Appendix B13. Dewatering Estimates for Intake Facilities (Final Draft)

1. Introduction and Purpose

The construction and operation of some Delta Conveyance Project (Project) facilities would require dewatering primarily anticipated at the intakes, with more localized dewatering required at planned bridge replacements and during miscellaneous site improvements, such as installation of utilities. This technical memorandum (TM) provides groundwater modeling-based estimates of dewatering rates and durations for dewatering at the intake facilities near Hood, California. This location was selected, as it likely represents typical dewatering scenarios for other elements of the Project. For the intake facilities, modeling included the construction and maintenance scenario for the sedimentation basins.

The results presented in this TM should only be considered preliminary and suitable for the assessment of viability at a conceptual engineering stage. The results rely on historical boring logs and aquifer test results, and in some cases, data gaps exist.

1.1 Organization

This TM is organized into the following sections:

- Introduction and Purpose
- Hydrogeology
- Model Construction
- Model Application – Intake Facilities
- Summary and Conclusions
- Recommendations
- References
- Tables
- Figures
- Attachment 1, Subsurface Cross-Sections at Intake Facilities

1.2 Modeling Objectives

The modeling objectives include estimating the base extraction rate (that is, the steady extraction rate required to maintain groundwater levels at the target dewatering levels), the time to achieve target dewatering levels, and the associated pumping rates. Because of the general uncertainty in hydrogeological properties at both sites, sensitivity evaluations were conducted to provide insight into the uncertainty of the estimates.

The general approach was to use site-specific, numerical groundwater flow models to evaluate the pumping rates and durations needed for dewatering.

1.3 Site Details

This section describes the facilities and scenarios the dewatering estimates were provided for.

1.3.1 Intake Facilities

The Project's Environmental Impact Report (EIR) (DWR, 2023) identified two intake locations along the Sacramento River (Figure 1). The evaluation described herein focuses on the conditions around Intake 5, south of Hood (Figure 2). Each intake would contain the features shown on Figure 3. A groundwater cutoff wall surrounding the sedimentation basin would be installed to elevation (El.) -85 feet (all elevations are in reference to North American Vertical Datum of 1988 [NAVD88]).

There would be a need for dewatering at the sedimentation basin during construction due to the site's proximity to the Sacramento River. During operations, there could be an infrequent need to empty the sedimentation basin for maintenance, which also could require dewatering for a short period.

The dewatering needs would be to dewater the footprint of the sedimentation basin to 5 feet below its base during construction and future maintenance (El. -20 feet).

2. Hydrogeology

2.1 Intake Facilities

The intake facilities would be situated adjacent to the Sacramento River. The river at the Intake 5 location is about 600 feet wide and 30 feet deep (DWR, 2020a). The riverbed is at about El. -20 feet, and the tops of the levees are higher than El. 20 feet. The surrounding land use is agricultural, with the land surface near El. 0 feet. River levels are above the ground surface at the lands to the east of the river levees and berms.

Project and historical boring logs between Hood and Intake 5 were compiled into conceptual cross sections (Attachment 1). The stratigraphy generally consists of interlayered alluvial deposits ranging from coarse sand to clay. Both sites have organic-rich, fine-grained deposits within the upper 20 feet.

Immediately south of Hood, the fine-grained deposits are underlain by abundant sands with some interbedded silts and clays to about El. -80 feet, followed by a thick sequence of silts and clays between about El. -80 and El. -120 feet.

At Intake 5, the upper organic-rich zone is underlain by about 30 feet of sands, with about 30 feet of silts and clays separating this from more sands in the El. -80 to -120 feet range. At both locations, the boring logs indicate fine and coarse intervals are not homogeneous; rather, they have discrete interbeds.

An aquifer test was performed between Hood and Intake 5 in 1982 (DWR, 1982) (Figure 2). The pumping and observation wells were screened within the upper 40 feet and encountered a sandy deposit from about 15 to 30 feet below ground surface (bgs). The pumping well produced 245 gallons per minute (gpm) for 24 hours. The resulting hydraulic conductivity (K) value of the upper sand unit was about 250 feet per day (fpd) (8.82×10^{-2} centimeters per second [cm/s]). Storativity ranged from 0.0005 to 0.023.

The Sacramento River is generally considered to be in continuity with the groundwater under lands along the river in Sacramento County, including the area of the intakes (SCGA, 2019).

3. Model Construction

The numerical groundwater flow models described herein use the MODFLOW 2005 code with the NWT configuration (MODFLOW-NWT) (Niswonger et al., 2011). This code was selected for the following reasons:

- MODFLOW-NWT is built on the U.S. Geological Survey (USGS) MODFLOW model (Harbaugh et al., 2000), which is in wide use and is well-documented. MODFLOW-NWT has been benchmarked and verified, meaning the numerical solutions generated by the code have been compared with one or more analytical solutions, subjected to scientific review, and used on previous modeling projects. The verification of the code confirms MODFLOW 2005-NWT can accurately solve the governing equations that constitute the mathematical model (Niswonger et al., 2011).
- MODFLOW-NWT is an improvement on earlier versions of the MODFLOW code, related to drying and rewetting of model cells.

3.1 Intake Facilities

A single groundwater flow model was constructed to represent conditions in the Intake 5 area, based on available data. The model was initially designed to simulate sedimentation basin dewatering, and was then modified slightly for the box conduit dewatering modeling.

3.1.1 Sedimentation Basin

Figure 4 shows the model location, grid, and boundary conditions for Intake 5. Cell sizes range from 20 feet by 20 feet, to 80 feet by 80 feet, with 13 layers; for a total of 331,240 active cells. The model grid was rotated 50 degrees counter-clockwise from north-south to place the grid orientation parallel with the Sacramento River.

Figure 5 shows a cross section through the Sacramento River and the sedimentation basin. Land surface topography and the bathymetry of the Sacramento River (DWR, 2020a) are the bases for the top of Model Layer 1. The model layer thickness was variable for Model Layer 1, and below the Model Layer 1 and Model Layer 2 interface, the layers are horizontal planar.

3.1.1.1 Hydraulic Properties

The hydraulic property distribution shown on Figure 5 represents one configuration, and was varied extensively during the modeling evaluation. The K value of the fine-grained units was set to 10 fpd horizontal (Kh) (3.5×10^{-3} cm/s) and 0.1 fpd vertical (Kv) (3.5×10^{-5} cm/s), for a Kh to Kv ratio of 100:1. These Kh and Kv values are greater than typical values for silt or clay deposits, and represent a conservative approximation, intending to account for discontinuities or interlayering. The Kh and Kv of the coarse or sandy deposits were generally held to 250 fpd (8.8×10^{-2} cm/s) and 2.5 fpd (8.8×10^{-4} cm/s), respectively, apart from evaluations where the Kh and Kv values were increased to 1,000 fpd (3.5×10^{-1} cm/s) and 10 fpd (3.5×10^{-3} cm/s), respectively.

3.1.1.2 Boundary Conditions

Model boundary conditions include a general head boundary (GHB) along the western and eastern model edges, a river boundary for the Sacramento River, and no-flow along the northern and southern model edges (Figures 5 and 6). The eastern GHB was set up with a head specified at 0 foot and a distance component of the conductance term set to 2,000 feet. The western GHB was set up with a head specified at El. -3.8 feet and a distance component of the conductance term also set to 2,000 feet. This configuration imposes a 0.0005 foot per foot (ft/ft) hydraulic gradient, approximately the value observed near the Sacramento River about 5 miles north of Hood, in fall 2016 (DWR, 2020b). Because the imposed hydraulic gradients are very flat, the exact direction of ambient groundwater flow should not influence the dewatering calculations. The K component of the GHBs was set to 250 fpd (8.8×10^{2} cm/s).

The cutoff wall, which is assumed to be a soil-cement-bentonite wall constructed using deep mechanical mixing, was simulated with the Horizontal Flow Barrier (HFB) package, with an assigned width of 4 feet and a K of 0.00028 fpd (1.0×10^{-7} cm/s).

4. Model Application – Intake Facilities

An extensive series of steady-state models was developed to evaluate the sensitivity of the base extraction rates related to key hydrogeological properties. This was followed by transient modeling with a more limited set of variables.

4.1 Sedimentation Basin

The sedimentation basin simulations include scenarios for both construction and maintenance dewatering. For construction dewatering, initial conditions are preconstruction conditions, with water levels slightly bgs. For maintenance cases, initial conditions are conditions with water levels in the sedimentation basin lowered to El. -10 feet by the draining of the basin through the outlet gates, or other means (for example, sump pumps).

4.1.1 Steady-state Case

The objective of the steady-state modeling was to determine reasonable ranges of groundwater flow into the sedimentation basin, with the installed cutoff wall to El. -85 feet, under a range of plausible K distributions. During the modeling, the water budget of the model was tracked, with particular attention to the drain rates. These models represent stabilized steady-state dewatering conditions.

4.1.1.1 Construction Dewatering

For the steady-state modeling, the drain package was implemented over the footprint of the sedimentation basin in Model Layer 3. The drain head was set to El. -20 feet, with a very high-K component of the conductance term (K = 1,000 fpd [3.5×10^{-1} cm/s]; drain thickness = 5 feet) to avoid adding additional resistance beyond that of the surrounding aquifer.

Table 1 summarizes the variables adjusted and the resultant model flow rates for the steady-state sensitivity evaluations (all tables are located at the end of the TM). The results are discussed here.

Base Case Cutoff

Models D0_10 and D0_20 modeled the river stage at El. 10 feet and El. 20 feet, respectively, with no drain implemented (no active dewatering). These represent approximate existing mid- and high-water conditions, with the cutoff wall installed, and represent the initial conditions for later transient modeling. When river stage is increased from El. 10 to El. 20 feet, river leakage rates increase by a factor of nearly 2, GHB inflows decrease by nearly 30 percent, and GHB outflows increase by nearly 25 percent

(Table 1). The high-stage condition (El. 20 feet) was used for most of the remaining steady-state model runs.

Variability of Low-K Soils within Cutoff Wall

Models D1 through D5 sequentially decrease the thickness of the low-K zone within the cutoff wall footprint, from 40 to 5 foot thick. The drain rate (the rate needed to maintain a target groundwater elevation of El. -20 feet) increases from 358 to 1,529 gpm as the clay thickness decreases. Most of the additional water is delivered via the GHB boundaries, with river leakage increasing by 42 gpm overall. Flow through the cutoff wall is very low for these simulations (around 2 gpm) (Table 1).

Models D6 through D10 repeat the sequential thinning of the low-K layer, but with the Kh and Kv of this layer reduced one order of magnitude from 10 to 1 fpd (3.5×10^{-3} to 3.5×10^{-4} cm/s) and 1 to 0.1 fpd (3.5×10^{-4} to 3.5×10^{-5} cm/s), respectively. Flow rates of the drain are reduced nearly an order of magnitude (range 41 to 287 gpm), with about a 0.5 gpm increase in flow through the wall (Table 1).

Breaches in the Low-K Soil Layer within the Cutoff Wall

Models D11 through D16 simulate vertical breaches that are 20, 40, and 80 feet wide in the clay layer, with two variations on the clay K (Table 1). The simulated breaches run continuously along the river-side edge of the sedimentation basin (Figure 5) and represent scenarios where the lower-K materials are not laterally continuous within the cutoff wall. For these simulations, the thickness of the clay was set at 30 feet, such that the effect of the breaching compares with previous models using 30-foot-thick lower-K zone D2 (higher-K clay) and D7 (lower-K clay). These simulations illustrate that even small breaches in the clay can dramatically increase groundwater flow into the dewatered area. With a 20-foot-wide breach, the drain rate increases from 459 to 611 gpm, with the higher-K clay (compare D2 with D11) and increases from 54 to 238 gpm with the lower-K clay (compare D7 with D12). With the 80-foot-wide breach, the flow rate increases to 934 gpm with the higher-K clay (D15) and 628 gpm with the lower-K clay (D16).

Variability of Cutoff Wall Properties

Model D17 simulates an order-of-magnitude decrease of the wall K from 0.028 fpd (1.0×10^{-5} cm/s) to 0.0028 fpd (1.0×10^{-6} cm/s) and a reduction of the wall thickness from 4 to 2 feet (with a high-K, 30-foot-thick clay layer). The effect is an increase of wall leakage from 2 to 38 gpm (comparing D2 with D17) (Table 1).

Variability of Soil Strata

Models D18 and D19 evaluate the condition where the clay layer is deeper, no longer confined within the cutoff wall, now beginning at the base of the cutoff wall and continuing below. Two cases were simulated, with 10-foot and 30-foot thicknesses. With a 10-foot-thick layer, the drain flows are very similar to flows with the clay at higher elevations (1,092 gpm [D19] versus 1,041 gpm [D4]). But with a 30-foot-thick layer, drain flows are much higher in the deeper case (686 gpm under D18 conditions versus 459 gpm under D2 conditions). The reason for this is likely that the clays are not continuous in the model past the boundary of the cutoff wall, only extending about 100 feet beyond the edge of the wall. This would allow groundwater to flow sideways through the clay and up into the sedimentation basin.

Variability in Hydraulic Conductivity

Model D20 tests the K of the coarse-grained sediments (high-K zone) by increasing K from 250 fpd (8.8×10^{-2} cm/s) to 1,000 fpd (3.5×10^{-1} cm/s) (with a 30-foot-thick clay layer). A comparison with Model D2 shows the drain rate increases by about 10 percent, from 459 to 498 gpm. The overall flow rate through the GHBs increases by about 50 percent, from 607 to 931 gpm.

The effect of increasing the K of the river bed was evaluated in Models D26 and D27, where the K was increased by one and two orders of magnitude, respectively. Compared with Model D2, the effect on the drain is relatively minor (increased drain rate from 459 gpm to 479 and 483 gpm), but the effect on overall river leakage is major (from 832 gpm to 1,661 and 1,846 gpm). This suggests errors in estimating river leakage rates have little bearing on the drain flux rates, at least with the current model configuration. Table 1 shows four cases where the drain rate increased substantially, and the additional water came from the boundary of the model on the eastern and western sides (GHBs); whereas, river leakage did not increase appreciably.

The steady-state modeling provides a range of about 200 to 1,000 gpm required to maintain target groundwater elevations (not to reach the target), under a reasonable range of conditions. The steady-state flow predictions are most sensitive to the Kv of the sediments within the cutoff wall and the presence and nature of vertical discontinuities within any clay strata. Variations in the riverbed Kv and bulk aquifer K appear to have little effect on estimated groundwater flow rates into the sedimentation basin.

4.1.1.2 Maintenance Dewatering

Both the construction and maintenance dewatering cases have the objective of dewatering to El. -20 feet; as such, the steady-state modeling described in Section 4.1.1.1 also applies to maintenance dewatering. The primary difference in the scenarios is the starting point for transient simulations.

Models D21 through D25 represent the maintenance-case initial conditions for transient modeling with different K assumptions. For these simulations, the drain head is specified at El. -10 feet, to represent the conditions at the end of sedimentation basin emptying for maintenance. The drain rates for these simulations represent the amount of water that would be flowing into the sedimentation basin upon drainage through the gates and into tunnels (Figure 3).

4.1.2 Transient Case

The transient sedimentation basin dewatering simulations include scenarios for construction dewatering and for maintenance dewatering. As discussed, initial conditions for construction dewatering are contemporary conditions, with water levels slightly below land surface. For maintenance cases, initial conditions are the point at which water levels in the sedimentation basin are assumed to be drawn down to the approximate sill elevation of the radial gates (El. -10 feet) by the draining of the reservoir through the outlet gates, or other means (for example, sump pumps).

Transient modeling requires estimates of aquifer storativity. Although the 1982 aquifer test (DWR, 1982) provided estimates of storativity (combined specific storage and specific yield) ranging from 4.0×10^{-5} to 2.3×10^{-2}, the values derived from the test were shown to be increasing throughout the test. As the dewatering program is scheduled to last much longer than the 1982 aquifer tests, these values were not used.

For the dewatering transient modeling, two values were used for specific yield (0.1 and 0.2), and a value of 1e-4 was used for specific storage. The specific yield is the more important parameter for dewatering efforts, and can have a major effect on the rate of drawdown during pumping.

Two distributions of K were evaluated under transient conditions:

1) 10-foot-thick clay layer within the cutoff wall, with Kh = 10 fpd (3.5×10^{-3} cm/s) and Kv = 0.1 fpd (3.5×10^{-5} cm/s)
2) 30-foot-thick clay layer within the cutoff wall, with Kh = 10 fpd (3.5×10^{-3} cm/s) and Kv = 0.1 fpd (3.5×10^{-5} cm/s)

The drain flux rates at steady-state for these configurations were 1,041 gpm (Model D4) and 459 gpm (Model D2), respectively (Table 1).

For transient modeling, an array of seven pumping wells (MODFLOW MNW package [Niswonger et al., 2011]) was placed between the cutoff wall and the base of the area to be dewatered (Figure 6). The wells were screened in Model Layers 2 through 5. Two total pumping rates were evaluated (that is, 1,000 gpm and 2,000 gpm) with the flow rate divided evenly among the 7 pumping wells (143 and 286 gpm per well, respectively).

Varying the thickness of the clay layer, the specific yield, and pumping rates resulted in eight scenarios each for construction and maintenance dewatering (Table 2). A virtual observation well was placed in the center of the modeled sedimentation basin to evaluate transient water levels during dewatering (Figure 6).

4.1.2.1 Construction Dewatering

Figure 7 shows the results of construction dewatering simulations by displaying the observation well heads from Model Layers 2 and 3. Note, groundwater levels in Model Layer 3 reach the El. -20-foot target more quickly than in Model Layer 2. Model Layer 2 represents low-permeability sediments that are slower to drain than the higher-K sandy deposits. Target drawdown is reached more quickly, at about 16 days with a higher pumping rate, thicker low-K zone, and lower specific yield (refer to the DT5 results on Figure 7). The models fail to reach target levels within 60 days in the two scenarios where the clay layer is thin and the pumping rate is 1,000 gpm (refer to DT2 and DT4 on Figure 7).

Figure 8 shows the timing of drawdown from Model Layer 2 only, for the 30-foot-thick clay layer scenarios (DT1, DT3, DT5, and DT7) and for the 10-foot-thick clay layer scenarios. Figure 8 presents the differences in timing for the higher and lower rates and different values of specific yield. These results suggest that 1,000 gpm of dewatering might not be adequate unless there is an abundance of finer-grained material within the perimeter of the cutoff wall. Conversely, 2,000 gpm (if dewatering wells can achieve this rate) might be needed to achieve target drawdowns within 2 to 6 weeks.

Although the sedimentation basin model runs were not explicitly designed to determine the necessary number and location of pumping wells, observations from the model budgets are insightful. The minimum pumping level in the extraction wells was set deep, at El. -100 feet, to minimize reductions to pumping rates due to limitations in transmissivity at the pumping well. And for most scenarios, pumping rates were not reduced. However, for scenarios with higher thicknesses of lower-K deposits within the cutoff wall, extraction rates were slightly reduced by the end of the simulations (DT1 11 percent, DT3 1 percent, and DT5 5 percent). This suggests that for less productive geological settings, additional wells could be needed to sustain target pumping rates; or conversely, in some cases, lower rates could meet drawdown requirements.

4.1.2.2 Maintenance Dewatering

Maintenance dewatering was conducted separately from construction dewatering, despite them having the same overall objective (dewater to El. -20 feet) because of differences in initial conditions and river stage. The initial conditions for the maintenance scenario start with groundwater rates into the sedimentation basin of 217 gpm for the 30-foot-thick clay layer and 1,000 (D21 in Table 1) or 495 gpm for the 10-foot-thick clay layer (D23 in Table 1).

Figure 9 shows the results for the 30-foot-thick clay layer at 1,000 gpm and 2,000 gpm pumping, with the variations in specific yield. Each scenario results in target dewatering by about 9 to 34 days after the initiation of pumping, with quicker durations at the higher pumping rate. Figure 9 also shows the results for the 10-foot-thick clay layer, with target drawdown not achieved at 1,000 gpm, and target drawdown achieved in about 13 to 24 days for 2,000 gpm.

4.2 Intake Dewatering Summary

Because of uncertainty in the lithological configuration between the proposed cutoff walls, several model configurations were used to simulate dewatering at these locations.

For the sedimentation basin, most modeling scenarios resulted in dewatering rates of between 200 and 1,000 gpm, with higher rates required (such as 2,000 gpm) to more quickly achieve target dewatering levels (2 to 6 weeks for initial dewatering, and 1 to 3 weeks for maintenance dewatering). The results appear to be most sensitive to the Kv of the materials within the perimeter of the cutoff wall, and relatively insensitive to the K of the Sacramento River sediments.

5. Summary and Conclusions

Dewatering evaluations were performed for the Delta Conveyance Project at the intake structures near Hood, California. Because site-specific aquifer performance data are limited or nonexistent, the modeling approach focused on providing results for reasonable ranges of aquifer properties. Extraction rates were provided for steady-state conditions (after the target water level had been reached), as well as for initial dewatering efforts (the process of reducing water levels to the target).

5.1 Intake Facilities

The intake facilities included the sedimentation basin. The sedimentation basin includes a perimeter cutoff wall to El. -85 feet. Target dewatering depth is El. -20 feet for both areas. Lithology is variable between (Figure 2), with pervious sands (K = approximately 250 fpd [8.8×10^{-2} cm/s]) and clay deposits of unknown continuity existing at different elevations between Hood and Randall Island.

5.1.1 Sedimentation Basin

Sedimentation basin modeling included initial dewatering during construction and dewatering for basin maintenance. The modeling results are based on simplistic depictions of site lithology. In all cases, the K value of the low-K deposits was set at a Kh of 10 fpd (3.5×10^{-3} cm/s) and a Kv of 1 fpd (3.5×10^{-4} cm/s). These K values are higher than a typical pure clay or silt, and are more representative of silty or clayey sands. These values were used to incorporate some conservatism in the dewatering rates.

Most of the simulated variations in the K distribution resulted in groundwater flow into the basin of about 200 to 1,000 gpm. This applies to both construction and maintenance phases. The predictions are most sensitive to the Kv of materials within the perimeter of the cutoff wall. Lateral discontinuities in thick layers of fine-grained deposits can also substantially increase needed extraction rates. Variations in riverbed K and bulk aquifer properties had little effect on results.

Transient modeling suggests that well extraction rates of 1,000 gpm would not achieve target dewatering levels, except in cases with robust and continuous lower-K zones within the cutoff wall. An overall extraction rate of 2,000 gpm achieved target dewatering levels in 2 to 6 weeks for the scenarios evaluated. For conceptual-level planning, a rate of 1,500 gpm can be assumed if dewatering is started sufficiently in advance of planned excavation. This 1,500-gpm flow rate would taper into the 200- to 1,000-gpm continuous rate after 2 to 6 weeks and would remain relatively constant through completion of basin first filling, with slight variations due to changes in river level.

Much like the construction phase dewatering, evaluations of maintenance dewatering suggest that 1,000 gpm is only a sufficient rate with continuous and thick low-K deposits; 2,000 gpm was predicted to dewater the basin within 1 to 4 weeks. For conceptual-level planning, a rate of 1,500 gpm can be assumed if dewatering is started sufficiently in advance of planned maintenance. This 1,500-gpm flow rate would taper into the 200- to 1,000-gpm continuous rate after 1 to 3 weeks and would remain relatively constant through completion of basin refilling, with slight variations due to changes in river level.

6. Recommendations

At all of the locations evaluated, site-specific lithologic data are limited, especially with respect to aquifer performance data, and even general groundwater condition. The modeling results presented herein are based on simplistic depictions of site lithology, and although attempts were made to provide boundaries for potential extraction rates and times-to-dewater, considerable uncertainty remains.

Site-specific aquifer testing is recommended at any location needing dewatering. Such testing should focus on the hydraulic aquifer properties of areas within any proposed cutoff wall, with particular attention to the Kv, and connectivity of both fine- and coarse-grained units.

7. References

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Tables

Table 1
Summary of Results from Sensitivity Analysis

Model ID	High K Zone	Low K Zone	Thickness Low K Zone	Riverbed Kv	Note	River Stage	Wall Thickness	Wall K	Drain	Through Slurry Wall	Up from Bottom	GHB In	GHB Out	River Leakage
	(Kh/Kv ft/d)	(Kh/Kv ft/d)	(ft)	(ft/d)		(ft)	(ft)	(ft/d)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm)
D0_10	250/2.5	10/0.1	30	0.016	No Drain or Wall	10	N/A	N/A	N/A	N/A	N/A	521	961	440
D0_20	250/2.5	10/0.1	30	0.016	No Drain or Wall	20	N/A	N/A	N/A	N/A	N/A	373	1189	816
D1	250/2.5	10/0.1	40	0.016		20	4	0.00028	358	1.8	356	555	1024	828
D2	250/2.5	10/0.1	30	0.016		20	4	0.00028	459	2.0	457	607	980	832
D3	250/2.5	10/0.1	20	0.016		20	4	0.00028	637	2.1	635	699	900	838
D4	250/2.5	10/0.1	10	0.016		20	4	0.00028	1041	2.1	1039	907	718	852
D5	250/2.5	10/0.1	5	0.016		20	4	0.00028	1529	1.9	1527	1158	499	870
D6	250/2.5	1/0.01	40	0.016	Lower K fine grained	20	4	0.00028	41	1.9	41	393	1168	816
D7	250/2.5	1/0.01	30	0.016	Lower K fine grained	20	4	0.00028	54	2.1	52	400	1163	817
D8	250/2.5	1/0.01	20	0.016	Lower K fine grained	20	4	0.00028	79	2.3	77	414	1153	818
D9	250/2.5	1/0.01	10	0.016	Lower K fine grained	20	4	0.00028	152	2.5	150	452	1121	821
D10	250/2.5	1/0.01	5	0.016	Lower K fine grained	20	4	0.00028	287	2.5	285	522	1060	826
D11	250/2.5	10/0.1	30	0.016	20 ft wide zone with no low K layer	20	4	0.00028	611	1.9	610	668	896	840
D12	250/2.5	1/0.01	30	0.016	20 ft wide zone with no low K layer	20	4	0.00028	238	2.0	236	476	1064	826
D13	250/2.5	10/0.1	30	0.016	40 ft wide zone with no low K layer	20	4	0.00028	734	1.9	732	720	830	845
D14	250/2.5	1/0.01	30	0.016	40 ft wide zone with no low K layer	20	4	0.00028	387	2.0	385	539	985	833
D15	250/2.5	10/0.1	30	0.016	80 ft wide zone with no low K layer	20	4	0.00028	934	1.8	932	805	725	854
D16	250/2.5	1/0.01	30	0.016	80 ft wide zone with no low K layer	20	4	0.00028	628	1.9	626	643	858	843
D17	250/2.5	10/0.1	30	0.016	More permeable wall	20	2	0.0028	489	38	451	622	967	833
D18	250/2.5	10/0.1	30	0.016	Low K layer below base of wall	20	4	0.00028	686	2.4	684	720	874	841
D19	250/2.5	10/0.1	10	0.016	Low K layer below base of wall	20	4	0.00028	1092	2.2	1089	932	694	854
D20	1000/10	10/0.1	30	0.016	High K	20	4	0.00028	498	2.0	496	931	1275	843
D21	250/2.5	10/0.1	30	0.016	Drain -10 ft	10	4	0.00028	218	1.0	217	483	1089	823
D22	250/2.5	10/0.1	20	0.016	Drain -10 ft	10	4	0.00028	303	1.0	302	528	1051	826
D23	250/2.5	10/0.1	10	0.016	Drain -10 ft	10	4	0.00028	496	1.0	495	627	965	833
D24	250/2.5	10/0.1	30	0.16	High Riverbed K Drain -10 ft	20	4	0.00028	238	1.1	237	186	1593	1644
D25	250/2.5	10/0.1	30	1.6	High Riverbed K Drain -10 ft	20	4	0.00028	242	1.1	241	120	1705	1827
D26	250/2.5	10/0.1	30	0.16	High Riverbed K	20	4	0.00028	479	2.1	477	306	1488	1661
D27	250/2.5	10/0.1	30	1.6	High Riverbed K	20	4	0.00028	483	2.1	481	239	1601	1846

Notes
K = Hydraulic Conductivity
Kv = Vertical Hydraulic Conductivity
GHB = General Head Boundary
gpm = gallons per minute
N/A = Not Applicable

Table 1

Transient Model Summary

ID	Description	Low K Thickness (ft)	Specific Yield	River Stage (ft)	Extraction Rate per Well (gpm)	Total Extraction Rate (gpm)
DT1	Construction	30	0.1	20	142.9	1000
DT2	Construction	10	0.1	20	142.9	1000
DT3	Construction	30	0.2	20	142.9	1000
DT4	Construction	10	0.2	20	142.9	1000
DT5	Construction	30	0.1	20	285.7	2000
DT6	Construction	10	0.1	20	285.7	2000
DT7	Construction	30	0.2	20	285.7	2000
DT8	Construction	10	0.2	20	285.7	2000
DTop1	Maintenance	30	0.1	10	142.9	1000
DTop2	Maintenance	10	0.1	10	142.9	1000
DTop3	Maintenance	30	0.2	10	142.9	1000
DTop4	Maintenance	10	0.2	10	142.9	1000
DTop5	Maintenance	30	0.1	10	285.7	2000
DTop6	Maintenance	10	0.1	10	285.7	2000
DTop7	Maintenance	30	0.2	10	285.7	2000
DTop8	Maintenance	10	0.2	10	285.7	2000

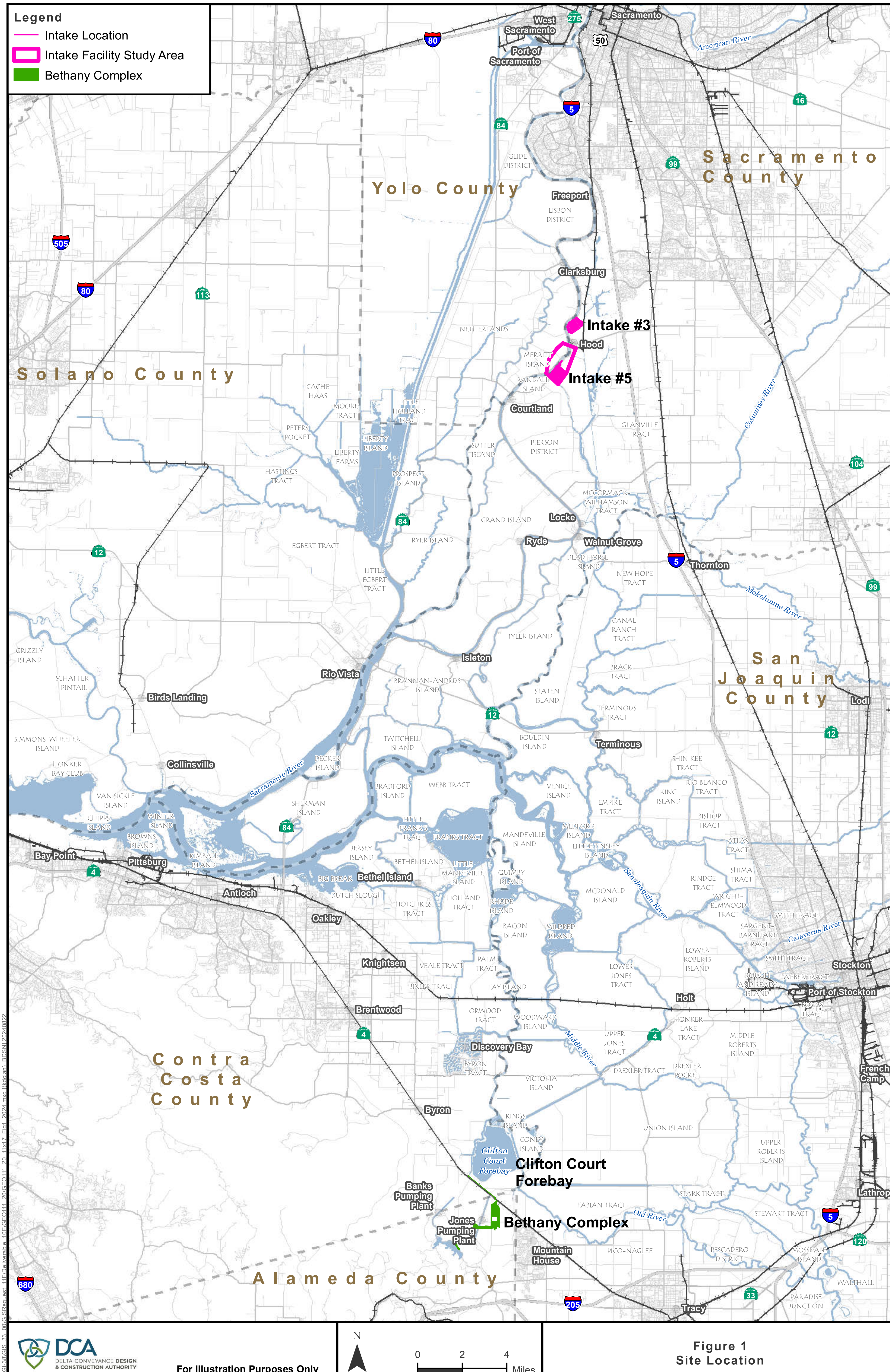
Notes

K = Hydraulic Conductivity

gpm = gallons per minute

Number of pumping wells = 7

Figures



![DCA Delta Conveyance Design & Construction Authority]

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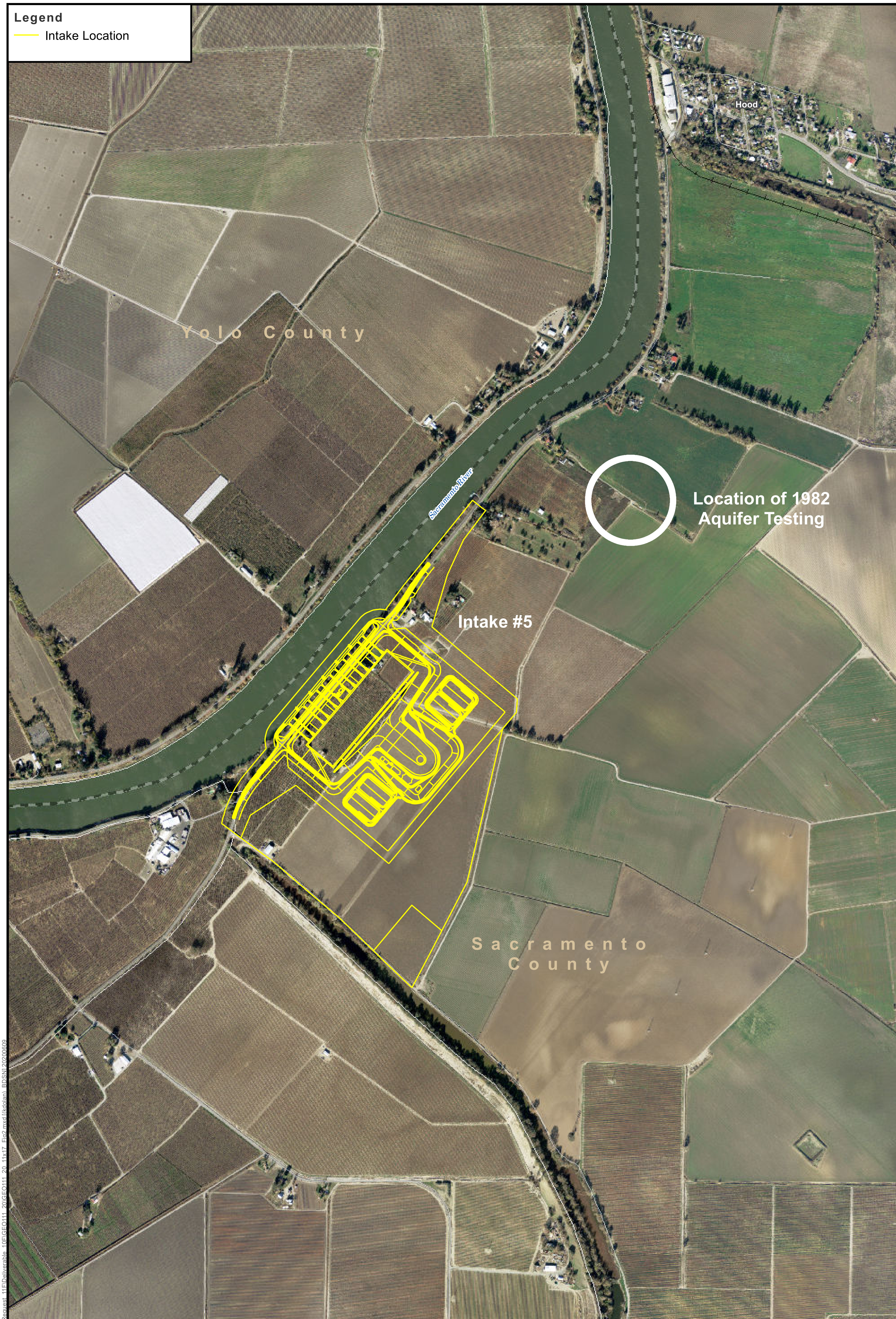
Figure 1
Site Location

Data Source: DCA, DWR



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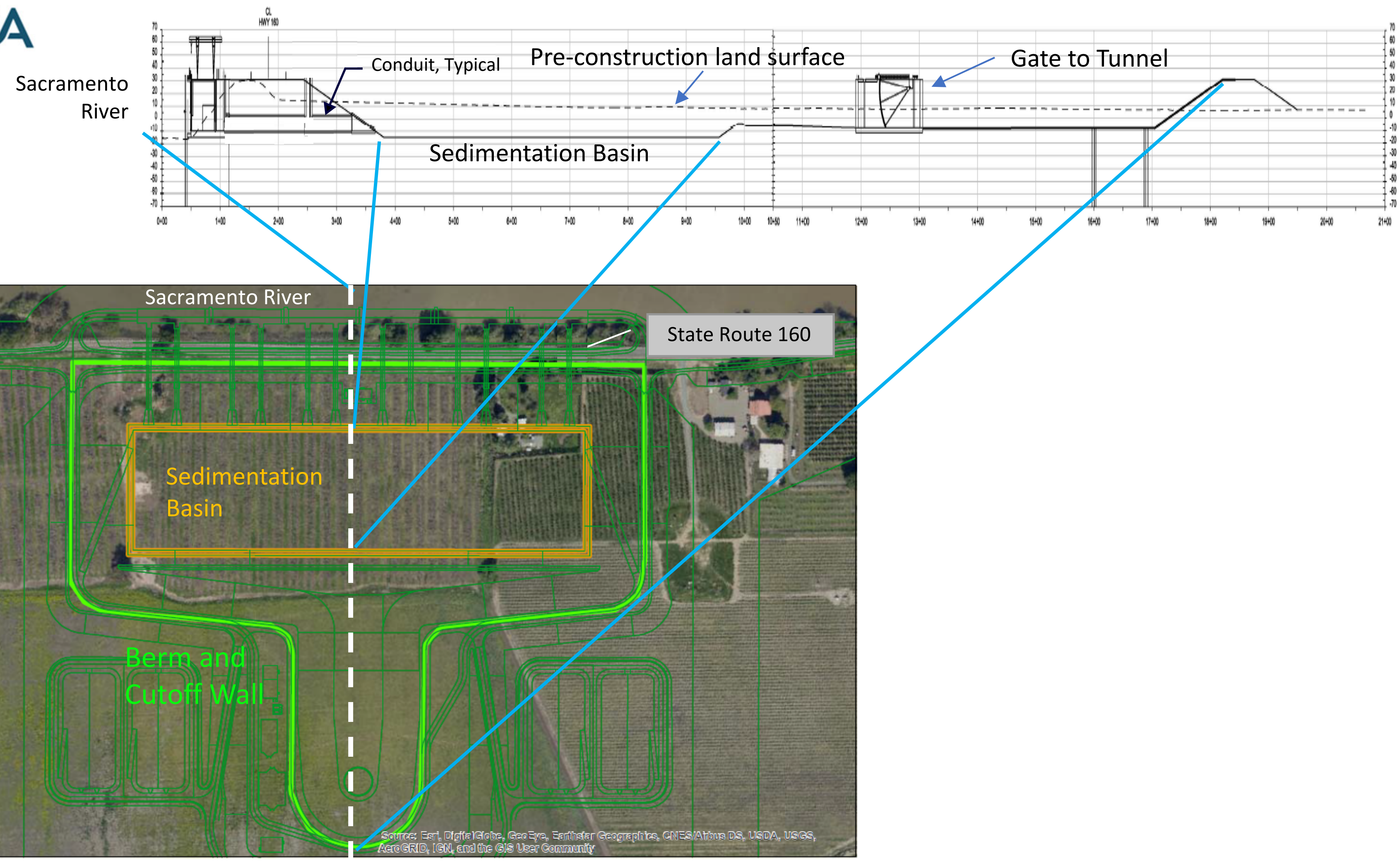
N

0 500 1,000 Feet

Figure 2
Intake Facility Study Area

Data Source: DCA, DWR

T:\WGI-38\GIS_33_00\GISRequest_11F\Deliverable_10F\GEO111_20\GEO111_20_11x17_Fig2.mxd [(kdolan)_BDSN] 20200609



Legend
Dewatering Areas

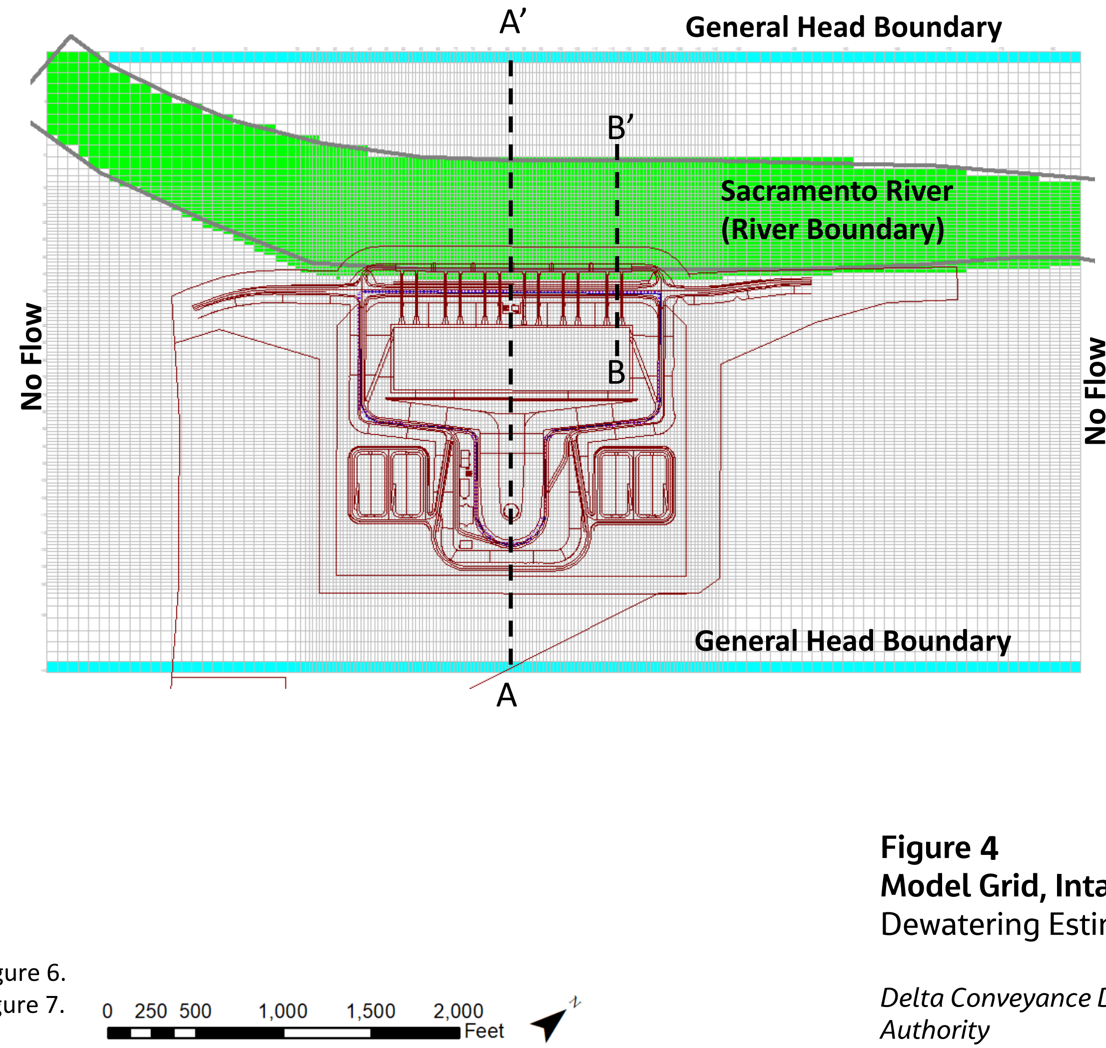
- Cutoff Wall (-85 ft)
- Sedimentation Basin (dewater to -20 ft, elev. -5 ft)
- Intake Polygons

0 250 500 1,000 Feet

Figure 3
Intake Facilities
Dewatering Estimates for Intake Facilities

Delta Conveyance Design & Construction Authority

JACOBS



Notes:
1. Location is Intake #5
2. 20 x 20 feet minimum cell size
3. 50 degree grid rotation
4. A-A' cross section shown on Figure 6.
5. B-B' cross section shown on Figure 7.

Figure 4
Model Grid, Intake Facilities
Dewatering Estimates for Intake Facilities

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DCA

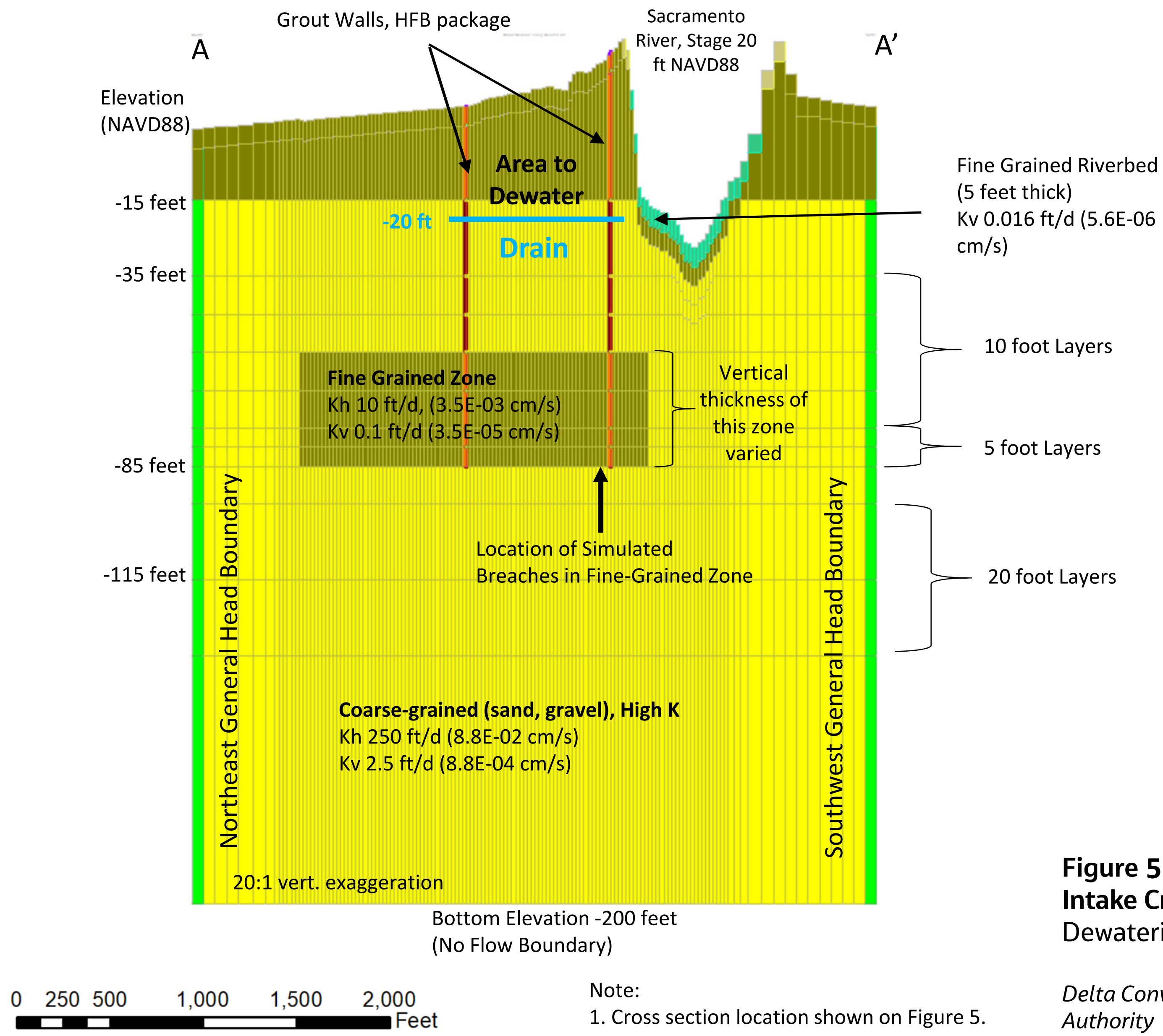


Figure 5
Intake Cross Section
Dewatering Estimates for Intake Facilities

Note:
1. Cross section location shown on Figure 5.

Well Locations

- Observation wells at center of basin to evaluate results, Layers 2-5
- 7 Pumping wells, screened in Layers 2-5

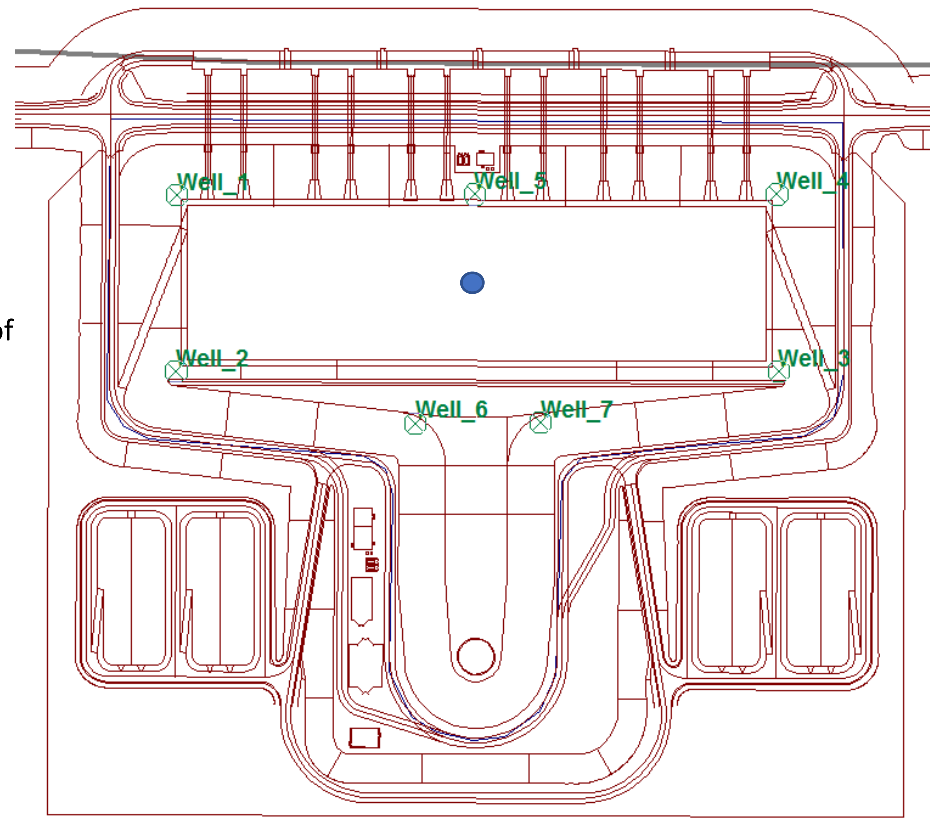
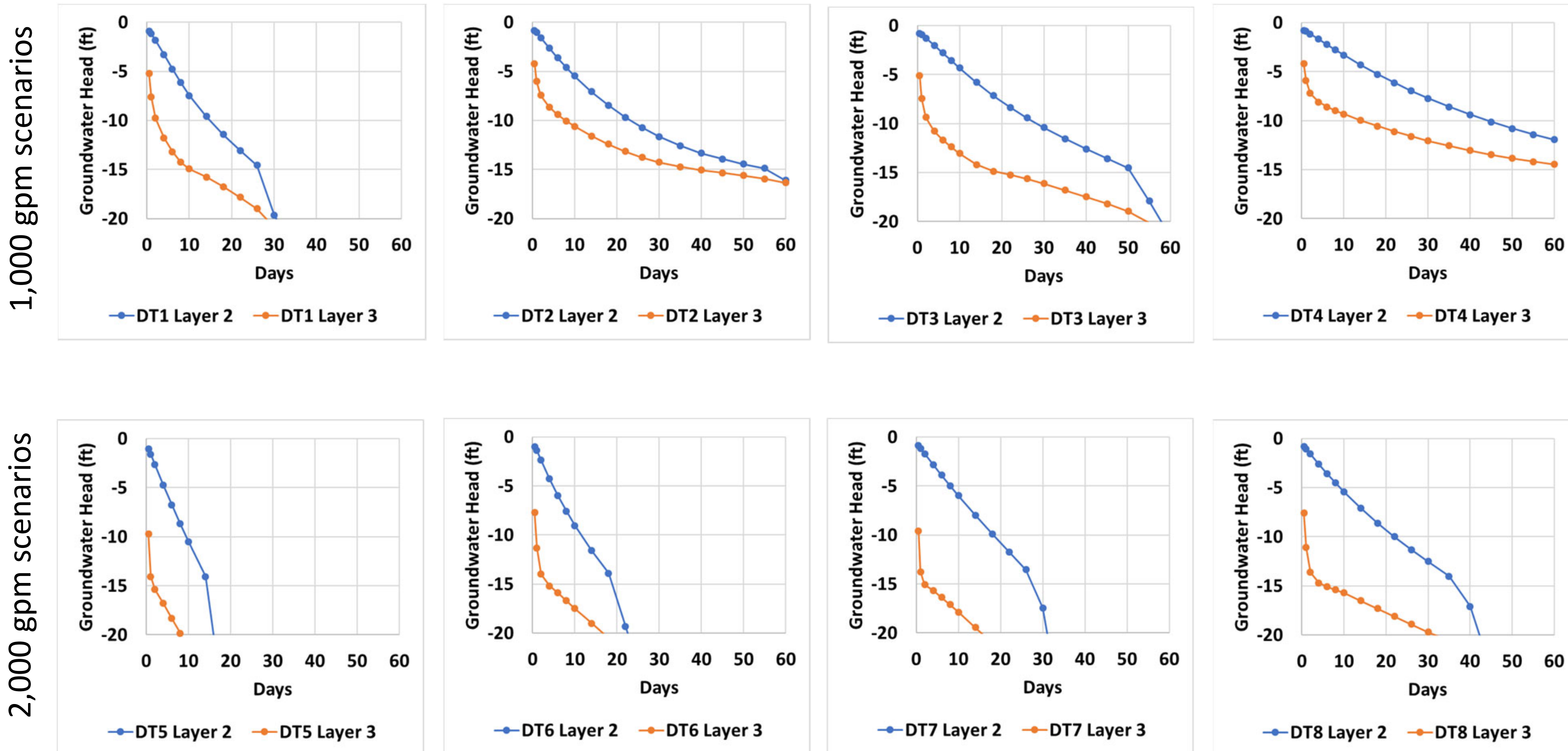


Figure 6
Intake Modeling Well Locations
Dewatering Estimates for Intake Facilities

Delta Conveyance Design & Construction Authority



Model Key

ID	Low K Thickness (ft)	Sy	Total Rate (gpm)
DT1	30	0.1	1000
DT2	10	0.1	1000
DT3	30	0.2	1000
DT4	10	0.2	1000
DT5	30	0.1	2000
DT6	10	0.1	2000
DT7	30	0.2	2000
DT8	10	0.2	2000

Note: These results illustrate potential nuances during dewatering, as the upper fine-grained layer is slower to dewater.

Figure 7
Construction Phase Transient Results, Layer Comparison
Dewatering Estimates for Intake Facilities

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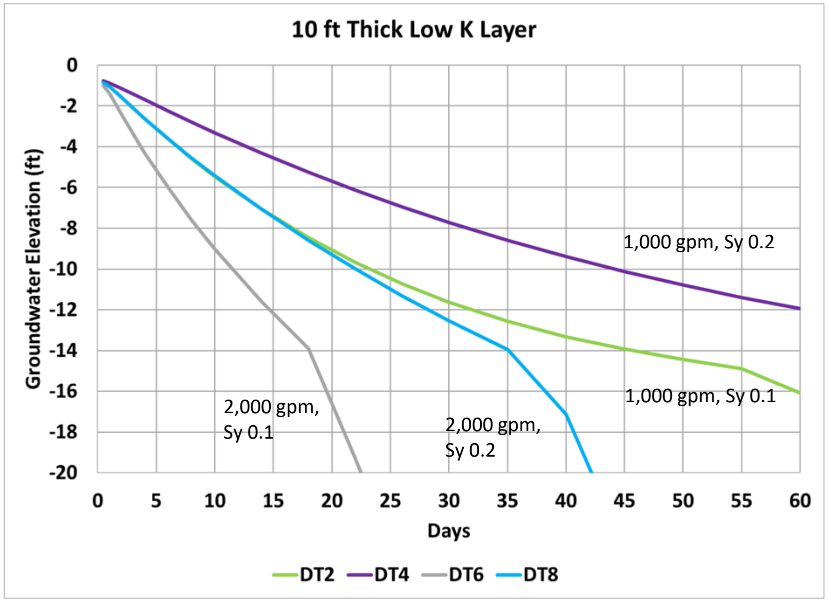

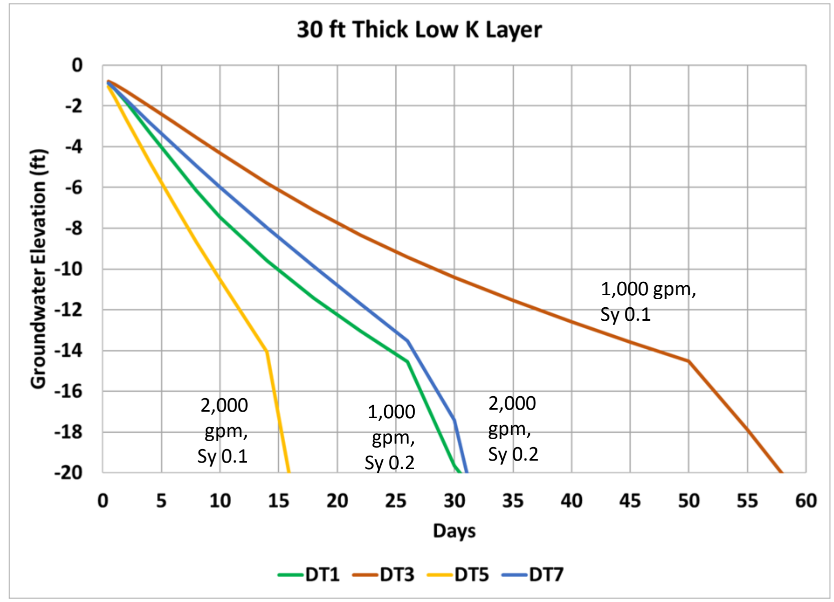

Model Key

ID	Low K Thickness (ft)	Sy	Total Rate (gpm)
DT1	30	0.1	1000
DT2	10	0.1	1000
DT3	30	0.2	1000
DT4	10	0.2	1000
DT5	30	0.1	2000
DT6	10	0.1	2000
DT7	30	0.2	2000
DT8	10	0.2	2000

Figure 8
Transient Results, Construction Phase, Model Layer 2
Dewatering Estimates for Intake Facilities

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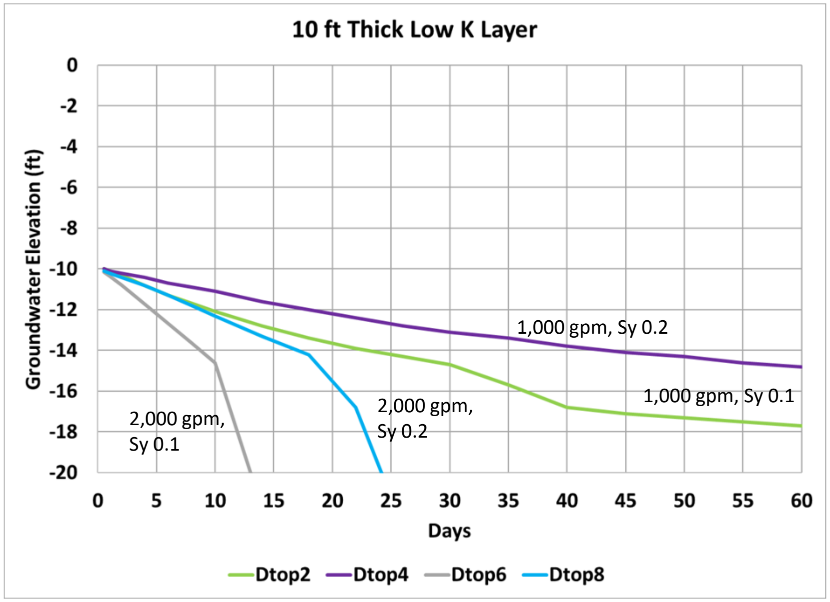

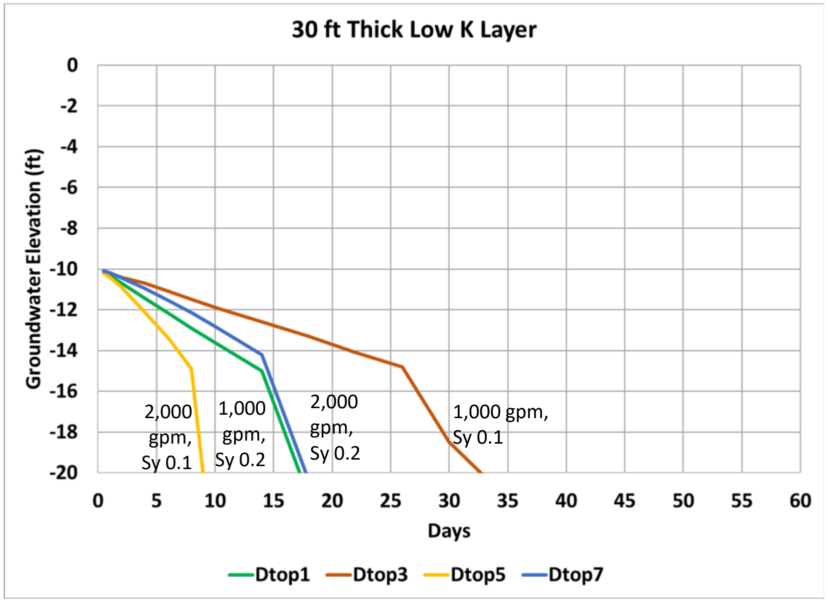

Model Key

ID	Low K Thickness (ft)	Sy	Total Rate (gpm)
DTop1	30	0.1	1000
DTop2	10	0.1	1000
DTop3	30	0.2	1000
DTop4	10	0.2	1000
DTop5	30	0.1	2000
DTop6	10	0.1	2000
DTop7	30	0.2	2000
DTop8	10	0.2	2000

Figure 9
Transient Results, Maintenance Phase, Model Layer 2
Dewatering Estimates for Intake Facilities

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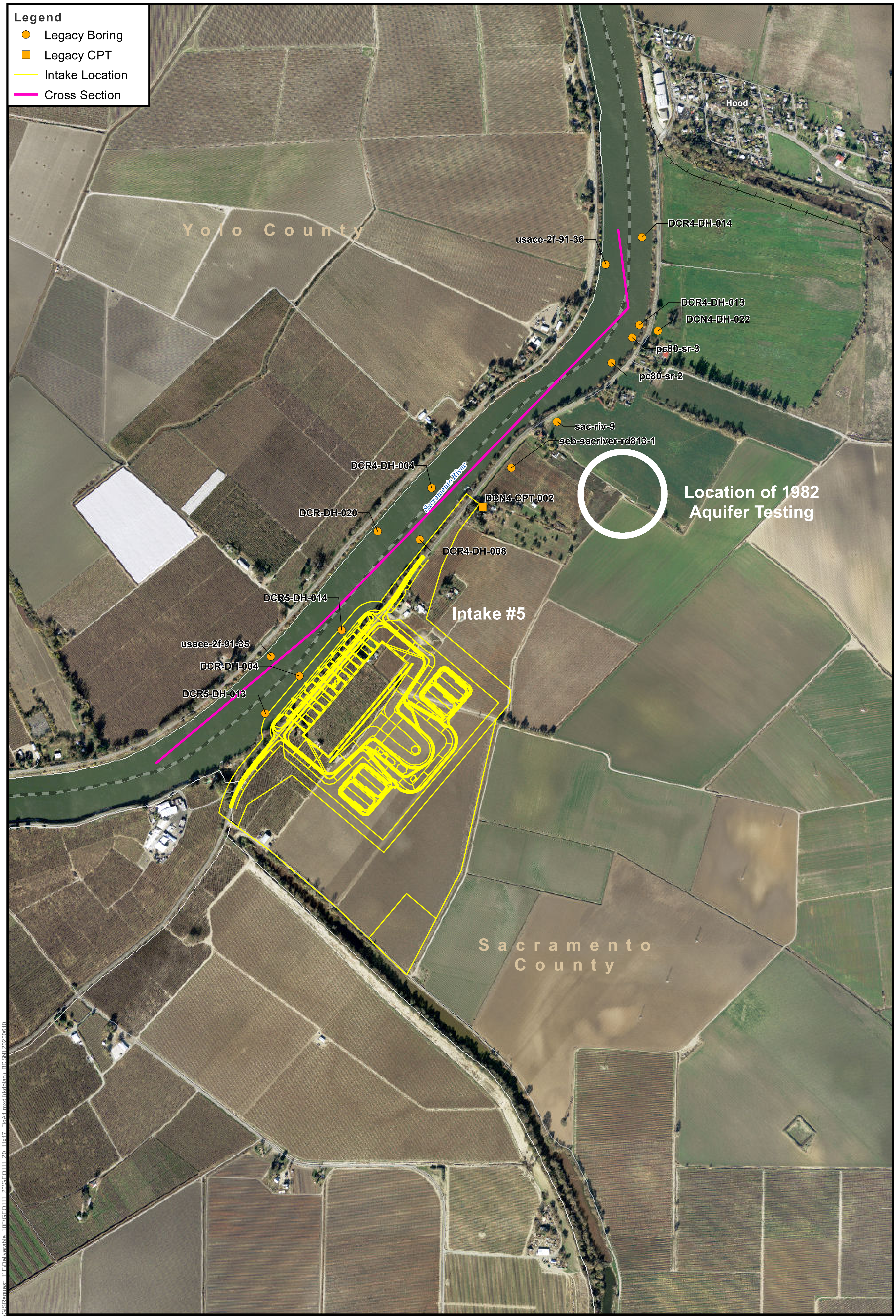
Attachment 1
Subsurface Cross Sections at Intake Facilities



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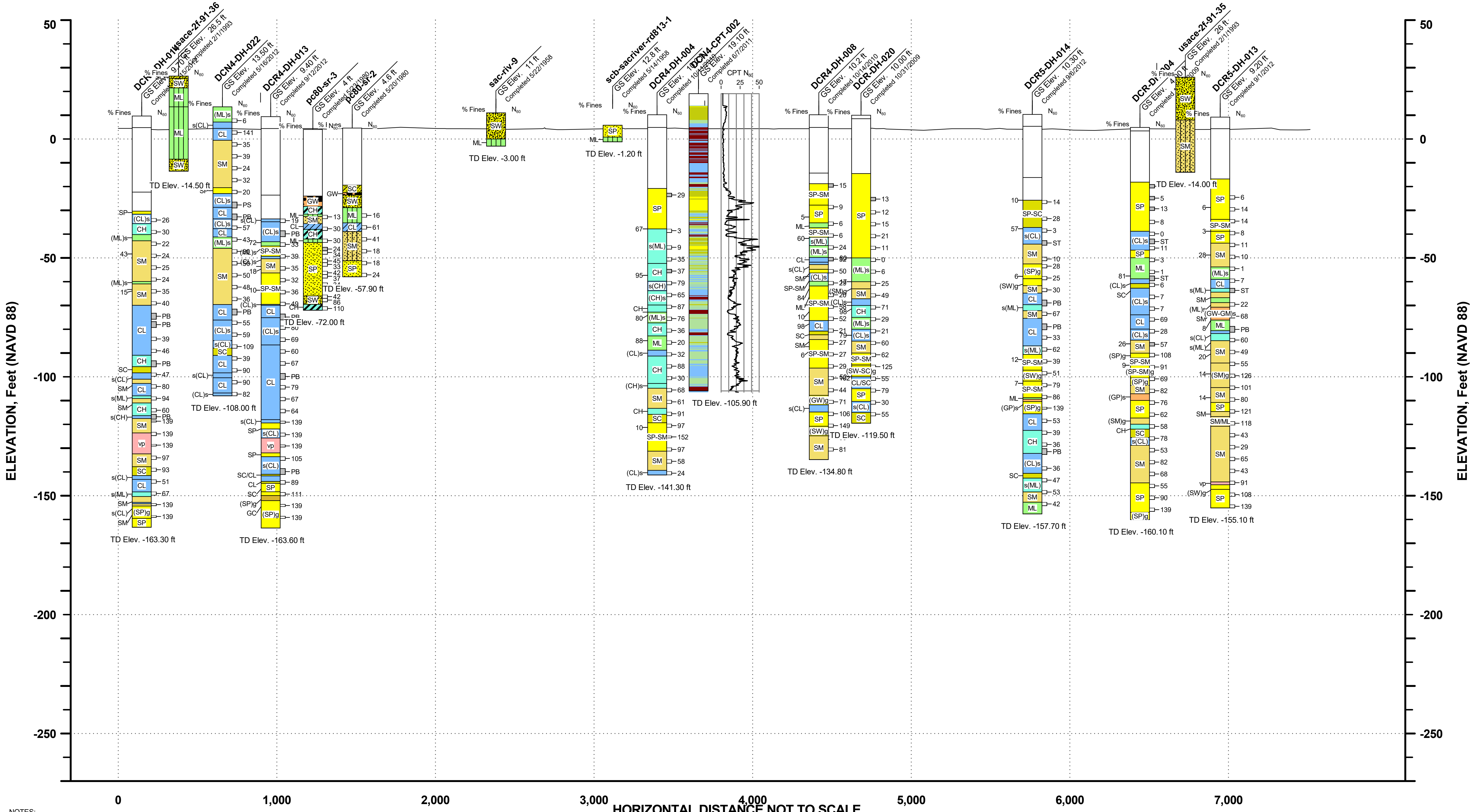
N

0 500 1,000 Feet

Figure A1
Boring Locations

Data Source: DCA, DWR



NOTES:

1. CORRELATION OF LITHOLOGIES BETWEEN WIDELY SPACED BORINGS IS NOT RECOMMENDED
2. GS Elev FOR OVERWATER BORINGS IS THE ELEVATION OF THE DRILL DECK

DCDCA-Geotechnical
DWR-Internal Only
WORKING DRAFT - Subject to Change

0 20 40 60 80 100 Vertical Scale 40.00 ft/in.

Delta Conveyance Design & Construction Authority
California Department of Water Resources

THINK SAFETY - ACT SAFELY

WORKING PROFILE

GRAPHIC BORING AND CPT LOGS

Figure A2