Appendix B7. Intakes Screen Sizing – North Delta Intakes (Final Draft)

1. Introduction and Purpose

The purpose of this technical memorandum (TM) is to document the methodology used for the conceptual sizing of the intake screens at the intakes C-E-3 and C-E-5 locations shown on Figure 1 (attached at end). Intake sizing for configurations using cylindrical tee screen systems are described the Concept Engineering Report (CER)Appendix B4 *Intake Structural Configuration and Fish Screen Type Analysis*. The results from this TM could be used to size an overall conceptual site footprint for each intake site.

1.1 Organization

This TM includes the following sections:

- Background
- Summary of Results
- Methodology
- Analysis and Evaluation
- Conclusions
- References
- Figures

2. Background

The Delta Conveyance Project (Project) would use two intake structures located at river mile (RM) 39.4 and RM 36.8 on the Sacramento River, each capable of conveying up to 3,000 cubic feet per second (cfs), for a total Project diversion flow of 6,000 cfs.

A large-diameter tunnel would convey flows from the intake structures to the Bethany Reservoir Pumping Plant approximately 45 miles downstream, prior to being delivered into the California Aqueduct at the existing Bethany Reservoir.

The primary functions of the intakes would be to:

- Provide facilities to accomplish diversions from the Sacramento River
- Provide features for the protection of fish and other aquatic resources
- Manage sediment for the benefit of downstream features
- Provide flow control to meet Project and regulatory requirements

2.1 Fish Protection

Fish protection is provided, in part, using fish screens to prevent fish from being entrained at the intake structure in the diverted water and allow them to safely move past the facility while swimming in the source water body.

Fish screens for the Project would comply with criteria and guidelines issued by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) for salmonids (NOAA 1997, 2018), the California Department of Fish and Wildlife (DFW; formerly Department of Fish and

Game, DFG) (DFG, 2010), and the U.S. Fish and Wildlife Service (USFWS). CDFW requirements are applicable to both salmonids and juvenile Delta fish species. USFWS requirements are applicable to juvenile Delta fish species and are typically promulgated via biological opinions versus a published set of criteria. Generally, NMFS requirements acceptable to CDFW and the USFWS, provided the approach velocity is limited for juvenile Delta fish species, as described in this TM.

For salmonids and juvenile Delta fish species at the locations of the proposed intakes, these agencies require fish screens with 1.75-millimeter (mm) (0.069-inch) or smaller openings and with at least a 27 percent open area.

The Project fish screens would be designed to protect juvenile Delta fish species (typically characterized as delta smelt) and salmonids occurring in the river. The determination of providing more stringent protection for Delta smelt versus salmonids depends on the location of the intakes along the river and other environmental considerations developed on a case-by-case basis with resource regulatory agencies.

Regulatory screen sizing criteria limit the maximum approach velocity, as follows:

- Delta smelt protection criteria: 0.2 foot per second (fps) per USFWS requirements as adopted by CDFW.
- Salmonid protection criteria: 0.33 fps per NMFS and CDFW requirements for riverine, lake, and tidal installations (subject to Agency review).

Approach velocity (V_A) is defined as the velocity component of the flow being diverted that is perpendicular to the fish screen face, as close to o the boundary layer of turbulence generated by the screen face as is physically possible (NOAA, 2018), which is typically 3 inches in front of the screen (USBR, 2009). It is determined for design by dividing the diversion flow rate (Q) by the effective wetted screen area (A_s), or:

$$V_A = Q / A_s \qquad \textbf{[Eq. 1]}$$

The actual area of the fish screen panels must be slightly larger than the computed value to facilitate real-time operational compliance with the limiting approach velocity at the design diversion flow rate.

To meet approach velocity design and performance criteria, the proposed intake facility will incorporate a number of design measures including: 1) configuring the intake facility in the river to hydraulically distribute the intake flows evenly across the screen surface; 2) providing a screen velocity baffling system behind each screen surface to further evenly distribute the intake flows; and 3) providing an additional screen area allowance factor (F_A) of 5 to 10 percent to lower the overall screen approach velocity due to expected velocity anomalies. During design, physical and/or computational river and intake modeling will be performed to determine the optimal layout and sizing to demonstrate compliance. Post-project field operational testing will also be performed to make any adjustments of the baffling system as necessary. The additional screen allowance factor was set between these values at this stage in the design. An F_A of 5-7 percent is warranted for the tee screen facility design due to less screen panel structural member interference, potentially better velocity control due to the small individual screen units (100 cfs units), and good velocity performance on similar projects. Specifically, an F_A of 6.75 percent was used for this analysis to maintain 100 cfs for each screen unit using the nominal sizing information presented below. During final design, the length and diameter of the tee screens can be slightly modified if a different F_A is selected. Such modification would not be expected to result in significant changes to the overall sizes of the intake systems described in this TM.

Field measurements may be required to verify hydraulic performance during commissioning and/or during post Project operations. Screen baffles may be adjusted, if necessary, during these evaluations for compliance purposes.

Because the screens would be designed and constructed to protect the most limiting fish species under consideration, an approach velocity of 0.2 fps was used for this sizing analysis.

For example, a fish screen designed for delta smelt protection with a 3,000-cfs diversion flow rate and 6.75 percent additional area would need to have an effective wetted fish screen panel area of about 16,013 square feet (ft^2) as follows:

$$F_A \times [Q / V_A] = A_s \qquad \textbf{[Eq. 2]}$$

Or, for example:

$$1.0675 * [3{,}000 \text{ cfs} / 0.2 \text{ fps}] = 16{,}013 \text{ ft}^2$$

2.2 Intake Structure and Screen Types

Intake sizing was developed for on-bank intake configurations using cylindrical tee screen systems in accordance with the intake structure and fish screen type recommended for further consideration as defined in the CER Appendix B4.

2.3 Controlling Elevations

Water surface elevations (WSELs) pertinent to intake sizing were based on the low design WSELs from CER Appendix B2 *River Hydrologic Criteria for Intake Sizing*. Similarly, compatible intake depths were determined using the river bottom information from two primary bathymetric evaluations of the river bottom topography in the vicinity of the intake sites (Wood Rogers, Inc. 2010; DWR 2019).

3. Summary of Results

Table 1 shows the results of the analysis undertaken using the design WSELs, the river bottom elevation, and sill elevation determined for each of the intake locations. Where the effective intake depths are less than 17.5 feet, the actual depths were used to determine the overall intake length. Intake lengths are shown for 3,000-cfs diversion flows at each intake location.

Table 1. Cylindrical Tee Screen Intake Structure Sizing Results

Intake Site	Design WSEL (ft)	River Bottom EL (ft)	Tee Screen Bottom EL (ft)	Overall Structure Length (ft)[a],[b]
C-E-3	3.72	-25	-13	964
C-E-5	3.61	-17	-13	964

[a] Intake length includes screens, columns, and other non-screen structural components described in Step 5 of the Methodology section.
[b] Overall structure lengths do not include training walls.
Notes:
EL = elevation
ft = foot (feet)

4. Methodology

The cylindrical tee fish screen size and associated length of the intake structure were calculated for the intake sites using a 3,000 cfs per intake diversion flow rate.

Calculations for each were performed using the steps described in this section.

4.1 Step 1: Determine Water Surface Elevation

The 99-percentile low WSEL to be used as the planning phase WSEL at each intake location was determined in the CER Appendix B2.

4.2 Step 2: Determine River Bottom Elevation

Using instream bathymetry (DWR, 2019), cross sectional surface profiles were plotted at each intake location (Figure 2 shows an example) to determine the river bottom elevations to be used for sizing. The 99-percentile low WSELs were depicted on the cross sections. Cross sections were evaluated, and a candidate river bottom elevation was determined.

4.3 Step 3: Size Screen Panels

Screen panel sizes were determined for each intake site as described in this section.

4.4 Screen Diameter

Screen diameter was coordinated with a local cylindrical screen manufacturer with extensive experience in fabricating cylindrical screens in the capacity range being considered. Given the magnitude of the diversion flow rates, the largest practical screen diameter for planning purposes was selected at 8 feet.

4.5 Screen Length

The length of an individual cylindrical screen unit was also determined in consultation with the same screen manufacturer. Overall screen length was limited to 29.33 feet, maximum.

4.6 Step 4: Determine Individual Screen Panel Flow Capacity and Number of Panels

Using the fabrication dimensions described and in consultation with the cylindrical tee screen manufacturer, the flow capacity of an individual screen unit was determined. This flow capacity was then reduced by 6.75 percent for overall facility sizing as described above. The resulting screen unit capacity is 100 cfs.

The number of cylindrical screen units was then established by dividing the overall diversion flow rate by 100 cfs.

4.7 Step 5: Determine the Overall Intake Structure Length

Using the number of screen units, the overall screen length was determined. The following assumptions were used:

- The space between cylindrical tee screen units is 1 foot.
- Each tee screen is piped to a 60-inch-diameter gate, piping, and flowmeter assembly housed in a dry-pit structure behind the intake structure face.
- A 20-foot-wide laydown area is required at each end of the structure, beyond the last tee screen assembly to facilitate installation and removal of piping from inside of the structure.
- The intake structure end walls are 3 feet thick.

4.8 Assumptions

The following assumptions were used to support the sizing analyses:

- An on-bank intake structure configuration with a cylindrical tee fish screen system would be used for the intakes.
- Controlling elevations would be as described in the Background section.
- Screen sizing assumes the juvenile Delta fish species (Delta smelt) approach velocity criteria (V_A = 0.2 fps) would be required to size the intakes.
- Dimensional assumptions are indicated in Step 5 of the Methodology section.
- Overall structure lengths do not include training walls. Training wall lengths should be estimated as part of conceptual layout efforts.

5. Analysis and Evaluation

Tables 2 and 3 show computational data and results of applying the sizing methodology to each intake site for a total diversion capacity of 3,000 cfs at each intake.

Table 2. Computational Data and Results for Intake Site C-E-3

Item	Value
Design WSEL (ft)	3.72
River Bottom (ft)	-25
Screen Sill Elevation (ft)	-17
Effective River and Flow Depth (ft)	20.72
Approach Velocity (fps)	0.2
Item	**Cylindrical Tee Screen**
Effective Height and Diameter (ft)	8
Effective Width (ft)	29.33
Effective Screen Area (ft^2)	536.17
Flow (with allowance factor) cfs	100.0
Intake length (ft) at 3,000 cfs [a]	964

[a] Intake length includes screens, columns, screen cleaner landings and other non-screen structural components described in Step 5 of the Methodology section.

Table 3. Computational Data and Results for Intake Site C-E-5

Item	Value
Design WSEL (ft)	3.61
River Bottom (ft)	-17
Screen Sill Elevation (ft)	-13.5
Effective River and Flow Depth (ft)	17.11
Approach Velocity (fps)	0.2
Item	**Cylindrical Tee Screen**
Effective Height and Diameter (ft)	8
Effective Width (ft)	29.33
Effective Screen Area (ft^2)	536.17
Flow (with allowance factor) cfs	100.0
Intake length (ft) at 3,000 cfs [a]	964

[a] Intake length includes screens, columns, screen cleaner landings and other non-screen structural components described in Step 5 of the Methodology section.

Figure 3 (attached at end) show preliminary conceptual layouts of the on-bank cylindrical tee screen structures, respectively, including the resulting sizing information for a 3,000 cfs capacity intake.

6. Conclusions

Intake structure sizes were estimated for on-bank intake structures using cylindrical tee screen systems. The resulting overall lengths could be used to site intake structures and layout facilities at the intake sites.

7. References

California Department of Fish and Game (DFG). 2010. "Appendix S, Fish Screen Criteria." June 19, 2000 version. *California Salmonid Stream Habitat Restoration Manual*. 4th Ed. State of California, The Resources Agency, Wildlife and Fisheries Division.

California Department of Water Resources (DWR). 2019. *Bathymetric survey on the Sacramento River from the confluence with the American River to Courtland*. North Central Region Office, Bathymetry Data Collection Section.

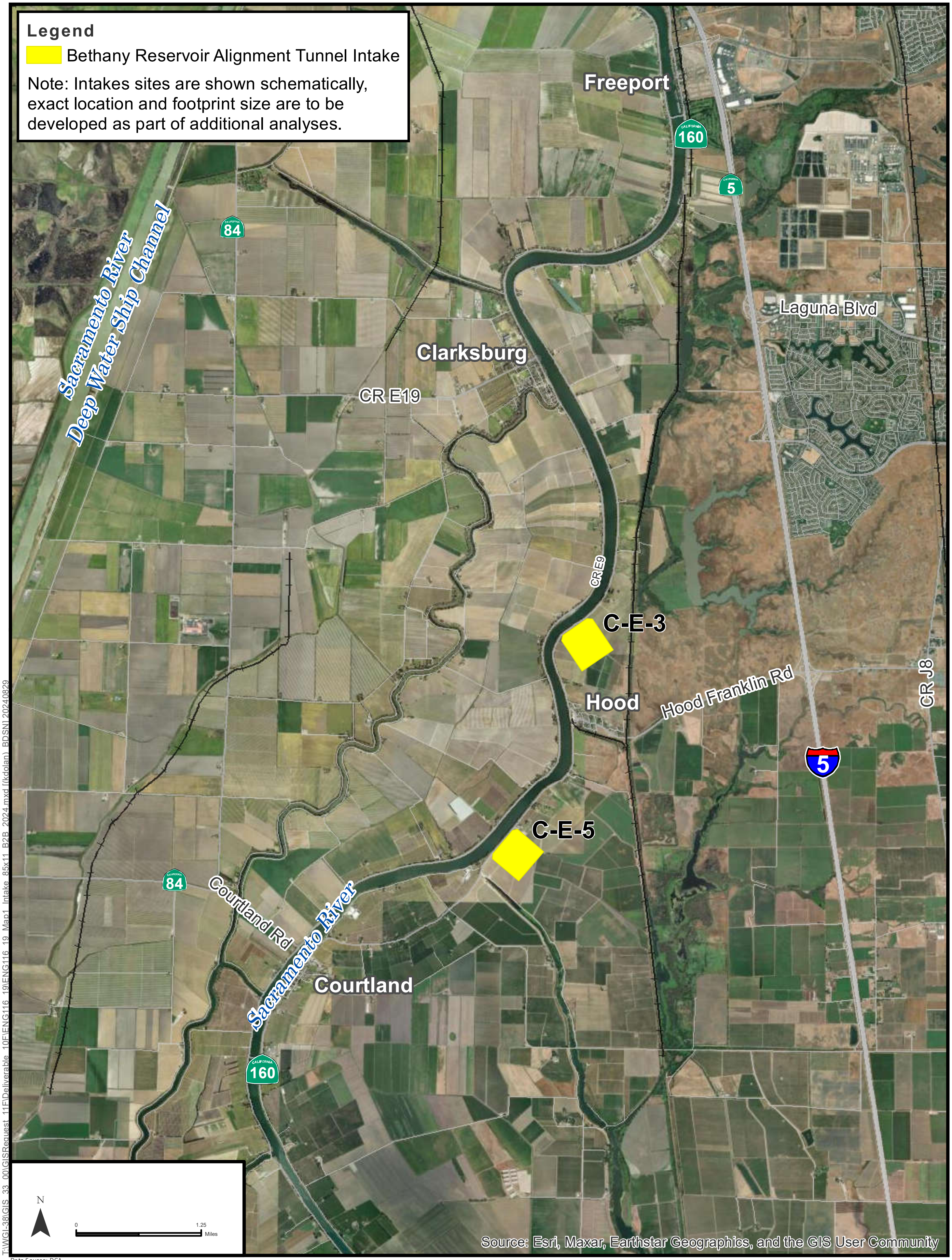
National Oceanic and Atmospheric Administration (NOAA). 1997. *Fish Screening Criteria for Anadromous Salmonids*. National Marine Fisheries Service Southwest Region.

National Oceanic and Atmospheric Administration (NOAA). 2018. NOAA Technical Memorandum NMFS-NWFSC-1xx, NOAA Fisheries West Coast Region Anadromous Salmonid Passage Design Guidelines. Peer Review Draft. National Marine Fisheries Service West Coast Region, Environmental Services Branch.

United States Department of the Interior, Bureau of Reclamation (USBR). 2009. Guidelines for Performing Hydraulic Field Evaluations at Fish Screening Facilities. Water Resources Technical Publication. April.

Wood Rogers, Inc. 2010. *Survey of Lower Sacramento River in Support of Hydraulic Model Development Utilizing Multi-Beam Bathymetric and LiDAR Methods*. Submittal of Fugro West, Inc. – Summary Report. State of California, Department of Water Resources, Contract Number 4600007989, Task Order No. 22.

Figures



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Data Source: DCA

Figure 1. Intake Sites

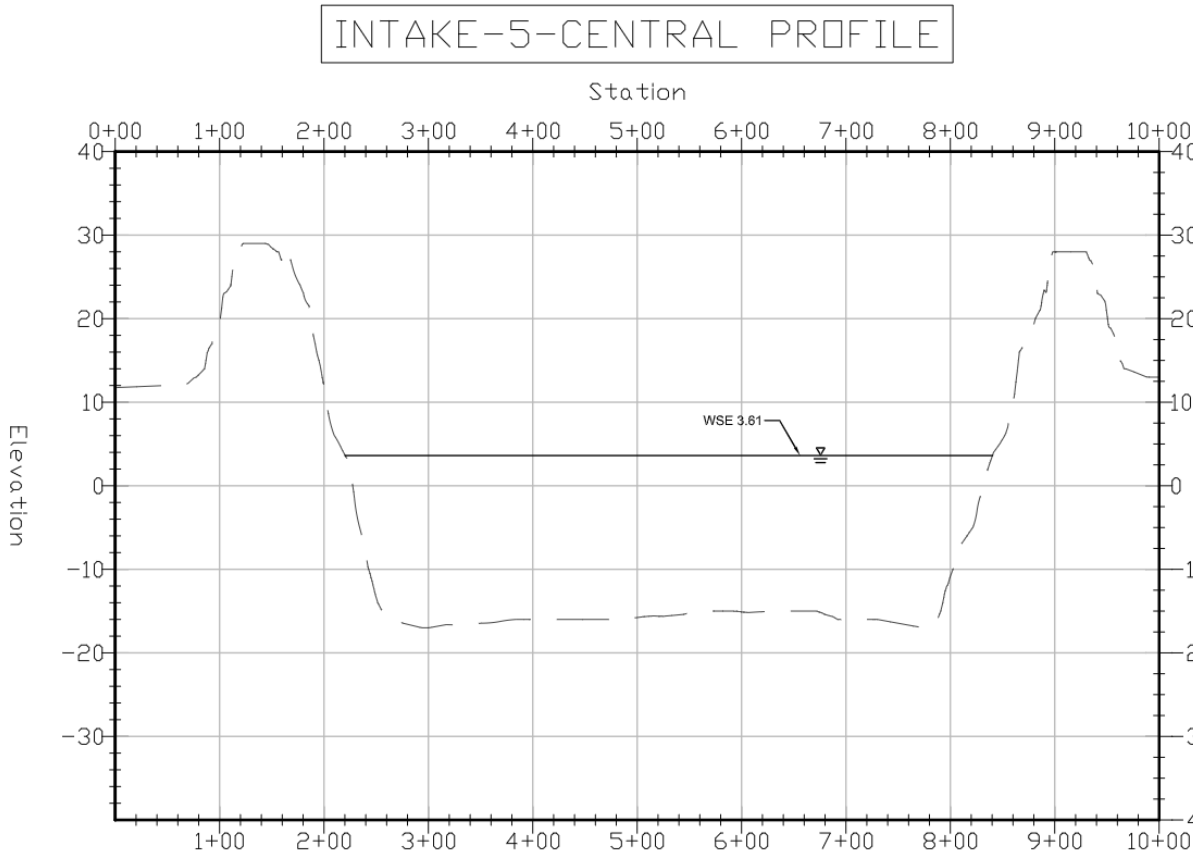
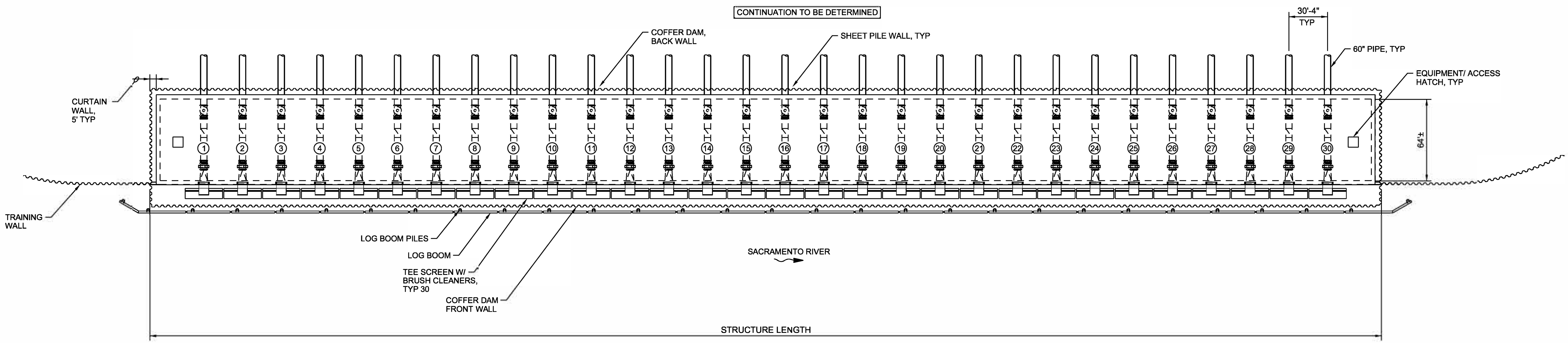


Figure 2. River Cross Section Example, Intake Site C-E-5

LEGEND

(#) SCREEN BAY NO.

SITE	DESIGN WSE (FT)	RIVER BOTTOM (FT)	TEE SCREEN BOTTOM (FT)	STRUCTURE LENGTH (FT) 3000 (CFS)
C-E-3	3.72	-25	-13	964
C-E-5	3.61	-17	-13	964



TYPICAL TEE SCREEN INTAKE STRUCTURE

2 PLAN
1"=40'
STO6-SM-1015IT

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

REV	DATE	DESCRIPTION	SUB.	APPD

DESIGNED: P RYAN
DRAWN: J SMITH
CHECKED:
APPROVAL RECOMMENDED:
APPROVAL BY:

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Figure 3. Intake Structure Typical Plan

INTAKE STRUCTURE
TYPICAL PLAN

PROJECT NO. W8X97000
SHEET NO. FIGURE 3
REV
SEQUENCE NO.