Subject:	**Southern Forebay Emergency Outlet Evaluation (Final Draft)**
Project feature:	Southern Forebay
Prepared for:	California Department of Water Resources (DWR) / Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
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1. Purpose and Introduction

The Delta Conveyance Project (Project) would include intakes along the Sacramento River between its confluences with American River and Sutter Slough, as well as a tunnel between the intakes and a forebay at the downstream terminus of the main tunnel (the Southern Forebay). Water would either flow by gravity or be lifted by the pumping plant from the tunnel into the Southern Forebay (SF). Discharge from the SF would occur through the Southern Forebay Outlet Structure, at the southern end of the reservoir, into the South Delta Conveyance facilities (SDCF) for connection to the existing State Water Project Harvey O. Banks (Banks) Pumping Plant and possibly the Central Valley Project C.W. Bill Jones Pumping Plant.

The SF would include a perimeter earthen embankment to retain the storage, an emergency spillway, and a secondary emergency outlet. This technical memorandum (TM) evaluates scenarios for emergency drawdown and outlet systems for the proposed SF and provides a recommendation for dewatering the forebay within the regulatory mandated time period.

2. Background

The proposed site for the SF is on Byron Tract near the existing Clifton Court Forebay (CCF). The SF would be an at-grade storage reservoir that would provide the storage needed to balance Project's supply and demand. The elevations provided in this TM are based on the North American Vertical Datum of 1988 (NAVD88).

The SF would be supplied water from the conveyance tunnel through the new pumping plant situated on the northern embankment of the SF (Figure 2-1). Discharge from the SF would occur through the Southern Forebay Outlet Structure, at the southern end of the reservoir.

The California Department of Water Resources (DWR), Division of Safety of Dams (DSOD) is the State agency with jurisdiction over the design, construction, and safe operations of the planned SF. For reservoirs impounding over 5,000 acre-feet of water (such as the proposed SF), DSOD criteria require an emergency outlet system to be capable of lowering the maximum storage depth by 10 percent within 7 to 10 days and draining the reservoir within 90 or 120 days, depending on factors such as downstream conditions, seismic hazards, and dam conditions (as determined by DSOD).

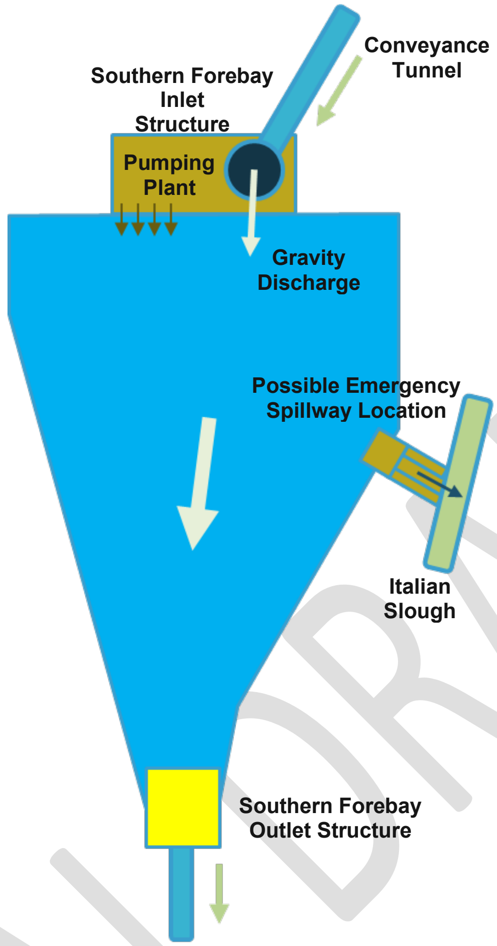

Figure 2-1. Schematic Layout of the Southern Forebay

3. Emergency Drawdown

During normal operation, the water surface elevations within the reservoir would be between Elevation (El) 5.5 and 17.5 feet (with a change in storage volume of 9,000 acre-feet over this range). Between El 5.5 feet and the low point of the reservoir floor (at El -7.0 feet, located at the Southern Forebay Outlet Structure), the storage volume would be approximately 7,300 acre-feet. In an emergency, water would be released by gravity through the Southern Forebay Outlet Structure, which can lower the reservoir from a maximum operating level of El 17.5 feet to elevations ranging between about El 1.0 and -1.0 feet within a few days, depending on the downstream conditions at the approach channel for the Banks Pumping Plant. This corresponds to removal of approximately 76 to 85 percent of the reservoir storage volume (drawdown to El 1.0 to El -1.0 feet, respectively) by gravity without the use of ancillary systems.

Figure 3-1 shows the maximum operating reservoir level and the remaining (dead) pool within the SF after the reservoir is lowered using the Southern Forebay Outlet Structure. The SF embankment would be relatively wide at its base and some amount of net head across the embankment base would be acceptable (that is, the SF interior would not need to be completely dewatered under emergency conditions).

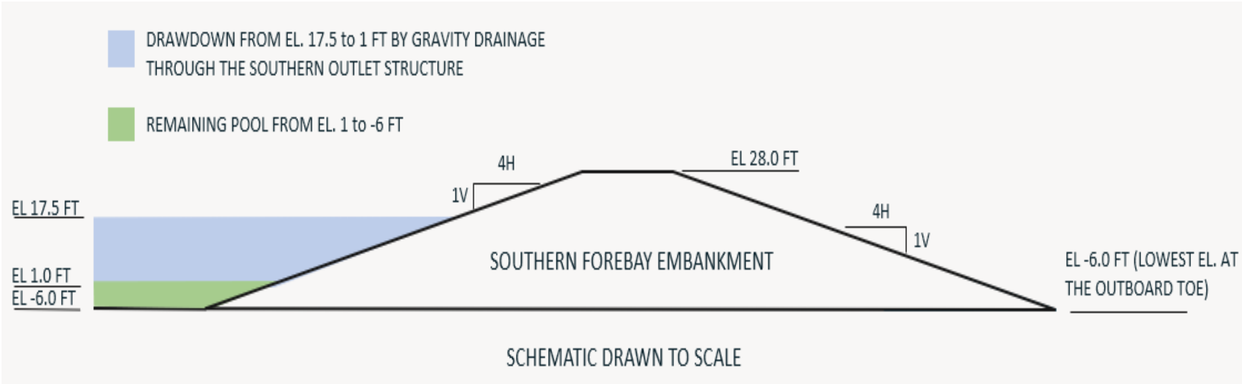

Figure 3-1. Schematic Section through Southern Forebay Embankment

Along the eastern side of the SF, the lowest existing ground surface elevation along the downstream embankment toe is about El -6.0 feet. The depth of the remaining storage after gravity release through the SF outlet would be up to 7.0 feet. Presently, there are various jurisdictional reservoirs within California that exist with dead pool above the outboard toe elevation. Given this precedent, the gravity release of reservoir storage to the dead pool elevation of El 1.0 to -1.0 feet is recommended to address DSOD emergency drawdown requirements.

The following sections discuss options to discharge all, or portions of, the remaining storage below dead pool.

4. Identification of Evaluation Criteria

Table 4-1 summarizes the criteria used for the qualitative evaluation of dewatering system scenarios to supplement gravity release through the reservoir outlet.

Table 4-1. Supplemental Dewatering Scenarios Evaluation Criteria

Criteria	Summary Description
Configuration Compatibility	Addresses compatibilities with the physical layout of the SF and the associated upstream and downstream conveyance features as follows: • Ability of each scenarios to interface with existing or proposed infrastructure • Method for directing flow and path of discharge flows • Scenarios that use existing or planned infrastructure were preferred to scenarios requiring construction of additional facilities
Operational Compatibility	• Considers the operational requirements for each supplemental dewatering scenario and the relative effectiveness of a scenario in dewatering the forebay
Logistics	• Includes the relative effort needed to construct, access, and operate the supplemental dewatering system scenario
Environmental & Permitting Conditions	• Considers the effects of a discharge release and the potential for inundation of nearby landowners, infrastructure, and future developments for each alterative
Relative Cost	• Considers the perceived construction complexity and logistical complexity. No formal cost estimate was prepared for this effort; the following items were considered in the relative cost analysis: – Constructability costs associated with existing or concurrently proposed infrastructure and requirements for infrastructure improvements – Logistical costs related to access constraints, power supply, controls, and space constraints

The following assumptions were used for this analysis:

- DSOD jurisdictional requirements for emergency drawdown are fully addressed by gravity drainage of the reservoir through the Southern Forebay Outlet Structure to a dead pool level of El 1.0 to -1.0 feet.
- Evaluation of supplemental dewatering scenarios assumes pumped or gravity inflows into the reservoir from the conveyance tunnel have been ceased.
- Exterior inundation was assumed to be secondary compared to the risk of catastrophic loss of the reservoir.

5. Scenario Evaluation and Comparison

5.1 Identification of Alternatives

Three dewatering scenarios to supplement gravity release through the reservoir outlet were considered (Figure 5-1):

- Scenario 1 – Southern Forebay Outlet Tunnel Dewatering System
  - Use the Southern Forebay Outlet Tunnel dewatering system to pump down the reservoir (Southern Forebay Outlet Structure gates open, downstream tunnel gates closed to prevent backflow).
- Scenario 2 – Bypass Pumping to Southern Forebay Outlet Tunnel
  - Close the Southern Forebay Outlet Structure bulkhead gates and pump reservoir water around those gates and into the Southern Forebay Outlet Tunnel (requires permanent or portable pumping system at Southern Forebay Outlet structure).
- Scenario 3 – Gravity Outlet Drain
  - Install an emergency outlet along the eastern side of the SF embankment. The gated outlet would release water by gravity flow. The intake elevation for this emergency outlet would be below the initial dead pool elevation but would not be able to completely empty the SF (as noted on Figure 5-1, the elevation of the intake would be about El -4.5 feet).

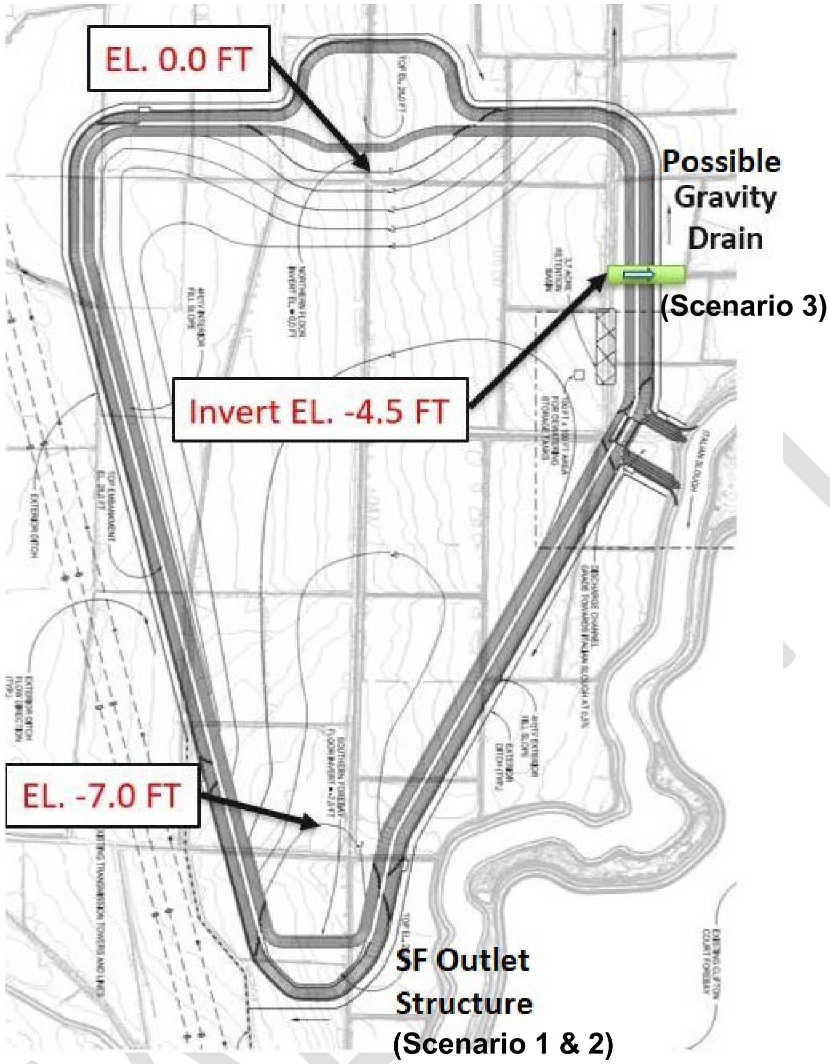

Figure 5-1. Proposed Supplemental Dewatering Locations within the Southern Forebay

5.2 Scenarios Evaluation and Comparison

The scenarios discussed here provide additional drawdown capacity beyond the dead pool level at El 1.0 to -1.0. Gravity drawdown of the reservoir to the dead pool level is intended to satisfy DSOD's emergency drawdown requirements given the robust embankment cross-section and remnant low driving head and low storage volume at the dead pool level.

The qualitative evaluation criteria described in Section 4 were used to assess each supplemental dewatering scenario. A rating of favorable, acceptable, or undesirable is provided for each of the criteria.

5.2.1 Scenario 1 – Southern Forebay Outlet Tunnel Dewatering System

The Southern Forebay Outlet Tunnel would include a dewatering system so the tunnels could be inspected and maintained in the dry. If necessary, the dewatering system for the Southern Forebay Outlet Tunnel could be used to draw down the SF beyond the dead pool to a lower level or completely dewater the reservoir. For this scenario, the Southern Forebay Outlet Tunnel dewatering system would be sized to dewater both the tunnel system and the SF dead pool.

Table 5-1 summarizes the evaluation of Scenario 1.

Table 5-1. Evaluation of Scenario 1 – Southern Forebay Outlet Tunnel Dewatering System

Criterion	Qualitative Rating	Comments
System Configuration Compatibility	Favorable	Presently included within the conceptual design as part of the south tunnel dewatering system. As a result, no new infrastructure required. Discharge from the dewatering system would remain within the Project system and conveys flows to the downstream Banks Pumping Plant.
System Operational Compatibility	Favorable	Pumps would be positioned downstream of the SF within the SDCF outlet structure and would be able to completely drain the SF. Maintenance of the pumps and associated backup power supplies would be anticipated over the service life of the Project.
Logistics	Favorable	No additional construction required. Operational access would already be in place for the dewatering system.
Environmental/ Permitting	Acceptable	No inundation of adjacent landowners is anticipated as all flows remain within the Project system.
Relative Cost Components	Favorable	No additional components necessary beyond the planned dewatering system, which is already incorporated into the Project. Dewatering system may need to be upsized.

5.2.2 Scenario 2 – Bypass Pumping to Southern Forebay Outlet Tunnel

Scenario 2 would rely on a dedicated pump system that would allow the reservoir to be dewatered beyond the dead pool level without having to dewater the downstream tunnels. This scenario would consist of a bypass pumping system located immediately upstream of the gates in the Southern Forebay Outlet Structure (Figure 5-2). The bypass pump scenario would consist of dual vertical turbine pumps (or high capacity can-style submersible pumps) located downstream of the trash racks and upstream of the bulkhead gates within the intake of the Southern Forebay Outlet Structure.

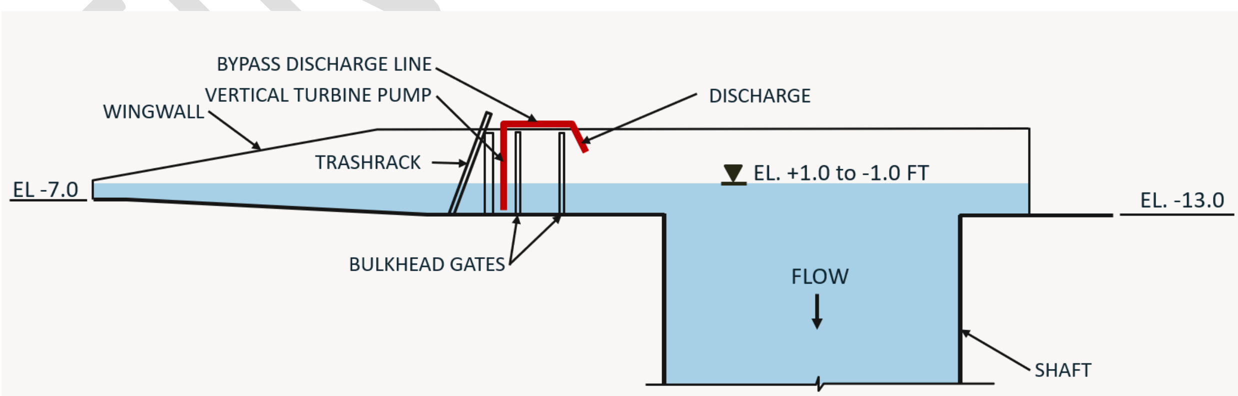

Figure 5-2. Schematic of Bypass Pumping to Southern Forebay Outlet Tunnel (Scenario 2)

The pumps would be mounted to the wingwalls on both sides of the outlet. The pump discharge piping would bypass the stoplogs on the outside of the structure as a buried pipe below the access road alignment. The system would include a primary dewatering pump, and a second backup pump would be included for redundancy or to accelerate the dewatering effort if desired. This scenario would require dedicated electrical service or provisions to incorporate standby engine generators (SEGs). Table 5-2 summarizes the evaluation of Scenario 2.

Table 5-2. Scenario 2 – Bypass Pumping to Southern Forebay Outlet Tunnel

Criterion	Qualitative Rating	Comments
System Configuration Compatibility	Acceptable	Adequate space is available within the currently proposed Southern Forebay Outlet Structure to install the pumps downstream of the trash racks and the associated discharge piping can be routed under the access road. This dewatering system would be limited to dewatering the SF only and would be separate from the currently proposed southern tunnel dewatering system. Discharge from the reservoir would remain within the Project system and conveyed to the downstream Banks Pumping Plant.
System Operational Compatibility	Acceptable	Pumps would be positioned within the low portion of the Southern Forebay Outlet Structure (El -13.0 feet) which would allow complete evacuation of the SF. Maintenance of the pumps and/or SEGs would be anticipated over the service life of the Project.
Logistics	Acceptable	Construction access would already be in place for construction of Southern Forebay Outlet Structure; however, electrical power or provisions for SEG support would need to be routed to the pumps which is currently not incorporated into the conceptual design of the Southern Forebay Outlet Structure. Permanent access would already be constructed for operational access to the Southern Forebay Outlet Structure deck. Some modifications would be necessary to gain access to the pumps for maintenance and servicing.
Environmental/Permitting	Acceptable	No inundation of adjacent landowners is anticipated as all flows remain within the Project system.
Relative Cost Components	Acceptable	Two pumps and the associated piping and electrical connections (or SEGs connections) would need to be added to the Southern Forebay Outlet Structure. These costs are anticipated to be less than the costs to construct the gravity outlet drain scenario (Scenario 3), but more than Scenario 1.

5.2.3 Scenario 3 – Gravity Outlet Drain

Scenario 3 would consist of a gravity outlet drain through the base of the embankment and would be located on the northeastern side of the SF. Figure 5-1 shows a possible location for the gravity drain. The invert (bottom) of the inlet structure would be installed approximately 0.5 feet above the inside toe of the SF embankment (to limit debris and sediment blocking emergency discharge). Figure 5-3 shows the general layout of Scenario 3.

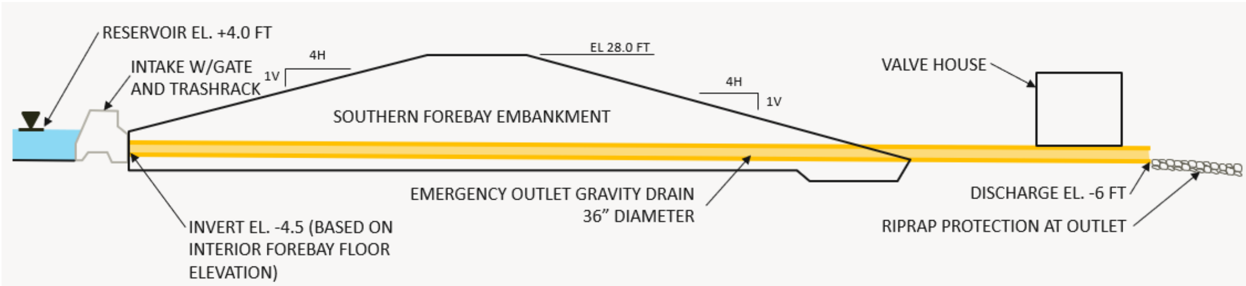

Figure 5-3. Scenario 3 – Gravity Outlet Drain Outlet Schematic

This scenario would include an upstream intake with trash racks and feed a conduit (preliminarily estimated as 36-inch-diameter) running from the SF floor through the base of the embankment to a valve house near the outboard toe. The valve house would contain a motor-operated valve to control the flow through the supplemental gravity outlet. Electricity would be needed at the valve house via a trenched/overhead line, and the valve would also need to be capable of being hand-operated. The diameter of the emergency outlet would be designed so it could drop the dead pool surface elevation to the invert of the intake structure within 90 days.

Approximately 10 to 20 feet from the outboard toe of the embankment, the emergency outlet would discharge onto an energy dissipator field (riprap channel) to reduce exit discharge velocities. It is anticipated that the energy dissipator would consist of large boulders and riprap, or a concrete structure, before flowing into existing irrigation channels. The discharge location depicted on Figure 5-3 was selected because it appeared to be the only area with sufficient external inundation capacity (existing ground elevations at or below El -5.0 feet).

Unless supplemented, Scenario 3 would not be able to completely evacuate the reservoir, and a net head across the SF embankment of about 1 to 2 feet would remain (above the lowest outboard ground surface elevation). This scenario also depends on the inundation storage capacity north of State Route 4, which may be achieved by flows through an existing large box culvert. The inundation area would include large portions of Byron Tract and could require the construction of relatively low (about 3-foot-tall) ring berms around the Discovery Bay Wastewater Treatment Plant and Contra Costa Water District intake on Old River, just south of State Route 4.

Table 5-3 summarizes the evaluation of Scenario 3.

Table 5-3. Evaluation of Scenario 3 – Gravity Outlet Drain

Criterion	Qualitative Rating	Comments
System Configuration Compatibility	Acceptable	Adequate space is available along the embankment to construct the outlet works and associated piping and valves; however, ground improvements would likely be needed to limit the post-construction settlement in this location as this infrastructure would be sensitive to settlement. Discharge from this configuration would require additional infrastructure on the downstream side of the embankment to safely convey the flows away from the toe of embankments. Volume of discharge would not be rediverted into the Project.

Table 5-3. Evaluation of Scenario 3 – Gravity Outlet Drain

Criterion	Qualitative Rating	Comments
System Operational Compatibility	Acceptable	A residual volume of water would remain in the SF because the outlet would be at an elevation above the lowest internal reservoir floor elevations. Maintenance of the valve would be anticipated over the service life of the Project. Cleaning of the upstream trash racks and inlet location would be required periodically.
Logistics	Acceptable	Construction access would already be in place for construction of embankments; however, the additional ground improvements would require extra equipment and resources to be mobilized to the area. In addition, construction of the intake and valve house would require a separate contractor capable of constructing the ancillary components of the system. A walkway would be needed to gain access to the intake structure within the forebay.
Environmental/ Permitting	Undesirable (based on inundation area)	Large areas of the Byron Tract would be inundated including adjacent to Discovery Bay, north of State Route 4. A ring berm would be needed around the Discovery Bay Wastewater Treatment Plant and Contra Costa Water District intake on Old River, just south of State Route 4. The necessary ring berms are not currently considered in the environmental documentation, so the additional impacts would be incurred.
Relative Cost Components	Undesirable	The construction of this scenario would require significantly more resources than the other two scenarios.

5.3 Summary of Evaluations

Table 5-4 summarizes the results of the evaluations.

Table 5-4. South Forebay Emergency Outlet Scenario Evaluation Summary

Criterion	Scenario 1 Southern Forebay Outlet Tunnel Dewatering System	Scenario 2 Bypass Pumping to Southern Forebay Outlet Tunnel	Scenario 3 Gravity Outlet Drain
	Qualitative Rating		
System Configuration Compatibility	Favorable	Acceptable	Acceptable
System Operational Compatibility	Favorable	Acceptable	Acceptable
Logistics	Favorable	Acceptable	Acceptable
Environmental/Permitting	Acceptable	Acceptable	Undesirable
Relative Cost	Favorable	Acceptable	Undesirable

6. Recommendations

DSOD criteria require an emergency outlet system to be capable of lowering the maximum storage depth by 10 percent within 7 to 10 days, and of draining the reservoir within 90 or 120 days depending on site-specific conditions. If emergency drawdown of the SF was required, water would be released by gravity through the Southern Forebay Outlet Structure, which would able to lower the reservoir from a maximum operating level of El 17.5 feet to elevations ranging between about El 1.0 and -1.0 feet within a few days. The released volume would correspond to a reduction in storage of approximately 76 to 85 percent by gravity within a matter of days without the use of ancillary systems, which is a significantly faster drawdown than required by DSOD.

Gravity drawdown of the reservoir through the Southern Forebay Outlet Structure would leave remnant storage up to 7 feet above the lowest outboard toe elevation (El -6.0 feet), which should be considered dead pool given the robust embankment cross-section and low driving head and low storage volume at the dead pool level. Presently, there are various jurisdictional reservoirs within California that exist with dead pool above the outboard toe elevation. Given this precedent, the gravity release of reservoir storage to the dead pool elevation of El 1.0 to -1.0 feet is recommended to address DSOD emergency drawdown requirements.

It may also be necessary to fully drain the reservoir for various reasons, such as the maintenance of the interior embankment slopes. A qualitative evaluation was performed to assess options to fully, or partially, drain the dead pool storage. The results of the qualitative evaluations indicate that using the Southern Forebay Outlet Tunnel dewatering system (Scenario 1) is the preferred option to fully drawdown the reservoir, because it has favorable characteristics in four of the five evaluation categories. A significant advantage for Scenario 1 is that it will use the Southern Forebay Outlet Tunnel dewatering system already intended for the Project, but also provides for a more robust reservoir drawdown system.

7. 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**
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This interim document is considered preliminary and was prepared under the responsible charge of Joseph de Larios, California Professional Engineering License GE2349.

Note to Reader

This is an early foundational technical document. Contents therefore reflect the timeframe associated with submission of the initial and final drafts. Only minor editorial and document date revisions have been made to the current Conformed Final Draft for Administrative Draft Engineering Project Report version.