Appendix G5. Potential Future Field Investigations (Final Draft)

1. Introduction and Purpose

Future geotechnical, hydrogeological, and agronomic testing, as well as construction test projects (geotechnical investigations) would be conducted during pre-construction and construction periods following the completion of the final Environmental Impact Report (EIR) for the Delta Conveyance Project (Project) to more specifically identify appropriate construction methods addressed in the final design documents (DWR, 2023). These investigations would also address the establishment of geological and groundwater monitoring programs that could extend during the design and construction phases of the adopted Project.

Because these investigations would be conducted following the adoption of the EIR, the investigations would be focused to address the Bethany Reservoir Alignment. The following discussions describe assumptions related to the types and potential extent of the future geotechnical investigations.

This document addresses the Bethany Reservoir Alignment for the Project design capacity of 6,000 cubic feet per second (cfs). Attachment A lists and summarizes the types of potential future investigations by facility and method to support 408 permitting, design, and construction phases. Attachment B lists and summarizes the types of instrumentation by facility and method during the construction phases. Attachment C describes the worker, vehicle, and equipment assumptions.

1.1 Organization

This TM is organized as follows:

- Introduction and Purpose
- Geotechnical Investigations to Support 408 Permitting
- Geotechnical Investigations Prior to Construction Phase
- Geotechnical Investigations During Construction Phase
- References
- Attachment A – Potential Future Field Investigations to Support 408 Permitting, Design and Construction
- Attachment B – Construction Instrumentation
- Attachment C – Equipment, Worker and Vehicle Assumptions

2. Geotechnical Investigations to Support 408 Permitting

The following activities are anticipated to be conducted between the adoption of the EIR and before the start of 65 percent level of design to support the submission of a formal 408 application to the U.S. Army Corps of Engineers (USACE) to address intake construction and the tunneled crossing of the Stockton Deep Water Ship Channel (SDWSC). These activities would require approximately 48 months to be completed, however the activities may not occur concurrently or sequentially and could occur over a longer time period. The duration of individual activities is presented in Attachment C.

2.1 Investigation at Facility Locations

The intakes and the section of tunnel beneath the SDWSC require a 408 permit. These facilities are identified in the Delta Conveyance Final Draft Concept Engineering Drawings, as well as the associated geographic information system (GIS) files. The following sections present the explorations planned at the facility locations.

2.1.1 Soil Borings and Cone Penetration Tests

Soil borings and cone penetration tests (CPTs) would be conducted within the construction boundaries of the intakes and within the SDWSC, as shown on the engineering concept drawings and associated GIS files, and adjacent non-project levees at the location of the proposed tunnel undercrossing. It is assumed that the entire area of the construction sites shown within the construction boundaries on associated GIS files would be disturbed during construction.

Drilling techniques would generate an approximately 4- to 8-inch-diameter boring. For CPTs, a cone-tipped rod with a diameter of 1 to 2 inches would be pushed through the ground. All CPTs would be grouted following completion, and all soil borings not planned for completion as a monitoring well would be completely grouted following completion.

This information would be used to develop design criteria for structure foundations, new and modified levee cross-sections, ground improvement, dewatering methods and quantities, belowgrade construction methods, and methods to reduce ground settlement risk at all construction sites and at the crossing of the SDWSC. The information would also be used to determine the depths and widths of groundwater cutoff walls to be installed at the intakes. Soil samples obtained during soil borings would also be analyzed to determine the structural capabilities of the soil to construct embankments and levees.

2.1.1.1 Intakes

At each intake, it is estimated that approximately 6 soil borings would be completed along the levee, and 5 soil borings and 10 CPTs would be completed across the remaining site footprint at each intake to support intake design. It is assumed that each soil boring or CPT would extend to approximately 150 feet (ft) below the ground surface.

2.1.1.2 Tunnel Alignment at the Stockton Deep Water Ship Channel

It is assumed that one soil boring would be conducted along the tunnel alignment within the SDWSC and that two CPTs would be conducted within the adjacent non-project levees. It is assumed that the soil boring and CPTs would each extend to approximately 200 ft below the ground surface. Soil samples obtained during exploration would be used to confirm the nature and strength of the native soil at the tunnel depth.

2.1.2 Groundwater Testing and Monitoring

At each intake, it is assumed that one 12-inch-diameter steel-cased test well would be installed in a 24-inch-diameter borehole to conduct pump tests. It is also assumed that vibrating wire piezometers would be installed in 4 of the levee borings and installation of 4-inch groundwater monitoring wells in 4 of the site borings at each intake to permit measurements of groundwater head, monitoring of groundwater elevations during the pumping tests, and the collection of water quality samples at the locations of intakes.

At each intake, a surface water gauge would be installed to track the elevation of the adjacent river for use in analysis of the results.

Pumping tests would be conducted in the test wells using a vertical turbine or submersible well pump capable of pumping up to 1,500 gallons per minute (gpm). A step-drawdown test would be completed at varied flow rates over a 3-day period, followed by a steady-state pumping test of up to 10 days in duration at a flow rate selected to prevent dewatering of the well and resulting pump cavitation. A period equal in duration to the pumping test would follow the completion of the step-drawdown test, during which the water level in the well would be allowed to recover to the pre-pumping level. Water levels before, during, and following the various tests would be monitored using automated data loggers, which would also record barometric pressure and the level of the river. It is assumed that management of the groundwater monitoring program would be conducted partially using remotely monitored instrumentation and partially by onsite personnel.

2.1.3 Summary of Explorations

Table 2.1 summarizes the planned explorations. Refer to Attachment A for additional details and quantities.

Table 2.1 Summary of Planned Geotechnical Investigations to Support 408 Permitting

Facility	Soil Borings on Land	Soil Borings Overwater	CPTs	Test Wells	Piezometers / Monitoring Wells[a]
Intake (Each)	11	0	10	1	8
Tunnel beneath SDWSC	0	1	2	0	0
Total (each)	11	1	12	1	8

[a] Installed in the "soil borings on land"

3. Geotechnical Investigations Prior to Construction Phase

The following activities are anticipated to be conducted between the adoption of the EIR and the start of construction, exclusive of the 408-support explorations. These activities would require approximately 48 months to be completed, however the activities may not occur concurrently or sequentially and could occur over a longer time period. The duration of individual activities is presented in Attachment C.

3.1 Investigation at Facility Locations

Facilities include the following, as identified in the Bethany Reservoir Alignment Engineering Concept Drawings and associated GIS files:

- Intakes
- Tunnel shafts
- Tunnel alignments
- Power lines
- Access roads and bridges

- Bethany Reservoir Pumping Plant and associated Surge Basin
- Bethany Reservoir Aqueduct
- Bethany Reservoir Discharge Structure.

The following sections present the explorations planned at the facility locations.

3.1.1 Soil Borings and Cone Penetration Tests

Soil borings, overwater soil borings, and CPTs would be conducted within the "construction boundaries" of the intakes, tunnel shafts, tunnel reaches, access roads and bridges, levees, the Bethany Reservoir Pumping Plant and associated Surge Basin and aqueducts, and the Bethany Reservoir Discharge Structure. It is assumed that the entire area of the construction sites shown within the construction boundaries on associated GIS files would be disturbed during construction.

The methods for soil borings and CPTs are as described in Section 2.1.1. Overwater borings would use a rotary drill rig mounted on a shallow-draft barge or ship. The barge or ship would be anchored into the bottom of the channel with two to four spuds or anchor lines to prevent the vessel from drifting while the work was being performed. The spuds would be steel pipes mechanically lowered into the channel bottom. The anchor lines would be located near the four corners of the barge and set some distance away to anchor the vessel.

The drill apparatus would be similar to the land-based apparatus described in Section 2.1.1 and would consist of a 6- to 8-inch-diameter conductor casing that extended from the barge or drill ship deck, through the water column, and into the soft sediments of the slough or river bottom. All drilling rods, samplers, and other down-hole equipment would be fully enclosed within the casing, effectively separating all drilling equipment and drilling fluids from the water body.

Soil samples would be collected from within the casing. The drill hole below the conductor casing would be approximately 3.5 to 7.0 inches in diameter. Only water would be circulated through the pumps and conductor casing when drilling and sampling within 15 to 20 feet of the slough or river mud line. For deeper drilling, the drilling fluid, consisting of a mixture of circulating water and drilling polymers and/or bentonite clay, would be introduced into the conductor casing via the drill string to create a more viscous drilling fluid (also called drilling mud). The drilling fluid would pass down the center of the drill rod to the cutting face in the formation being drilled, and would return up the drilled hole with the suspended cuttings. The drilling fluids and cuttings would be confined by the borehole walls and the conductor casing. Return drill fluids would pass through the conductor casing to the barge or ship deck, and then through a tee connection at the head of the conductor casing into the drilling fluid recirculation tank.

This information would be used to develop design criteria for structure and bridge foundations, new or modified levee cross-sections, ground improvement, the selection of tunnel boring machine methods, dewatering methods and quantities, belowgrade construction methods (such as at the shafts, pumping plant, and aqueducts), and methods to reduce ground settlement risk at all construction sites and along the tunnel alignment. The information also would also be used to determine the depths and widths of groundwater cutoff walls to be installed at select construction sites.

Soil samples obtained during soil borings also would be analyzed to determine the structural capabilities of the soil and/or reusable tunnel material to construct tunnel shaft pads, levee improvements, and embankments. Soil and water quality tests would be conducted to determine the potential for the presence of high concentrations of metals or organic materials that might be designated as hazardous and would require specific treatment and/or disposal methods.

3.1.1.1 Intakes

At each intake, it is estimated that 20 on land soil borings and 15 on land CPTs would be completed across the footprint at each intake to support intake final design. It is assumed that each soil boring or CPT would extend to approximately 150 ft below the ground surface. At each intake, it is estimated that three overwater soil borings would be completed across the footprint within the river to support intake final design. It is assumed that each overwater soil boring would extend to approximately 150 ft below the mudline.

3.1.1.2 Tunnel Shafts

At each planned tunnel launch, maintenance, and reception shaft sites, it is estimated that six soil borings and six CPTs would be completed. It is assumed that each soil boring or CPT would extend to approximately 200 ft below the ground surface.

3.1.1.3 Tunnel Alignments between Tunnel Shafts

It is assumed that soil borings would be conducted in phases along the tunnel alignment between the tunnel shafts at a spacing of approximately every 1,000 ft during design or pre-construction phases. A single overwater soil boring would be completed at each river, canal, or slough crossing. It is assumed that vibrating wire piezometers would be installed in land boreholes at a frequency of on average every third borehole to permit measurements of groundwater head.

It is assumed that CPTs would be conducted along the tunnel alignments between the soil borings such that the spacing between soil borings and CPTs would be approximately 500 ft during design or pre-construction phases. In addition, CPTs would be advanced adjacent to a soil boring for one of each eight prior soil borings to allow for a correlation between CPT readings and soil samples from borings.

It is assumed that the described geotechnical investigations would be conducted within 50 ft on either side of the tunnel alignment centerline, except where access would require slightly greater offsets. Explorations would also be conducted at each levee crossing from within the levee crown. It is assumed that each soil boring, overwater soil boring, or CPT would extend to approximately 200 ft below the ground surface or water body mudline, as applicable.

Soil samples obtained during exploration would be used to confirm the suitability of soil conditioning and to perform additional environmental testing on both the conditioned soil and the native soil at the tunnel depth.

3.1.1.4 Power Lines

It is estimated that soil borings would be completed to a depth of 75 ft at each of the tower locations for the high-voltage powerlines that would be constructed along the alignments from the Western Area Power Administration (WAPA) Tracy Substation to the Bethany Complex and from the Pacific Gas and Electric's (PG&E's) Brentwood substation to the Bethany Complex, as depicted in the applicable GIS files. Towers would be anticipated to be constructed at 1,000-ft-average intervals along the powerline alignments. Where a trenchless installation of power lines is anticipated, it is assumed that 3 borings would be completed at each crossing location to 100 feet below mudline or ground surface (also as depicted in the applicable GIS files).

3.1.1.5 Access Roads

It is assumed that one soil boring would be completed every 750 ft for the access roads and a minimum of 4 borings for each parking/park and ride area. It is assumed that each soil boring would extend to approximately 15 ft below the ground surface.

3.1.1.6 Access Road Bridges

In accordance with the American Association of State Highway and Transportation Officials (AASHTO) (2018), it is assumed that one soil boring would be completed at each bridge substructure with a minimum of two borings and a maximum of eight borings per bridge. The depth of exploration would extend below the anticipated pile or shaft tip elevation a minimum of 20 ft, or at least two times the minimum pile group dimension, whichever was deeper. The minimum boring depth would be 75 ft, while the maximum boring depth would be 200 ft, measured below the mudline.

3.1.1.7 Bethany Reservoir Pumping Plant and Surge Basin

At the Bethany Reservoir Pumping Plant and Surge Basin, approximately 30 CPTs and 25 borings are planned to evaluate the subsurface conditions beneath the pumping plant, the substation, surge tanks, and within the Surge Basin. It is assumed that each soil boring or CPT would extend 250 ft in depth, with an approximate average depth of 150 ft below the ground surface.

3.1.1.8 Bethany Reservoir Aqueduct

It is assumed that soil borings would be conducted in phases along the Aqueduct alignment between the Bethany Reservoir Pumping Plant and the Bethany Reservoir Discharge Structure, exclusive of the tunneled sections, at a spacing of approximately every 500 ft during design or pre-construction phases.

It is assumed that the geotechnical investigations would be conducted within 150 ft on either side of the Aqueduct alignment centerline unless access limitations require slightly greater offsets. It is assumed that each soil boring would extend to approximately 50 ft below the ground surface.

At each of the two planned tunneled sections of the Aqueduct (Jones Penstock Tunnel and Conservation Easement Tunnel), eight soil borings would be completed. It is assumed that each soil boring would extend to approximately 150 ft below the ground surface at the Jones crossing and from 50 to 250 ft below the ground surface at the easement crossing.

In addition to the eight soil borings described, up to two inclined boreholes would be completed for the Conservation Easement Tunnel from a point outside the Conservation Easement in order to avoid the need to access the Conservation Easement from the surface. The inclined boreholes would be up to 800 ft long.

3.1.1.9 Bethany Reservoir Discharge Structure

At the Bethany Reservoir Discharge Structure, approximately five borings are planned to evaluate the subsurface conditions beneath the associated apron and bridge. Exploration for the discharge shafts is addressed as part of the Aqueduct Conservation Easement Tunnel. The depth of exploration will extend below the anticipated pile or shaft tip elevation a minimum of 20 ft, or at least two times the minimum pile group dimension, whichever is deeper. Boring depth is assumed to be 75 ft. It is assumed that no over-water explorations are required.

3.1.1.10 Levees

At the proposed ring levee at the Twin Cities Tunnel Launch Shaft site, borings would be spaced at approximately 500 ft on center and advanced to a depth of 50 ft below grade along the centerline of the proposed levee. A paired boring would be completed at the planned landside toe of the levee every 1,000 ft on center. It is assumed that each soil boring would extend to an average depth of 50 ft below grade. For all levee improvement projects, 3 holes are planned about every 500 ft (through the centerline of the levee, at the landside toe, and approximately 150 ft from the landside toe). It is assumed that each soil boring would extend to an average depth of 100 ft below grade.

3.1.1.11 Rail Lines

It is assumed that one soil boring would be completed every 750 ft for the rail lines. It is assumed that each soil boring would extend to approximately 50 ft below the ground surface.

3.1.2 Groundwater Testing and Monitoring

It is assumed that a 12-inch-diameter steel-cased test well would be installed in a 24-inch-diameter borehole to conduct pump tests. It is assumed that one test well for pump tests would be installed at each tunnel shaft and at each intake, and that two would be installed at the Bethany Reservoir Pumping Plant and Surge Basin, and at each of the two planned tunneled sections of the Aqueduct (Jones Penstock Tunnel and Conservation Easement Tunnel).

It is assumed that a 4-inch groundwater monitoring well would be installed in site borings to permit measurements of groundwater head, monitoring of groundwater elevations during pumping tests, and the collection of water quality samples at the locations of intakes, tunnel shafts, Bethany Reservoir Pumping Plant and Surge Basin, Bethany Reservoir Aqueduct, and Bethany Reservoir Discharge Structure. Monitoring well and test well installation methods were described in Section 2.1.2, Groundwater Testing and Monitoring.

At each of the intakes, it is assumed that monitoring wells would be installed in 8 of the 20 planned soil borings. These monitoring wells would be utilized during pumping tests performed in the test wells in addition to the ones installed during 408-support explorations.

For the tunnel alignment, it is assumed that vibrating wire piezometers would be installed in boreholes drilled along the tunnel alignment at a frequency of on average every third borehole. The piezometers would be grouted in place at one or more depths per borehole to allow the measurement of water pressure at a specific horizon.

For the tunnel shafts, three of the six soil borings would include the installation of vibrating wire piezometers for groundwater monitoring, as discussed in Section 3.1.1.3.

For the Bethany Reservoir Pumping Plant and Surge Basin, it is assumed that up to 10 of the planned soil borings would be completed as monitoring wells.

For the Bethany Reservoir Aqueduct, it is assumed that vibrating wire piezometers or monitoring wells would be installed in planned boreholes at a frequency of on average every fourth borehole to permit measurements of groundwater head. At each of the two planned tunneled sections of the Aqueduct (Jones Penstock Tunnel and Conservation Easement Tunnel), it is assumed that three of the eight soil borings would be completed as monitoring wells.

For the Bethany Reservoir Discharge Structure, it is assumed that two of the five soil borings would be completed as monitoring wells.

At locations near surface water bodies, such as the intakes, a surface water gauge would be installed to track the elevation of the adjacent surface water body for use in analysis of the results.

Pumping tests would be conducted in the test wells using a vertical turbine or submersible well pump capable of pumping up to 1,500 gpm. A step-drawdown test would be completed at varied flow rates over a 3-day period, followed by a steady-state pumping test of up to 10 days in duration at a flow rate selected to prevent dewatering of the well and resulting pump cavitation. A period equal to the duration of the step-drawdown test would follow the pumping test, during which the water level in the well would be allowed to recover to the pre-pumping level. Water levels before, during, and following the various tests would be monitored using automated data loggers, which would also record barometric pressure and the level of the adjacent surface water body (if applicable). Water quality samples would be obtained periodically during the test to evaluate the constituents of the groundwater.

The groundwater monitoring program would be implemented to determine the seasonal variations in groundwater elevations, the constituents of the groundwater (including nature and presence of dissolved gas), and the interrelation between groundwater and surface water levels for several years before construction. It is assumed that management of the groundwater monitoring program would be conducted partially using remotely monitored instrumentation and partially by onsite personnel.

3.1.3 Test Trenches

It is assumed that test trenches (approximately 30 ft long, 3 ft wide, and 10 ft deep) would be implemented at all the facilities to confirm near-surface soils and to investigate buried magnetic anomalies. Trenches would be immediately backfilled following observations of the soil conditions encountered in the trench.

3.1.4 Monument Installation

It is assumed that metal survey monuments would be installed at all construction sites and approximately every mile along the tunnel alignment to allow the remote monitoring of surface elevations prior to the start of construction. Monuments could be approximately 10-feet by 10-feet base and 3 feet high to be of adequate size to be visible from satellite-based Interferometric Synthetic Aperture Radar (InSar) used for remote monitoring. It is assumed that concrete foundations would be installed for the monuments and that monuments would be left in place for the duration of construction. It is assumed that periodic monitoring of survey monuments would be conducted by security and onsite personnel.

3.1.5 Summary of Exploration

Table 3.1 summarizes the explorations planned following the adoption of the EIR and before the construction phase. Refer to Attachment A for additional details and quantities.

Table 3.1 Summary of Planned Geotechnical Investigations Prior to Construction Phase

Facility	Land Soil Boring	Overwater Soil Boring	CPTs on Land	Test Wells	Monitoring Wells	Test Trenches (30 ft long x 3 ft wide x 10 ft deep)	InSar Monuments
Tunnel	Every 1000 ft OC	At river crossings	1000 feet OC plus at every 8th boring location	0	At every 3rd boring location	0	1 mile OC
Shafts (Each)	6	0	6	1	At every 2nd boring location	10	1
Roadways	Every 750 ft OC plus 4 per park and ride lot	0	0	0	0	20	0
Bridges	Every substructure (minimum of 2, maximum of 8 per bridge)	Every overwater substructure (maximum of 6 per bridge)	0	0	0	10	0
Powerlines	Every 1000 ft OC	0	0	0	0	10	0
Levees (new)	500 ft OC at CL and 1000 ft OC at LS toe	0	0	0	0	30	2
Levees (improvements)	500 ft OC at CL, LS toe, and 150-ft from LS toe	0	0	0	0	20	2
Rail Lines	750 ft OC	0	0	0	0	20	0
Pumping Plant	25	0	30	2	10	20	1
Aqueduct	500 ft OC, plus 16 for tunnels	0	0	2	At every 4th boring location, plus 6 for tunnels	20	2

Facility	Land Soil Boring	Overwater Soil Boring	CPTs on Land	Test Wells	Monitoring Wells	Test Trenches (30 ft long x 3 ft wide x 10 ft deep)	InSar Monuments
Discharge Structure	5	0	0	0	0	5	1
Intake (Each)	20	3	15	1	Within 8 of the 20 planned borings at each intake	10	1
Totals	Refer to Attachment A	Refer to Attachment A	Refer to Attachment A	Refer to Attachment A	Refer to Attachment A	Refer to Attachment A	Refer to Attachment A

Notes:
CL – centerline
LS – landside
OC – on center

3.2 Geotechnical Pilot Studies for Settlement

It is assumed that pilot studies would be conducted to test geotechnical response to placement of fill at up to three tunnel shaft sites, especially at Delta islands, such as New Hope Tract, Canal Ranch Tract, Terminous Tract, King Island, Lower Roberts Island, Upper Jones Tract, and Union Island.

The test fills would be anticipated to be within or adjacent to the shaft pad sites, within the construction boundaries of the Project. The test fills would be approximately 10 ft high and roughly 1,000 square feet in base area. The material would be purchased from a commercial enterprise that provides soil. The studies would include the installation of inclinometers, piezometers, and borehole extensometers within soil borings, as well as settlement plates buried within the fill, to verify estimates of consolidation and lateral spreading of pad fills in peat and soft soils.

Additional soil borings and CPTs would be completed to a depth of 100 ft within and adjacent to the test fill areas before their placement. Inclinometers and extensometers would be installed in holes drilled to at least 75 ft within an adjacent to the test fills. It is assumed that management of the pilot studies would be conducted by onsite personnel. Table 3.2 and Attachment A summarize these studies.

Table 3.2 Summary of Geotechnical Pilot Studies for Settlement Prior to Construction Phase

Facility	Soil Borings	CPTs	Inclinometers	Extensometers
Settlement Test Site (Each of up to 3)	10	20	4	6

3.3 Validation of Ground Improvement Methods

Ground improvement would likely consist of a combination of excavation of unsuitable soils and replacement with compacted suitable fill material, surcharging to induce consolidation before final construction, and in-situ techniques to mix amendments (such as cement) into the foundation to add strength and resistance to liquefaction, including the installation of a grid of deep mechanically mixed (DMM) soil shear walls with cement under the footprints of large structures. It is assumed that final site-specific methods would be determined through future geotechnical investigations, and test installations, especially on land with substantial deposits of peat and loose or soft soils, including New Hope Tract, Canal Ranch Tract, Terminous Tract, King Island, Lower Roberts Island, Upper Jones Tract, and Union Island. These investigations would include trial mix and DMM construction programs to confirm appropriate area and volume replacement ratios, desired cement content, and testing to confirm in situ strength and lateral extent.

It is assumed that each test zone would be approximately 1,000 square feet and extend to a depth of 75 ft and utilize a method such as DMM. Up to three test zones would be completed.

It is assumed that approximately 25 CPTs would be performed to a depth of 75 ft to evaluate the suitability of the improvement at a single test site, as summarized in Table 3.3 and Attachment A.

Table 3.3 Summary of Investigations to Validate Ground Improvement Methods Prior to Construction Phase

Facility	Soil Borings on Land	CPTs on Land	Test Wells	Monitoring Wells
Ground Improvement Test Site (Each of up to 3)	0	25	0	0

3.4 Pile Installation Methods at the Intake Locations

Intake locations would include the construction of temporary in-river cofferdams. The cofferdams would employ the use of interlocking steel sheetpiles. It is assumed that pilot studies would be conducted to test pile installation and possible acoustic mitigation measures in the river at a select intake site along the Sacramento River (assume testing at one site; 2 days for each type of pile and each installation method). The studies would include equipment to monitor vibrations in air and water and noise while test-driving a variety of a pile types using vibratory and driving methods to validate rates and penetration depths. It is assumed that a sheetpile pair, such as an AZ-40 pile, an H-pile, such as a HP14x89, and a steel pipe, such as a 30-inch pipe with 5/8-inch wall thickness would be driven using a vibratory hammer and a conventional diesel pile driving hammer. Both would be suspended from a crane, operating from a barge within the river.

It is assumed that approximately 25 CPTs would be performed in the river from a barge to determine the in-situ density of the soils before, during, and after test pile installation, as summarized in Table 3.4 and Attachment A.

Table 3.4 Summary of Investigations to Test Pile Installation Prior to Construction Phase

Facility	Soil Borings on Land	CPTs Overwater	Test Wells	Monitoring Wells
Pile Installation Test Site (1 Test Site)	0	25	0	0

3.5 Vibratory Testing of Dynamic Properties

It is assumed that vibratory testing of dynamic properties of peat would be conducted in the Delta to validate peat soil response during earthquakes. This would include continuation of previous studies in the Delta, including those on Sherman Island (Reinert et. al. 2014), or additional peat studies on up to two sites at Lower Roberts, Upper Jones Tract, or Union Island, as summarized in Table 3.5 and Attachment A.

Table 3.5 Summary of Investigations to Support Vibratory Testing of Dynamic Properties Prior to Construction Phase

Facility	Soil Borings on Land	CPTs on Land	Test Wells	Monitoring Wells
Dynamic Properties Test Site (Each of up to 2)	5	25	0	0

3.6 Location of Buried Groundwater and Natural Gas Wells

Desktop surveys of documented wells would be conducted and would include research of historical topographical mapping that may document the presence of wells that were not identified in the State of California oil and gas database, as maintained by California Department of Conservation (previously known as DOGGR, and now known as CalGem [Geologic Energy Management Division]). A field test program would be used to evaluate the suitability of various geophysical techniques to detect buried and abandoned wells.

To identify and/or confirm the location of well casings, including wells that have not been identified in published data base, the use of wide-area airborne methods (drone, helicopter, and/or fixed-wing aircraft) to conduct magnetic surveys followed by more site-specific walk- or tow-over ground-based magnetic surveys is assumed. These surveys would be conducted at intake and tunnel shaft locations, along tunnel reaches, and at the Bethany Complex to identify buried groundwater and natural gas and oil wells. Surface geophysical surveys would also be used at these locations, as described here. The locations of identified wells would be evaluated to determine methods to abandon, relocate, or avoid the wells.

It is assumed that a low-flying helicopter would conduct the airborne magnetic surveys over the facility sites and the entire tunnel alignment. A helicopter similar to a Bell 407 would be used to tow a device containing field magnetic sensors approximately 50 ft below the helicopter. The helicopter would fly at a low altitude of approximately 150 ft altitude, towing the field magnetic sensors at approximately 100 ft altitude. It is assumed that the helicopter would fly a total distance of approximately 400 miles over 3 days.

In addition to detecting wells, the airborne magnetic surveys could also detect other metallic features, such as pipelines. To differentiate between wells and other metallic features, the helicopter would make an average of 7 passes along the tunnel alignment, with flight lines offset 50, 100, and 200 ft on either side of the tunnel centerline, for a total of 7 passes. Anomalies that appeared on successive profiles depicting a linear feature could then be excluded from the data. Utilizing this approach, the approximate location of wells located within 100 ft of the tunnel centerline should be able to be inferred.

Following the use of airborne magnetic surveys, ground-based walk-over magnetic surveys would be conducted to refine the locations of the wells. The walk-over ground based magnetic surveys would be conducted using the Cesium Vaper Total Field Magnetometer (CVTFM) method. For the CVTFM method, a magnetometer and GPS positioning unit would be hand-carried by a technician to measure the ambient magnetic field. The technician would walk a line collecting readings (Figure 1). This process would be repeated for the next line spaced approximately 10 ft (3 meters) to 15 ft (4.6 meters) away from the first. Survey areas would be approximately 100 ft wide by 100 ft long. Approximately 300 areas would be surveyed using the walk-over CVTFM method.

Figure 1. Cesium Vaper Total Field Magnetometer. Source: Rogers et al. 2005

3.7 West Tracy Fault Study

Up to 5 test trenches (up to approximately 1,000 ft long, 3 ft wide, and 20 ft deep) would be excavated along a line running from the southeast of Byron to the southeast of Clifton Court Forebay to further investigate the nature and location of the West Tracy Fault between the town of Byron and the area southeast of Clifton Court Forebay (Figure 2). The trenches would be shored in accordance with California Division of Occupational Safety and Health (Cal-OSHA) requirements and fenced to prevent accidental entry. The temporary work area for the trenches would be approximately 200 feet wide (100 feet on each side of the centerline of the trench). The trenches would remain open for up to 6 weeks, depending on the findings, and would be backfilled completely upon the completion of observation of soil conditions within the trench.

In addition to the test trenches, 2 arrays of surface geophysical surveys 10,000 ft long and 3 ft wide (described in more detail in Section 3.1.3) would be completed before, and along the alignment of, the excavation of the test trenches. The temporary work area for the geophysical surveys would be approximately 50 feet wide. Additionally, up to 15 CPTs and 6 soil borings would be completed to a depth of 150 ft. Select soil samples from the test borings would be subjected to age-dating laboratory testing.

Section 3.7.1 provides additional information on the geophysical survey methods. Table 3.6 and Attachment A summarize these studies. Figure 2 includes a map of these studies.

Table 3.6 Summary of Investigations to Support West Tracy Fault Studies Prior to Construction Phase

Facility	Soil Borings on Land	CPTs on Land	Test Trenches (1000 ft long, 3 feet wide, and 20 ft deep)	Geophysical Arrays (10,000 ft long)
West Tracy Fault Studies	6	15	6	2

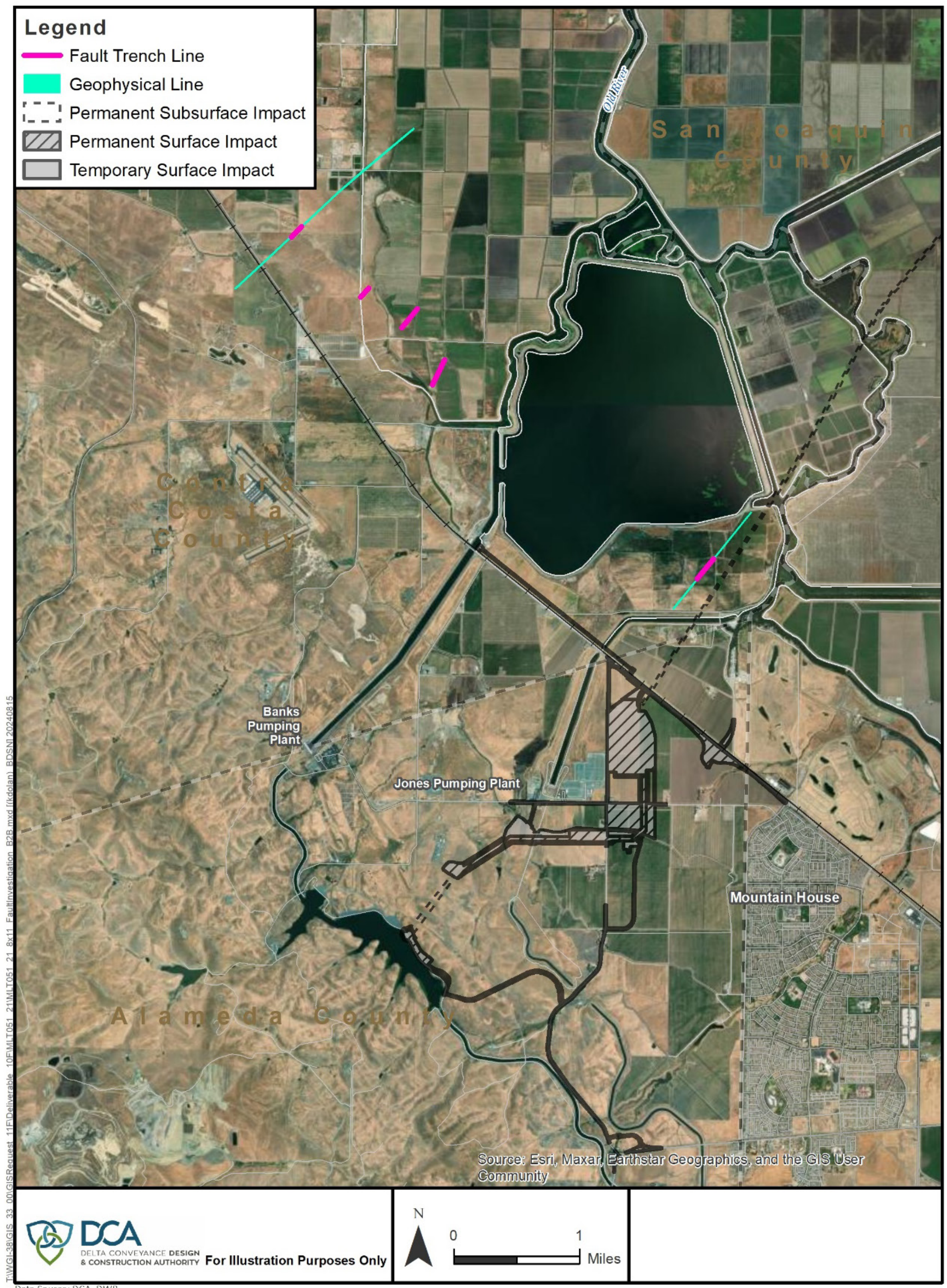

Figure 2. West Tracy Fault Study Location

3.7.1 Geophysical Survey Methods

Geophysical surveys would consist of noninvasive (that is, does not require a soil boring) techniques that could be used to provide information on subsurface conditions and anomalies, such as buried casings or abandoned wells. Seismic Refraction/Reflection (Seismic) techniques would be used at each of the two linear sites, referred to as geophysical arrays. For these seismic surveys, seismic sensors (approximately 0.5 inches [1.27 centimeters] in diameter and 5 inches [13 centimeters] long) would be driven into the ground 3 to 5 inches deep at a spacing of approximately 6.5 ft (2 meters). A vehicle such as the EnviroVibe Minibuggy would be positioned every 10 to 20 ft (3 to 6 meters) and a pad would be lowered onto the ground to inject a seismic signal into the ground using swept frequency vibratory motion. The frequency sweeps would be performed while sensor readings were taken. The sweeps take less than 30 seconds to complete. The source would then be moved along the line and another sweep would be performed. This process would be repeated along the entire length of the geophysical array. The EnviroVibe Minibuggy is a small rubber-tire truck-mounted source (approximately 8 ft [2 meters] wide, 20 ft [6 meters] long, and 8 ft [2 meters] high) that creates minimal ground disturbance, much like typical rubber-tired farming equipment (Figure 3). Vibrations induced are relatively small, while mild vibrations can typically be felt by people within approximately 50 ft (15 meters) of the EnviroVibe Minibuggy; at 100 ft (30 meters), vibrations are typically not detectible by people. The levels of vibration are much smaller than vibrations required to induce damage in buildings and infrastructure.

Figure 3. EnviroVibe Minibuggy. Source: Industrial Vehicles International 2019

3.8 Bethany Fault Study

One surface geophysical survey would be completed perpendicular to the tunneled portion of the Bethany Reservoir Aqueduct (Figure 4). It would be approximately 210 ft long and 3 ft wide. The temporary work area for the geophysical survey would be approximately 50 feet wide.

The survey method would be Electrical Resistivity Tomography (ERT). For the ERT method, a linear array of removable small steel spike electrodes (approximately 0.5 inches [1.27 centimeters] in diameter by 8 inches [20 centimeters] long) would be driven 6 to 8 inches (15 to 20 centimeters) into the ground at a spacing of up to 10 feet (3 meters) along the survey line. Low amperage current would be injected into the ground between varying pairs of electrodes and readings would be taken. The survey would be conducted by foot.

At each test setup low amperage currents would be sent over two electrodes for up to a few seconds while voltage readings in other electrodes are taken. This procedure would be repeated over a period of a few hours along the survey line. The total investigation would be completed in one day.

Figure 4. Geophysical Survey at Bethany Reservoir Aqueduct

3.9 Agronomic Testing

An optional analysis could involve agronomic testing, including investigations and testing of compacted soil rehabilitation methods and rehabilitation treatments for agricultural crop or native grass species establishment. Agronomic testing would be intended to validate the reuse assumptions prior to construction based on representative samples and likely tunneling conditioners. This pilot-scale testing would be used to refine program-level approaches and strategies to reusable tunnel material (RTM) stockpiling and reuse.

This information has been provided at a programmatic level of detail only and would require additional information.

3.9.1 Compacted Soil Rehabilitation Treatments for Post-Construction Agricultural/Grassland Establishment

Following construction, portions of larger construction sites at the intakes, tunnel launch shaft sites, and Bethany Complex are proposed to be restored for agricultural or wild land uses. Field investigations and tests would be used to identify and validate methods to minimize the effects of soil compaction due to construction activities and restore the agricultural and/or wild land potential for the disturbed lands.

A field-scale test program would be conducted to evaluate methods to rehabilitate disturbed sites following construction. The purpose of the test program would be to measure the growth (biomass, cover, vigor) of vegetation within experimental plots and analyze differences in plant growth between amendment types and amendment combinations compared to control plots, for each vegetation type seeded. The field investigation, site preparation, and testing would be conducted over approximately 1 acre at Intake C-E-5 and would be conducted over 10 to 24 months.

If the parcel was not previously compacted, approximately 12 inches of topsoil would be stripped from a test area, then heavy compaction equipment would be used to compact the soil repeatedly to mimic construction activities.

The parcel would be divided into test plots. Each compacted test plot would be ripped, spread with topsoil, and disked. Experimental amendments (that is, gypsum, compost, aged woodchip, or other based on recommendations from Delta farmers with soil rehabilitation experience) would be applied to each test plot and incorporated into the soil profile with another pass with ripping equipment. The selection of amendments would be refined based on recommendations from Delta farmers with soil rehabilitation experience, and based on a literature review on the rehabilitation of soils common to the Delta.

Up to three vegetation types with relatively similar watering requirements would be planted per amendment treatment combination. All vegetation would be identified as non-invasive species to protect nearby parcels not involved in the testing program. Control test plots would also be prepared (no compaction or amendments, disking only) and seeded at each site. Five randomized and interspersed replicates for each amendment combination, including controls, would be created. Each test plot would be approximately 10 ft wide by 20 ft long (with additional buffer in between plots) to allow for ripping, disking, and seeding equipment to be used.

Equipment used in the testing could include large compactors, farm tractors, bulldozers, semi-trucks (amendment delivery), seeding equipment, and small soil moving equipment.

3.9.2 Rehabilitation Treatments for Native Grass Establishment

RTM would be removed from the tunnel boring operations and stored at the tunnel launch shaft sites at the Twin Cities Complex and Lower Roberts Island along the Bethany Reservoir Alignment. Field investigations would be used to identify methods to establish vegetation on the stored RTM or land rehabilitated for agricultural or habitat uses following construction.

The field investigation for RTM rehabilitation treatments would include a greenhouse-scale test program and a field-scale test program.

3.9.2.1 Greenhouse-scale Testing

The greenhouse-scale tests would be conducted by an academic organization or horticulture nursery group at an existing greenhouse. The tests would be conducted in greenhouse test pots over approximately 2 to 4 months. A small-scale greenhouse testing program would allow a wide range of topsoil/amendment combinations to be evaluated within a shorter timeframe; and therefore, identify a smaller number of amendments to use in a larger field-scale study.

Site sourced soil collected from the Twin Cities Complex would be treated with conditioners expected to be used for the Project to create material with properties similar to RTM generated during tunneling operations. The soil would be sourced from shallow test pits, as described and accounted for in Section 3.1.3, and identified as from the same geologic unit as typical tunnel-depth RTM.

The “RTM” would be placed into pots, with various combinations of amendments (that is, sulfur, lime, fertilizer, or other amendments recommended by RTM conditioner manufacturer) and topsoil would be added and mixed with “RTM” in the upper layer of pot. Control treatments would include pots with unamended topsoil and pots with unamended RTM soil. At least 10 randomized replicates for each treatment combination and control would be included. Pots would be seeded with fast-growing grass or forb species and watered until sufficient plant growth occurred to detect differences in plant biomass and vigor between treatments.

No heavy equipment would be used for the greenhouse-scale testing. The testing would include an existing greenhouse, topsoil, amendments, and grass or forb seeds.

3.9.2.2 Field-scale Testing

The field-scale tests would be conducted for 10 to 24 months. The parcel used for testing would be up to 1 acre in size and would be located within the Project footprint at the Twin Cities Complex.

Approximately 12 inches of soil would be stripped from a test area and the topsoil would be stockpiled in a separate 0.5-acre area adjacent to the test site (also within the Project footprint). Site sourced soil would be treated with conditioners expected to be used for the Project to create material with properties similar to RTM generated during tunneling operations. The soil would be sourced from shallow test pits, as described and accounted for in Section 3.1.3 and identified as from the same geologic unit as typical tunnel-depth RTM. The RTM would be placed and spread in the test area and divided into test plots. Based on the results of the greenhouse-scale tests, several amendments or amendment combinations would be applied to the test plots and ripped into the RTM to incorporate amendment into the RTM. Varying amounts of topsoil (such as 6 inches, 12 inches, or zero topsoil) would be applied as a secondary treatment factor. Fast-growing grasses or forbs would be seeded in all plots. All vegetation would be identified as non-invasive species to protect nearby parcels not involved in the testing program. Five randomized and interspersed replicates for each treatment combination and control would be created. Each test plot would be approximately 10 ft wide by 20 ft long to allow use of ripping, disking, and seeding equipment.

Equipment used in the testing could include farm tractors, bulldozers, semi-trucks (amendment delivery), seeding equipment, and small soil moving equipment.

3.10 Utility Potholing

It is assumed that utility potholing, utilizing either a vacuum excavator or a backhoe, would be conducted to confirm locations of existing utilities such as public and residential utilities, surface water diversions, and agricultural drainage features. It is assumed that utility potholing would be conducted at locations near the intakes, underground supervisory control and data acquisition (SCADA) and power corridors, road and bridge modifications including intersections, tunnel shaft sites, the Bethany Complex, and along the tunnel alignment, as summarized in Table 3.7. Refer to Attachment A for additional details and quantities.

The investigations would include vacuum or backhoe excavations, followed by noninvasive surface field surveys. Some features would not require utility potholing and would be located using only noninvasive surface field surveys.

The vacuum excavator would use air under a vacuum to remove soil surrounding buried utilities through suction. The soil would be agitated by a crew member while another crew member vacuums the soil out of the exploration hole. This vacuum process safely excavates the soil, leaving the utilities intact. Each vacuum excavation investigation, including set-up, backfill, and clean up, would take approximately 1.5 hours.

In some cases, a backhoe would be used to expose the utility to determine its location. Backhoe locating would be used where the exact location of the utility can't be established, and an exploratory excavation is required to locate the utility. This method would mostly be applicable to certain agricultural irrigation and drainage features. Under this method, a backhoe would excavate the soil to determine the location of buried utilities. Each backhoe excavation investigation, including set-up, backfill, and clean up, would take approximately 2.5 hours.

The average depth of investigation for either method would be between 5 to 10 feet. The excavations would be backfilled with soil cuttings from the excavation or with grout, depending on method, feature owner, and permit requirements. Excess cuttings would be disposed of off-site at a permitted disposal site. The investigations would be conducted within the construction boundaries of the Project, as shown on the engineering concept drawings and associated GIS files.

Table 3.7 Summary of Utility Potholing during Pre-Construction Phase

Facility or Site	Vacuum Excavations	Potholing Excavations
Intake C-E-3	2	6
Intake C-E-5	2	6
SCADA Route from Intakes to Sacramento	8	0
Power Alignment from Franklin Substation to Intakes	4	0

Facility or Site	Vacuum Excavations	Potholing Excavations
Intake Haul Road at Town of Hood	8	0
Bridge Modifications and Intersection work at Hood-Franklin Road and Intake Haul Road	4	0
Intake Haul Road and SCADA Ductbank	8	4
Lambert Road Widening, Lambert Batch Plant, and Power Alignment at Lambert Road and Franklin Boulevard	8	2
SCADA Route from Lambert Road and Franklin Boulevard to Eschinger Road	4	0
Twin Cities Road, Franklin Boulevard, Dierssen Road Widening	3	4
Twin Cities Complex	0	8
New Hope Tract Maintenance Shaft	0	2
Canal Ranch Tract Maintenance Shaft	1	0
Terminous Tract Reception Shaft	2	0
SCADA Route on State Route 12	6	0
King Island Maintenance Shaft	2	1
Lower Roberts Island Double Launch Shaft	0	6
Lower Roberts Island Levee Improvements	0	4
Lower Roberts Island Access Road and Bridge through Port of Stockton	10	0
Lower Roberts Island SCADA Route	6	0
Upper Jones Tract Maintenance Shaft	0	1
Union Island Maintenance Shaft	0	1
Bethany Complex, Bethany Reservoir Pumping Plant and Surge Basin	6	4
Bethany Complex, Aqueduct and Discharge Structure	9	2
Bethany Complex Raw Water Feed from Skinner Facility	1	0
Byron Highway Widening and Lindemann Road Interchange	6	0
Kelso Road Widening	2	0
New Access Roads within Bethany Complex Area	6	4
Mountain House Road Widening	3	3
New Bethany Reservoir Access Road	2	0
Grant Line Road Widening and Roundabout	2	0
SCADA Route to Mountain House	8	0

Facility or Site	Vacuum Excavations	Potholing Excavations
SCADA Route to Banks Pumping Plant	2	0
Power from Brentwood	6	0
Power Alignment from WAPA Tracy Substation	0	0
Park-and-Ride Lots	4	0
Tunnel Alignment	2	2

Notes: Information regarding utility and underground features is limited, therefore all potholing excavation quantities are estimates. It is assumed that most open drains with piped crossings could be located by conventional survey without ground disturbance. This table includes utility locating that includes either vacuum or backhoe excavation, non-invasive utility location is not included. Power and SCADA are included in listed facilities or sites, unless otherwise listed.

4. Geotechnical Investigations during Construction Phases

The following activities are anticipated to be conducted after the start of construction. These activities are primarily related to the installation of monitoring equipment, such as inclinometers, confirmatory sampling for areas of ground improvement, and investigations related to evaluation of changes in anticipated conditions or alternative contractor means and methods. Geotechnical investigations or the installation of monitoring equipment would be conducted within the first 2 years following the start of Year 1 construction.

4.1 Soil Borings and Cone Penetration Tests

It is assumed that additional soil borings and CPTs would be conducted within the "construction boundaries" of the intakes, tunnels, tunnel shafts, access roads and bridges, powerlines, Bethany Reservoir Pumping Plant and Surge Basin, Bethany Reservoir Aqueduct, and Bethany Reservoir Discharge Structure. It is assumed that the entire area of these construction sites would be disturbed during construction.

The geotechnical investigations during the construction phase would generally be conducted within the first 2 years of the proposed construction period, including during the period when ground improvement activities would be conducted, although they could extend throughout the duration of construction and commissioning to account for delayed starts and to resolve disputes. These investigations could be conducted at any location within the construction boundaries and would also be used to confirm the suitability of construction means and methods planned by the contractor.

It is assumed that exploration during construction would be on the order of 10 percent of the total exploration conducted to support design activities, plus 40 additional explorations to address ground improvement confirmation at each intake and shaft sites as well as 80 additional explorations at the Bethany Complex.

Table 4.1 Summary of Geotechnical Investigations during Construction Phases

Facility	Soil Borings on Land	CPTs on Land
Tunnel	10 percent	10 percent
Shafts (Each)	10 percent	10 percent + 40
Roadways	10 percent	not applicable

Facility	Soil Borings on Land	CPTs on Land
Bridges	10 percent	not applicable
Levees	10 percent	not applicable
Rail	10 percent	not applicable
Powerlines	10 percent	not applicable
Bethany Complex	10 percent	10 percent + 80
Intake (Each)	10 percent	10 percent + 40
Totals	Refer to attachment A	Refer to attachment A

OC – on center
10 percent = 10 percent of design-level investigation quantities

A summary is provided in Table 4.1. Refer to Attachment A for details and quantities of explorations conducted during construction.

4.2 Construction Monitoring

4.2.1 Monitoring for Ground Movement during Construction

It is assumed that inclinometers and extensometers would be installed in vertical borings along levees at the intakes, King Island, Lower Roberts Island, Upper Jones Tract, Victoria Island, Union Island, and Coney Island; and along levees near bridge improvements along Hood-Franklin Road over Snodgrass Slough and the access road to Lower Roberts Island over Burns Cut and Turner Cut. Inclinometers and extensometers are also planned at the Bethany Complex. The average installation depth is assumed to be 150 ft. No instrumentation is assumed at the new levees, while inclinometers are planned at 1000-ft centers along areas of levee improvements.

It is assumed that tilt meters, settlement plates, and survey monuments would be installed at all construction sites and approximately every mile along the tunnel alignment. Some of the survey monuments would be approximately 2 inches in diameter. However, monuments located near levees could be approximately 3 ft by 3 ft base and 8 to 10 ft high to be of adequate size to be visible from satellites, as described in Section 3.1.4. It is assumed that periodic monitoring of this instrumentation would be conducted by security and onsite personnel.

4.2.2 Groundwater Monitoring

If groundwater monitoring wells were installed before construction, those monitoring wells could continue to be used during and following construction. Additional groundwater monitoring wells could be installed during construction if permanent easements or land ownership were not acquired before to construction, or if initial monitoring results indicated the need for more detailed information related to groundwater elevation or water quality. It is anticipated that the groundwater monitoring locations would be located at the intakes, tunnel shafts, access roads, Bethany Complex, and at approximately every 2 miles along the tunnel alignment between shafts. Monitoring wells would be up to 4 inches in completed diameter. It is assumed that management of the groundwater monitoring program would be conducted partially using remotely monitored instrumentation and partially by onsite personnel.

4.2.3 Summary of Instrumentation

Table 4.2 and Attachment B summarize the instrumentation planned at the facility locations.

Table 4.2 Summary of Instrumentation Planned during Construction Phases

Facility	Inclinometers	Extensometers	Test Wells	Monitoring Wells
Tunnel	Every 5,000 ft OC	Every 5,000 ft OC	none	Every 5,000 ft OC as required
Shafts (Each)	3	4	1	2
Roadways	none	none	none	none
Bridges (Each)	2	none	none	none
Levees	1,000 ft OC (repair)	none	none	none
Rail	none	none	none	none
Powerlines	none	none	none	none
Bethany Complex	21	12	2	8
Intake (Each)	4	4	1	2
Totals	Refer to Attachment B	Refer to Attachment B	Refer to Attachment B	Refer to Attachment B

4.2.4 Location of Buried Groundwater and Natural Gas Wells

It is assumed that land surveys, drilling, and trenching would be used at all intake and tunnel shaft locations, along tunnel alignments, and at the Bethany Complex to identify and abandon buried groundwater and natural gas and oil wells before and during construction.

It is assumed that 40 percent of the ground-based CVTFM surveys conducted during the design phase prior to construction (described in Section 3.6), or 120 locations, would require additional investigations to determine exact locations of buried groundwater or natural gas wells. It is assumed that 3 test trenches (approximately 30 ft long, 3 ft wide, and 10 ft deep) would be implemented at each of the 120 locations.

5. References

American Association of State Highway and Transportation Officials (AASHTO). 2018. Policy on Geometric Design of Highways and Streets. 7th Edition.

California Department of Water Resources (DWR). 2023. Delta Conveyance Project Final Environmental Impact Report. SCH# 2020010227. December.

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Rogers, B.M., J.R. Cassidy, M.I. Dragila. 2005. "Ground-Based Magnetic Surveys as a New Technique to Locate Subsurface Drainage Pipes: A Case Study." *Applied Engineering in Agriculture*. Vol. 21, No.3. pp. 421-426.

Attachment A
Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Summary of 408 Support-Phase Exploration and Monitoring

Facility	Approximate Number of Soil Borings (backfilled)	Approximate Number of Soil Borings (overwater backfilled)	Approximate Number of Test Wells	Approximate Number of Soil Borings Completed as Piezometers	Approximate Footage of Soil Borings	Approximate Number of CPTs	Approximate Footage of CPTs
Tunnels	0	1	0	0	200	2	400
Intakes	22	0	2	16	6,000	20	2,400
Totals	22	1	2	16	6,200	22	2,800

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Summary of Design-Phase (Prior to Construction) Exploration and Monitoring

Facility	Approximate Number of Soil Borings (backfilled)	Approximate Number of Overwater Soil Borings (backfilled)	Approximate Number of Test Wells	Approximate Number of Soil Borings Completed as Piezometers	Approximate Footage of Soil Borings	Approximate Footage of Overwater Soil Borings (backfilled)	Approximate Number of CPTs	Approximate Footage of CPTs
Tunnels	150	11	0	77	45,380	2,200	266	53,180
Shafts	33	0	11	33	13,200	not applicable	66	13,200
Roadways & Bridges	218	11	0	0	4,410	975	0	not applicable
Levees	50	0	0	50	6,975	not applicable	0	not applicable
Rail	44	0	0	0	2,200	not applicable	0	not applicable
Powerlines	68	0	0	0	5,175	not applicable	0	not applicable
Bethany Complex	41	0	4	22	8,995	not applicable	30	4,500
Intakes	24	6	2	16	6,000	900	30	3,600
Totals	628	28	17	199	92,335	4,075	392	74,480

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Summary of Design-Phase (Prior to Construction) Exploration and Monitoring

Pilot Studies for Settlement

Facility	Approximate Number of Soil Borings (backfilled)	Approximate Number of CPTs (overwater)	Approximate Number of Test Wells	Approximate Number of Soil Borings Completed as Piezometers	Approximate Footage of Soil Borings and Wells	Approximate Number of CPTs	Approximate Footage of CPTs	Sesimic Geophysical Arrays	Approximate Total Footage of Arrays	Test trenches	Approximate Footage of Trenches
Pilot Studies for Settlement	10	0	0	0	500	20	1,000	not applicable	not applicable	not applicable	not applicable
Ground Improvement Test	0	0	0	0	not applicable	25	1,250	not applicable	not applicable	not applicable	not applicable
Pile Installation Methods	0	25	0	0	not applicable	0	not applicable	not applicable	not applicable	not applicable	not applicable
Dynamic Soil Properties	10	0	0	0	500	50	2,500	not applicable	not applicable	not applicable	not applicable
West Tracy Fault	6	0	0	0	900	15	2,250	2	9,000	6	6,000
Totals	26	25	0	0	1,900	110	7,000	2	9,000	6	6,000

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Summary of Utility Potholing during Pre-Construction Phase (All Options, Unless Otherwise Noted)

Facility or Site (Corridor)	Vacuum Excavations	Potholing Excavations	Total Excavations	Feature Type	Comments
Intake C-E-3	2	6	8	Raw Water	Assume potential to need to determine locations of 4 existing surface water diversion and 4 agricultural drain features.
Intake C-E-5	2	6	8	Raw Water	Assume potential to need to determine locations of 4 existing surface water diversion and 4 agricultural drain features.
SCADA Route from Intakes to Sacramento	8	0	8	Miscellaneous	Assume potential to need to determine locations of 8 miscellaneous utilities/features.
Power Alignment from Franklin Substation to Intakes	4	0	4	Miscellaneous	Assume potential to need to determine locations of 4 miscellaneous utilities/features.
Intake Haul Road at Town of Hood	8	0	8	Utilities	Assume potential to need to determine locations of 8 existing public (residential) service utilities.
Bridge Modifications and Intersection work at Hood-Franklin Road and Intake Haul Road	4	0	4	Utilities	Assume potential to need to determine locations of 4 existing public (residential) service utilities.
Intake Haul Road and SCADA Ductbank	8	4	12	Raw Water and Agricultural Drainage	Assume potential to need to determine locations of 3 existing surface water diversion and 9 agricultural drain features.
Lambert Road Widening, Lambert Batch Plant, and Power Alignment at Lambert Road and Franklin Boulevard	8	2	10	Utilities, Agricultural Drainage, Miscellaneous	Assume potential to need to determine locations of 6 existing public service utilities, 2 agricultural drainage features, plus 2 miscellaneous utilities/features.
SCADA Route from Lambert Road and Franklin Boulevard to Eschinger Road	4	0	4	Miscellaneous	Assume potential to need to determine locations of 4 miscellaneous utilities/features.
Twin Cities Road, Franklin Boulevard, Dierssen Road Widening	3	4	7	Agricultural Drainage, Miscellaneous	Assume potential to need to determine locations of 6 miscellaneous utilities/features, plus 1 agricultural drainage feature.
Twin Cities Complex	0	8	8	Agricultural Drainage /Irrigation	Assume potential to need to determine locations of 4 existing irrigation and 4 agricultural drain features.
New Hope Tract Maintenance Shaft	0	2	2	Agricultural Drainage	Includes site and road widening/improvements for access from Blossom Road; assume potential to need to determine location of 2 agricultural drainage features.
Canal Ranch Tract Maintenance Shaft	1	0	1	Miscellaneous	Assume potential to need to determine location of 1 miscellaneous utility/feature.
Terminous Tract Reception Shaft	2	0	2	Miscellaneous	Includes site and turn pocket work on Highway 12; assume potential to need to determine locations of 2 miscellaneous utilities/features in Highway 12.
SCADA Route on State Route 12	6	0	6	Miscellaneous	Assume potential to need to determine location of 6 miscellaneous utility/feature.
King Island Maintenance Shaft	2	1	3	Agricultural Drainage /Irrigation and Miscellaneous Utilities	Includes site and connection to adjacent W 8 Mile Road; assume potential to need to determine locations of 1 existing irrigation/agricultural drain feature and 2 public service utilities.
Lower Roberts Island Double Launch Shaft	0	6	6	Agricultural Drainage /Irrigation	Assume interface with access road/rail at W House Rd, just east of RTM area; assume potential to need to determine locations of 6 existing irrigation/agricultural drain features.
Lower Roberts Island Levee Improvements	0	4	4	Agricultural Drainage /Irrigation	Major irrigation and drainage features at the levees appear to be visible and conventional surveys should suffice; assume potential to need to determine locations of 4 existing buried irrigation/agricultural drain features.
Lower Roberts Island Access Road and Bridge through Port of Stockton	10	0	10	Utilities, Miscellaneous	Assume potential to need to determine locations of 8 existing public service utilities plus 2 miscellaneous utilities/features. Includes EBMUD Aqueducts.
Lower Roberts Island SCADA Route	6	0	6	Miscellaneous	Assume potential to need to determine location of 6 miscellaneous utility/feature.
Upper Jones Tract Maintenance Shaft	0	1	1	Agricultural Drainage /Irrigation	Includes site and connection to adjacent Bacon Island Road; assume potential to need to determine location of 1 existing irrigation/agricultural drain feature.
Union Island Maintenance Shaft	0	1	1	Agricultural Drainage /Irrigation	Includes site and connection to adjacent Bonetti Road; assume potential to need to determine location of 1 existing irrigation/agricultural drain feature.
Bethany Complex, Bethany Reservoir Pumping Plant and Surge Basin	6	4	10	Utilities, Agricultural Drainage /Irrigation, Miscellaneous	Also includes Mountain House Road from Byron Highway to Kelso Road; assume potential to need to determine locations of 4 existing public service utilities, 4 irrigation/agricultural drainage features, plus 2 miscellaneous utilities/features.
Bethany Complex, Aqueduct and Discharge Structure	9	2	11	CVP, DWR, Agricultural Drainage /Irrigation, gas/fuel, Miscellaneous	Assume potential to need to determine locations of 3 CVP crossings, 1 DWR fiber cable; 2 irrigation/agricultural drainage features, 3 gas/fuel line, plus 2 miscellaneous utilities/features.
Bethany Complex Raw Water Feed from Skinner Facility	1	0	1	Miscellaneous	Assume potential to need to determine location of 1 miscellaneous utility/feature.
Byron Highway Widening and Lindemann Road Interchange	6	0	6	Utilities, Miscellaneous	Assume potential to need to determine locations of 4 existing public service utilities plus 2 miscellaneous utilities/features.
Kelso Road Widening	2	0	2	Miscellaneous	Assume potential to need to determine locations of 2 miscellaneous utilities/features.
New Access Roads within Bethany Complex Area	6	4	10	Agricultural Drainage /Irrigation, Miscellaneous	Includes new roads south of Byron Highway, not listed elsewhere; assume potential to need to determine locations of 8 irrigation/agricultural drainage features, plus 2 miscellaneous utilities/features.
Mountain House Road Widening	3	3	6	CVP, Agricultural Drainage /Irrigation, Miscellaneous	Includes new bypass road just north/west of Grant line; Assume potential to need to determine locations of 1 CVP crossing, 3 irrigation/agricultural drainage features, plus 2 miscellaneous utilities/features.
New Bethany Reservoir Access Road	2	0	2	DWR	Assume potential to need to determine location of DWR fiber at 2 locations.
Grant Line Road Widening and Roundabout	2	0	2	Miscellaneous	Assume potential to need to determine locations of 2 miscellaneous utilities/features.
SCADA Route to Mountain House	8	0	8	Miscellaneous	Assume potential to need to determine locations of 8 miscellaneous utilities/features.
SCADA Route to Banks Pumping Plant	2	0	2	Miscellaneous	Assume potential to need to determine locations of 2 miscellaneous utilities/features.
Power from Brentwood	6	0	6	Miscellaneous	Assume potential to need to determine locations of 6 miscellaneous utilities/features.
Power Alignment from WAPA Tracy Substation	0	0	0	Miscellaneous	Assume none required.
Park-and-Ride Lots	4	0	4	Miscellaneous	Assume potential to need to determine locations of 2 miscellaneous utilities/features at each site, 2 sites.
Tunnel Alignment	2	2	4	Miscellaneous	Assume up to 4 buried utilities crossing the tunnel alignment would be explored to form a baseline location for settlement monitoring.

Notes: Information regarding utility and underground features is limited, therefore all potholing excavation quantities are estimates. It is assumed that most open drains with piped crossings could be located by conventional survey without ground disturbance. This table includes utility locating that includes either vacuum or backhoe excavation, non-invasive utility location is not included. Power and SCADA are included in listed facilities or sites, unless otherwise listed.

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Summary of Construction-Phase Exploration

Facility	Approximate Number of Soil Borings	Approximate Footage of Soil Borings	Approximate Number of CPTs	Approximate Footage of CPTs
Tunnels	15	4,538	27	5,318
Shafts	3	1,320	58	89,320
Roadways & Bridges	22	441	0	not applicable
Levees	5	698	0	not applicable
Rail	4	220	0	not applicable
Powerlines	7	518	0	not applicable
Bethany Complex	4	900	83	12,450
Intakes	2	600	45	9,960
Totals	63	9,234	212	117,048

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Approximate Number of Investigations Along Tunnel Alignment

Tunnel Section	Tunnel Length (feet)	Approximate Number of Soil Borings	Approximate Number of Soil Borings Completed as Piezometers (subset of total)	Approximate Number of Overwater Soil Borings	Approximate Average Boring Depth (ft)	Approximate Average Overwater Boring Depth (ft)	Approximate Number of CPTs	Approximate Average CPT Depth (ft)
Tunnel Reception Shaft at Intake C-E-3 to Tunnel Maintenance Shaft at Intake C-E-5	13,200	12	4	0	200	200	15	200
Tunnel Maintenance Shaft at Intake C-E-5 to Tunnel Launch Shaft Site on Twin Cities Complex	29,800	29	10	0	200	200	34	200
Tunnel Launch Shaft Site on Twin Cities Complex to Tunnel Maintenance Shaft on New Hope Tract	24,200	23	8	2	200	200	27	200
Tunnel Maintenance Shaft on New Hope Tract to Tunnel Maintenance Shaft on Canal Ranch Tract	15,800	15	5	1	200	200	18	200
Tunnel Maintenance Shaft on Canal Ranch Tract to Tunnel Reception Shaft on Terminous Tract	27,000	26	9	1	200	200	30	200
Tunnel Reception Shaft on Terminous Tract to Tunnel Maintenance Shaft on King Island	20,800	20	7	1	200	200	23	200
Tunnel Maintenance Shaft on King Island to Dual Tunnel Launch Shaft on Lower Roberts Island	29,400	28	9	1	200	200	33	200
Dual Tunnel Launch Shaft on Lower Roberts Island to Tunnel Maintenance Shaft on Upper Jones Tract	27,000	26	9	1	200	200	30	200
Tunnel Maintenance Shaft on Upper Jones Tract to Tunnel Maintenance Shaft on Union Island	22,200	21	7	2	200	200	25	200
Tunnel Maintenance Shaft on Union Island to Tunnel Reception Shaft Site at the Bethany Reservoir Pumping Plant	27,500	27	9	2	200	200	31	200
TOTAL	236,900	227	77	11	45380	2200	266	53180
					Total Footage	Total Footage		Total Footage

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Approximate Number of Investigations at Tunnel Shafts

Shafts	Approximate Number of Soil Borings	Approximate Number of Soil Borings Completed as Piezometers (subset of total)	Approximate Average Boring Depth (ft)	Approximate Number of CPTs	Approximate Average CPT Depth (ft)	Approximate Number of Test Wells (200 ft)
Tunnel Reception Shaft at Intake C-E-3	6	3	200	6	200	1
Tunnel Maintenance Shaft at Intake C-E-5	6	3	200	6	200	1
Tunnel Launch Shaft Site on Twin Cities Complex	6	3	200	6	200	1
Tunnel Maintenance Shaft on New Hope Tract	6	3	200	6	200	1
Tunnel Maintenance Shaft on Canal Ranch Tract	6	3	200	6	200	1
Tunnel Reception Shaft on Terminous Tract	6	3	200	6	200	1
Tunnel Maintenance Shaft on King Island	6	3	200	6	200	1
Dual Tunnel Launch Shaft on Lower Roberts Island	6	3	200	6	200	1
Tunnel Maintenance Shaft on Upper Jones Tract	6	3	200	6	200	1
Tunnel Maintenance Shaft on Union Island	6	3	200	6	200	1
Tunnel Reception Shaft Site at the Bethany Reservoir Pumping Plant	6	3	200	6	200	1
TOTAL	66	33	13200	66	13200	11
			Total Footage		Total Footage	

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Approximate Number of Investigations for Rail

Facility	Length (feet)	Approximate Number of Soil Borings	Approximate Average Boring Depth (ft)
Twin Cities Complex	20000	28	50
Dual Tunnel Launch Shaft on Lower Roberts Island	11000	16	50
TOTAL	31000	44	2200
			Total Footage

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Approximate Number of Investigations for Roadways

Facility	Access Road (feet)	Approximate Number of Soil Borings	Approximate Average Boring Depth (ft)	Bridge (spans)	Approximate Number of Soil Borings	Approximate Average Boring Depth (ft)	Approximate Number of Overwater Soil Borings	Approximate Average Overwater Boring Depth (ft)
Access from Intake C-E-5 to Intake C-E-3	1000	2	15	6	2	75	5	75
Access from Twin Cities Complex to Intake C-E-5	27200	37	15	0	0	not applicable	0	not applicable
Access to Twin Cities Complex	15300	21	15	0	0	not applicable	0	not applicable
Access to Tunnel Maintenance Shaft on New Hope Tract	1500	3	15	0	0	not applicable	0	not applicable
Access to Tunnel Maintenance Shaft on Canal Ranch Tract	0	1	15	0	0	not applicable	0	not applicable
Access to Tunnel Reception Shaft on Terminous Tract	4000	6	15	0	0	not applicable	0	not applicable
Access to Tunnel Maintenance Shaft on King Island	0	1	15	0	0	not applicable	0	not applicable
Access to Dual Tunnel Launch Shaft on Lower Roberts Island	28000	38	15	13	2	100	6	100
Access to Tunnel Maintenance Shaft on Upper Jones Tract	0	1	15	0	0	not applicable	0	not applicable
Access to Tunnel Maintenance Shaft on Union Island	0	1	15	0	0	not applicable	0	not applicable
Access to Pumping Plant and Mountain House shaft	30000	41	15	3	4	100	0	not applicable
Access to Bethany Discharge Structure and Aqueducts	32000	44	15	5	6	100	0	not applicable
Hood Franklin Park and Ride Lot		4	15	0	0	not applicable	0	not applicable
Charter Way Park and Ride Lot		4	15	0	0	not applicable	0	not applicable
TOTAL	139000	204	3060	27	14	1350	11	975
			Total Footage			Total Footage		Total Footage

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Approximate Number of Investigations for Levees

Facility	Length (feet)	Approximate Number of Soil Borings	Approximate Number of Soil Borings Completed as Piezometers (subset of total)	Approximate Average Boring Depth (ft)
Tunnel Launch Shaft Site on Twin Cities Complex	20160	62	31	50
Lower Roberts Island Levee Repair	6000	39	20	100
TOTAL	20160	101	50	6975

Total Footage

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Note: no investigations assumed for powerlines on existing poles and no investigations for buried power within roadways (addressed by roadway borings)

Approximate Number of Investigations for Powerlines

Facility	Powerlines (feet)	Approximate Number of Soil Borings	Approximate Average Boring Depth (ft)
Bethany Pumping Plant	64000	65	75
Trenchless crossings	not applicable	3	100
TOTAL	64000	68	5175
			Total Footage

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Approximate Number of Investigations for Bethany Complex

Facility	Approximate Number of Soil Borings	Approximate Number of Soil Borings Completed as Piezometers (subset of total)	Approximate Average Boring Depth (ft)	Approximate Number of CPTs	Approximate Average CPT Depth (ft)	Approximate Number of Test Wells (150 feet)
Bethany Reservoir Pumping Plant and Surge Basin	25	10	150	30	150	2
Bethany Aqueduct (9,200 feet)	17	4	50	0	not applicable	0
Bethany Aqueduct Tunnels (3,700 feet)	16	6	150	0	not applicable	2
Bethany Reservoir Discharge Structure	5	2	75	0	not applicable	0
TOTAL	63	22	8995	30	4500	4
			Total Footage (see Note 1)		Total Footage	

Note 1: Includes two 800-foot-long inclined coreholes for the Conservation Easement Tunnel

Attachment A. Potential Future Field Investigations to Support 408 Permitting, Design and Construction

Approximate Number of Investigations for Intakes

Facility	Approximate Number of Soil Borings (levee)	Approximate Number of Levee Soil Borings Completed as Piezometers (subset of total)	Approximate Average Boring Depth (ft)	Approximate Number of Soil Borings (site)	Approximate Number of Site Soil Borings Completed as Piezometers (subset of total)	Approximate Average Boring Depth (ft)	Approximate Number of Overwater Soil Borings	Approximate Average Overwater Boring Depth (ft)	Approximate Number of CPTs (site)	Approximate Average CPT Depth (ft)	Approximate Number of Test Wells (site - 150 feet)
Intake C-E-3	10	4	150	10	4	150	3	150	15	120	1
Intake C-E-5	10	4	150	10	4	150	3	150	15	120	1
TOTAL	20	8	3000	20	8	3000	6	900	30	3600	2
			Total Footage			Total Footage		Total Footage		Total Footage	

Attachment B
Construction Instrumentation

Attachment B: Construction Instrumentation

Note: Soil borings and CPTs conducted during construction are summarized in Attachment A and are not reproduced here.

Construction Instrumentation Summary

Facility	Approximate Number of Inclinometers	Approximate Number of Extensometers	Total Footage of Borings to install inclinometers and extensometers	Approximate Number of Test Wells	Approximate Number of Piezometers	Total Footage of Borings to install test wells and monitoring wells
Tunnels	36	36	11,214	0	36	5,607
Shafts	33	44	11,550	11	22	4,950
Roadways & Bridges	8	0	750	0	0	0
Levees	7	0	700	0	0	0
Rail	0	0	0	0	0	0
Powerlines	0	0	0	0	0	0
Bethany Complex	21	12	3,990	2	8	1,110
Intakes	8	8	2,400	2	4	900
Totals	113	100	30,604	15	70	12,567

Attachment B: Construction Instrumentation

Approximate Number of Instruments Along Tunnel Alignment

Tunnel Section	Tunnel Length (feet)	Approximate Number of Inclinometers	Approximate Average Instrument Depth (ft)	Approximate Number of Extensometers	Approximate Average Instrument Depth (ft)	Approximate Number of Test Wells	Approximate Number of Piezometers	Approximate Average Piezometer Depth (ft)
Tunnel Reception Shaft at Intake C-E-3 to Tunnel Maintenance Shaft at Intake C-E-5	13,200	2	150	2	150	0	2	150
Tunnel Maintenance Shaft at Intake C-E-5 to Tunnel Launch Shaft Site on Twin Cities Complex	29,800	5	150	5	150	0	5	150
Tunnel Launch Shaft Site on Twin Cities Complex to Tunnel Maintenance Shaft on New Hope Tract	24,200	4	150	4	150	0	4	150
Tunnel Maintenance Shaft on New Hope Tract to Tunnel Maintenance Shaft on Canal Ranch Tract	15,800	2	150	2	150	0	2	150
Tunnel Maintenance Shaft on Canal Ranch Tract to Tunnel Reception Shaft on Terminous Tract	27,000	4	150	4	150	0	4	150
Tunnel Reception Shaft on Terminous Tract to Tunnel Maintenance Shaft on King Island	20,800	3	150	3	150	0	3	150
Tunnel Maintenance Shaft on King Island to Dual Tunnel Launch Shaft on Lower Roberts Island	29,400	5	150	5	150	0	5	150
Dual Tunnel Launch Shaft on Lower Roberts Island to Tunnel Maintenance Shaft on Upper Jones Tract	27,000	4	150	4	150	0	4	150
Tunnel Maintenance Shaft on Upper Jones Tract to Tunnel Maintenance Shaft on Union Island	22,200	3	150	3	150	0	3	150
Tunnel Maintenance Shaft on Union Island to Tunnel Reception Shaft Site at the Bethany Reservoir Pumping Plant	27,500	5	150	5	150	0	5	150
TOTAL	236,900	36	5607	36	5607	0	36	5607
			Total Footage		Total Footage			Total Footage

Attachment B: Construction Instrumentation

Approximate Number of Instruments at Tunnel Shafts

Shafts	Approximate Number of Inclinometers	Approximate Average Inclinometer Depth (ft)	Approximate Number of Extensometers	Approximate Average Extensometer Depth (ft)	Approximate Number of Test Wells	Approximate Number of Monitoring Wells	Approximate Average Well Depth (ft)
Tunnel Reception Shaft at Intake C-E-3	3	150	4	150	1	2	150
Tunnel Maintenance Shaft at Intake C-E-5	3	150	4	150	1	2	150
Tunnel Launch Shaft Site on Twin Cities Complex	3	150	4	150	1	2	150
Tunnel Maintenance Shaft on New Hope Tract	3	150	4	150	1	2	150
Tunnel Maintenance Shaft on Canal Ranch Tract	3	150	4	150	1	2	150
Tunnel Reception Shaft on Terminous Tract	3	150	4	150	1	2	150
Tunnel Maintenance Shaft on King Island	3	150	4	150	1	2	150
Dual Tunnel Launch Shaft on Lower Roberts Island	3	150	4	150	1	2	150
Tunnel Maintenance Shaft on Upper Jones Tract	3	150	4	150	1	2	150
Tunnel Maintenance Shaft on Union Island	3	150	4	150	1	2	150
Tunnel Reception Shaft Site at the Bethany Reservoir Pumping Plant	3	150	4	150	1	2	150
TOTAL	33	4950	44	6600	11	22	4950
		Total Footage		Total Footage			Total Footage

Attachment B: Construction Instrumentation

Approximate Number of Instruments for Roadways

Facility	Bridge (spans)	Approximate Number of Inclinometers	Approximate Average Inclinometer Depth (ft)
Access from Intake C-E-5 to Intake C-E-3	6	2	75
Access from Twin Cities Complex to Intake C-E-5	0	0	not applicable
Access to Twin Cities Complex	0	0	not applicable
Access to Tunnel Maintenance Shaft on New Hope Tract	0	0	not applicable
Access to Tunnel Maintenance Shaft on Canal Ranch Tract	0	0	not applicable
Access to Tunnel Reception Shaft on Terminous Tract	0	0	not applicable
Access to Tunnel Maintenance Shaft on King Island	0	0	not applicable
Access to Dual Tunnel Launch Shaft on Lower Roberts Island	13	2	100
Access to Tunnel Maintenance Shaft on Upper Jones Tract	0	0	not applicable
Access to Tunnel Maintenance Shaft on Union Island	0	0	not applicable
Access to Pumping Plant and Mountain House shaft	3	2	100
Access to Bethany Discharge Structure and Aqueducts	5	2	100
Hood Franklin Park and Ride Lot	0	0	not applicable
Rio Vista Park and Ride Lot	0	0	not applicable
Charter Way Park and Ride Lot	0	0	not applicable
Byron Park and Ride Lot	0	0	not applicable
West Grant Line Park and Ride Lot	0	0	not applicable
Pavilion Pkwy Park and Ride Lot	0	0	not applicable
TOTAL	27	8	750
			Total Footage

Attachment B: Construction Instrumentation

Approximate Number of Instruments for Levee Improvements

Facility	Length (feet)	Approximate Number of Inclinometers	Approximate Average Inclinometer Depth (ft)
Lower Roberts Island Levee Repair	6000	7	100
TOTAL	6000	7	700
			Total Footage

Attachment B: Construction Instrumentation

Approximate Number of Instruments at Bethany Complex

Shafts	Approximate Number of Inclinometers	Approximate Average Inclinometer Depth (ft)	Approximate Number of Extensometers	Approximate Average Extensometer Depth (ft)	Approximate Number of Test Wells	Approximate Number of Monitoring Wells	Approximate Average Well Depth (ft)
Bethany Reservoir Pumping Plant and Surge Basin	10	150	4	150	1	2	150
Bethany Aqueduct (9,200 feet)	3	30	0	0	0	2	30
Bethany Aqueduct Tunnels (3,700 feet)	4	150	4	150	1	2	150
Bethany Reservoir Discharge Structure	4	75	4	75	0	2	75
TOTAL	21	2490	12	1500	2	8	1110
		Total Footage		Total Footage			Total Footage

Attachment B: Construction Instrumentation

Approximate Number of Instruments for Intakes

Facility	Approximate Number of Soil Borings to install inclinometers (levee)	Approximate Average Boring Depth (ft)	Approximate Number of Soil Borings to install extensometers (site)	Approximate Average Boring Depth (ft)	Approximate Number of Piezometers	Approximate Average Piezometer Depth (ft)	Approximate Number of Test Wells	Approximate Average Test Well Depth (ft)
Intake C-E-3	4	150	4	150	2	150	1	150
Intake C-E-5	4	150	4	150	2	150	1	150
TOTAL	8	1200	8	1200	4	600	2	300
		Total Footage		Total Footage		Total Footage		Total Footage

Attachment C
Equipment, Worker and Vehicle Assumptions

Attachment C. Equipment, Worker and Vehicle Assumptions

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
15' Borings On Land	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Drill Rigs - 50-foot deep borings [a]	1	1	1	60	10	500	0.50
	Water Truck [b]	1	1	2	60	10	250	0.38
	Liftgate Truck [a]	1	1	1	60	4	250	0.38
	Geotechnical Team Vehicles - 5 vehicles	1	5	5	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	1	2	2	60	10		
	Regulatory Agency Vehicles - 2 vehicles	1	2	2	60	2		
	Engineering Team Vehicle - 1 vehicle	1	1	1	60	10		

[a] It was assumed 1 total round trip for the drill rig and liftgate truck.
[b] It was assumed 2 round trips per day to account for water truck refills each day.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
50'-75' Borings On Land	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Drill Rigs - 50- to 75-foot deep borings [a]	2	1	1	60	10	500	0.50
	Water Truck [b]	2	1	4	60	10	250	0.38
	Liftgate Truck [a]	2	1	1	60	4	250	0.38
	Geotechnical Team Vehicles - 5 vehicles	2	5	10	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	2	2	4	60	10		
	Regulatory Agency Vehicles - 2 vehicles	2	2	4	60	2		
	Engineering Team Vehicle - 1 vehicle	2	1	2	60	10		

[a] It was assumed 1 total round trip for the drill rig and liftgate truck.
[b] It was assumed 2 round trips per day to account for water truck refills each day.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
100'-150' Borings On Land	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Drill Rigs - 100- to 150-foot deep borings [a]	4	1	1	60	10	500	0.50
	Water Truck [b]	4	1	8	60	10	250	0.38
	Liftgate Truck [a]	4	1	1	60	4	250	0.38
	Geotechnical Team Vehicles - 5 vehicles	4	5	20	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	4	2	8	60	10		
	Regulatory Agency Vehicles - 2 vehicles	4	2	8	60	2		
	Engineering Team Vehicle - 1 vehicle	4	1	4	60	10		

[a] It was assumed 1 total round trip for the drill rig and liftgate truck.
[b] It was assumed 2 round trips per day to account for water truck refills each day.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
175'-200' Borings On Land	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Drill Rigs - 175- to 200-foot deep borings [a]	7	1	1	60	10	550	0.50
	Water Truck [b]	7	1	14	60	10	250	0.38
	Tractor-Trailer Lowboy Truck [c]	2	1	2	60	2	500	
	Liftgate Truck [a]	7	1	1	60	4	250	0.38
	Geotechnical Team Vehicles - 5 vehicles	7	5	35	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	7	2	14	60	10		
	Regulatory Agency Vehicles - 2 vehicles	7	2	14	60	2		
	Engineering Team Vehicle - 1 vehicle	7	1	7	60	10		
	Traffic Control - 2 vehicles	7	2	14	60	10		

[a] It was assumed 1 total round trip for the drill rig and liftgate truck.
[b] It was assumed 2 round trips per day to account for water truck refills each day.
[a] It was assumed 2 total round trips for the tractor-trailer lowboy truck. It would be mobilized at the beginning and end of each investigation.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
Up to 200' CPT on Land	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	CPT Truck [a]	2	1	1	60	10	500	
	Grout Truck [a]	2	1	1	60	2	250	
	Tractor-Trailer Lowboy Truck [b]	2	1	2	60	2	500	
	Geotechnical Team Vehicles - 4 vehicles	2	4	8	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	2	2	4	60	10		
	Regulatory Agency Vehicles - 2 vehicles	2	2	4	60	2		
	Traffic Control - 2 vehicles	2	2	4	60	10		

[a] It was assumed 1 total round trip for the CPT truck and grout truck because they would be present throughout the entire investigation.

[b] It was assumed 2 total round trips for the tractor-trailer lowboy truck. It would be mobilized at the beginning and end of each CPT.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Over Water Borings	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Hazard Survey Boat (<50 HP) [a]	8	1	8	20	4	364	0.45
	Drill Rig Barge/Tugboat or Ship [b]	8 days on site, 2 days operating	1	1	180	10 hours each day of operations (2 days)	1167	0.50
	Worker Transport Boat [c]	9	2	10	20	4	384	0.38
	Geotechnical Team Vehicles - 4 vehicles	8	4	32	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	8	2	16	60	10		
	Regulatory Agency Vehicles - 2 vehicles	8	2	16	60	2		

[a] It was assumed that the hazard survey boat would operate each day of the investigation and include a total of 8 round trips. The average hours assume 4 hours per roundtrip of travel from a nearby marina to the investigation area.

[b] It is assumed that one drill rig barge with one tugboat would travel at 8 knots or 9.2 mph (full) for 10 hours from Port of Stockton to the investigation area. This would take 10 hours each way. Each investigation would require one round trip.

[c] It was assumed that two worker transport boats would be required to transport the field reconnaissance team one day during site clearances. It was assumed that one worker transport boat would be required to transport the geotechnical team and monitors each day the investigation is occurring.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Over Water CPT	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Hazard Survey Boat (<50 HP) [a]	4	1	4	20	4	364	0.45
	CPT Handling Boats [b]	4	2	2	20	4	364	0.45
	Worker Transport Boat [c]	5	2	6	20	4	384	0.38
	Geotechnical Team Vehicles - 4 vehicles	4	4	16	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	4	2	8	60	10		
	Regulatory Agency Vehicles - 2 vehicles	4	2	8	60	2		

[a] It was assumed that the hazard survey boat would operate each day of the investigation and include a total of 4 round trips. The average hours assume 4 hours per roundtrip of travel from a nearby marina to the investigation area.

[b] Two CPT boats are assumed for each day of operations. It was assumed that the CPT boat would operate each day of the investigation and include a total of 4 round trips each. The average hours assume 4 hours per roundtrip of travel from a nearby marina to the investigation area.

[c] It was assumed that two worker transport boats would be required to transport the field reconnaissance team one day during site clearances. It was assumed that one worker transport boat would be required to transport the geotechnical team and monitors each day the investigation is occurring.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
175'-200' Monitoring Wells	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Drill Rigs - 175- to 200-foot deep borings [a]	7	1	1	60	10	550	0.50
	Water Truck [b]	7	1	14	60	10	250	0.38
	Tractor-Trailer Lowboy Truck [c]	2	1	2	60	2	500	
	Liftgate Truck [a]	7	1	1	60	4	250	0.38
	Geotechnical Team Vehicles - 5 vehicles	7	5	35	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	7	2	14	60	10		
	Regulatory Agency Vehicles - 2 vehicles	7	2	14	60	2		
	Engineering Team Vehicle - 1 vehicle	7	1	7	60	10		

[a] It was assumed 1 total round trip for the drill rig and liftgate truck.

[b] It was assumed 2 round trips per day to account for water truck refills each day.

[c] It was assumed 2 total round trips for the tractor-trailer lowboy truck. It would be mobilized at the beginning and end of each investigation.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
175'-200' Test Wells	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Drill Rigs - 175- to 200-foot deep borings [a]	7	1	1	60	10	550	0.50
	Water Truck [b]	7	1	14	60	10	250	0.38
	Tractor-Trailer Lowboy Truck [c]	2	1	2	60	2	500	
	Liftgate Truck [a]	7	1	1	60	4	250	0.38
	Geotechnical Team Vehicles - 5 vehicles	7	5	35	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	7	2	14	60	10		
	Regulatory Agency Vehicles - 2 vehicles	7	2	14	60	2		
	Engineering Team Vehicle - 1 vehicle	7	1	7	60	10		

[a] It was assumed 1 total round trip for the drill rig and liftgate truck.

[b] It was assumed 2 round trips per day to account for water truck refills each day.

[c] It was assumed 2 total round trips for the tractor-trailer lowboy truck. It would be mobilized at the beginning and end of each investigation.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Hours Per day on Site	Horsepower	Load Factor
800' Inclined Borehole	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Drill Rigs - 800-foot inclined borings [a]	30	1	1	60	10	550	0.50
	Water Truck [b]	30	1	60	60	10	250	0.38
	Tractor-Trailer Lowboy Truck [c]	2	1	2	60	2	500	
	Liftgate Truck [a]	30	1	1	60	4	250	0.38
	Geotechnical Team Vehicles - 5 vehicles	30	5	150	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	30	2	60	60	10		
	Regulatory Agency Vehicles - 2 vehicles	30	2	60	60	2		
	Engineering Team Vehicle - 1 vehicle	30	1	30	60	10		

[a] It was assumed 1 total round trip for the drill rig and liftgate truck.

[b] It was assumed 2 round trips per day to account for water truck refills each day.

[c] It was assumed 2 total round trips for the tractor-trailer lowboy truck. It would be mobilized at the beginning and end of each investigation.

		Average Duration (days)	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Pumping Tests	Vertical turbine or submersible well pump[a], [b]	13	1	n/a	n/a	24	200	
	Geotechnical Team Vehicles - 2 vehicles	13	2	26	60	10		
	Regulatory Agency Vehicles - 2 vehicles	13	2	26	60	2		

[a] A pump capable of pumping up to 1500 gallons per minute is assumed.

[b] Drilling of actual well is covered under test well assumptions.

		Average Duration (days)	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Test Trenches (30 ft long x 3 ft wide x 10 ft deep)	Excavator [a]	0.5	1	1	1	5	200	
	Tractor-Trailer Lowboy Truck [b]	0.5	1	0.5	60	1	500	
	Field reconnaissance team - 5 vehicles	0.5	5	2.5	60	1		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	0.5	2	1	60	5		
	Geotechnical Team Vehicles - 3 vehicles	0.5	3	1.5	60	5		
	Regulatory Agency Vehicles - 2 vehicles	0.5	2	1	60	1		

[a] It is assumed that two test trenches could be excavated per day, thus the average duration per location is 0.5 days.

[b] It is assumed that a tractor-trailer lowboy truck would be required to transport the excavator, but that it would only require one round trip for every two investigations.

		Average Duration (days)	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Test Trenches (1,000 ft long x 3 ft wide x 20 feet deep)	Excavator [a]	3	1	1	1	10	200	
	Tractor-Trailer Lowboy Truck [b]	3	1	2	60	2	500	
	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	3	2	6	60	10		
	Geotechnical Team Vehicles - 3 vehicles	3	3	9	60	10		
	Regulatory Agency Vehicles - 2 vehicles	3	2	6	60	2		

[a] It is assumed that the larger test trenches would take three days for each test trench.

[b] It is assumed that a tractor-trailer lowboy truck would be required to transport the excavator and would be mobilized at the beginning and end of the investigation, thus requiring two round trips.

		Average Duration (days)	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Monument Installation [a]	Heavy duty pickup truck with pulled concrete mixer	7	1	7	60	2		
	Portable welder with small engine	7	1	7	n/a	10	10	
	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	7	2	14	60	10		
	Geotechnical Team Vehicles - 1 vehicles	7	1	7	60	10		
	Regulatory Agency Vehicles - 2 vehicles	7	2	14	60	2		

[a] At this time, no fencing or equipment to install fencing is assumed.

		Average Duration (days)	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Test Fills for Settlement Study [a]	Dump truck to haul soil to site [b]	6	36	36	40	0.5		
	Excavator [c]	6	1	n/a	n/a	4		
	Tractor-Trailer Lowboy Truck [c]	6	1	1	40	n/a		
	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	6	2	12	60	10		
	Geotechnical Team Vehicles - 2 vehicles	6	2	12	60	10		
	Regulatory Agency Vehicles - 2 vehicles	6	2	12	60	2		

[a] These assumptions are only for the test fills. The assumptions for borings/CPTs to evaluate the tests are covered by borings or CPT assumptions.

[b] It is assumed that 36 truckloads will deliver material over 6 days.

[c] The tractor-trailer lowboy truck would be used to deliver the excavator to the site.

		Average Duration (days)	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Ground Improvement Test Zones [a]	CDSM Cement	20	1			10		
	Air Compressor 375 CFM	20	1			10		
	Grove RT Crane 30T	20	1			10		
	DMM Deep Soil Mixer	20	1			10		
	DMM Grout Mix Plant	20	1			10		
	Portable 90 Kw Diesel	20	1			10		
	Case 590 SupN Loader	20	1			10		
	Water Pump 4" Electric	20	1			10		
	Pickup 1/2T 2 WD	20	1	20	60	10		
	Truck Flatbed 4 T Highway	20	1	20	60	10		
	Mechanic Truck	20	1	20	60	10		
	Truck Water 4M gallon	20	1	20	60	10		
	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	20	2	40	60	10		
	Ground Improvement Team Vehicles - 10 vehicles	20	10	200	60	10		
	Geotechnical Team Vehicles - 3 vehicles	20	3	60	60	10		
	Regulatory Agency Vehicles - 2 vehicles	20	2	40	60	2		

[a] These assumptions are only for the ground improvement tests. The assumptions for CPTs to evaluate the test are covered by CPT assumptions.

		Average Duration (days)	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Test Pile Installation [a]	Vibratory hammer [b]	2	1	n/a	n/a	n/a	400	
	Diesel pile driving hammer [c]	2	1	n/a	n/a	n/a	275 kJ[d]	
	Crane [e]	4	1	n/a	n/a	n/a	550	
	Drill Rig Barge/Tugboat or Ship [f]	4 days on site, 2 days operating	1	1	180	10 hours each day of operations (2 days)	1167	0.50
	Worker Transport Boat [g]	5	2	6	20	4	384	0.38
	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Geotechnical Team Vehicles - 4 vehicles	4	4	16	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	4	2	8	60	10		
	Regulatory Agency Vehicles - 2 vehicles	4	2	8	60	2		

[a] These assumptions are only for the test piles. The assumptions for CPTs to evaluate the test are covered by overwater CPT assumptions.

[b] It is assumed that the vibratory hammer includes its own hydraulic power pack with diesel engine.

[c] While located on the crane, it is assumed that the pile driving hammer includes a separate diesel engine of approximately 275 kJ.

[d] Note that hp was not immediately available.

[e] It is assumed the crane is operating on a barge and is a 200 ton crane.

[f] It is assumed that one drill rig barge with one tugboat would travel at 8 knots or 9.2 mph (full) for 10 hours from Port of Stockton to the investigation area. This would take 10 hours each way. Each investigation would require one round trip.

[g] It was assumed that two worker transport boats would be required to transport the field reconnaissance team one day during site clearances. It was assumed that one worker transport boat would be required to transport the geotechnical team and monitors each day the investigation is occurring.

		Average Duration (days) [b]	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip [b]	Average Operations Hours Per day on Site	Horsepower	Load Factor
Airborne Magnetic Surveys [a]	Helicopter (Bell 407 or similar)	3	1	n/a	400 miles total over 3 days	10	674 takeoff (5 min), 630 max continuous	
	Geotechnical Team Vehicles - 1 vehicles	3	1	3	60	10		

[a] Method is assumed to be Cesium Vaper Total Field Magnetometer towed by helicopter.

[b] Assumes 400 miles of flying over 3 days to conduct 7 profiles and additional QC checks.

Note: Assumes that no reconnaissance or biological monitor is required.

		Average Duration (days) [b]	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip [c]	Average Operations Hours Per day on Site	Horsepower	Load Factor
Walk-Over Magnetic Surveys [a]	Field reconnaissance team - 5 vehicles	0.25	5	1.25	15	0.5		
	Geotechnical Team Vehicles - 3 vehicles	0.25	3	0.75	15	2.5		
	Regulatory Agency Vehicles - 2 vehicles	0.25	2	0.5	15	0.5		

[a] Method is assumed to be Cesium Vaper Total Field Magnetometer. No onsite vehicle/generator required.

[b] One survey is assumed to be a single 100 ft x 100 ft area, assumed to survey 4 per day, thus average duration is 0.25 days per survey.

[aC] 15 miles per vehicle is assumed for a roundtrip per investigation because the total roundtrip would be 60 miles and 4 investigations would be completed for every 60 mile commute.

		Average Duration (days)	Number of Vehicles per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip	Average Operations Hours Per day on Site	Horsepower	Load Factor
Geophysical Survey - Land-Based	Field reconnaissance team - 5 vehicles	1	5	5	60	2		
	Envirovibe Rig [a], [b]	8	1			10	500	
	Tractor-Trailer Lowboy Truck [a], [b], [c]	2	1	2	60	2	500	
	Geotechnical Team Vehicles - 5 vehicles	8	5	40	60	10		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	8	2	16	60	10		
	Regulatory Agency Vehicles - 2 vehicles	8	2	16	60	2		

[a] It was assumed that the geophysical survey would take up to 8 working days to complete each 1000 ft array.

[b] 500 hp was assumed for the tractor-trailer lowboy truck and Envirovibe Rig.

[[a]] It was assumed 2 total round trips for the tractor-trailer lowboy truck. It would be mobilized at the beginning and end of each survey to transport the Envirovibe Rig.

	Equipment	Average Duration (days) [a]	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip [b]	Average Operations Hours Per day on Site	Horsepower	Load Factor
Utility Potholing - Vacuum Excavation	Vacuum excavator with Tier 4 diesel engine	0.25	1	0.25	15	2.5	150	0.05
	Field reconnaissance team - 5 vehicles	0.25	5	1.25	15	0.5		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	0.25	2	0.5	15	2.5		
	Geotechnical Team Vehicles - 3 vehicles	0.25	3	0.75	15	2.5		
	Regulatory Agency Vehicles - 2 vehicles	0.25	2	0.5	15	0.5		

[a] It is assumed that four potholes could be excavated per day, thus the average duration per location is 0.25 days.

[b] 15 miles per vehicle is assumed for a roundtrip per investigation because the total roundtrip would be 60 miles and 4 investigations would be completed for every 60 mile commute.

	Equipment	Average Duration (days) [b]	Number of Vehicles or pieces of equipment per Investigation	Number of Roundtrips Per Investigation	Average Mileage per Round Trip [c]	Average Operations Hours Per day on Site	Horsepower	Load Factor
Utility Potholing - Backhoe Excavation	Backhoe [a]	0.25	1	0.25	15	2.5	67	
	Tractor-Trailer Lowboy Truck	0.25	1	0.25	15	0.5	500	
	Field reconnaissance team - 5 vehicles	0.25	5	1.25	15	0.5		
	Biological & Cultural Resources Monitors Vehicles - 2 vehicles	0.25	2	0.5	15	2.5		
	Geotechnical Team Vehicles - 3 vehicles	0.25	3	0.75	15	2.5		
	Regulatory Agency Vehicles - 2 vehicles	0.25	2	0.5	15	0.5		

[a] The backhoe has a maximum hp of 100. However, it is assumed that the backhoe operates at 2/3 capacity, or 67 hp.

[b] It is assumed that four potholes could be excavated per day, thus the average duration per location is 0.25 days.

[c] 15 miles per vehicle is assumed for a roundtrip per investigation because the total roundtrip would be 60 miles and 4 investigations would be completed for every 60 mile commute.