40-foot-inside-diameter main tunnel at the 1,500-cfs flow condition. To ensure operation within the pumps' POR when flow is not pumped to Bethany Reservoir and under lower SHCs, throttling would be required in the discharge piping for each Jones Pumping Plant Approach Channel pump. This would be accomplished by partially opening each pump's pump control valve until suitable back-pressure at the pump discharge was established. For example, Figure 2 illustrates the extreme low head SHC being elevated (indicated as adjusted extreme low head SHC) by up to 35 feet to bring the SHC to within the POR envelope of the pumps. As Figure 2 shows, lower SHCs at lower flows would enable the pump to operate within the pump's POR, requiring less pressure drop across the pump control valve. During periods where the operating SHCs are at or above the adjusted extreme low head SHC, no throttling would be required at the discharge of each pump. As an alternative approach to this operating scenario, the wet well steady-state water surface level could be lowered during operations to decrease the suction head at each pump and maintain the adjustable extreme low head SHC, as Figure 2 shows, without throttling at the pump discharge. Either way, the BRPP footprint would not change. Further evaluation of this operating scenario and corresponding operation strategies would be performed during future phases of the design.

The minimum and maximum flow envelope defining the pumps' POR along the SHCs (high head and adjusted extreme low head SHCs) for a single pump (at reduced speed) and all pumps operating in parallel (at maximum speed) is shown by the yellow shaded region. As Figure 2 shows, a small region of SHCs and flow capacities fall outside of the POR between the combination of one and two pumps operating in parallel. However, these conditions are well-within the manufacturer's recommended AOR and the pumps would be able to operate successfully in that region.

The maximum TDH condition to pump 1,500 cfs to the Jones Pumping Plant approach channel would be 88 feet. As Figure 2 shows, the maximum design flow condition is established with three pumps operating in parallel at their maximum rated speeds and within the POR of all pumps in operation. To achieve the minimum capable flow of 275 cfs along the high head SHC within the POR, a single pump operating at 70 percent of its maximum rated speed would be required. To achieve the minimum capable flow of 225 cfs along the adjusted extreme low head SHC within the POR, a single pump operating at 50 percent of its maximum rated speed would be required. Lower flows at many SHCs could be achieved within the pump's AOR and at lower speeds. To maintain operations within each pump's POR for flows less than the maximum design capacity of 1,500 cfs along the operating envelope defined between the high head and adjusted extreme low head SHCs, the pumps must operate in parallel at reduced speeds. The number of pumps and corresponding operating speeds could be determined by the intersection of the POR affinity curves with the SHCs. For example, to achieve 750 cfs along the high head and adjusted extreme low head SHCs shown on Figure 2, two pumps operating in parallel and at reduced speed would be required.

Based on this candidate pump selection, three pumps operating in parallel at maximum speed would be required to achieve the maximum design flow condition of 1,500 cfs along the high head SHC. Two of the three pumps are required to be operated with variable-frequency drives for SHCs above the adjusted extreme low SHC. This can be determined by inspecting the POR flow curves on Figure 2. For a constant-speed pump operation, the envelope of SHCs must be within the POR (red and blue affinity curves for the pump) at the maximum pump speed. As Figure 2 shows, this does not occur until three pumps are in operation and the previous two pumps in combination are operated near their maximum rated speeds and the minimum SHCs are above the adjusted extreme low SHC. This would require that the constant-speed pump could only be started as the last pump in sequence when the maximum design flow capacity of 1,500 cfs was required and would limit its operational use. Based on this candidate pump selection, it is recommended that all pumps dedicated to conveying flows to the Jones Pumping Plant approach channel operate with variable-frequency drives.

To ensure operational reliability, three duty pumps with one standby pump (N+1) have been included in the concept design for pumping flow to the Jones Pumping Plant. This combination would permit the standby pump unit to be operated at any time and help maintain equal run times for all pumps.

2.4.4.2 BRPP Project Design Capacity of 6,000 cfs

Figure 3 shows the SHCs developed for the high head and extreme low head static head conditions defined in Table 4 that determine the envelope of expected hydraulic conditions associated with the maximum design flow capacity of 6,000 cfs for the project plotted against the candidate pump performance curves. For the project design flow capacity of 6,000 cfs, flow would be pumped to Bethany Reservoir. No flow would be pumped to the Jones Pumping Plant Approach Channel.

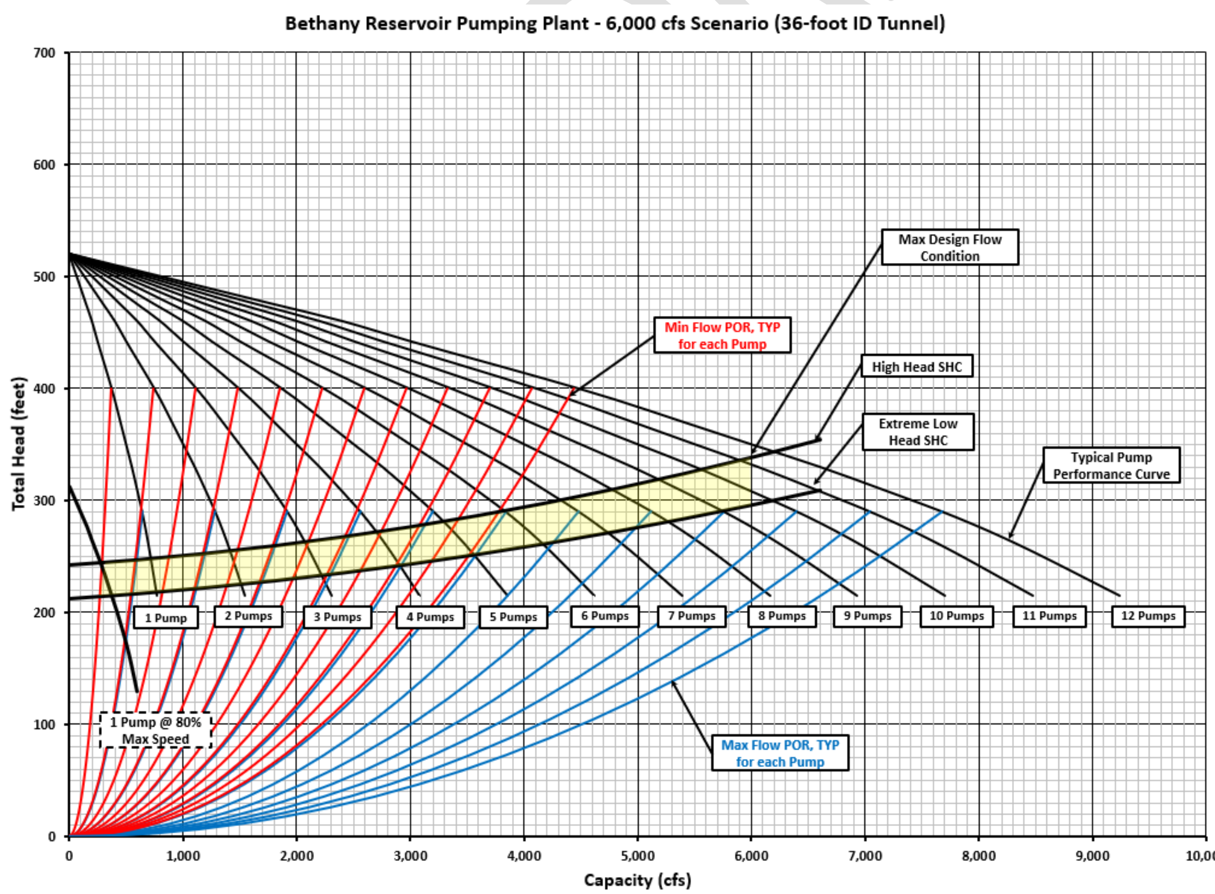


Figure 3 Pump Selection for the BRPP Maximum Design Capacity of 6,000 cfs

The candidate pump selection identified on Figure 3 is the Ebara, Model 2600X1800VLM (500 cfs at 400 feet) at the maximum operating speed of 400 rpm. Model 2600X1800VLM is a 25,000-hp pump with a design flow capacity of 500 cfs at 350 feet of TDH.

The POR for each pump and for parallel operation has been plotted on Figure 3. The minimum and maximum flows defining each pump's POR are shown with red and blue affinity curves, respectively, and are plotted across the SHCs for each pump. The minimum and maximum flow envelope defining the pumps POR along the SHCs for a single pump (at reduced speed) and all pumps operating in parallel (at maximum speed) is shown by the yellow shaded region. The shaded region verifies that all design flows within the envelope of SHCs are well-within the candidate pump's POR.

Figure 3 depicts the envelope of SHCs plotted against the pump performance curves to achieve the maximum project design flow of 6,000 cfs to the Bethany Reservoir. The maximum design head condition to pump 6,000 cfs to the Bethany Reservoir is 338 feet. The maximum design flow condition is established with 12 pumps operating in parallel at their maximum rated speeds and within the POR of all pumps in operation.

The minimum flow achieved along the high head SHC with a single pump in operation is 300 cfs. This is determined by the intersection of the lowest flow of the pump's POR (red curve) and the high head SHC. At this condition, the single pump is operating at 80 percent of its maximum rated speed. To achieve the minimum flow of 600 cfs (10 percent of the maximum design flow to the Bethany Reservoir of 6,000 cfs) a single pump operating at a speed of 93 percent of its maximum rated speed would be required. As Figure 3 shows, the candidate pumps are capable of achieving the complete design range for the project within the pumps' POR.

To maintain operations within each pump's POR for flows less than the maximum design flow capacity of 6,000 cfs along the SHCs, the pumps must operate in parallel at reduced speeds. The number of pumps and corresponding operating speeds can be determined by the intersection of the POR affinity curves with the SHCs. For example, to achieve 3,000 cfs along the high head and extreme low head SHC shown on Figure 3, five pumps operating in parallel and at reduced speed would be required to maintain operation within the pumps' POR.

Based on this candidate pump selection, 8 of the 12 pumps are required to be operated with variable-frequency drives. This can be determined by inspecting the POR affinity curves on Figure 3. For a constant-speed pump operation, the envelope of SHCs (high head and extreme low head SHCs) must be within the POR (red and blue affinity curves for the pump) at the maximum pump speed. As Figure 3 shows, this does not occur until eight pumps are in operation and are operated at their maximum rated speeds. Based on the extreme low head SHC, this would require that the constant-speed pumps could only be started as the last 4 pumps in a 12-pump sequence, which would limit their operational use for design flow capacities above 5,000 cfs at lower TDH conditions. Based on this candidate pump selection, it is recommended that all pumps dedicated to conveying flows to the Bethany Reservoir operate with variable-frequency drives. By equipping all pumps with variable-speed drives there will be no restrictions in the starting sequence (for all duty and standby pumps) for any combination of pumps.

To ensure operational reliability, 12 variable-speed duty pumps with 2 variable-speed standby pumps (N+2) have been included in the concept design for pumping flow to the Bethany Reservoir. Each standby pump has been interconnected into two discharge aqueducts, as shown on the engineering concept drawings. This interconnection would permit the standby pump units to be operated at any time and maintain similar overall run times for all 14 pumps.

2.4.4.3 BRPP Project Design Capacity of 4,500 cfs

Figure 4 shows the SHCs developed for the high head and extreme low head static head conditions defined in Table 5 that determine the envelope of expected hydraulic conditions associated with the maximum project design capacity of 4,500 cfs for the project, plotted against the candidate pump performance curves. For this project design flow capacity, a maximum of 4,500 cfs would be pumped to the Bethany Reservoir. No flow would be pumped to the Jones Pumping Plant Approach Channel.

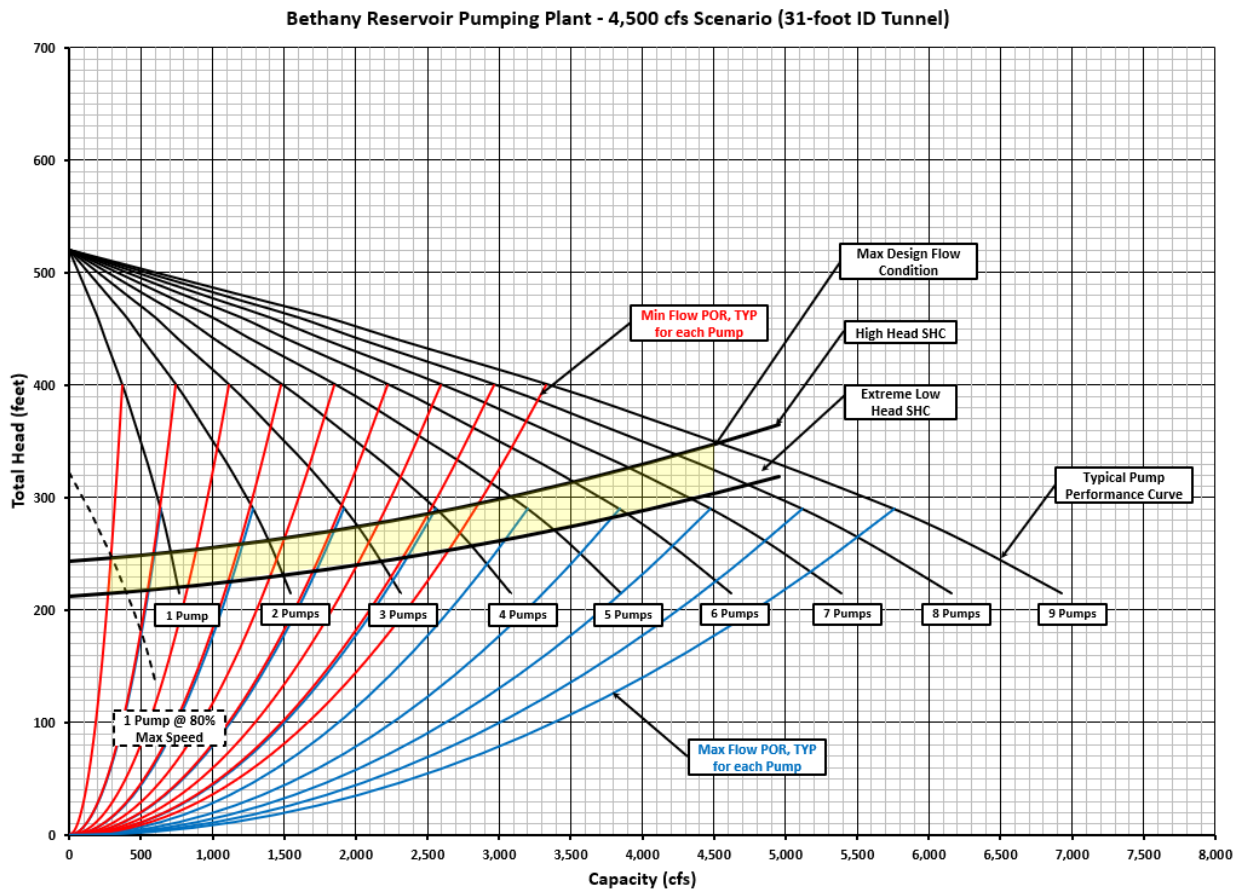


Figure 4 Pump Selection for the BRPP Maximum Design Capacity of 4,500 cfs

The candidate pump selection identified on Figure 4 is the Ebara, Model 2600X1800VLM (500 cfs at 400 feet) at the maximum operating speed of 400 rpm. Model 2600X1800VLM is a 25,000-hp pump with a design flow capacity of 500 cfs at 350 feet of TDH.

The POR for each pump and for parallel operation has been plotted on Figure 4. The minimum and maximum flows defining each pump's POR are shown with red and blue affinity curves, respectively, and are plotted across the SHCs for each pump. The minimum and maximum flow envelope defining the pumps POR along the SHCs for a single pump (at reduced speed) and all pumps operating in parallel (at maximum speed) is shown by the yellow shaded region. The shaded region verifies that all design flows within the envelope of SHCs are well-within the candidate pump's POR.

Figure 4 depicts the envelope of SHCs plotted against the pump performance curves to achieve the maximum project design capacity of 4,500 cfs to the Bethany Reservoir. The maximum design head condition to pump 4,500 cfs to the Bethany Reservoir is 348 feet. The maximum design flow condition is established with nine pumps operating in parallel at their maximum rated speeds and within the POR of all pumps in operation.

The minimum flow achieved along the high head SHC with a single pump in operation is 300 cfs. This is determined by the intersection of the lowest flow of the pump's POR (red curve) and the high head SHC. At this condition, the single pump is operating at 80 percent of its maximum rated speed. To achieve the minimum flow of 450 cfs (10 percent of the maximum design flow to the Bethany Reservoir of 4,500 cfs) a single pump operating at a speed of 93 percent of its maximum rated speed would be required. As Figure 4 shows, the candidate pumps are capable of achieving the complete design range for the project completely within the pumps' POR.

To maintain operations within each pump's POR for flows less than the maximum project design capacity of 4,500 cfs along the SHCs, the pumps must operate in parallel at reduced speeds. The number of pumps and corresponding operating speeds can be determined by the intersection of the POR affinity curves with the SHCs. For example, to achieve 2,500 cfs along the high head and extreme low head SHCs shown on Figure 4, four pumps operating in parallel and at reduced speed would be required to maintain operation within the pumps' POR. Referring back to Figure 4, to achieve 2,500 cfs along the extreme low head SHC, five pumps would be required to maintain operation with the pump's POR.

Based on this candidate pump selection, six of the nine pumps are required to be operated with variable-frequency drives. This can be determined by inspecting the POR affinity curves on Figure 4. For a constant-speed pump operation, the envelope of SHCs (high head and extreme low head SHCs) must be within the POR (red and blue affinity curves for the pump) at the maximum pump speed. As Figure 4 shows, this does not occur until six pumps are in operation and are operated at their maximum rated speeds. Based on the extreme low head SHC, this would require that the constant-speed pumps could only be started as the last four pumps in sequence when the maximum desired flow capacities were above 3,800 cfs. Based on this candidate pump selection, it is recommended that all pumps dedicated to conveying flows to the Bethany Reservoir operate with variable-frequency drives. By equipping all pumps with variable-speed drives, there would be no restrictions in the starting sequence (for all duty and standby pumps) for any combination of pumps.

To ensure operational reliability, nine variable-speed duty pumps with two variable-speed standby pumps (N+2) have been included in the concept design for pumping flow to the Bethany Reservoir. Each standby pump has been interconnected into two discharge aqueducts, as shown on the engineering concept drawings. This interconnection will permit the standby pump units to be operated at any time and maintain similar overall run times for all 14 pumps.

2.4.4.4 BRPP Project Design Capacity of 3,000 cfs

Figure 5 shows the SHCs developed for the high head and extreme low head static head conditions defined in Table 6 that determine the envelope of expected hydraulic conditions associated with the maximum project design capacity of 3,000 cfs for the project, plotted against the candidate pump performance curves. For this project design flow capacity, a maximum of 3,000 cfs would be pumped to the Bethany Reservoir. No flow would be pumped to the Jones Pumping Plant Approach Channel.

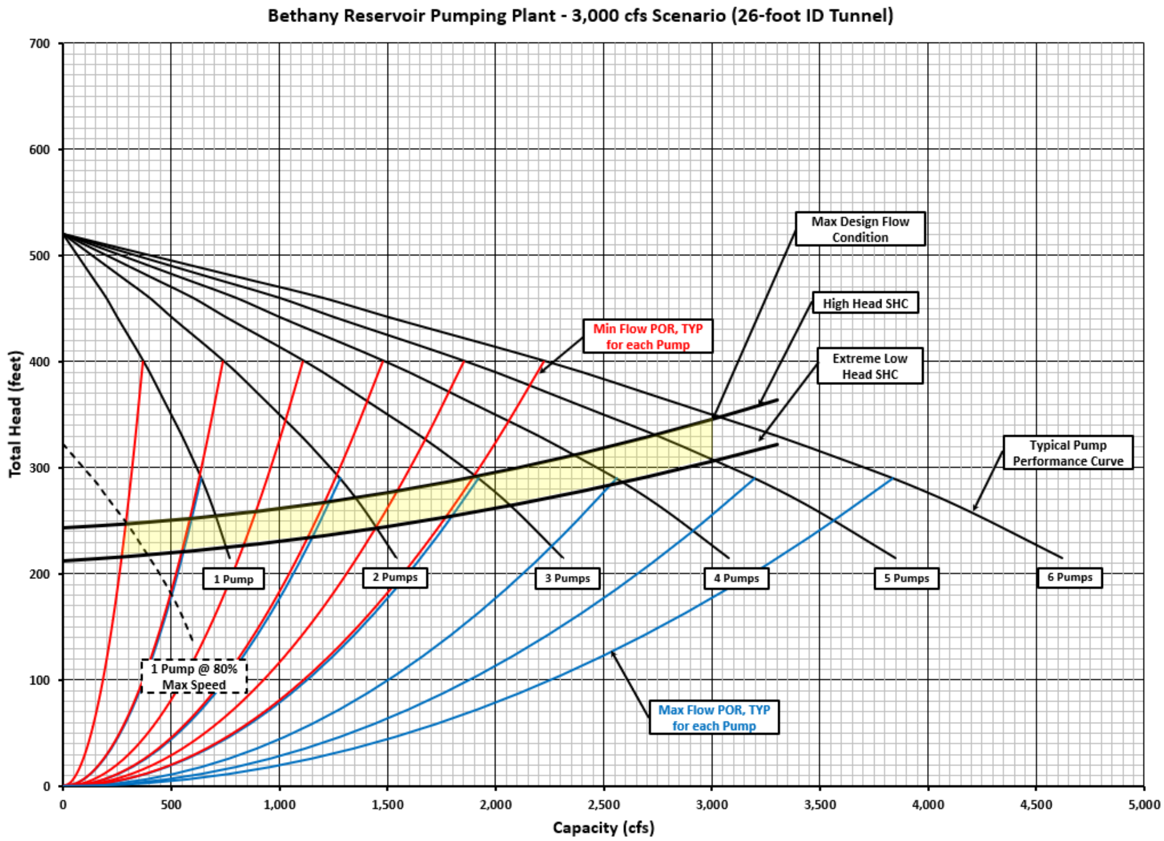


Figure 5 Pump Selection for the BRPP Maximum Design Flow Capacity of 3,000 cfs

The candidate pump selection identified on Figure 5 is the Ebara, Model 2600X1800VLM (500 cfs at 400 feet) at the maximum operating speed of 400 rpm. Model 2600X1800VLM is a 25,000-hp pump with a design flow capacity of 500 cfs at 350 feet of TDH.

The POR for each pump and for parallel operation has been plotted on Figure 5. The minimum and maximum flows defining each pump's POR are shown with red and blue affinity curves, respectively, and are plotted across the SHCs for each pump. The minimum and maximum flow envelope defining the pumps POR along the SHCs for a single pump (at reduced speed) and all pumps operating in parallel (at maximum speed) is shown by the yellow shaded region. The shaded region verifies that all design flows within the envelope of SHCs are well-within the candidate pump's POR.

Figure 5 depicts the envelope of SHCs plotted against the pump performance curves to achieve the project design capacity of 3,000 cfs to the Bethany Reservoir. The maximum design head condition to pump 3,000 cfs to the Bethany Reservoir is 345 feet. The maximum design flow condition is established with six pumps operating in parallel at their maximum rated speeds and within the POR of all pumps in operation.

The minimum flow achieved along the high head SHC with a single pump in operation is 300 cfs. This is determined by the intersection of the lowest flow of the pump's POR (red curve) and the high head SHC. At this condition, the single pump is operating at 80 percent of its maximum rated speed achieves the minimum flow design flow condition (10 percent of the maximum design flow to the Bethany Reservoir of 3,000 cfs). As Figure 5 shows, the candidate pumps are capable of achieving the complete design range for the project completely within the pumps' POR.

To maintain operations within each pump's POR for flows less than the project design capacity of 3,000 cfs along the SHCs, the pumps must operate in parallel at reduced speeds. The number of pumps and corresponding operating speeds can be determined by the intersection of the POR affinity curves with the SHCs. For example, to achieve 1,000 cfs along the high head and extreme low head SHCs shown on Figure 5, two pumps operating in parallel and at reduced speed would be required to maintain operation within the pumps' POR.

Based on this candidate pump selection, four of the six pumps are required to be operated with variable-frequency drives. This can be determined by inspecting the POR affinity curves on Figure 5. For a constant-speed pump operation, the envelope of SHCs (high head and extreme low head SHCs) must be within the POR (red and blue affinity curves for the pump) at the maximum pump speed. As Figure 5 shows, this does not occur until four pumps are in operation and are operated at their maximum rated speeds. Based on the extreme low head SHC, this would require that the constant-speed pumps could only be started as the last two pumps in sequence when the maximum desired flow capacities were above 2,500 cfs. Based on this candidate pump selection, it is recommended that all pumps dedicated to conveying flows to the Bethany Reservoir operate with variable-frequency drives. By equipping all pumps with variable-speed drives there will be no restrictions in the starting sequence (for all duty and standby pumps) for any combination of pumps.

To ensure operational reliability, six variable-speed duty pumps with two variable-speed standby pumps (N+2) have been included in the concept design for pumping flow to the Bethany Reservoir. Each standby pump would be interconnected into the discharge aqueducts, as shown on the engineering concept drawings. This interconnection would permit the standby pump units to be operated at any time and maintain similar overall run times for all fourteen pumps.

2.5 Aqueduct Surge Tanks

Four above ground surge tanks would be used for hydraulic transient-surge mitigation for the BRPP's discharge pipelines. Each aqueduct pipeline would be directly connected to a dedicated surge tank by a 12-foot-inside-diameter welded steel pipe, and a belowground vault containing up to four 72-inch check valves arranged in parallel, as shown on the engineering concept drawings. Each tank would be sized to an inside diameter of 75 feet with a side wall height of up to 20 feet to provide the required depth for intended storage volume and freeboard including internal vertical clearance needed during a tank overflow condition. The tanks' internal free-water surface would be under atmospheric pressure. When a hydraulic transient-surge event occurred within any given BRPP discharge aqueduct pipeline and the internal pressure within that pipeline (at the tank location) fell below the free-water surface elevation within the connecting tank, the Surge Tank's check valves would open and allow stored water from the tank to enter the pipeline. Each Surge Tank has been sized to provide sufficient stored water volume to maintain the internal pressure of each pipeline to within their intended limits. When operating pressure within each pipeline would be above the connecting Surge Tank's free-water surface elevation, the Surge Tank's check valves would remain in the closed position and stored water within the Surge Tank would not enter the connecting pipeline. A diaphragm actuated control valve would be included in each valve vault and would use the head from the connecting pipeline to automatically fill and maintain the free-water surface within any Surge Tank at a predetermined set-point level.

Each tank would include a 36-inch-inside-diameter overflow pipe that would prevent each tank from overfilling. Each 36-inch-inside-diameter overflow pipe would be routed below ground to the BRPP wet well inlet conduit and drain by gravity.

The finished floor elevation of each Surge Tank would be set an elevation of about 45.0 feet. The finished floor elevation of each belowground vault would be set an elevation of about 8.0 feet with the top of the cover slab set at an elevation of 46.0 feet. Each vault would have access provisions for Operations and Maintenance staff and the roof deck would include removable panels for the removal and installation of valves and piping within each vault.

2.6 Electrical Building

An electrical building would be located immediately adjacent to the BRPP structure and would have a finished floor elevation of about 47.0 feet. The electrical building would house the variable-frequency drives for the main pumps and the electrical equipment for the cooling systems associated with the variable-frequency drives and main pump motors. Other ancillary electrical gear, including low-voltage motor control centers, distribution panels, and similar equipment would also be installed in the electrical building. The variable-frequency drives for the tunnel dewatering pumps would be located within the BRPP, as shown on the engineering concept drawings. Additionally, a control room will be located within the electrical building for operation of the BRPP facilities and other features in the Bethany Complex. Due to heat considerations, a dedicated transformer for each variable-frequency drive would be located outside of the electrical building. Each transformer would be powered directly from the main electrical substation at the site. Supply power voltage and motor voltages are shown on the engineering concept drawings.

2.7 HVAC Mechanical Equipment Yard and Pumping Plant

An HVAC mechanical equipment yard would be provided adjacent to the electrical building to provide the HVAC service for the electrical building. There would be up to five pad-mounted, direct expansion (DX) air handler units (AHUs) and up to two pad-mounted cooling towers installed within the HVAC mechanical equipment yard. The sizes of the DX AHUs and cooling towers would vary based on the final selected project design capacity, plus corresponding electrical gear and pump sizes. Currently, all main pumps are assumed to operate with water cooled variable-frequency drives and water-cooled motors.

The AHUs and cooling towers would be placed on concrete equipment pads. A wall would be constructed around the HVAC mechanical equipment yard for visual screening and noise abatement. Adequate space would be provided around the equipment and within the screening walls and the HVAC equipment yards to allow for periodic access to perform maintenance on the AHUs.

The finished grade elevation of the equipment yard would be about 47.0 feet.

The BRPP belowground structure is subdivided into four quadrants. Each quadrant would be served by make-up air units and exhaust fans to provide ventilation into the spaces. Six emergency exit stair towers would be ventilated by supply fans. The ventilation equipment would be located within the belowground structure. Sizing of the ventilation equipment would vary based on the project design capacity selected and corresponding size and number of pump and motor units. Separate rooms within the belowground structure would contain the variable-frequency drives and AHUs for the tunnel dewatering pumps, as shown on the engineering concept drawings. Sizing of the AHUs would vary, based on the selected sizes of the dewatering pumps for the project. Surge tank vaults located outside of the belowground structure utilize ventilation fans, which would operate when the vault spaces were occupied.

2.8 Electrical Interconnect Site

As shown in the engineering concept drawings, an electrical interconnection would be provided near the high-voltage overhead power transmission system located west of the BRPP. Two electrical feeder lines would be routed from the electrical interconnect site to the electrical substation located within the BRPP site.

2.9 Electrical Substation

The two high-voltage electrical feeders from the electrical interconnect site, one currently assumed to be from the WAPA Tracy Substation and one from the PG&E Brentwood Substation, as described in the TM entitled *Electric Power Transmission – Bethany Reservoir Alternative TM* (DCA 2021d), would terminate at an electrical substation constructed to provide electrical service to the facilities associated with the BRPP and Surge Basin.

The electrical substation would have an area of approximately 87,500 square feet and the finished grade elevation would be about 48.5 feet. Security fencing would be provided around the perimeter of the substation to restrict access.

2.10 Generator Building

A standby engine generator (SEG) would be located within a building adjacent to the electrical substation to supply emergency power to life-safety and critical control systems. Fuel for the SEG would be provided immediately adjacent to the generator building. The fuel storage area would be surrounded by a block wall and containment, consistent with the quantity and type of fuel selected, would be provided.

SEG noise abatement would be provided within the building. The finished floor elevation for the building would be about 47.0 feet.

2.11 Equipment Storage Building

An equipment storage and operations maintenance building would be located on the site near the BRPP structure and electrical building. The equipment storage building would be equipped with large vertical opening doors capable of allowing large transport trucks to drive through for material / equipment drop off and pickup. The vehicle openings and drive aisles would be wide enough to accommodate two-way travel through the building.

Within the building, there would be offices, a welding shop, a machine shop, vehicle maintenance shop, plus bridge cranes and monorail hoists to support the operations maintenance requirements. Both shops would be fully outfitted to perform a wide array of activities and permit multiple personnel to utilize the spaces simultaneously.

There would be two material storage bays located on either side of the vehicle drive aisle. There would be space accommodations for storage of the following:

- Two spare motors for main pumps.
- Two spare impellers for main pumps.
- Pump accessories.
- Two submersible vertical turbine pumps for tunnel dewatering.
- Submersible dewatering pump column sections including connecting discharge piping.

- Submersible pump cable reels for each submersible vertical turbine dewatering pump.
- Lubricating oil storage.
- Miscellaneous other parts and supplies.

The building height would accommodate delivery and offloading of pump motors, pump column sections, and other long equipment and materials. The finished floor elevation for the building would be about 49.0 feet.

2.12 Tunnel Dewatering

The tunnel dewatering process would use the main pumps within the BRPP and portable submersible pumps that would be installed in the tunnel reception shaft within the Surge Basin structure. The main pumps would be used to initially dewater the tunnel shafts and the BRPP wet well down to a wet well water surface elevation of -50 feet or lower, depending on the allowable suction requirements associated with the main pumps. The radial gates upstream of the Sacramento River intake outlet shafts would be closed and no additional flow from the intakes would enter the tunnels after the start of the dewatering process.

Submersible vertical turbine pumps were considered as the dewatering pumps for the tunnel. The dewatering pumps could normally be stored per the manufacturer's instructions in the equipment storage building when not in use or they may be left permanently installed in the vertical reception shaft within the surge basin structure. In either case, the pumps would be stored or periodically operated in accordance with the manufacturer's instructions. Each pump would be supported by the surge basin's bridge deck structure, as shown on Figure 6. Sole plates would be permanently embedded in the top deck of the bridge structure. A permanent 60-inch pump discharge pipeline supported by the bridge structure would convey the pumped flow from the main tunnel into the BRPP (at the intermediate floor elevation of 3.0 feet) and would be interconnected to a main pump's discharge pipeline, as shown on Figure 7. A flow meter and flow control valves would measure and regulate the dewatering flow from up to two dewatering pumps operating in parallel and maintain their operation within the allowable operating range of each pump. The tunnel and wet well dewatering flow would be pumped up to Bethany Reservoir. The variable speed drives for the dewatering pumps would be located within the BRPP in separate mechanical rooms located in the northern end of the structure at the intermediate floor elevation of 3.0 feet.

2.12.1 Tunnel Dewatering Sequence

The tunnel dewatering process for the conceptual level design of the project would utilize the following sequence:

- Temporary dewatering pumps and connecting piping would be installed at the Surge Basin structure.

- All control gates and radial gates at each Sacramento River Intake structure would be closed. Stop log gates would be installed for secondary isolation at the radial gate structures (tunnel inlets) if personnel would enter the tunnel after it is dewatered.

- Main pumps within the BRPP would be started using a pre-determined time-delay sequence between each pump start and the operating speeds of the pumps would be adjusted to maintain up to 500 cfs through each pump.

- Main pumps would be stopped when the BRPP wet well WSEL reaches -50.0 feet. Each pump would be stopped in increments of 0.5 feet of falling wet well level. If ten pumps would be running, the lead pump would be stopped at the wet well WSEL of -45.0 feet. All pump discharge isolation gate valves and pump control valves would be closed.

- Up to a 12-hour time delay following shutdown of the main pumps would be required to dissipate transient waves developed within the tunnel (due to the shutdown of the main pumps) prior to starting the dewatering pumps.

- Both submersible vertical turbine dewatering pumps would be started, and their operating speeds would be adjusted to maintain the predetermined output dewatering flow capacity as described in the *Hydraulic Analysis of Delta Conveyance Options – Bethany Reservoir Alternative TM* (DCA 2021c). Flowmeters would be included on the pump discharge piping system and located within the BRPP belowground structure. Dewatering pumps would be operated until the WSEL within the tunnel at the Surge Basin Reception Shaft is within 1.5 feet above the tunnel invert. When the WSEL within the Surge Basin Reception Shaft is 1.5 feet above tunnel invert, the dewatering pumps would be stopped.

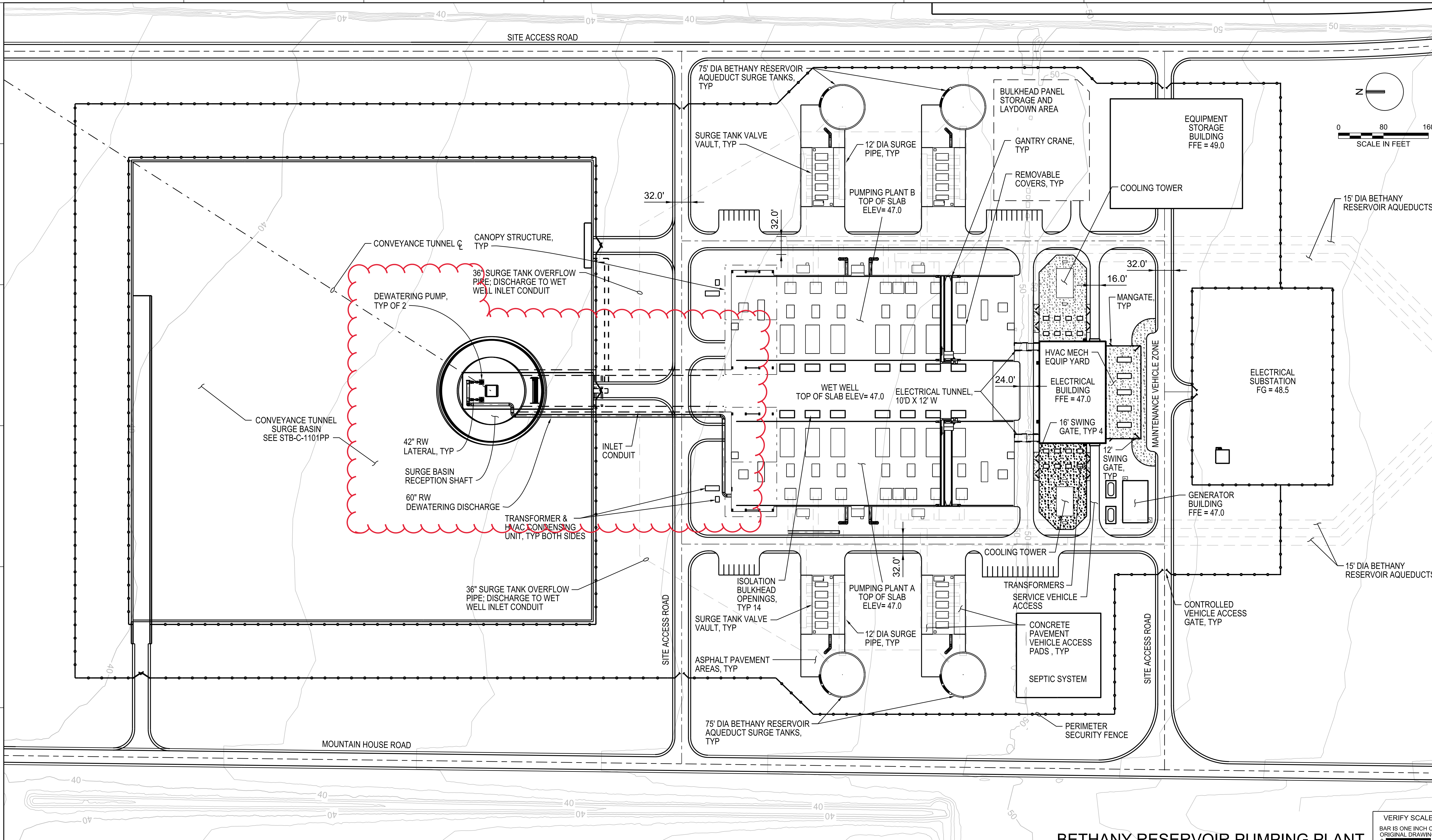
- Submersible pumps of smaller rated capacity would be installed in the Surge Basin Reception Shaft to complete the tunnel dewatering process. Pump discharge piping would be connected to the permanent shaft dewatering discharge piping systems. Pumped flow capacities would be regulated by flow control valves to avoid the formation of hydraulic jumps within the tunnel.

- Total estimated time to dewater the tunnel and connecting shafts with an initial static HGL of 26.3 feet (the maximum Sacramento River WSEL at C-E-5) would be approximately 31 days.

The hydraulic analysis including evaluation of candidate pumping equipment and system modeling for the dewatering process is further described in the *Hydraulic Analysis of Delta Conveyance Options – Bethany Reservoir Alternative TM* (DCA 2021c).

3. BRPP and Surge Basin Site Plan Configuration

The BRPP and Surge Basin site layout was developed to provide adequate space for the facilities required to operate the BRPP and Surge Basin following the construction of the tunnel and the other large facilities associated with the BRPP. The site was configured to locate structures near other structures that have functional dependencies to create a site with intentional distribution and circulation. The site layout accounts for operations and maintenance access and setbacks required by codes, with the goal of limiting the facility footprint permanent areas of impact. The following sections provide detailed information regarding the specific site elements.



BETHANY RESERVOIR PUMPING PLANT

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

REV	DATE	DESCRIPTION	SUB.	APPD

DESIGNED
APPROVAL RECOMMENDED
DRAWN
APPROVAL BY
CHECKED

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

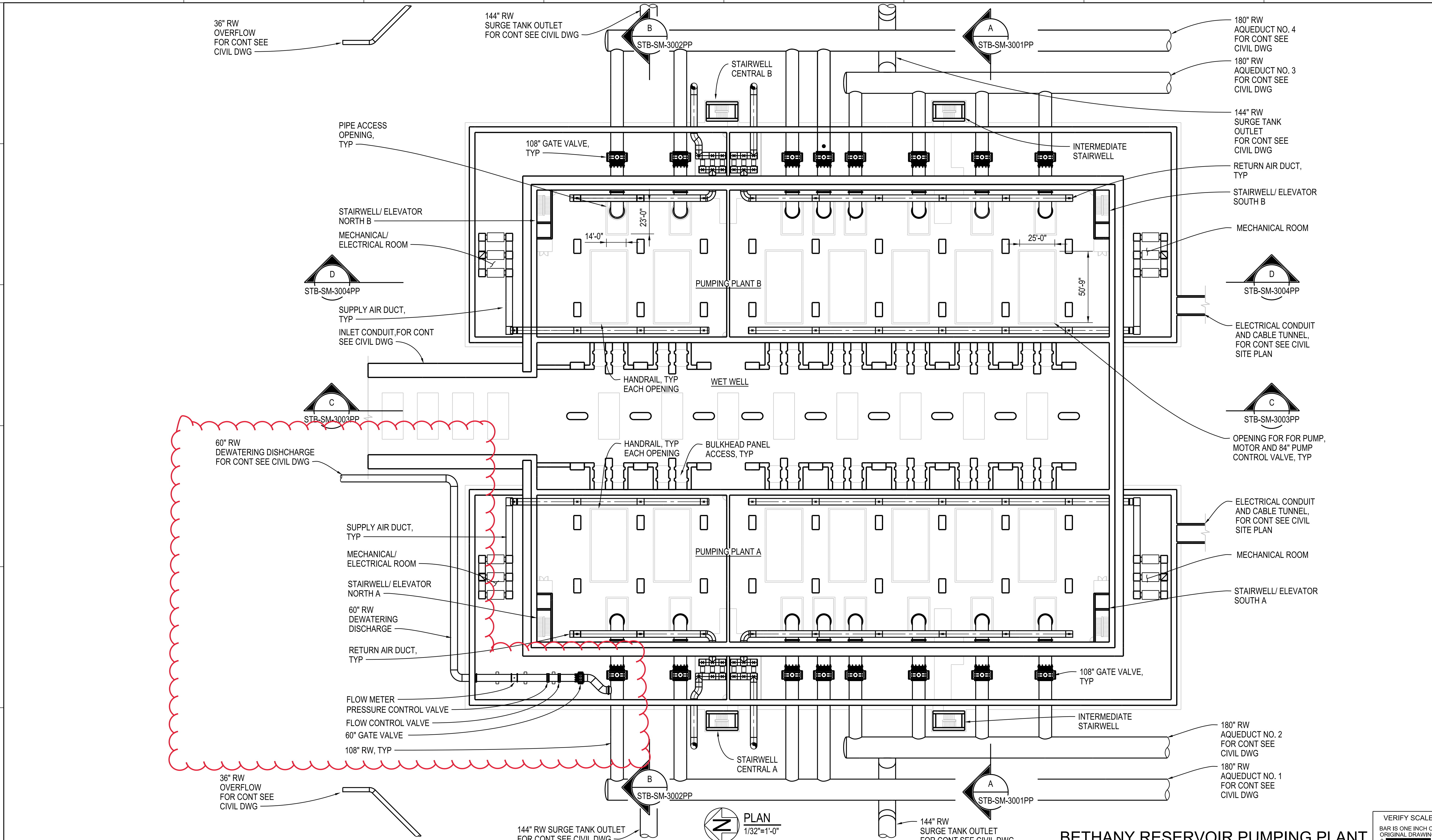
ENGINEERING PROJECT REPORT
DELTA CONVEYANCE PROJECT
SINGLE TUNNEL - BETHANY RESERVOIR ALTERNATIVE

6000 CFS SITE PLAN

PROJECT NO. W8X97000
SHEET NO. STB-C-1004DPP
REV
SEQUENCE NO.

STB-C-1004DPP_W8X97000.dgn

PLOT DATE:1/12/2021 PLOT TIME:5:18:51 PM



BETHANY RESERVOIR PUMPING PLANT

ENGINEERING PROJECT REPORT
DELTA CONVEYANCE PROJECT
SINGLE TUNNEL - BETHANY RESERVOIR ALTERNATIVE

6000 CFS ALT LOWER LEVEL PLAN AT EL 3.00

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DESIGNED	A NAIMEY
DRAWN	G JAMROS
CHECKED	
APPROVAL RECOMMENDED	
APPROVAL BY	

REV	DATE	DESCRIPTION	SUB.	APPD

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

PROJECT NO. W8X97000
SHEET NO. STB-SM-1004DPP
REV
SEQUENCE NO.

6000 CFS_STB-SM-1004DPP_W8X97000.dgn

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3.1 Site Location

The BRPP and Surge Basin site would be located at the southern terminus of the main tunnel and situated on land south of Byron Highway, east of Mountain House Road, and north of Kelso Road. The land is currently being used for agricultural purposes. There are high-voltage overhead transmission lines located immediately west and north of the site. The existing WAPA Tracy substation is located adjacent to the site on the western side of Mountain House Road. Refer to the engineering concept drawings for site location plans.

3.2 Footprint Characteristics

The permanent site footprint size varies for each project design capacity. Table 7 provides the overall site dimensions and acreage for the BRPP and surge basin footprint.

Table 7. BRPP and Surge Basin Overall Site Footprint Dimensions for the Range of Project Design Capacities

Project Design Capacity (cfs)	Width (feet)	Length (feet)	Area (acres)
3,000	1,145	2,100	55
4,500	1,165	2,185	58
6,000	1,165	2,256	60
7,500	1,165	2,441	65

The existing topography of the site generally slopes south to north. The grading of the site follows the existing topography, with higher finished grade elevations of 48.5 feet at the southern end of the site and the top of the Surge Basin wall elevation of 42.0 feet at the northern end of the site. The top-of-slab elevation for the BRPP is 47.0 feet

3.3 Access

The BRPP would be accessed from the Byron Highway immediately north of the site, at a new interchange constructed at Lindemann Road. Additionally, the site would be accessible from Interstate 580, located approximately 3 miles south of the site, via West Grant Line Road and Mountain House Road.

A new frontage road would be constructed for the Lindemann Road interchange, parallel to the Byron Highway on the southern side, extending south into the site. This new frontage road would also connect to the Byron Highway at the existing Mountain House Road intersection. The new frontage road would allow site vehicles to use Mountain House Road on the western side of the site and a new north-south access road on the eastern side of the site. Improvements to Kelso Road would provide roadway connections to Mountain House Road and the new north-south access road along the southern side of the site.

The number of points of direct site access from Mountain House Road and the new north-south access road varies slightly, depending on the design capacity option, with one less connection point from Mountain House Road to the BRPP for the site layouts for 3,000 cfs and 4,500 cfs project design capacities than for the 6,000 cfs and 7,500 cfs project design capacities. There would be one point of direct site access to the Surge Basin from Mountain House. For the 7,500 and 6,000 cfs project design capacities, there would be two direct points of access from Mountain House Road and two direct points of access from the new north-south road. Refer to the engineering concept drawings for site plans showing access roads.

The site access and interior circulation roads would generally be two-lane roads with 12-foot travel lanes and 3-foot paved shoulders. Paved access would be provided to each of the BRPP facilities. A portion of the facility access approaches, and drive aisles, would have varying widths based on access requirements and would not have paved shoulders. Vehicles would be permitted to drive on the BRPP wet well slab to facilitate operations and maintenance needs. Additionally, vehicle access drive aisles would be provided to the electrical building to allow vehicles to back into the building overhead doors for the delivery and loading of equipment. Drive-through access would be provided for the equipment storage building to accommodate material and equipment deliveries and loading.

3.4 Perimeter Site Security Fencing

Perimeter site security fencing would be provided around the exterior of the BRPP and Surge Basin aera. Additional security fencing would be provided around the top of wall for the Surge Basin and around the interior portion of the electrical substation yard to further limit access to these two facilities. The security fence would consist of an 8-foot-tall chain-link fence with three-strand barbed wire apron.

Security cameras would be located in strategic locations throughout the facility to provide video imagery of the exterior perimeter and key locations within the facility. Additionally, security cameras would be provided at the points of vehicle access for monitoring.

Controlled vehicle access gates would be motorized and accessible via keycards.

3.5 Facility Layout

Refer to the engineering concept drawings for site plans showing the facility layout.

The Surge Basin would be located at the northern end of the site. The Surge Basin is located approximately 145 feet from the northern east-west interior site access road and approximately 235 feet north of the BRPP.

For the 6,000-cfs project design capacity, two 180-inch-inside-diameter BRPP pump discharge pipelines would be located east of the BRPP structure and two would be located west of the BRPP. The pipelines would become parallel and comprise the Bethany Reservoir Aqueduct to convey pumped flow to Bethany Reservoir. Similar to the discharge pipelines, Surge Tanks and Surge Tank valve vaults would be located west and east of the BRPP, with one Surge Tank dedicated to each discharge pipeline.

The electrical building would be located about 45 feet south of the BRPP, with a subgrade electrical tunnel providing a connection from the electrical building to the east and west pump dry pit areas. The electrical building would be centered along the BRPP's southern wall. The HVAC mechanical equipment yard is separated from the electrical building by 25 feet to the south. This 25-foot setback would allow for equipment access and HVAC duct routing. Cooling tower and electrical transformer yards would be provided on the eastern and western sides of the electrical building.

The electrical substation would be located approximately 150 feet south of the electrical building and the generator building would be located southwest of the electrical building. The electrical substation has a footprint of 250 feet by 350 feet. The electrical substation is located at the southern end of the site.

The equipment storage building would be located southeast of the BRPP and adjacent to the new north-south access road to allow vehicles to drive to-from access road through the building and to the BRPP.

An area would be reserved east of the BRPP for bulkhead panel storage and laydown area. Additionally, a septic system and drainfield area would be provided southwest of the BRPP, towards Mountain House Road.

3.6 Vehicle Circulation

The interior access roads would be configured to allow vehicles to circulate throughout the site and minimizing dead ends. The BRPP site points of access from external roadways are interconnected with the onsite road network. Access drives would be provided to allow vehicles to drive onto and across the BRPP slab if desired. Thirty-five feet radii would be provided at interior site access road intersections to accommodate large truck turning movements.

3.7 Pedestrian Circulation

Pedestrian travel routes would be provided throughout the BRPP site to allow for movement amongst the various facilities and vehicle parking areas. Concrete sidewalks would be provided to provide efficient routing from vehicle parking areas and connectivity between the facilities.

3.8 Parking

Passenger vehicle parking areas would be provided in several locations near the various buildings. The number of permanent parking spaces provided would vary for each project design capacity with a total of about 50 dedicated spaces provided for a project design capacity of 6,000 cfs, based on the anticipated number of personnel and visitors. The passenger vehicle parking would be configured using perpendicular (90-degree) orientation. A long parallel parking area would be provided for maintenance vehicles to service the HVAC equipment located in the mechanical equipment yard south of the electrical building.

4. References

Delta Conveyance Design and Construction Authority (DCA). 2021a. South Delta Pumping Plant Basis of Conceptual Design Technical Memorandum. Final Draft.

Delta Conveyance Design and Construction Authority (DCA). 2021b. Hydraulic Analysis Criteria Technical Memorandum. Final Draft.

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

Delta Conveyance Design and Construction Authority (DCA). 2021d. Electric Power Transmission – Bethany Reservoir Alternative Technical Memorandum. Final Draft.

Delta Conveyance Design and Construction Authority (DCA). 2021e. Central and Eastern Corridors to the Proposed Project – Environmental Documentation Information Template. Final Draft.

American National Standards Institute, Inc., ANSI/HI Standard 9.6.3, Rotodynamic Pumps – Guidelines for Operating Regions (ANSI. 2017).

5. 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 (EDM) and the DCA.

Approval Names and Roles			
Prepared by	**Internal Quality Control review by**	**Consistency review by**	**Approved for submission by**
Tony Naimey / EDM Pumping Plant Lead	Phil Ryan / EDM Design Manager	G. Buchholz / DCA Environmental Consultant	Terry Krause / EDM Project Manager

This interim document is considered preliminary and was prepared under the responsible charge of Anthony M. Naimey, California Professional Engineering License M28450.