Final Feasibility Level Basis of Design Report – HC Conveyance Facilities (rev 1)

Sites Reservoir Project

June 24, 2021

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The initial concept of the Sites Reservoir Project was initiated in 1957 by the California Department of Water Resources and by the U.S. Bureau of Reclamation (Reclamation) in 1964. Over the decades, the project size and components have been revised and studied to gain a better understanding of the need and cost.

On August 26, 2010, the Sites Project Authority (Authority) was formed when seven regional entities, including several local water agencies and counties, executed the Joint Exercise of Powers Authority. The primary purpose of the Authority, as stated in the agreement, is to pursue the development and construction of the Sites Reservoir Project, which has long been viewed as an ideal location for additional off-stream storage to provide direct and real benefits to instream flows, the Delta ecosystem, and water supply. In 2021, the Authority has 32 regional members.

Most recently, a feasibility study was completed by Reclamation that results in a project cost of roughly $5 billion. In September 2019, representatives from the Authority Board and Reservoir Committee began undertaking a value planning process to identify and evaluate additional alternatives that could make the project more affordable for the project's participants. This decision was based on ongoing discussions with permitting agencies, expected project cost, cost per acre-foot, and existing participation levels. An Ad Hoc Value Planning Workgroup was formed and continued to meet through April 2020. The workgroup produced the *Sites Project Value Planning Alternatives Appraisal Report* (Sites Program Management Team 2020) in April 2020 and recommended that the Authority adopt Alternative VP7, which was a 1.5-million-acre-foot reservoir and project, with an estimated cost of $3 billion. The Authority approved moving forward with Alternative VP7.

This report documents the feasibility study engineering effort conducted by Jacobs Engineering for the conveyance facilities associated with Alternative VP 7. The Authority designated "HC" for conveyance facilities, being led by Jacobs and "HR" for reservoir facilities being led by AECOM. This report provides: a brief project description and conveyance facility description, design criteria, and a more detailed description of the conveyance facilities. The appendices provide 14 supporting technical memoranda that were generated during this feasibility-level engineering effort, from June 2020 to June 2021. Not all of these memoranda are referenced in the body of this report. During this effort, 153 design drawings were generated to a 10 to 15% design, to support the development of a Class IV cost estimate, and the development of the project environmental impact statement/environmental impact report. The current total project cost estimate, including construction, mitigation, and other soft costs in 2021 dollars is $3.9 billion. The HC conveyance drawing set is revision 3, dated April 30, 2021 (Jacobs, 2021a). The Sites Reservoir Project HC Conveyance Facilities Feasibility Design Basis of Estimate cost report is dated June 2 2021 (Jacobs, 2021b)..

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1.0 Background

The initial concept of the Sites Reservoir Project was initiated in 1957 by the California Department of Water Resources and by the U.S. Bureau of Reclamation (Reclamation) in 1964. Over the decades, the project size and components have been revised and studied to gain a better understanding of the need and cost.

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1.1 Project Description

The project consists of a large reservoir, ancillary roads, and conveyance facilities. The Authority decided to segregate the design of these facilities into an HR (Segment H Reservoir) segment that is responsible for design of the reservoir features, including several dams, inlet/outlet tunnels at Golden Gate Dam, as well as relocation of roads displaced by the reservoir. The other segment is known as the HC (Segment H Conveyance) segment and includes improvements to the two existing diversion canals from the Sacramento River to the Project Area (Tehama-Colusa Canal and Glenn-Colusa Irrigation District Canal), regulating reservoirs (existing Funks Reservoir and new Terminal Regulating Reservoir), two pumping generating plants (PGP), large-diameter pipelines from each PGP to Sites Reservoir, and a large-diameter pipeline to convey water from the Tehama-Colusa Canal (TCC) to the Colusa Basin Drain or Sacramento River near Dunnigan, California. Detailed descriptions of each facility are provided in the next section. An overall site plan of the project area is provided in Figure 1.

1.2 General Description of Facilities

Following is a list of the individual new facilities and existing facilities requiring improvements.

- Improvements to the TCC Authority Red Bluff Pumping Plant on the Sacramento River
- Glenn-Colusa Irrigation District (GCID) Canal Improvements upstream of the Terminal Regulating Reservoir (TRR)

- TRR–East (Alternative 1)
- TRR–West (Alternative 2)
- TRR PGP
- TRR Pipelines
- Funks Reservoir – Sediment Removal
- Funks PGP
- Funks Pipelines
- Western Area Power Administration (WAPA) or Pacific Gas and Electric (PG&E) Substation/ Switchyard
- Power Transmission Lines
- Dunnigan Pipeline
- Administration and Operations Building
- Maintenance and Storage Building
- Access Roads

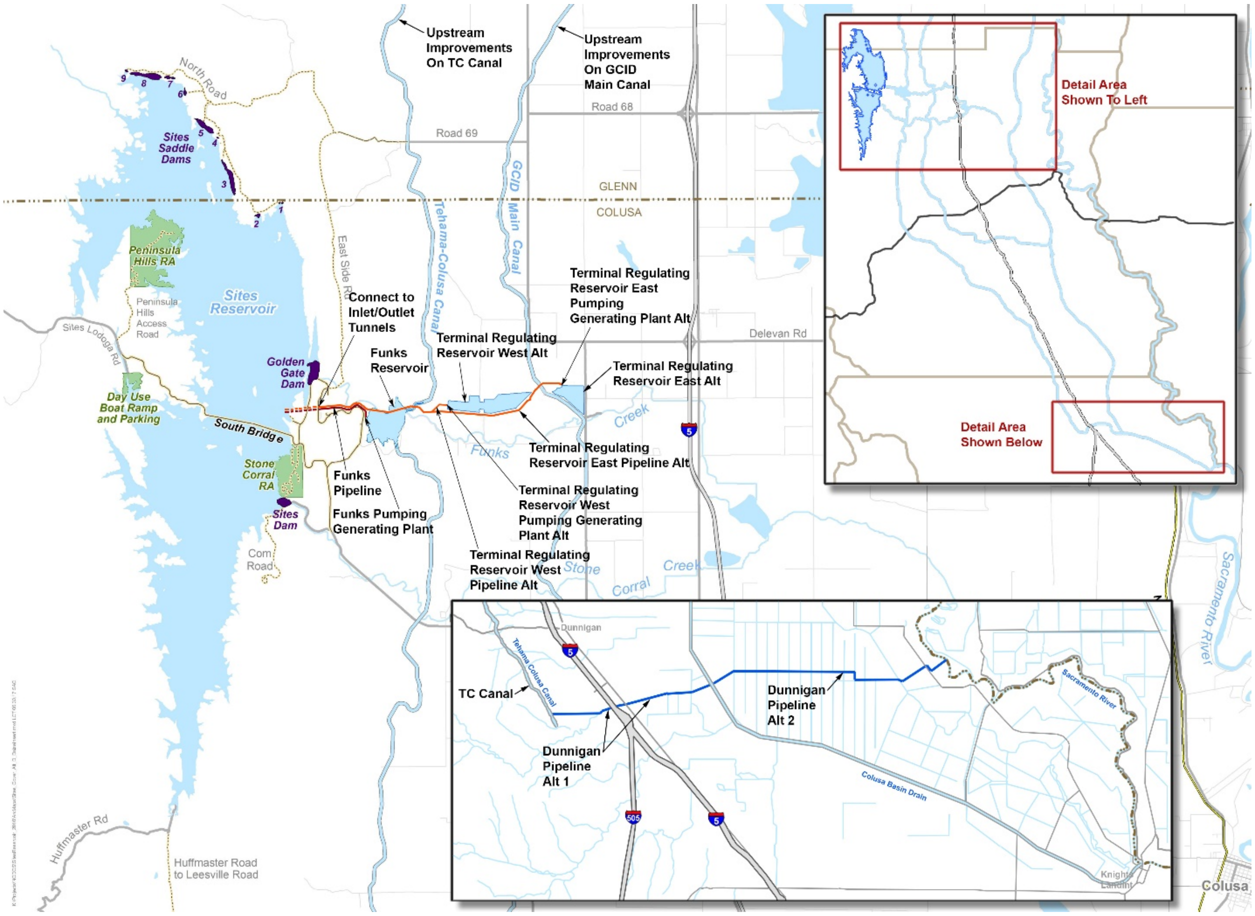

Figure 1. Project Area Site Plan

Improvements to the TCC Red Bluff Pumping Plant

The Red Bluff Diversion is located on the Sacramento River in Red Bluff, California. The facility includes a 2,500 cubic feet per second (cfs) capacity 1,180-foot-long fish screen structure, forebay, pumping plant (current capacity 2,000 cfs), an electrical switchyard, and a 660-foot-long access bridge, canal, and siphon under Red Bank Creek, to deliver water from the Sacramento River into the TCC and Corning Canal. This facility was constructed and put into operation in October 2012. The pumping plant was designed to accommodate the Sites Project and includes space to add two additional 250 cfs pumping units, bringing the total pumping capacity to 2,500 cfs.

GCID Main Canal Improvements

The GCID Main Canal delivers water from the Sacramento River to water users along its route, from its diversion point approximately 5 miles northwest of Hamilton City to southeast of the City of Williams. The canal is a 65-mile unlined earthen channel, with capacity varying from 3,000 cfs at the upstream end to 300 cfs at the southern terminus, where it spills into the Colusa Basin Drain. Water conveyed by the canal is pumped by the Hamilton City Main Pump Station into the GCID Main Canal.

Improvements to the GCID Main Canal will include a 3,000 cfs headworks structure just downstream of the Hamilton City Diversion, two new siphon structures (Willow Creek and Walker Creek), modifications to an existing railroad siphon at Willows, canal earthwork, and some canal bank gravel road improvements. The need for replacement of the siphons and railroad crossing will be determined after a canal hydraulic model is completed, as well as a condition assessment anticipated for early 2021.

TRR

This is a new reservoir that will be hydraulically connected to the GCID Main Canal about three miles east of Funks Reservoir and just upstream of the Funks Creek Siphon, at milepost 41.3 on the GCID Main Canal. The footprint of the TRR will be approximately 130 acres, with a storage volume of approximately 600 acre-feet. The TRR will also include gates to control water in and out of the GCID Main Canal. There are two alternative locations for the TRR: one on the eastern side of the GCID Main Canal (TRR-East) and one on the western side of the GCID Main Canal (TRR-West).

TRR PGP

This is a PGP that will be used to pump water from the TRR to the Sites Reservoir. This facility will also include hydroelectric turbines to generate electricity when flow is released from Sites Reservoir to the TRR and GCID Main Canal. As part of this PGP facility, there will also be an energy-dissipation facility that will allow releases back to the TRR as backup to the hydroelectric turbine facilities. The pumping plant will have a capacity of 1,800 cfs; the generating plant will have a capacity of 1,000 cfs.

TRR Pipelines

These are two parallel, 12-foot-diameter pipelines used to convey water between the TRR PGP and the Sites Reservoir. These pipelines will connect from the piping manifold at TRR PGP to the downstream side of the proposed 32-foot-diameter tunnel connected to the Site Reservoir inlet/outlet structure. The approximate length of these pipelines for TRR-East is 4.4 miles (23,200 feet) each. The approximate length of these pipelines for TRR-West is 2.5 miles (13,000 feet) each. Just downstream of the piping manifold that connects the TRR pipelines to the inlet/outlet tunnel, there is a 42-inch-diameter environmental water pipeline that is approximately 2, 550 feet long; it discharges into Funks Creek. This pipeline is not used for construction purposes, but is a long-term solution to provide water to Funks Creek just downstream of the proposed Golden Gate Dam.

Funks Reservoir

Reclamation constructed the Funks Reservoir in the mid-1970s with the intent of providing operational flexibility for the TCC. There are check structures on the TCC just upstream and downstream of the reservoir. The TCC is located about 1 mile east of the proposed Sites Reservoir. At the time of construction, the reservoir had a useable capacity of 1,170 acre-feet between operating levels of 199.5 and 205.2 feet elevation, and 1,080 acre-feet of inactive storage below elevation 199.5 feet, for a total capacity of 2,250 acre-feet; however, the addition of sediment from Funks Creek and the TCC have likely reduced the total storage volume. Additionally, a cofferdam will be constructed within Funks Reservoir to facilitate construction of the TRR pipelines. The resulting storage volume reductions will be offset by sediment removal and excavation where storage capacity can be regained. The spillway has a capacity of 22,500 cfs. The project will remove accumulated sediment to recapture the design storage volume. Funks Reservoir is usually dewatered for canal maintenance between the end of December and early February.

Funks PGP

This is a pumping and generating plant that will be used to pump water from Funks Reservoir to the Sites Reservoir. This facility will also include hydroelectric turbines to generate electricity when flow is released from Sites Reservoir to Funks Reservoir and, ultimately, the TCC. There will also be an energy-dissipation facility as part of this PGP facility that will allow releases back to Funks Reservoir as backup to the hydroelectric turbine facilities. The pumping plant will have a capacity of 2,100 cfs; the generating plant will have a capacity of 2,000 cfs.

Funks Pipelines

These are 2 parallel, 12-foot-diameter pipelines used to convey water between the Funks PGP and the Sites Reservoir. These pipelines will connect from the piping manifold at Funks PGP to the downstream side of the proposed 32-foot-diameter tunnel connected to the Site Reservoir inlet/outlet structure. The approximate length of these pipelines are 1 mile(5,200 feet) each.

Dunnigan Pipeline

The Dunnigan Pipeline consists of either a 9-foot-diameter or 10.5-diameter pipeline that will be used to release water from the TCC to the Sacramento River. The concept is to release flow from Sites Reservoir to Funks Reservoir, where the flow will then go south about 40 miles to near the end of the TCC. At this point, flow will be diverted into the Dunnigan Pipeline, where flow will head either to the Colusa Basin Drain (CBD, which flows to Sacramento River (Alternative 1), or directly to the Sacramento River (Alternative 2). If the pipeline discharges directly into the Sacramento River, there will be a valve that will allow a portion of the water to be discharged in the CBD. Alternative 1 consists of a 9-foot-diameter pipeline that is about 4 miles (20,900 feet) long and discharges into the CBD. Alternative 2 consists of a 10.5-foot-diameter pipeline that is about 9.4 miles (49,500 feet) long and discharges into the Sacramento River.

WAPA or PG&E Substation/Switchyard

There are 230 kilovolt (kV) electrical transmission lines running near the proposed project area. Specifically, the WAPA transmission lines run very close to Funks Reservoir in a north-south direction, with a parallel 230 kV line owned by PG&E a few miles east of the WAPA transmission lines. It is anticipated that one of these transmission lines will be connected to provide power for the project, as well as receive generated electrical power from the hydroelectric turbines. Switchyards and substations will be needed to provide power to both the TRR PGP and Funks PGP.

Electrical Transmission Lines

Electrical transmission lines will be required to connect the WAPA or PGE 230 kV transmission lines to the TRR PGP and the Funks PGP.

Administration and Operations Building

At this time, staffing requirements for operating and maintaining the Sites facilities has not been defined, but an administration and operations building is provided, based on drawings obtained from Reclamation. This building is anticipated to be next to the Funks PGP.

Maintenance and Storage Building

A building will be required to provide maintenance and storage associated with the project. A drawing from Reclamation of the building was used in the feasibility design. This building is anticipated to be next to the Funks PGP.

Access Roads

Access to the proposed TRR-East site would likely be from McDermott Road, which lies adjacent to the proposed reservoir. Access to the Funks complex (PGP and Reservoir) is currently accomplished using the O & M road along the TCC. Access to the proposed TRR-West site would come off the access to the Funks complex. A new access road will be required that allows larger equipment and year-round access. It is also anticipated that roads will be constructed within the TRR-East or TRR-West and Funks Pipeline easements, not only to provide access to the pipelines and electrical power transmission lines, but also to act as a secondary access road to the project facilities. Exhibits and descriptions of access roads are in the constructability TM in Appendix K.

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2.0 Design Criteria

2.1 General Criteria

The purpose of this section is to provide the currently known design criteria used as the basis for design. There have been previous studies of these facilities that summarized design criteria, some of which are applicable to this current project; but, in many cases, the criteria have changed. Given that the design is in very early stages, these criteria are subject to change as the design progresses.

2.2 Civil – Site Design

The site design for this project will include grading, drainage, site security, and access roads. General criteria have been established for these features, as summarized in Tables 1 and 1A.

Table 1. Site Civil Design Criteria

Subject	Criteria
Coordinate System	
Horizontal Datum	NAD83, California State Plane Coordinates, Zone 2
Vertical Datum	NAVD 88
Drainage (Site and Roadway)	
Depth	Minimum 1 foot
Ditch Drain Slopes	Minimum 0.5 percent
Ditch Side Slopes	Maximum 2H:1V
Paved and Unpaved Roads	
Cross Slopes	Minimum 2 percent Maximum 4 percent
Grade	Maximum 6 percent
Widths	30 foot maximum 24 feet minimum
Fill Slopes	Recommended 4:1 Maximum 2:1
Cut Slopes	Recommended 4:1 Maximum 2:1

Table 1 will be revisited after the geotechnical field investigation is completed to confirm or revise. Table 1A provide design criteria for the access roads around and between the facilities. Additional design criteria will be provided and established for offsite roads based on local agency standards.

Existing topography for this area was provided by the U.S. Bureau of Reclamation and was used in the previous feasibility study by AECOM. The mapping is set in NAD83 State Plane Coordinate system California, Zone 2, U.S. survey feet. The vertical datum appears to be NAVD 88, based on a comparison of the Funks Reservoir Dam crest elevation with the elevation shown in the original as-built drawings for the Funks Dam from December 2, 1974 (which are currently assumed to be on NGVD29). We are proceeding with this design assumption, while awaiting confirmation from Reclamation on the vertical datum of the contours they provided.

Table 1A. Access Road Criteria

Design Standard	Design Criteria	Reference
Classification	Local/Rural	AASHTO GB 5.2
Terrain	Rolling	
Design Speed (DS)	20 mph	AASHTO GB Table 5-1
Design Vehicle	WB-65	
Maximum Grade	11%	AASHTO GB Table 5-2
Min. Stopping Sight Distance	115'	AASHTO GB Table 5-3
Min. K Values	7 (Crest) 17 (Sag)	AASHTO GB Table 5-3
Min. Horizontal Radius Curve	107' (w/Normal Crown)	AASHTO GB Table 3-13
Cross Slope	2% Min - 6% Max	AASHTO GB 5.2.1.6
Foreslopes	4:1 recommended	AASHTO GB 5.2.2.8.3
Clear Zone	7-10 ft	RDG Table 3-1
Roadway Dimensions	24' wide with 4:1 slopes	
Roadway Dimensions	30' wide with 2:1 slopes	Additional width provided for barrier protection
Pavement Section	Aggregate Base (depth TBD)	

Civil – Pipeline Design

This section describes the criteria for the transmission main pipelines, including Funks, TRR, and Dunnigan pipelines. Initially, pipe types being considered included: 1) reinforced-concrete cylinder pipe – American Water Works Association (AWWA) Standard C300-16, and AWWA M9-3rd edition; and 2) welded-steel pipe (WSP) AWWA C200-05 and AWWA M11-4th edition. Based on experience, the application for this pipe and discussions with pipe manufactures for both reinforced-concrete cylinder pipe and WSP, the pipe anticipated for use on this project is WSP. Appendix A contains detailed design criteria for the transmission pipelines using WSP.

Consideration will be given on a case-by-case basis to determine if road crossings will require special backfill requirements such as controlled low strength material. Loading calculations will be provided in later phases of design to determine the required backfill material.

Mechanical Design

To be Added in Future Design Phases – see later sections for specific criteria for Funks and TRR.

Structural Design

The structures described in this document will be designed in accordance with the current governing codes and standards applicable to the construction of buildings, structures, and appurtenances in the State of California. Detailed design criteria for each facility will be further developed in future design phases following field investigations and facility design refinement.

Reinforced-concrete Hydraulic Structures

Hydraulic structures will be designed in accordance with ACI 350, using the alternate service load method or the strength method with durability factors.

Miscellaneous Concrete Structures

Miscellaneous, non-hydraulic, concrete structures, including building slabs and foundations, will be designed in accordance with ACI 318.

Structural Steel

Structural steel will be designed in accordance with the latest edition of the American Institute of Steel Construction (AISC) Steel Construction Manual and the AISC Specification for Structural Steel Buildings. Design will use either the allowable stress design method or the load and resistance factor design. Structural steel bolted connections shall be designed in accordance with the Research Council on Structural Connections Specification for Structural Joints Using High-Strength Bolts.

Masonry Structures

Masonry structures shall be designed in accordance with the latest edition of The Masonry Society Building Code Requirements and Specifications for Masonry Structures (TMS 402). Design shall use either the allowable stress design method or the load and resistance factor design method.

Loads

Table 2 shows the structural loads.

Table 2. Structural Loads

Subject	Criteria
Gravity	
Dead	Weight of structure and permanent equipment
Floor Live	Superimposed uniform or concentrated loads
Roof Live	20 psf minimum
Conform to ASCE 7, Chapter 4 except:	Process Areas – 200 psf
	Electrical Rooms – 300 psf
	Where significant, use the actual weights of equipment
Wind	
Power Generating Facilities: Conform to ASCE 7, Chapter 26-30:	Risk Category III
	Basic Wind Speed (ASCE 7-16 3 second gust) 99 MPH

Table 2. Structural Loads

Subject	Criteria
	Exposure Category C
All other facilities: Conform to ASCE 7, Chapter 26-30:	Risk Category II
	Basic Wind Speed (ASCE 7-16 3 second gust) 93 MPH
	Exposure Category C
Earthquake	
Conform to following references:	CBC Chapter 16
	ASCE 7 Chapters 11-23
	Power Generating Facilities: Risk Category III All other facilities: Risk Category II
	Project Geotechnical and Seismicity Report (to be published)
	Hydrodynamic Loads – ACI 350.3, Seismic Design of Liquid Containing Concrete Structures and ASCE 7-16 Chapter 15
Other	
Vehicle	AASHTO HS-20 Truck and Caltrans P13 permit vehicle
Railroad Live Load	Cooper E80
Lateral Earth Pressures	Conform to criteria listed in the project geotechnical report (to be published)
Flood Protection	Design for 100-year frequency flood levels, including debris protection and location of all critical equipment (pumps, panels)
Load Combinations	Conform to ASCE 7 Chapter 2 for service and strength level combinations

psf = pounds per square foot

Materials

Table 3 shows the structural materials and properties.

Table 3. Structural Materials and Property

Material	Property
Structural concrete	F’c = 4,500 psi at 28 days, normal weight
Reinforcing steel	ASTM A615, Grade 60, F_y = 60 kilopounds per square inch (ksi)
Reinforcing steel to be welded	ASTM A706, Grade 60, F_y = 60 ksi
Masonry	
Concrete masonry units (CMU)	TMS 6-13, 1.4.B.2, F’c = 2,000 psi
Mortar	ASTM C270, F’c = 1,800 psi
Grout	ASTM C476, F’c = 2,000 psi

Table 3. Structural Materials and Property

Material	Property
Structural Steel	
Steel plates, shapes except W-shapes, and bars	ASTM A572 Gr. 50, F_y = 50 ksi or ASTM A36, F_y = 36 ksi
W-shapes and WT-shapes	ASTM A992, (Fy = 50 ksi)
Rectangular (and square) hollow structural sections (HSS)	ASTM A500 Grade C, F_y = 50 ksi
Round hollow structural sections (HSS)	ASTM A500 Grade C, F_y = 46 ksi
Steel pipe	ASTM A53, Grade B, F_y = 35 ksi
Steel pipe for sleeves and piles	API Specification for Pipeline 5L, PSl2; sleeve grade 52; piles grade 65
Stainless Steel	
Bars and shapes	ASTM A276, AISI Type 304L, F_y = 25 ksi
Plate	ASTM A167, AISI Type 304L, F_y = 25 ksi
Bolts and Rods	
High-strength steel bolts	ASTM A325, Type 1 bolts with A563 nuts
Steel bolts	ASTM A307, Grade B or A36
Anchor rods	ASTM F1554, Grades 36, 55, and 105 (hooked, headed, or threaded and nutted) as appropriate for application or ASTM A36 (threaded rods either plain or upset ends)
Stainless steel bolts	ASTM F593, AISI Type 304, Condition CW
Post-tensioning bars	ASTM A722, 150 ksi ultimate stress
Concrete-adhesive anchors	Stainless Steel Hilti or equal
Concrete-grouted anchors	Galvanized
Grating	
Grating for pedestrian loads	Galvanized steel
Grating vehicular loads	Galvanized steel
Fiberglass grating	Molded or pultruded fiberglass
Handrail and guardrail	Galvanized steel

Electrical Design

Table 4 summarizes electrical design criteria.

Table 4. Electrical Design Criteria

Subject	Criteria	Comments
Utilization Voltage	• Motor control for large pump motors – 13,800 volts (V) • Motors for large pump motors – TBD	For large pump motors on variable-speed drives, motor voltage will be determined by equipment supplier as best suited for the motor\drive

Table 4. Electrical Design Criteria

Subject	Criteria	Comments
	• Motors 1 horsepower (HP) to 400 HP – 480V • Fractional HP motors – 120V, 208V, 480V, as required • HVAC – 120V, 208V, 480V, as required • Convenience Loads – 120V • Lighting – 120, 208V, as required	equipment selection. Voltage will be selected in the range of 4160V to 13,800V.
Medium-Voltage Switchgear	Metal-Clad Switchgear, 15kV, 3,000A maximum. Standards: Institution of Electrical and Electronics Engineers, Inc. (IEEE) C37.20.2.	
Medium-Voltage Motor Control	Voltage source, variable-speed drive, with the following features: • Input section for isolation, short-circuit, and overload protection • 24-pulse or higher isolation transformer • Motor protection relay	Variable-speed drive allows pump to operate more efficiently, provides near unity power factor on the line side of the drive, and allows the motor voltage to be different than the line voltage for better coordination of motor and drive equipment selection.

General Requirements

An electrical building is planned to house electrical equipment for distribution, motor control, and hydro generation. The similarity between the Funks and TRR PGPs will allow for similarity in the general arrangement of the electrical building and electrical equipment. Consistency between the designs of these facilities will be accommodated to the extent possible. Electrical equipment will be specified that complies with National Electrical Manufacturers Association and American National Standards Institute (ANSI)\IEEE standards. UL-listed or label equipment, or equipment label or listed by a Nationally Recognized Testing Laboratory, will be specified where equipment with the required ratings can be provided in accordance with their respective safety standards.

Electrical power will be received from the substation at 13.8kV by two separate lineups of switchgear. The switchgear will distribute at this voltage for motor control, and connection of the hydro generation, and will be stepped down for low-voltage use. Three-phase 480V and 208/120V power will be provide for ancillary equipment.

Medium-voltage Switchgear

Two lineups of indoor, metal-clad, switchgear will divide power distribution as evenly as possible between the medium-voltage loads. A main-tie-main bus arrangement will be provided to isolate medium- and low-voltage buses and reduce the effect of a bus fault, feeder fault, or switchgear failure on the operation of equipment. A remote operating panel will be provided to allow operator control of circuit breakers. Arc-resistance switchgear and arc-flash energy hazard reduction techniques will be evaluated.

Medium-voltage, Variable-speed Drives and Motor Protection

Variable-speed drives will be provided for large induction motors. An input section, with disconnect switch and fused vacuum contactor or circuit breaker, will be specified to provide isolation from the medium-voltage switchgear without having to rack out a switchgear circuit breaker. Each drive will be a fully integrated system, capable of controlling medium-voltage power at its input and operating the driven equipment from the local control interface without external programmable devices. Each drive will have its own short-circuit and overload protection. Drives will be provided with a separate low-voltage power for ventilation and control. Line side harmonics will be mitigated with a 24-pulse or higher isolation transformer, which is standard for drives connected to 8,000-horsepower and higher motors.

Variable-speed drives for large motors can be provided with air or water cooling. Air-cooled drives typically require large air-conditioning systems to remove heat from the drive out of the building. Air-cooled technology is recommended to reduce cost and complexity of drive maintenance.

Motor protection will be provided by a separate motor protection relay (MPR) integrated into the drive system. The MPR will allow current- and temperature-based motor protections to be provided, independent of the variable-speed drive control. The MPR will provide connections for motor stator, motor bearing, and pump bearing temperature sensors, as well as for current transformers to measure phase, ground, and differential current.

Standby Power

Depending on operational requirements, standby uninterruptible power supplies and/or standby generation will be provided to maintain operation of plant control, communications, and ancillary equipment. Because of the size of the pumping units, no backup generation is planned for pumping facilities.

2.3 Red Bluff Diversion Improvements

The Red Bluff Diversion Pumping Plant that currently pumps water into the TCC has a capacity of 2,000 cfs. A portion of this flow also is diverted to the Corning Canal. It is anticipated that additional flow beyond the 2,000 cfs will be required to convey flow to Funks Reservoir and, ultimately, Site Reservoir. The current design involves adding two 250 cfs pumps to match the existing seven 250 cfs pumps. The existing pumping plant also includes two 125-cfs pumps. This will increase the capacity from 2,000 to 2,500 cfs.

Improvements will include the two pumps and motors, discharge piping, electrical switchgear, and instrumentation and control to program pump operation.

2.4 GCID Main Canal Improvements

GCID recently gave the design team a preliminary list of improvements resulting from the plan to use the GCID Main Canal to convey water for the Sites Project. These improvements include:

- Construct new Main Canal headgate structure
- Increase capacity of railroad bridge near Willows
- Increase capacity of the Walker Creek siphon and Willow Creek siphon near Willows
- Add earthwork to various sections of the GCID Main Canal where freeboard is less than 2.5 feet under full flow conditions (see Drawings for locations and quantities)
- Addition of aggregate base to top of canal bank roads in various areas (see Drawings for locations)

It should be noted that replacement of the two siphons and railroad bridge is not confirmed. Determination of whether these existing structures will need to be replaced depends on the results of a canal hydraulic modeling task to determine if the structure present hydraulic limitations. Assuming the structures are not capacity limiters, then a condition assessment is expected in early 2021 to determine if replacement is needed for structural integrity reasons.

Criteria presented in this section for other Sites specific facilities mostly apply to these GCID improvements, but all criteria will be defined once additional design information about GCID facilities is obtained.

2.5 Funks Area

Funks Reservoir

The existing Funks Reservoir is a regulating reservoir on the TCC. The reservoir will be used as a source of water to pump to and receive discharged water from Sites Reservoir. The Funks Reservoir water surface elevation (WSE) is controlled by a check structure (#16) where the TCC enters the reservoir and a check structure (#17) where the TCC leaves the Sites Reservoir. Therefore, the reservoir operational WSE can only vary slightly from the TCC, especially since the reservoir contains no irrigation specific turnouts. The reservoir WSE typically ranges from 200 to 205 feet, although the preferred operating range is 202 to 204 feet. The minimum WSE in the reservoir is 198 feet, in order to flow south in the TCC while providing the head required for downstream turnouts.

The initial volume of the Funks Reservoir is approximately 2,200 acre-feet, but only about 1,100 acre-feet is useable storage within the TCC operating range. Based on review of bathymetry data collected in September 2020, pre-construction topography from Reclamation, and aerial photos, sediment has deposited in the reservoir predominately on the eastern side, which has reduced the total storage. Improvements to Funks will include reshaping the shoreline of the reservoir to accommodate the Funks PGP (expected to be located on the western shore), performing excavation to construct the PGP approach channel, constructing a cofferdam in support of the TRR pipeline construction, excavating and filling to place the TRR pipelines across the north side of the reservoir, and removing sediment. The excavation and sediment removal are anticipated to restore the original capacity of Funks Reservoir and offset the loss in capacity caused by the cofferdam construction. Excavation will proceed to an elevation of approximately 197 feet in the reservoir and 185.5 feet near the proposed PGP on the western side. No excavation will occur within the cultural areas identified on the eastern side of Funks Reservoir. The excavation and reshaping of the reservoir bottom is necessary to allow the large flow to and from the PGP to be unimpeded. As the design progresses, additional information will determine the minimum reservoir depth near the Funks PGP.

The cofferdam needed to construct the TRR pipelines in the northern portion of Funks Reservoir will be constructed using earthfill material excavated from the bottom of the reservoir. A geomembrane liner on the upstream slope in combination with limited jet grouting (if needed) will be used to limit seepage through the cofferdam. The slopes of the earthfill cofferdam will be 3H:1V, consistent with US Bureau of Reclamation’s recommendations described in the Reclamation Design Standards Manual (2012) for slopes with a geosynthetic liner.

An additional benefit of placing the PGP on the western side is providing better circulation of flow in the reservoir, given the canal inflow and outflow are on the eastern side of reservoir. This design also uses the currently unusable storage volume below elevation 198 feet. Although the useable storage will not change, adding the PGP will allow almost all of the reservoir to have circulation due to the PGP since the PGP inlet floor elevation is near the bottom of the reservoir.

Funks Pumping Generating Plant

General Information

Table 5 overviews the components of the Funks area.

Table 5. Funks Area

Subject	Criteria
Flows	
Pumping Plant	2,100 cfs
Generating Plant	1,000 cfs
Energy Dissipation	1,000 cfs

Consideration was given to using a single unit to provide both pumping and generation versus having separate units. As part of this analysis, a comparison of the units at the Gianelli PGP at San Luis Reservoir, which contain single units to pump and generate, versus the proposed Sites Project which recommends using separate pumps and generating turbines. This comparison is summarized in a TM contained in Appendix B.

Mechanical Design

Table 6 details the mechanical design of the pumping design components.

Table 6. Funks Pumping Unit

Subject	Criteria
Operational Criteria	
Pumping Plant	2,100 cfs
Pumps, Motors, and Ancillary Equipment	
Number of Pumping Units	13 (12 duty + 1 standby)
Capacity at Rated Point	175 cfs @ 320 feet
Static Head, Maximum	298 feet
Static Head, Minimum	135 feet
Rated Pump Efficiency	89 percent
Pump Type and Configuration	Vertical Mixed Flow, Multi-Stage
Pump Shaft Lubrication	Shaft-enclosing Tube with External water-flush, or Oil-drip System
Pump Shaft Seal	Packing
Pump Materials	
Discharge Head	Fabricated Steel, Epoxy Lined & Coated
Column	Fabricated Steel, Epoxy Lined & Coated
Shaft	17-4 PH Stainless Steel

Table 6. Funks Pumping Unit

Subject	Criteria
Impellers	Silicon Bronze or Stainless Steel
Bowls	Cast or Ductile Iron
Impeller Wear Rings	Bronze
Bowl Wear Rings	Stainless Steel
Lineshaft Bearings	Water-Flush: Synthetic Rubber Oil-Drip: Bronze
Motor	
Size	8,000 horsepower
Type	Induction, Vertical Solid Shaft, High Thrust
Nominal Speed	505 rotations per minute (rpm)
Voltage	4,000 V or 13,200 V
Enclosure	WPII
Ambient Rating	50 degrees Celsius
Non-Reverse Ratchet	No
Insulated Bearings and Shaft Grounding	Yes
Drive Type	Adjustable Speed Drives
Valves and Accessories	
Large Isolation Valves	Butterfly, Class 250B, per AWWA C504
Small Isolation Valves	Ball, Bronze or Stainless Steel
Large Check Valves	Tilting Disc w/Hydraulic Damper
Small Check Valves	Swing, Bronze
Air Valves	Cast or Ductile Iron with Stainless Steel Trim

Table 7 details the mechanical design of the generating unit components.

Table 7. Funks Generating Units

Subject	Criteria
Operational Criteria	
Generating Flow	2,000 cfs (2 @ 1,000 cfs each)
Turbines	
Type of Units	Francis Turbine
Head, Maximum	289.5 feet
Head, Minimum	125.4 feet

Table 7. Funks Generating Units

Subject	Criteria	
Capacity at Rated Point	1,000 cfs	1,000 cfs
Head, Rated	255.9 feet	190.3 feet
Operational Head, Maximum	319 feet	238 feet
Operational Head, Minimum	153.5 feet	114 feet
Rated Turbine Output	20 megawatts (MW)	14.5 MW
Speed	360 rpm	300 rpm
Generator		
Nominal Speed	360 rpm	300 rpm
Voltage	13.8 kV	13.8 kV
Valves and Accessories		
Turbine Isolation Valves	78” Ball, Hydraulic Operator	

Structural Design

The structures within the PGPs will be designed to support and access the mechanical, electrical, and control equipment. The pumping generating plants include the following significant structures:

- Pump Station
- Turbine Generator Building
- Energy-Dissipation Valve Structure

Pump Station

The concrete pump station structure will support the pumps at the edge of the reservoir. Walls will be designed to support the retained soil and interior water pressure. The pump station will be designed with specific attention given to pump vibration. The pump station will be sized to create a fundamental baseline frequency rate that provides at least 20% frequency separation from the pumps to avoid resonance. A trash rack will be installed at the front of the wet well to prevent debris from entering the wet well. The trash rack will be designed for a maximum head differential of 3 feet. Bulkhead slots will be provided at each wet well to allow bulkheads to be installed and isolate pumps bays for maintenance. The roof of the pump station adjacent to the bulkheads will be designed for crane outrigger loads. The pump station electrical equipment will be housed in a building constructed over the pump station unit intakes. The electrical building will be constructed with solid grouted concrete masonry unit (CMU) walls. Lateral support of the electrical building will be provided by metal roof decking and CMU shear walls. Wall and roof insulation will be provided to meet the governing design codes and associated energy usage criteria.

Turbine Generator Building

The concrete turbine generator building will house the Francis turbine, generator, draft tube, turbine inlet valve, associated piping appurtenances, and mechanical and electrical equipment. The turbine will discharge into a draft tube prior to exiting into the reservoir. Consideration will be given for providing access for future maintenance and removal (via temporary crane and removable roof sections) of all major pieces of equipment. The at grade portion of the turbine generator building roof will be designed for pedestrian live loads and will be bollard protected from vehicular traffic.

The majority of the building will be below grade and will retain soil on three sides and water on the fourth side. However, a small aboveground portion will be provided for access to the stairway. The aboveground portion of the building will consist of concrete walls to match the adjacent energy-dissipation structure. The building is assumed to be without personnel and will provide only minimal ventilation and heating to suit the housed equipment. Unit control will be possible from local panels in the turbine generator buildings, but primary control is assumed to be remote.

Energy-Dissipation Valve Structure

The concrete energy-dissipation valve structure includes a stilling basin and fixed-cone valve to dissipate energy before water enters the reservoir. Spray will be controlled at the fixed-cone valves by including hoods with the valves. The geometry of the stilling basin is sized in accordance with *Hydraulic Design of Stilling Basins and Energy Dissipators* (A.J. Peterka, USBR, 1984). The end of the structure will include a concrete roof designed to support vehicle traffic loads to provide access to the adjacent pump station bulkheads and trash racks.

Electrical Design

All electrical equipment for the pumping units, as well as lower-voltage auxiliary power, will be placed inside a building. The objective is to place this building as close to the pumping units to provide shorter conductor lengths to the pumps. Having the motor control equipment and starters close to the pumping units also allows quick access for operational reasons.

Pipeline

The Funks dual 12-foot-inner-diameter (ID) welded-steel pipelines connect to the 23-foot Sites Inlet/outlet tunnels, via a transition manifold, which includes isolation valves. From the connection, the pipelines generally run east in parallel with the TRR dual pipelines. After curving around Funks Creek and hilly areas, the Funks pipelines run south, deviating from the TRR pipelines alignment, to the Funks Pumping Generating Plant. The total length of the pipeline alignment is approximately 1 mile.

Administration and Operations Building

The administration and operations building contains the offices, control and communications rooms, and restrooms required to operate the project facilities. The building will be constructed with CMU walls and designed in accordance with the California Building Code. Finalization of the floorplan and color scheme for this building will be addressed in future design phases.

Maintenance and Storage Building

The maintenance and storage building include space for equipment storage and maintenance rooms to support the project facilities. The building will be constructed with CMU walls and designed in accordance with the California Building Code. Finalization of the floorplan and color scheme for this building will be addressed in future design phases.

2.6 TRR Area

TRR-East Reservoir

The TRR-East reservoir will be constructed using earthen embankments around the perimeter of the reservoir, connected hydraulically to the existing GCID Canal. These embankments are generally founded on materials identified as soft clays and potentially liquefiable granular soils. Based on these adverse soils and a high likelihood that the reservoir falls under regulation of the Division of Safety of Dams, ground improvement in the form of cement deep soil mixing is anticipated to be required below the embankment to key into the more competent materials. These berms are anticipated to be constructed using material excavated within the TRR-East reservoir footprint and the TRR-East pipeline excavation between the GCID Canal and the TCC.

The GCID Canal is the conveyance source of water for the TRR-East and its PGP to pump water into Sites Reservoir. The GCID Canal is also the primary conveyance for releases of water from Sites Reservoir through the PGP and into the TRR-East. The GCID Canal operational ranges, capacities, and other operational constraints and considerations are the primary factors in the design criteria for the TRR.

Access between the east and west sides of the GCID Canal adjacent to the TRR will be over a new bridge between the TRR embankment near the gate structures and the west side of the GCID Canal. The bridge is anticipated to consist of a precast concrete span between the banks of the GCID with concrete abutments founded on piles that penetrate into the stiffer material below the surface to provide stability.

The reach of the GCID Main Canal that is adjacent to TRR is delineated upstream by a check structure that is approximately 6 miles upstream of the location of TRR and is delineated downstream by a check structure adjacent to the southern end of the TRR (this check structure is at the siphon under Funks Creek). Within this reach of the GCID Main Canal, adjacent to TRR, the operating level (the WSE) within the canal, typically ranges from 123.0 to 123.2 feet in the summer, and typically goes no lower than 121.8 feet in the winter. The maximum design WSE is 124.0 feet, and the lowest WSE corresponds to a drained condition in the canal during the winter shutdown (January to February). The bottom of the canal is approximately elevation 112.7 feet, and the canal embankment crests range from about elevation 128 to 130 feet. The maximum flow capacity of the GCID Main Canal is understood to be approximately 1,800 cfs.

The TRR PGP is sized to correspond to the 1,800 cfs maximum capacity of the GCID Main Canal. A design criterion for the project is the ability to capture and store water from the GCID Main Canal in the TRR in the event the TRR PGP shuts down unexpectedly. That is, when the TRR PGP shuts down, terminating pumping from the TRR and GCID Main Canal (at rates up to 1,800 cfs), continuing flows from the GCID Main Canal will either be accommodated by the TRR or continue down the GCID Main Canal. The TRR is intended to accommodate (capture) those flows because that quantity/flow of water would otherwise not be used or captured downstream of this location. The GCID Main Canal can be operated to shut off these flows, but doing so takes at least 2 to 3 hours. Therefore, the corresponding design criterion for the TRR is to be able to accommodate inflows of up to 1,800 cfs, for up to 4 hours. This corresponds to a storage capacity (for these inflows alone) of approximately 600 acre-feet which the storage volume used for design of the TRR.

Additional storage capacity within the TRR requires either additional plan-area size (for hydraulic needs within this same elevation range within the TRR) or accommodation either above or below this elevation range, depending on the hydraulic constraints.

The spillway design will also consider the flow from the GCID Canal plus the flow from the Sites pipeline. The spillway will be located at the southernmost corner of the TRR-East and discharge into Funks Creek.

TRR-West Reservoir

The TRR-West reservoir will be connected hydraulically to the existing GCID Canal and constructed via primarily mass excavation. Hydraulic connection of TRR-West to the GCID Canal will occur through the inlet/outlet canal facilities located adjacent to the west of the GCID Canal. The inlet/out canal facilitates will flow through several check structures into the main and extension reservoirs to the west. The main and extension reservoirs will be independently located relative to a pair of assumed underground natural gas pipelines and overhead transmission lines running north-south through the site. The two reservoirs will be connected hydraulically by a tunnel passing underneath the buried pipelines. The subsurface materials in this area are assumed to consist primarily of fine-grained deposits and Pleistocene clays, so that extensive ground improvement would not likely be required, as compared to TRR-East.

The GCID Canal is the conveyance source of water for the TRR-West and its PGP to pump water into Sites Reservoir. The GCID Canal is also the primary conveyance for releases of water from Sites Reservoir through the PGP and into the TRR-West reservoir. The GCID Canal operational ranges, capacities, and other constraints and considerations are the primary factors in the design criteria for the TRR.

Access to the TRR-West area will need to be constructed from either the TCC to the West or the property north of the Main reservoir. Access roads will also be constructed, surrounding and in between the Main and Extension reservoirs of TRR-West.

The reach of the GCID Main Canal that is adjacent to the TRR-West inlet/outlet canal facilities is delineated by check structures that are approximately 6 miles upstream and 1 mile downstream (this check structure is at the siphon under Funks Creek) of the inlet/outlet connection. Within this reach of the GCID Canal, adjacent to TRR-West inlet/outlet facilities, the operating level or WSE within the canal typically ranges from 123.0 to 123.2 feet in the summer, and goes no lower than 121.8 feet in the winter. The maximum design WSE is 124 feet, and the lowest WSE corresponds to a drained condition in the canal during the winter shutdown (January to February). The bottom of the canal is at elevation 112.7 feet, and the canal embankment crests range from about elevation 128 to 130 feet. The maximum flow capacity of the GCID Canal is understood to be approximately 1,800 cfs.

The TRR-West PGP is sized to correspond similarly to the TRR-East PGP, with a maximum capacity of 1,800 cfs. A design criterion for the project is the ability to capture and store water from the GCID Canal in the TRR-West if the TRR-West PGP shuts down unexpectedly. That is, when the TRR-West PGP shuts down, terminating pumping from the TRR-West reservoirs and GCID Canal (at rates up to 1,800 cfs), then continuing flows from the GCID Canal will either be accommodated by the TRR-West or continue down the GCID Canal. The TRR-West is intended to accommodate (capture) those flows because that quantity/flow of water would otherwise not be used or captured downstream of this location. The GCID Canal can be operated to shut off these flows, but doing so takes at least 2 to 3 hours. Therefore, the corresponding design criterion for the TRR is to be able to accommodate inflows of up to 1,800 cfs, for up to 4 hours. This corresponds to a storage capacity (for these inflows alone) of approximately 600 acre-feet, which is the storage volume used for design of the TRR.

Additional storage capacity within the TRR-West requires either additional plan-area size (for hydraulic needs within this same elevation range within the TRR-West) or accommodation either above or below this elevation range, depending on the hydraulic constraints.

TRR Pumping Generating Plants

General Information

Table 8 overviews the components of the Funks area.

Table 8. TRR Area

Subject	Criteria
Pumping Plant	2,100 cfs flow
Generating Plant	1,000 cfs flow
Energy Dissipation	1,000 cfs flow

Mechanical Design

Table 9 details the components of the pumping units.

Table 9. TRR Pumping Units

Subject	Criteria
Operational Criteria	
Pumping Plant	1,800 cfs
Pumps, Motors, and Ancillary Equipment	
Number of Pumping Units	13 (12 duty + 1 standby)
Capacity at Rated Point	150 cfs @ 420 feet
Static Head, Maximum	379 feet
Static Head, Minimum	216 feet
Rated Pump Efficiency	88 percent
Pump Type and Configuration	Vertical Mixed Flow, Multi-Stage
Pump Shaft Lubrication	Shaft-enclosing Tube with External Water-flush, or Oil-drip System
Pump Shaft Seal	Packing
Pump Materials	
Discharge Head	Fabricated Steel, Epoxy Lined & Coated
Column	Fabricated Steel, Epoxy Lined &Coated
Shaft	17-4 PH Stainless Steel
Impellers	Silicon Bronze or Stainless Steel
Bowls	Cast or Ductile Iron
Impeller Wear Rings	Bronze
Bowl Wear Rings	Stainless Steel
Lineshaft Bearings	Water-Flush: Synthetic rubber Oil-Drip: Bronze

Table 9. TRR Pumping Units

Subject	Criteria
Motor	
Size	9,000 hp
Type	Induction, Vertical Solid Shaft, High Thrust
Nominal Speed	590 rpm
Voltage	4,000 V or 13,200 V
Enclosure	WPII
Ambient Rating	50 degrees Celsius
Non-Reverse Ratchet	No
Insulated Bearings and Shaft Grounding	Yes
Drive Type	Adjustable Speed Drive
Valves and Accessories	
Large Isolation Valves	Butterfly, Class 250B per AWWA C504
Small Isolation Valves	Ball, Bronze or Stainless Steel
Large Check Valves	Tilting Disc w/Hydraulic Damper
Small Check Valves	Swing, Bronze
Air Valves	Cast or Ductile Iron with Stainless Steel Trim

Table 10 details the components of the generating units.

Table 10. TRR Generating Units

Subject	Criteria
Operational Criteria	
Generating Flow	1,000 cfs (2 @ 500 cfs each)
Turbines	
Type of Units	Francis Turbine
Head, Maximum	370.1 feet
Head, Minimum	206.5 feet
Capacity at Rated Point	500 cfs
Head, Rated	290 feet
Operational Head, Maximum	330.7 feet
Operational Head, Minimum	211.8 feet
Rated Turbine Output	11.5 MW
Speed	514 rpm

Table 10. TRR Generating Units

Subject	Criteria
Generator	
Nominal Speed	514.3
Voltage	13.8 kV
Valves and Accessories	
Turbine Isolation Valves	60-inch Ball, Hydraulic Operator

Structural Design

The structures within the PGPs will be designed to support and access the mechanical, electrical, and control equipment. The PGPs include the following significant structures:

- Pump Station
- Turbine Generator Building
- Energy-Dissipation Valve Structure

Pump Station

The concrete pump station structure will support the pumps at the edge of the reservoir. Walls will be designed to support the retained soil and interior water pressure. The pump station will be designed with specific attention given to pump vibration. The pump station will be sized to create a fundamental baseline frequency rate that provides at least 20% frequency separation from the pumps to avoid resonance. A trash rack will be installed at the front of the wet well to prevent debris from entering the wet well. The trash rack will be designed for a maximum head differential of 3 feet. Bulkhead slots will be provided at each wet well to allow bulkheads to be installed and isolate pumps bays for maintenance. The roof of the pump station adjacent to the bulkheads will be designed for crane outrigger loads. The pump station electrical equipment will be housed in a building constructed over the pump station unit intakes. The electrical building will be constructed with solid grouted CMU walls. Lateral support of the electrical building will be provided by metal roof decking and CMU shear walls. Wall and roof insulation will be provided to meet the governing design codes and associated energy usage criteria.

Turbine Generator Building

The concrete turbine generator building will house the Francis turbine, generator, draft tube, turbine inlet valve, associated piping appurtenances, and mechanical and electrical equipment. The turbine will discharge into a draft tube prior to exiting into the reservoir. Consideration will be given for providing access for future maintenance and removal (via temporary crane and removable roof sections) of all major pieces of equipment. The at grade portion of the turbine generator building roof will be designed for pedestrian live loads and will be bollard protected from vehicular traffic.

The majority of the building will be below grade and will retain soil on three sides and water on the fourth side. However, a small aboveground portion will be provided for access to the stairway. The aboveground portion of the building will consist of concrete walls to match the adjacent energy-dissipation structure. The building is assumed to be without personnel and will provide only minimal ventilation and heating to suit the housed equipment. Unit control will be possible from local panels in the turbine generator buildings, but primary control is assumed to be remote.

Energy-Dissipation Valve Structure

The concrete energy-dissipation valve structure includes a stilling basin and fixed-cone valve to dissipate energy before water enters the reservoir. Spray will be controlled at the fixed-cone valves by including hoods with the valves. The geometry of the stilling basin is sized in accordance with the Bureau of Reclamation's *Hydraulic Design of Stilling Basins and Energy Dissipators* (A.J. Peterka, USBR, 1984). The end of the structure will include a concrete roof designed to support vehicle traffic loads to provide access to the adjacent pump station bulkheads and trash racks.

Electrical Design

All electrical equipment for the pumping units, as well as lower-voltage auxiliary power will be placed inside a building. The objective is to place this building as close to the pumping units to provide shorter conductor lengths to the pumps. Having the motor control equipment and starters close to the pumping units also allows quick access for operational reasons.

Pipeline

The TRR dual 12-foot-ID, welded-steel pipelines connect to the 32-foot-diameter Sites Reservoir intlet/outlet tunnel, via a transition manifold, which includes isolation valves. From the connection, the pipelines generally run east in parallel to the Funks dual pipelines. After curving around Funks Creek and hilly areas, the TRR pipelines cross across the top portions of the Funks Reservoir under the waterline. A cofferdam is anticipated to be constructed within Funks Reservoir to create the working area for construction of the pipelines in Funks. Northeast of Funks Reservoir, the pipelines then cross the TCC by means of a trenchless crossing. East of the TCC, the pipelines continue to run east, parallel to a drainage canal to the GCID Main Canal. The pipelines cross this GCID Main Canal via trenchless methods before entering the TRR pumping generating plant.

Environmental Pipeline

The Environmental 42-inch-diameter, welded-steel pipeline branches off from the north TRR pipeline.

2.7 Dunnigan Pipeline

The Dunnigan Pipeline design will be in accordance with the requirements in Appendix A as previously referenced. The pipeline is anticipated to be gravity flow with the following WSE assumptions used for calculating the pipe diameter.

- TCC at inlet structure – 160 feet
- Outlet structure at CBD – 32 feet
- Outfall structure at Sacramento River – 40 feet

Energy dissipation using fixed-cone valves and stilling basins will be required at the downstream end of the pipeline. Spray will be controlled at the fixed-cone valves by including hoods with the valves. The geometry of the stilling basins is sized in accordance with the Bureau of Reclamation's *Hydraulic Design of Stilling Basins and Energy Dissipators* (A.J. Peterka, USBR, 1984).

2.8 Electrical Supply

Point of Interconnection

The Preliminary 230kV Schematic Plan depicts the point of interconnection (POI) looping in and then back out of the new TRR substation (see Section 3). The TRR substation will then connect to the new Funks substation. This interconnection configuration is subject to approval by the Transmission Operator and the system operator, California Independent System Operator.

The POI, transmission and substation design criteria, dependent on the POI option, will incorporate the following references:

- California General Order 95, Rules for Overhead Electric Line Construction
- WAPA Service and Generation Interconnection Requirements
- PG&E Interconnection Requirements
- PG&E Substation Design Criteria
- PG&E and WAPA Transmission Line Design Criteria

The latest edition and addenda of the following publications, as applicable, will be incorporated in the design specifications codes and standards sections.

- ANSI
- IEEE
- Association of Edison Illuminating Companies
- Transmission Interconnections Handbook
- North America Electric Reliability Corporation Standards
- National Fire Protection Agency 70 National Electric Code
- National Electrical Safety Code (ANSI C2)

Transmission Lines

Codes and Standards

In addition to the POI requirements, transmissions lines will be designed in accordance with the latest edition and addenda of the following publications, as applicable, which will be incorporated in the design specifications.

- California Building Code 2016, Title 24 Vol. 2
- ASCE-113, Substation Structure Design Guide
- ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures
- ANSI/AISC 41-10, Seismic Provisions for Structural Steel Buildings

Substations

The transmission operating voltage of 230 kV will be stepped down via transformer, to the 13.8 kV operating voltage of the turbine generators and the pump motors at each new pumping site. The proposed substations will use two 100 megavolt-ampere (MVA) transformers to step down the voltage. The transformers will be three winding, to reduce nominal current ratings below 3,000 amperes and minimize short-circuit levels to comply with Arc Flash requirements in accordance with Occupational Safety and Health Administration regulations. This configuration will allow two independent, double-ended 13.8 kV switchgear lineups to reliably connect the motors and generators to the transmission system.

The substation design will include that the primary safety equipment, including breakers and utility grade relays, to disconnect the interconnection facilities immediately upon a fault detection on the 230 kV transmission system and the 13.8 kV pumping station systems, to minimize potential loss of life and property. When operating in the generation mode, the facility will automatically trip offline (disconnect from the transmission system) when the relays detect that power has been interrupted on the transmission line into the substation. Transmission line-protective equipment will perform one of the following, as stated anticipated to be in the Interconnection Agreement:

1. Automatically clear a fault and restore power.
2. Rapidly isolate only the faulted section so that the 230 kV system affected by any outage is minimized.

The protection system will be designed with sufficient redundancy such that the failure of any one component will permit the substations to be safely and reliably isolated from the transmission system under fault conditions. Fiberoptic cable will be used for communication protection between each pumping station and the POI.

The substations will include a control enclosure containing power, control, relaying, monitoring and communications. The control enclosure will contain redundant, protective relays and supervisory control and data acquisition (SCADA)/remote telemetry units for transmitting information. The control enclosure will be designed to meet the Bulk Power Protection Criteria of the North America Electric Reliability Corporation Standards, as well Federal Energy Regulatory Commission or Transmission Operator (TO)/California Independent Service Operators (CAISO)-specific requirements.

The TO has standardized their protection requirements; however, system variables will impact the protection requirements, such as generator size and type, number of generators, fault duties, line characteristics (such as, voltage, impedance, and ampacity) and pre-existing protection schemes. For example, high-speed fault clearing may or may not be required to minimize equipment damage and potential impact to system stability.

2.9 Rights-of-way and Easements

Pipelines

Rights-of-way (ROWs) and/or permanent easements (PE) will be required for long-term operation and maintenance of the large-diameter pipelines. In addition, a temporary construction easement (TCE) will be required during initial construction. Following construction, the TCE will no longer be needed and the ROW or PE will be used if repairs are required. Careful consideration must be given to provide widths of PE and TCE that are balanced between what is optimally needed for construction versus the cost of obtaining easements.

Exhibits have been developed to depict the preliminary proposed easements. However, these exhibits have not been thoroughly vetted and are not included at this time.

Transmission Lines

For the interconnect between Funks and TRR-East or TRR-West, the transmission lines are anticipated to be located parallel and within the same easement as the pipelines. Up to four 230 kV transmission lines are required for the project: two for the source supply to either Funks or TRR-East or TRR-West (depending on the option), and two for the Funks-to-TRR-East or -TRR-West substations. The two, looped, source circuits will be installed on a set of common double-circuit, steel monopole structures (Figure 2) and have their own easement requirement where they are not parallel to any pipeline. The two Funks-to-TRR circuits will be installed on their own common set of double-circuit, steel monopole structures (Figures 3, 4, and 5) within the pipeline easement.

In the sections where four circuits are required, specifically, for the approximately 1 mile between the existing WAPA 230 kV lines and the Funks substation (the WAPA option) or for the approximately 1.7 miles between the existing PG&E 230 kV lines and TRR-East Substation (the PG&E option), the routing and ROW have not been fully established. The ROW will depend on the substation locations, the substation orientation for ingress and egress of the transmission lines, and the physical location of the POI. The transmission lines may be located on a common ROW or on separate ROWs.

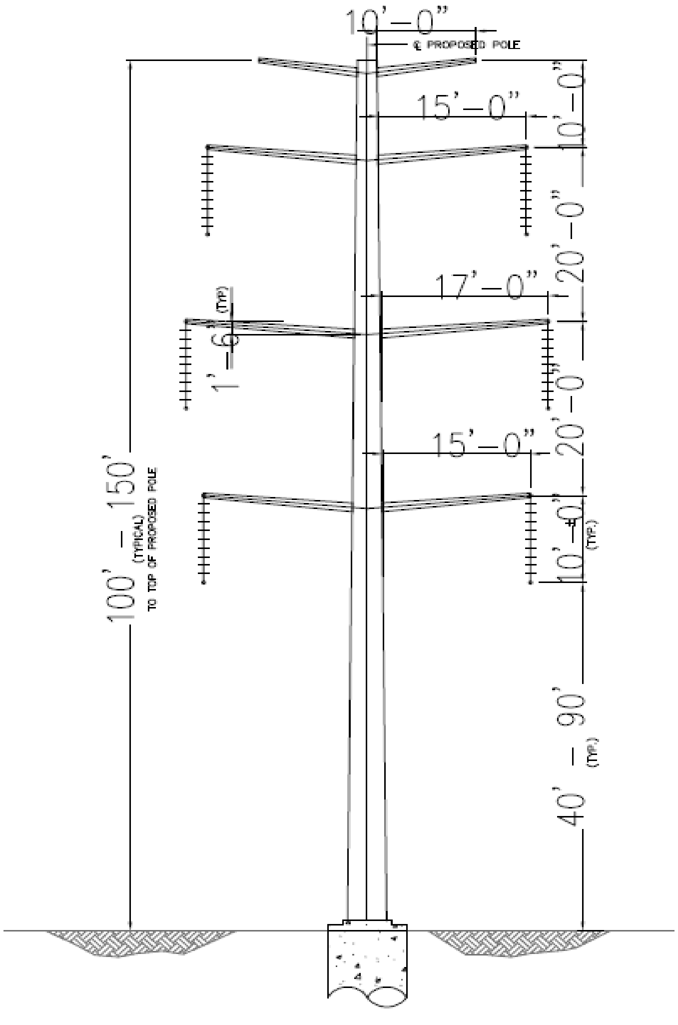

Figure 2. Double-Circuit Source Transmission Poles

Routing the transmission lines within the 100-foot-wide corridor running parallel to the TRR pipeline ROW is the design team's intent for: the approximately 2.9-mile-long section of the 230 kV Funks-to-TRR-East transmission lines between the existing WAPA 230 kV lines and TRR-East (under the WAPA option), the approximately 2.2-mile-long section of the 230 kV Funks-to-TRR transmission lines between the existing PG&E 230 kV lines and Funks (under the PG&E option), or the approximately 1.5-mile-long section of the 230 kV Funks-to-TRR-West transmission lines (under the PG&E option), where just one double-circuit line is required. The width of the corridor has been estimated based on a suitable edge distance of the lines to the northerly edge of the ROW, as required for trees, future buildings, wire blowout events occurring during strong wind conditions, and transmission line installation and maintenance; the width estimate is also based on suitable edge distance to the southerly edge of the ROW, as required for pipeline equipment access, worker safety, and foundational stability during water pipeline trenching operations. The structures will be spaced to reduce impacts on farming/grazing lands.

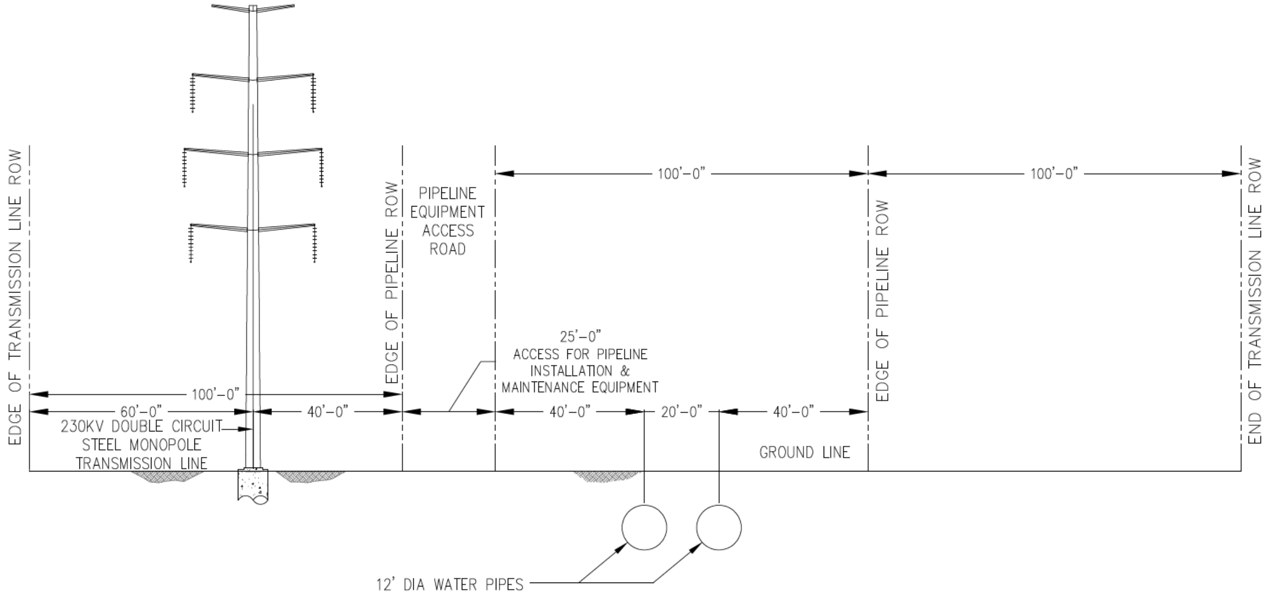

Figure 3. Funks TRR-East or Funks TRR-West Interconnect for PG&E Option between Existing WAPA and PG&E Corridors

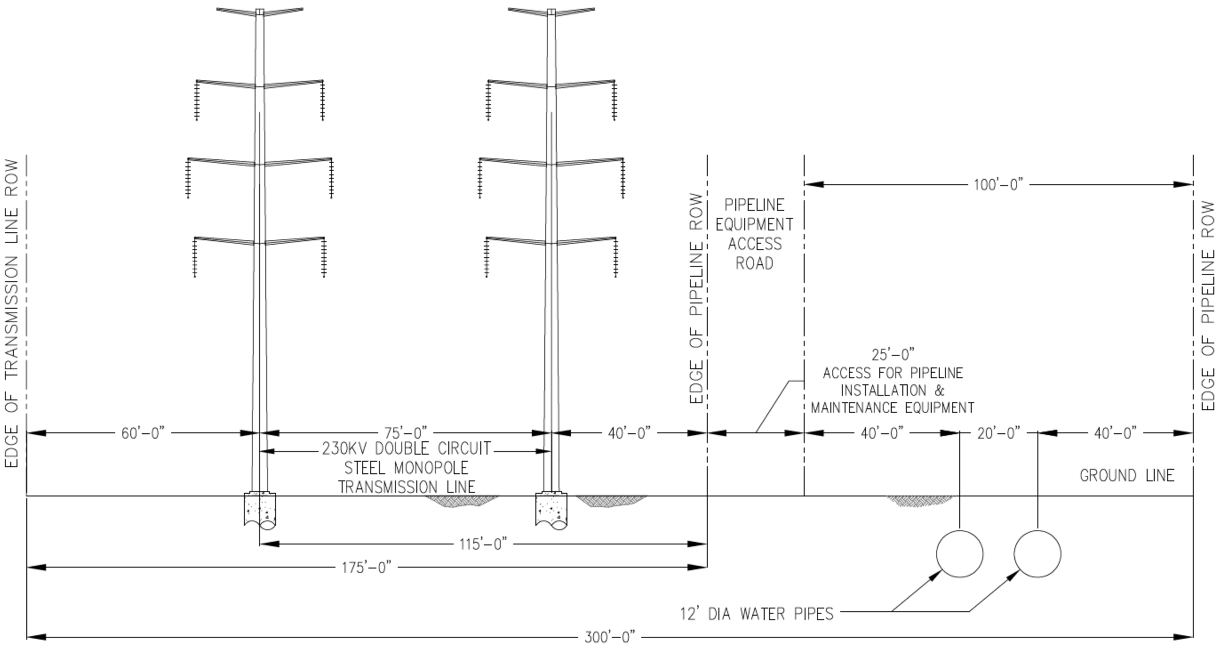

Figure 4. Funks TRR-East or Funks TRR-West Interconnect PG&E Option between Existing PG&E Corridor and TRR-East or TRR-West

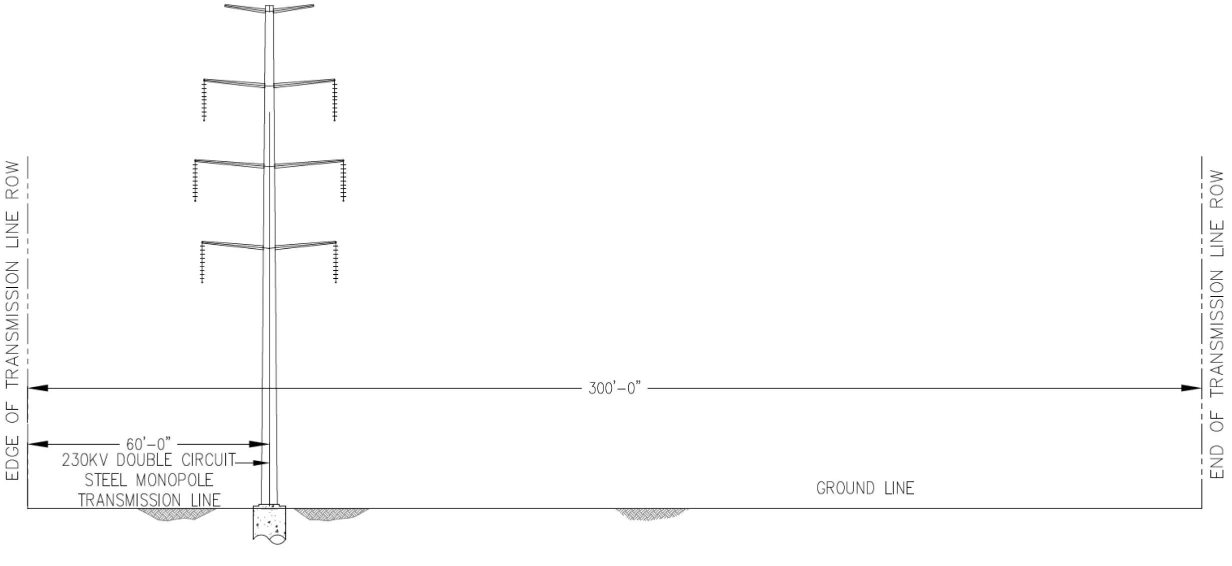

Figure 5. Funks TRR-East or Funk TRR-West Interconnect PG&E Option between Existing WAPA Corridor and Funks

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3.0 Description of Facilities

This section describes the proposed facilities where applicable. In most instances, the descriptions in this section are more clearly understand by looking at the drawings associated with this deliverable (revision 3 drawings, dated April 30, 2021, are in a separate file).

3.1 Red Bluff Diversion

The Red Bluff Diversion is an existing facility that will require minimal improvements because provisions were made during original design and construction to add the two required pumps.

3.2 GCID Main Canal Improvements

Following are general descriptions of improvements required for GCID facilities. Main Canal Headgate Structure

The existing headgate structure will be left in place to continue to serve as a bridge between County Road 203 and County Road 205. The existing headgate structure will continue to operate during construction of the new headgate structure, and diversion activities will continue throughout construction. The existing headgate will not be adequate for proposed winter operation during high river flows because of the large head-drop (decrease of water elevation) across the structure during high river levels. A new headgate structure will be constructed upstream of the existing structure. The new headgate structure will include eight automated gates. The water level and flow control functions will involve operating conditions that would result in water surface drops across the head gate of between 3 and 15 feet. The canal reach immediately downstream of the new head gate structure will be lined with concrete for approximately 35 feet to prevent erosion resulting from the turbulent flow conditions.

A temporary bypass channel will need to be created around the new headgates location to allow continued flow to downstream users while the structure is being constructed. The details of this bypass channel location will be developed in the next phase of work.

Railroad Siphon

The California Northern Railroad siphon at mile 26.6, near Willows, does not meet design and operation criteria for the Sites Project; the siphon will need to be replaced. The existing railroad siphon structure was built in the early 1900s and includes five 7.25-foot by 6-foot barrels. At maximum existing flows of approximately 2,000 cfs, the head loss across the railroad siphon, resulting from high flow velocity and poor entrance and exit transitions, reduces upstream canal freeboard to marginal conditions. The structure's age, hydraulic capacity restrictions, and use as a major transportation link lead to the recommendation for its replacement. The new structure will consist of five barrels to approximately match the existing dimensions with improved entrance and exit transitions. The structure will be sized to support the design railroad live load.

The proposed replacement of the railroad siphon would require coordination and planning with railroad operators. Construction restrictions may exist regarding minimizing interference with regular railroad operations. To the extent possible, replacement of the railroad siphon would take place during periods of lowest train traffic, and railroad shutdown time would be minimized.

Walker Creek Siphon and Willow Creek Siphon

The Walker Creek and Willow Creek siphons located near Willows do not meet design and operation criteria for the Sites Project; the siphons will need to be replaced. The existing siphons are a compilation of two construction projects. There are four siphon barrels presumably constructed in the early 1900s and two barrels added as an addition in the mid-1970s. At maximum existing flows of approximately 2,000 cfs, the head loss across the siphons reduces upstream canal freeboard to marginal conditions. The structures' age and hydraulic capacity restrictions lead to the recommendation for replacement. The new siphons will consist of five 10-foot-wide by 8.5-foot-tall barrels.

The proposed replacement of the siphons will require a canal bypass during construction and will need to be coordinated with the creek crossings. Environmental restrictions and creek flows may present challenges for the canal bypass.

3.3 Funks Area

Pumping Generating Plants

The PGPs will consist of the pumping plant, hydro-generating turbine(s), and the energy-dissipation structure.

Pumping Station

The pumping station will consist of 13 pumps in a single row, with 6 pumps feeding into one 12-foot-diameter pipe, 6 pumps feeding into the other pipe, and the final pump as a standby pump that feeds into either pipe. The pumps were sized in consultation with a pump manufacturer. Because of the large head fluctuation in the Sites Reservoir levels and resulting pumping heads, all pumps are currently anticipated to have a variable-speed drive to adjust to the variable pumping heads, while staying within the pump operating range and efficiency. A TM was prepared to provide comparison of using adjustable speed drives versus only constant speed drives for this pumping plant. This TM can be found in Appendix C.

Generating Turbines

The hydro turbines at Funks have been initially designed in consultation with a manufacturer. The manufacturer determined that the wide range of generating head, in relation to the overall design head, prevents selection of a single turbine that covers the full range. The conceptual design is two turbines of a similar size, but with different speeds to use different design heads to cover the full range, with at least one unit and an overlapping unit, to have two functioning units in the middle head range.

The two generating units will be a 20 MW turbine (1,000 cfs at 255-foot head) and a 14.5 MW turbine (1,000 cfs at 190-foot head). The turbines are anticipated to be vertical Francis style. The draft tube discharge will need to be submerged, so the turbines will be in an underground structure with a roof.

Energy Dissipation

The energy-dissipation structure has been initially designed in consultation with a manufacturer. The manufacturer determined that a single 60-inch-diameter, fixed-cone valve with a hood will provide approximately 1,000 cfs discharge over the full range of head differential resulting from fluctuating reservoir levels. There will be a 60-inch-diameter, fixed-cone valve on each of the two 12-foot-diameter pipes, for a total of two 60-inch-diameter, fixed-cone valves and a total flow of 2,000 cfs.

Electrical

An electrical building will house most of the electrical equipment to protect it from the elements. The building size is about 50 feet wide by 280 feet in length. This building will be placed on top of the pumping unit intakes to save space and be close to the pumping units. The electrical building will be constructed with solid grouted CMU walls. CMU walls were selected to provide a durable vandal resistant exterior wall surface.

Reservoir

Improvements to the Funks Reservoir are anticipated to include removal of sediment build-up, as discussed previously. Regrading of the reservoir bottom near the proposed Funks PGP will also be necessary to provide a clear path of water to and from the PGP.

Pipeline

Preliminary hydraulic analysis indicates that two 12-foot-ID pipelines will be used to convey water between Funks and Sites Reservoir in both directions. The total length of the pipeline alignment is about 1 mile.

The two pipelines will connect two 23-foot-diameter inlet/outlet tunnels to the Site Reservoir, using large-diameter piping manifold. The design proposes to have the two Funks pipelines connect to one of the inlet/outlet tunnels.

3.4 TRR Area

Pumping Generating Plants

The PGPs will consist of the pumping plant, hydro-generating turbines, and the energy-dissipation structure.

Pumping Station

The PGPs will consist of the pumping station, hydro-generating turbine(s), and the energy-dissipation structure. The pumping station will consist of 13 pumps in a single row, with 6 pumps feeding into one 12-foot-diameter pipe, 6 pumps feeding into the other pipe, and the final pump as a standby pump that feeds into either pipe. The pumps were sized in consultation with a pump manufacturer. Because of the large head fluctuation in the Sites Reservoir levels and resulting pumping heads, all pumps are currently anticipated to have a variable-frequency drive to adjust to the variable pumping heads while staying within the pump operating range and efficiency. A TM was prepared to provide comparison of using adjustable speed drives versus only constant speed drives for this pumping plant. This TM can be found in Appendix C.

Generating Turbines

The hydro turbines at TRR have been initially designed in consultation with a manufacturer. The manufacturer determined that a single 11.5 MW turbine (500 cfs at 290-foot head) on each 12-foot-ID pipe will work under the variable head conditions. The turbines are anticipated to be vertical Francis style. The draft tube discharge will need to be submerged, so the turbines will be in an underground structure with a roof.

Energy Dissipation

The energy-dissipation structure has been initially designed in consultation with a manufacturer. The manufacturer determined that a single 60-inch-diameter, fixed-cone valve with a hood will provide approximately 500 cfs discharge over the full range of head differential, resulting from fluctuating reservoir levels. There will be a 60-inch-diameter, fixed-cone valve on each of the two 12-foot-ID pipes, for a total of two 60-inch-diameter, fixed-cone valves and a total flow of 1,000 cfs.

Electrical

An electrical building will house most of the electrical equipment to protect it from the elements. The building size is about 50 feet wide by 280 feet in length. This building will be placed on top of the pumping unit intakes to save space and be close to the pumping units. The electrical building will be constructed with solid grouted CMU walls. CMU walls were selected to provide a durable vandal resistant exterior wall surface.

Reservoir

This is an entirely new reservoir that is currently sited adjacent to the GCID Main Canal just north of Funks Creek. The reservoir volume is anticipated to be about 600 acre-feet to accommodate about 4 hours of an 1,800 cfs canal flow from GCID if there is a shutdown and a place needed to store the water.

Pipeline

Preliminary hydraulic analysis indicates that two 12-foot-ID pipelines will be used to convey water between TRR and Sites Reservoir, in both directions. The total length of the pipeline alignment is about 4.5 miles.

The two pipelines will connect to the 32-foot-diameter inlet/outlet tunnel to the Site Reservoir, using large-diameter piping manifold. It is proposed to have the two Funks pipelines connect to the other tunnel that is not connected to the Funks pipelines.

3.5 Administration/Operation and Maintenance/Storage Buildings

An administration and operation building, and a maintenance and storage building will be placed slightly northwest of the Funks PGP.

3.6 Dunnigan Pipeline

The Dunnigan Pipeline connects to the intake structure on the TCC. The Dunnigan Pipeline downstream termination point has two alternatives. Alternative A goes from the TCC to the CBD. Alternative B goes from TCC to the Sacramento River. Either of these pipelines will flow at 1,000 cfs and be based on gravity head from the TCC. Once the pipeline leaves the intake structure, it heads east, crossing and then paralleling Bird Creek. Soon after reaching Bird Creek, the pipeline will be tunneled under Interstate 5 and then Highway 99 and a railroad. The pipeline continues to head east along Bird Creek to the CBD. The 9-foot pipeline would end at this drain per and outlet structure. If the pipeline is to continue, it would cross the drain, head north, and then head east along rice fields to the Sacramento River. The pipeline will cross over Highway 45 and a levee and into the river through an outfall structure.

The proposed length of Alternative A alignment is about 4 miles. Preliminary calculations show a 9-foot (108-inch) ID, with 2 tunneled crossings (I-5 and 99W/RR) that require 10.5-foot (126-inch) casings. The total length of pipeline is 20,000 feet, with 300-foot and 250-foot tunneled crossings. Two 60-inch-diameter, fixed-cone valves, spaced 16 feet apart, will be placed at the discharge stilling basin to dissipate energy and adjust the flow.

The proposed length of the Alternative B alignment is about 10 miles. Preliminary calculations show a 10.5-foot (126-inch) ID, with 3 tunneled crossings (I-5, 99W/RR, and CBD) that require 12-foot (144-inch) casings. The total length of pipeline is 51,600 feet, with 300-, 250-, and 250-foot tunneled crossings. A portion of the flow will discharge to the CBD with one 36-inch-diameter fixed-cone valve and stilling basin. The pipeline will ultimately terminate at the Sacramento River outlet structure.

Both of these alignments are shown in the drawings, under separate cover.

A third alternative pipeline alignment known as the Harrington Pipeline (located about 8 miles north of Dunnigan Pipeline) from the TCC to the CBD was studied and summarized in a TM located in Appendix D. The TM recommends keeping the Dunnigan Pipeline to convey water back to the Sacramento River. The TM was presented to the Sites Ad Hoc Operations and Engineering Work Group on August 11, 2020 and they decided that the Harrington Pipeline was not a viable alternative.

The structures associated with the Dunnigan Pipeline include the following intake and discharge structures.

- TCC Intake Structure
- CBD Outlet Structure
- Sacramento River Outfall Structure

TCC Intake Structure

The intake structure will be used to divert water from the existing concrete lined TCC into the Dunnigan Pipeline. The intake structure will be a concrete structure that supports the control gates and associated gate operators. A concrete bridge deck will provide vehicle access across the top of the structure. Stop log slots will be provided upstream and downstream to isolate the control gates for maintenance.

Colusa Basin Drain Outlet Structure

The outlet structure for option A includes a stilling basin and two fixed-cone valves to dissipate energy before water enters the existing CBD canal. The outlet structure for option 2 includes a stilling basin and one fixed-cone valve to dissipate energy before water enters the existing CBD canal. The geometry of the stilling basin used in either option is sized in accordance with the Bureau of Reclamation’s Hydraulic Design of Stilling Basins and Energy Dissipators and valves will include hoods to control spray.

Sacramento River Outlet Structure

The pipeline will terminate in an energy dissipating structure. The energy dissipating structure will be located on the west side of the Sacramento River levee and will discharge water through the levee to the River with ten 36-inch-diameter pipes. The structure on the west side of the levee will be located such that it is outside the area of influent of the levee slope. The ten 36-inch-diameter pipelines is based on the United States Army Corp of Engineers not allowing penetrations through the levee below the high water level. The outlet structure discharge into the Sacramento River will include a vertical drop exclusion barrier, based on interpretation of NOAA Fisheries design guidelines, to prevent the passage of anadromous fish into the pipeline. The minimum vertical drop will be 10-feet at the top of the levee onto rip rap extending to the River. Refinement of this structure design and coordination with the Army Corp of Engineers will be completed in the next design phase if this option is selected.

3.7 Electrical Supply

Point of Interconnection

The POI for the project will require that an Application for Interconnection Request be submitted and processed under the CAISO Interconnection Process. The location of the POI to either the WAPA or PG&E 230-kV transmission lines will depend on the results of a system impact study (SIS), which will be required to be performed by the independent system operator of the transmission system, CAISO.

The interconnection application process includes that the project enters into a SIS agreement, which requires the project to compensate CAISO for its actual costs to undertake the SIS. CAISO will include in the agreement a non-binding estimate of the cost and a timeframe for completing the SIS. The SIS report will state the results of the power flow, short-circuit, and stability analyses, and will provide the requirements or potential impediments to the requested POI, including a preliminary indication of the cost and length of time necessary to correct any problems identified in the SIS. The SIS report will also provide a preliminary list of facilities required to be upgraded to accommodate the supply of power to the project.

The application process then entails CAISO performing a facilities study (FS). The Project will enter into a FS agreement, which requires the project to compensate CAISO for its actual costs to perform the FS. CAISO will include in the agreement a non-binding estimate of the cost and timeframe for completing the FS. Upon completion of the FS, CAISO will provide the FS report. The report will specify the estimated cost of the equipment, engineering, procurement, and construction work needed to implement the conclusions of the SIS. The FS report will also identify the electrical switching configuration of the connection equipment, including: the transformer, switchgear, meters, and other station equipment. The report shall include a +/- 20 percent cost estimate of facilities necessary for the interconnection, and an estimate of the time required to complete the construction and installation of such facilities.

The application process then entails the project entering into the Interconnection Agreement, (IA). The IA will require that the actual costs associated with the equipment, environmental, engineering, procurement, construction, and any other work needed to accomplish the interconnection be payable by the project. The IA will specify the interconnection and network facilities that will be required to interconnect the project.

The California Independent System Operator interconnection procedures place applications into groups, known as clusters, for projects that are interconnecting in the same area to be studied together.

This process will begin when the turbine and generator system designs become more developed, which is expected to be in the summer of 2022.

Transmission Lines

A POI to a high-voltage electric transmission line will be required for the project. Interconnecting to the transmission system is necessary to provide for the supply of power to operate the large-horsepower pumps at the Funks PGP, and the PGP located at either TRR-East or TRR-West. In addition, the interconnection to the transmission system will allow Funks PGP and the TRR PGP to send energy produced to the transmission system during the periods when they are using their turbines/generators.

Several existing high-voltage transmission lines are in the vicinity of the project; all of these lines run north to south. These transmission lines include two 230 kV lines owned and operated by WAPA, and four 230 kV lines owned and operated by PG&E. WAPA and PG&E are defined as the TOs of their respective high-voltage transmission lines. Each of these lines is a potential POI source for the project. The Transmission Agency of Northern California, (TANC), owns a 500-kV, high-voltage transmission line that runs parallels to the WAPA lines; however, this transmission line is not considered to be a potential POI for the project.

See Figures 6 and 7 for schematic sketches showing the WAPA and PG&E alternative POI arrangements, and the required transmission line lengths to the proposed Funks and TRR-East or -West substations. Under either alternative POI, the power will be delivered to the project via looped (two circuits) 230 kV to the supply power for the pumps. The looped circuits would also receive power from the Funks PGP and TRR PGP when their turbine/generators are operating. The looped circuits are typically installed on double-circuit steel monopole structures (poles), as shown earlier in Figure 2. The poles would be approximately 100 to 150 feet high and supported atop reinforced-concrete foundations that are augured and designed in accordance with the results of the geotechnical investigation. The conductor size will be designed to match or be larger than the existing conductor size of the transmission line, which will be interconnected via the loop. One or two fiberoptic cables can be used as shield wire, the size of which will be determined by fault current requirements and TO telecommunication requirements.

In addition to the loop POI design, there will be two additional 230 kV transmission line radial taps installed between the Funks and TRR substations. The transmission line structures for these lines will be double-circuit, steel monopole structures, as shown in Figure 4. The poles would be approximately 100 to 150 feet high and supported atop reinforced-concrete foundations that are designed in accordance with the results of the geotechnical investigation. The conductor size is estimated to be 795 kcmil aluminum conductor steel reinforced (ACSR). In some sections of the transmission line; the double-circuit, monopole tap lines may share a common ROW with the double-circuit, monopole looped circuits (see Section 2.9).

The configuration of the transmission lines will depend on the selected POI, which is described in the following subsections.

WAPA POI Option

This option proposes to loop the existing WAPA 230 kV Keswick-O'Banion transmission line into and out of the Funks substation, as shown schematically on Figure 6. The length of the looped, double-circuit, steel monopole line will be approximately 1 mile, in a generally westerly direction to Funks. Two new, three-pole, single-circuit structures will be cut into the existing transmission line; the existing wires between these two structures will be removed. The new conductors in the first spans toward Funks will be installed low on the poles to achieve the proper clearances as they cross under the existing TANC 500 kV transmission line to two, new, double-pole, single-circuit (or one, new, double-pole, double-circuit) steel H-Frame structures. Minimum phase-to-phase and phase-to-ground clearances will be in accordance with WAPA and TANC standards, and the *State of California Public Utility Commission Rules for Overhead Electric Line Construction*. Conductors will match or exceed the conductor size of the existing WAPA line.

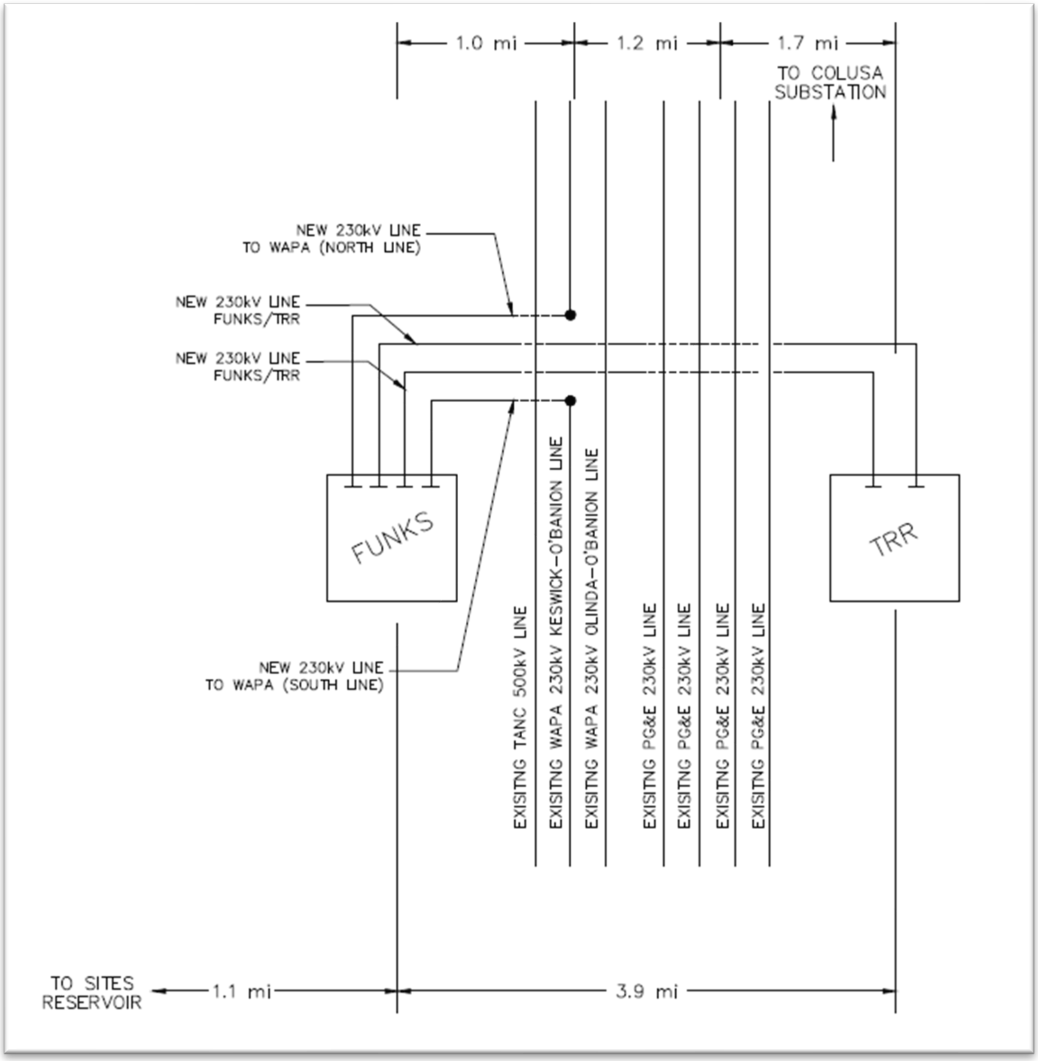

Figure 6. Schematic of WAPA POI Option

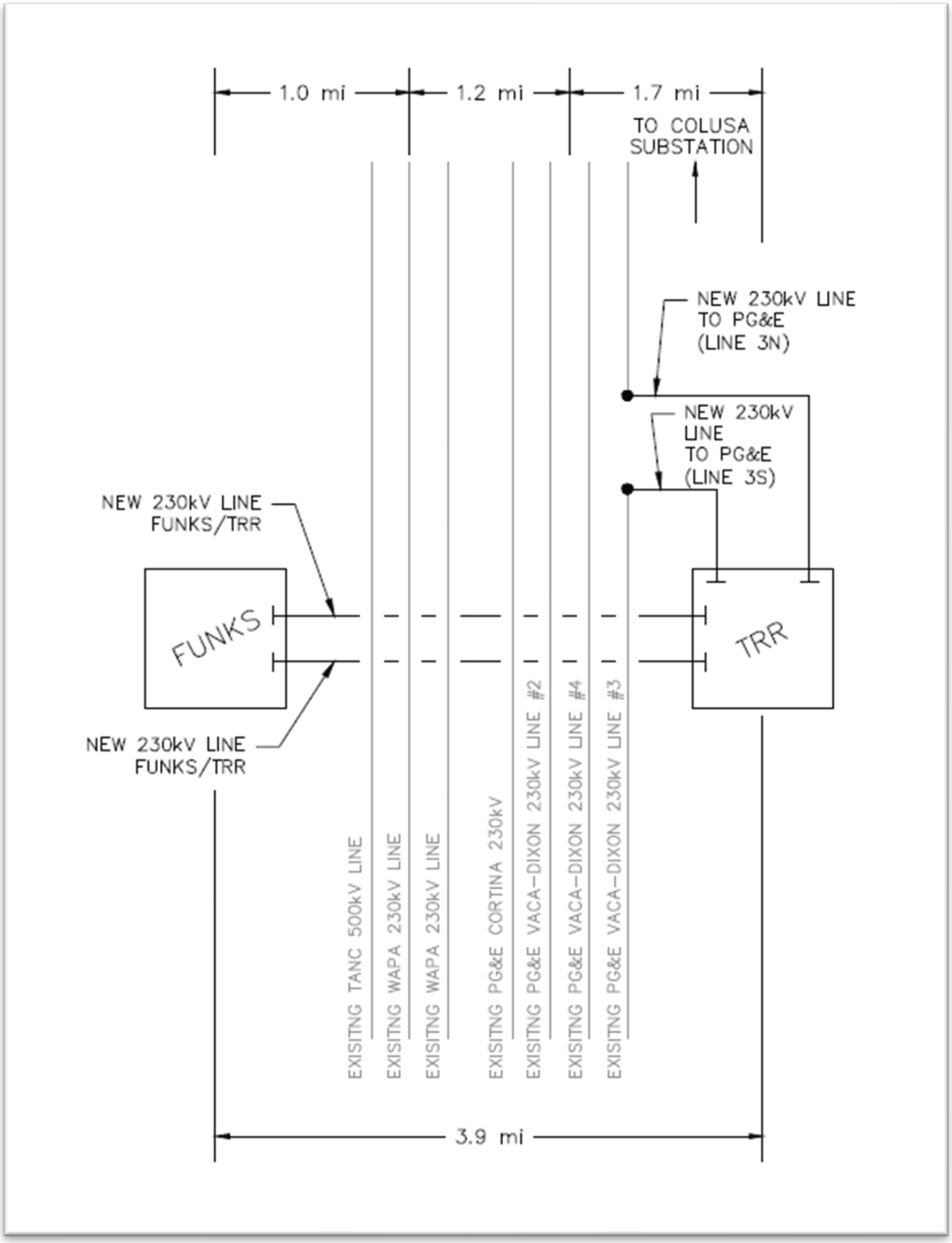

Figure 7. Schematic of PG&E POI Option

Two, new, 230 kV, radial lines will also be constructed between the Funks and TRR substations, on double-circuit, steel, monopole structures, for a length of approximately 3.9 miles. H-Frame construction will be used at the crossings below the TANC 500 kV Line, the two WAPA 230 kV lines, and the four PG&E lines.

Although the structures between Funks and TRR will be designed to accommodate two 230 kV circuits, it is possible that only one circuit will be initially installed. The conductor will be 795 kcmil ACSR.

PG&E POI Option

This option proposes to loop one of the existing PG&E 230 kV transmission lines into and out of the TRR substation, as shown schematically on Figure 7. The looped, double-circuit, steel monopole line will be approximately 1.7 miles, in a generally easterly direction to TRR-East or approximately 0.7 mile to TRR-West. Two, new, monopole-pole, single-circuit structures will be cut into the existing transmission line; and the existing wires between these two structures will be removed. Conductors will match or exceed the conductor size of the existing PG&E line.

Two new 230 kV radial lines will also be constructed between the TRR and Funks substations, on double-circuit, steel monopole structures, for a length of approximately 3.9 miles to TRR-West and approximately 1.5 miles to TRR-West. Single- or double-circuit, steel, H-Frame pole construction will be used at the crossings below the existing TANC 500 kV Line, the two WAPA 230 kV lines, and the four PG&E lines, to achieve proper minimum phase-to-phase and phase-to-ground clearances, in accordance with WAPA and TANC standards, and the *State of California Public Utility Commission Rules for Overhead Electric Line Construction*.

Although the structures between Funks and TRR will be designed to accommodate two 230 kV circuits, it is possible that only one circuit will be initially installed. The conductor will be 795 kcmil ACSR.

Substations

Each pumping/hydroelectric generator substation at the TRR and Funks Reservoir will have a new 230 kV to 13.8 kV substation. The substations will service a net pumping energy demand, estimated at 80 MVA at Funks and 90 MVA at the TRR site, totaling 170 MVA of demand load.

In terms of generation, estimates indicate that Funks Reservoir will have a net generating capacity of 38.3 MVA and that TRR will have a net generating capacity of 25.6 MVA. The project's total net generating capacity to the grid is estimated to be 63.9 MVA.

The project estimated pumping energy requirements and power generation are summarized as shown in Tables 11 and 12.

Table 11. Project Pumping Summary

Site	Net Pumping Power (MW)	Other Auxiliary Loads (MW)	Transformer and T Line Losses (MW)	Total Pumping Power (MW)	Total Pumping Power @ 0.85 Power Factor (PF) (MVA)
Funks	67.1	1	0.1	68.2	80.2
TRR	75.4	1	0.1	76.5	90.0
Total	**142.4**			**144.7**	**170.2**

Table 12. Project Generating Summary

Site	Net Generating Power (MW)	Other Auxiliary Loads (MW)	Transformer and T Line Losses (MW)	Total Power Generation (MW)	Total Power Generation @ 0.85 PF (MVA)
Funks	33.4	1	0.1	34.5	38.3
TRR	21.9	1	0.1	23.0	25.6
Total	**55.3**			**57.5**	**63.9**

The substations will be designed to for the total pumping power requirements (import) or total generation requirements (export).

3.8 Site Civil and Roadway Improvements

Site Civil

Funks Area

The proposed Funks PGP site is located in Colusa County, on the northwestern side of the existing Funks Reservoir. Access is provided to both the southern and northern ends of the site, as described in the roadway improvement section.

Asphalt concrete-paved, onsite, vehicular access will be provided between the proposed PGP and substation, with facility spacing to accommodate an operational crane with outriggers extended. Asphalt concrete-paved, onsite parking and vehicular access will also be provided at the two buildings on site, the maintenance and storage building, and the administrative and operations building. Additional gravel parking will be provided near the pumping generating plant.

The proposed substation and overall site will be enclosed by a security fence (6-foot-tall, chain-link fabric with 1-foot of three-strand barbed wire on top) with 30-foot-wide, double-swing access gates on the southern and northwestern sides. The switchyard will have internal gates as well as one external gate to accommodate access requirements.

Site drainage will be conveyed offsite directly into the Funks Reservoir via gentle swales or overland flow. Offsite stormwater runoff will be collected on the western side of the site in a ditch and conveyed around the site and into the Funks Reservoir.

The proposed Funks PGP site is in a Federal Emergency Management Agency (FEMA) Area of Minimal Flood Hazard, Zone X.

TRR Area

The proposed TRR is located in Colusa County, north of the GCID Main Canal and just West of McDermott Road. The site will be accessed via a maximum 30-foot-wide asphalt concrete, paved road from McDermott Road. Paved parking will be provided near the pumping generating plant.

Vehicular access will be provided inside the proposed switchyard, as well as to the pumping generating plant and inlet and outlet structures, with facility spacing to accommodate an operational crane with outriggers extended. The proposed switchyard and overall site will be fenced with 7-foot chain-link fence and access gates on the southern and eastern sides.

Site drainage will be conveyed offsite to the existing GCID Main Canal or directly into the TRR via gentle swales or overland flow.

The proposed TRR site is located within a designated FEMA Special Flood Hazard Areas, Zone A, Without Based Flood Elevation. A base flood elevation will need to be determined prior to project approval.

Roadway Improvements

Funks Area

The Funks PGP site will be accessed via a 30-foot-wide asphalt, concrete-paved road from Maxwell Sites road to the south. Existing gravel and roads will be improved to be 30 feet wide with asphalt concrete surfacing for the southern access; these will be relocated through the PGP site. A 30-foot-wide gravel bypass road may be provided to the west of the site. On the northern side of the site, the existing dirt road will be improved to be a 30-foot-wide gravel road that will follow the existing road alignment until it reaches the TRR pipeline. At that location, a new 30-foot-wide access road will be built alongside the Funks and TRR pipelines to the connection with the Sites tunnels.

Most of the road is within a FEMA Area of Minimal Flood Hazard, Zone X, but a portion of the existing gravel road to the northwest of the PGP site and adjacent to the existing creek is located within a FEMA Special Hazard Flood Area without Base Flood Elevation, Zone A. This portion may need to be raised if all-season access from that direction will be required.

TRR Area

The TRR and site improvements will be accessed via the existing McDermott Road. No roadway improvements are anticipated on existing roads.

3.9 Summary of Other Analysis

Additional analysis was conducted for the Sites Project as follows and found in Appendices to this report:

- Utilizing proposed pipeline and other facilities to convey emergency drawdown of Sites Reservoir (Appendix E)
- Option to provide 10 cfs of base flow to the head of Funks Creek (Appendix F)
- Evaluation of potential hydroelectric revenue (Appendix G)

4.0 Acronyms and Abbreviations

ACSR	aluminum conductor steel reinforced
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
Authority	Sites Project Authority
CAISO	California Independent System Operator
CBC	California Building Code
cfs	cubic foot per second
CMU	concrete masonry unit
FEMA	Federal Emergency Management Agency
FS	facilities study
GCID	Glenn-Colusa Irrigation District
IA	Interconnection Agreement
ID	inner diameter
IEEE	Institution of Electrical and Electronics Engineers, Inc.
JPA	Joint Powers Authority
ksi	kilopounds per square inch
kV	kilovolt
MPR	motor protection relay
MVA	millivolt-ampere
MW	megawatt
PE	permanent easement
PF	power factor
PG&E	Pacific Gas & Electric
PGP	Pumping Generating Plant
POI	point of interconnection
Reclamation	U.S. Bureau of Reclamation
ROW	right-of-way
rpm	rotation per minute
SIS	system impact study
TANC	Transmission Agency of Northern California
TCC	Tehama-Colusa Canal

TCE	temporary construction easement
TO	Transmission Operator
TRR	Terminal Regulating Reservoir
V	volt
WAPA	Western Area Power Administration
WSE	water surface elevation
WSP	welded-steel pipe

5.0 Citations

Jacobs. 2021a. Sites Reservoir Project Task Order 2 Feasibility Study HC Conveyance Facilities. Revision 3 April 30.

Jacobs. 2021b. *Sites Reservoir Project HC Conveyance Facilities Feasibility Design Basis of Estimate Cost Report*. June 2.

Sites Program Management Team. 2020. *Sites Project Value Planning Alternatives Appraisal Report*. April.

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Appendix A
Pipeline Design Criteria

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Survey and Mapping		
Horizontal Drawing Scale	1 inch = 200 feet (ft)	
Vertical Drawing Scale	1 inch = 20 ft	
Photo Plans	0.2-ft pixel resolution at 50 scale	
Contours	2 ft minor 10 ft major	
Pipeline Sizing/Hydraulics		
Maximum Velocity (normal)	10 ft per second	
Maximum Velocity (emergency)	35 ft per second	
Largest Standard Pipe	12-foot inside diameter	This is largest common pipe to be transported as fabricated. Larger pieces are considered special and excluded from this requirement.
Head Loss	Dynamic head determined using Hazen-Williams value of: C_{HW} = 120 (high friction case) C_{HW} = 145 (low friction case)	
Pipe Inside Diameter	Varies	
Pressure Considerations	Working Pressure = varies Design Pressure = varies Applies for design of the pipeline fittings, specials, and appurtenances Maximum Surge = not to exceed 1.33 times the design pressure Test Pressure = not to exceed 1.25 times the design pressure	
Drawings	Hydraulic profile(s) will be included in the drawings.	
Horizontal Alignment		
References	American Water Works Association (AWWA). *Concrete Pressure Pipe (M9) 3rd Edition*. American Water Works Association (AWWA). *Steel Pipe – A Guide for Design and Installation (M11) 5th Edition*.	
Drawing Layout	Stationing will be shown on the drawings. Northing/Easting will be shown at horizontal points of intersection (HPIs).	
	Locations of appurtenances shown on the drawings.	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Horizontal Bends	Combine horizontal and vertical angle points wherever possible and call out as "Combined Bend" in the plan view. Bends less than or equal to 3.75° or ¾" maximum pullout can be made with standard joint deflection in the field at the joints that fall on either side of the HPI.	
	Larger bends than standard joint deflections can be made using a beveled end joint on either side of the location of the HPI. Maximum bevel at any joint not to exceed 5°. Bends greater than 5° are made using fabricated elbows. Horizontal curves are identified on the drawings.	
Vertical Alignment		
References	American Water Works Association (AWWA). *Concrete Pressure Pipe (M9) 3rd Edition*. American Water Works Association (AWWA). *Steel Pipe – A Guide for Design and Installation (M11) 5th Edition*.	
Drawing Layout	Minimal slopes shown in ft/ft between vertical points of intersection (VPIs). VPI elevations control actual slope. Minimum slope = 0.001 ft/ft or 0.1%. Avoid flat (0% slope) reaches. Surface slopes greater than 10% may require trench cutoff walls. Minimum cover over pipe is 6 ft unless otherwise approved. Pipe stationing and centerline elevations will be shown at VPIs.	
Utility Crossings	Maintain a minimum clearance (as coordinated with utility owner) between utilities crossing the water pipeline to be identified in future submittals.	
Vertical Bends and Curves	Combine horizontal and vertical angle points wherever possible and call out as combined point of intersection in the plan view. Bends less than or equal to 5° can be made with standard joint deflection in the field at the joints that fall on either side of the HPI.	
	Larger bends than standard joint deflections can be made using a beveled end joint on either side of the location of the VPI. Maximum bevel at any joint not to exceed 5°.	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
	Bends greater than 5° are made using fabricated elbows.	
Pipe Material		
References	For steel coil, refer to American Society for Testing and Materials (ASTM) A1018/A1018M for specification of structural steel. For steel plate, refer to ASTM A516/A516M for specification of structural steel. American Society of Civil Engineers. *Steel Penstock Design Manual of Practice (MOP) 79*. American Water Works Association (AWWA). C200-05.	
Material	In accordance with AWWA C200: Coils: ASTM A1018/A1018M Structural Steel Grade 36, Type 2 Modified 1. Manganese: 1.5% maximum 2. Aluminum: 0.02% minimum 3. Phosphorus: 0.025% maximum 4. Sulphur: 0.015% maximum Plate: ASTM A516/A516M Grade 65 Yield strength: 42 kilopounds per square inch (ksi), minimum Tensile strength: 63 ksi, minimum Maximum measured yield strength 85% of measured tensile strength Min Elongation: 21% in 2-in gauge length Carbon equivalent (CE) <0.45	
	Fully killed, fine-grained practice, continuous cast Toughness: 25 ft-lbs at 30°F for pipe wall thickness 7/16 in or above, per Charpy Test	
Minimum Wall Thickness	See Pipe Structural Section.	
Standard Barrel Length	40 ft maximum.	
Pipe Structural Section		
References	AWWA M11 5th Edition. AWWA C200-05. ASCE MOP No. 79 – Steel Penstocks.	
Procedure (see brief procedures below)	1. Minimum handling 2. Hoop stress (Barlow) 3. External loading (Spangler, soil buckling, highway, railroad, construction, and vacuum) 4. Longitudinal stress	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
	5. Biaxial stress 6. Collapse (Stewart's) 7. Mitered bend wall thickness	
Internal Pressure	Values determined using pump station hydraulic analysis and system surge analysis.	
Factory Test Pressure	In accordance with AWWA C200 5.3.	
(1) Minimum Handling	thickness = D/240	
(2) Hoop Stress	Barlow formula P=2tS/D, where S = the allowable hoop stress as described in the right-hand column. AWWA M11 §4.1.	
(3) External Loading Spangler Soil Buckling	Deadload (DL): based on actual unit weight of backfill material. AWWA M11 §6.4. Live load (LL): based on HS-20 highway loads and E-80 railroad loads, per AWWA M11 Chapter 6. Construction loading per AWWA M11 Chapter 6 using extreme external LL from a large loader. AWWA M11 §6.8. Pipe is required to withstand full vacuum in the soil buckling analysis. External load combinations applied for determining soil buckling are as follows: 1. DL + LL (Construction) 2. DL + LL (HS-20) 3. DL + LL (E-80) 4. DL + PV (Internal Vacuum Pressure)	
(4) Longitudinal Stresses	Evaluate for the following two conditions: 1) warm weather temperature installation; 2) bulkhead stresses. Pipe wall and joint selection must be consistent with the condition that proves to be the limiting case. For longitudinal joint stresses, joint efficiencies are: e = 0.45 (single-welded lap) e = 0.55 (double-welded lap) e = 0.70 (butt weld, no radiographic test [RT]) e = 0.85 (butt weld, partial RT) e = 1.00 (butt weld, full RT) AWWA C206 for guidance on welding procedures.	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Warm Weather Installation	Warm weather installation allowable working longitudinal stress is the lesser of: 1. Tensile strength divided by 2.4, or 2. Yield strength divided by 1.5, or 3. The lesser of the above multiplied by the joint efficiency to obtain the allowable working longitudinal stress The allowable working longitudinal stress has to be greater than the longitudinal stress as calculated per AWWA M11, Chapter 8. The temperature stress is divided by the thermal load stress multiplier to calculate the longitudinal stress.	
Bulkhead Stresses	Allowable working longitudinal stress is the lesser of tensile strength divided by 2.4, yield strength divided by 1.5, or allowable hoop stress multiplied by the joint efficiency. The allowable working longitudinal stress has to be greater than the bulkhead stress, which is 50% of the hoop stress.	
(5) Biaxial Stress Cold Weather Installation	Cold weather installation allowable working biaxial stress is the lesser of yield strength divided by 1.5, or tensile strength, divided by 2.4. The lesser of the above two values is multiplied by the joint efficiency of the spiral weld. The allowable working biaxial stress has to be greater than the Von Mises Biaxial Stress as directed by ASCE Manual 79, Chapter 3. The temperature stress is divided by the thermal load stress multiplier to calculate the longitudinal stress and the biaxial stress. Spiral Weld Joint Efficiency = 0.85	
(6) Collapse	Stewart's Formula: Collapsing pressure determined using AWWA M11 §4.4. Stewart's Formula only applies in locations listed in the column to the right and if negative pressures are calculated from the surge analysis at those locations.	
(7) Mitered Bends	Thickness of mitered bends determined using procedure in AWWA M11 Chapter 9.	
Soil Loads	In accordance with depth per unit soil weights from geotechnical reports (to be published).	
Thrust Forces for Bends and Valves	AWWA M11 Chapter 13.	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Pipe Joints		
References	AWWA C200-05. AWWA C207. AWWA C208. AWWA C219. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 1, Part 2. ASME 16.5 and ASME 16.47.	
Joint Types	The standard field joint is single-welded lap. Other welded joints include double-welded lap, butt joint welds, and butt strap welds. Flanged joints or restrained flexible joints may be used at connections as described below. Strength of welded joint efficiency as stated in AWW M11. Butt strap welds have the same joint efficiency as a double-welded lap joints.	
Special Joints	Flexible-type pipe coupling with harness restraints per modified AWWA M11 and AWWA C219. Flexible-type couplings configured as a dismantling joint in accordance with AWWA C219. Provide with suitable thrust restraining capability. Insulating joints depend on soil corrosivity. Generally, provide insulating joints at: • Connections to pump stations • Between pipe in low-resistivity soils and pipe in high-resistivity soils • Upon entering and/or exiting vaults • Connections to electrically grounded equipment (valves) within vaults	
	Use flanged joints as follows: • Flanged joints are used at combination air-release vacuums (CARVs), blowoffs, and other locations as needed • ASME B16.5 and ASME B16.47, class 150 or class 300, bolted flanges for pipe where appropriate Use restrained flexible joints as follows: • Restrained flexible joints are used downstream of the blowoff riser pipe and blowoff pump well	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Thrust Restraint	Do not use unrestrained joint system unless it has been verified that no forces must be restrained at a particular joint. Use full force (PA) as basis for thrust design. Flexible couplings: anchor each side of coupling for resultant axial thrust force. Fittings: for fully restrained pipeline consider longitudinal force as described in AWW M11. Restrained Dismantling Joint: anchor each side of coupling across the joint for resultant axial thrust force.	
Elbows, Tees, Wyes, Bends	Comply with AWWA C208. Minimum radius = 2.5 times pipe outer diameter, unless designed for smaller radius per AWWA C208. Use elbows as follows: • 2-piece (0° to 22.5° deflection angle) • 3-piece (22.5° to 45° deflection angle) • 4-piece (45° to 67.5° deflection angle) • 5-piece (67.5° to 90° deflection angle)	
Nozzles, Dished Heads, and Test Heads	Design in accordance with ASME BPVC, Section VIII, Division 1.	
Pipeline Testing		
References	AWWA C206. AWWA M11. ASME BPVC, Section IX. American Welding Society (AWS) D1.1 for field welds.	
Hydrotesting	AWWA M11 Chapter 12. Test pressure not to exceed 125% of the conservative design pressure. Hydrostatic testing required for the main pipeline and includes the blowoff isolation valve, CARV, and related appurtenances. Maximum filling velocity not to exceed 1.0 feet per second, with calculated based on the full area of pipe. Hydrotesting of the blowoff piping and related appurtenances downstream of the blowoff isolation valve will not be required. Pipe with welded joints and flange joints to have zero allowable leakage.	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Field-welded Joint Testing	Test in accordance with ASME BPVC Section IX for shop welds and AWS D1.1 for field welds. Field Single-Welded Lap Joints: Visual inspection of 100% of welds plus 100% full circumference liquid penetrant (PT) or magnetic particle (MT) test on single lap welds. Field Double-Welded Lap Joints and Butt Strap Joints: Visual inspection of 100% of welds plus test double-welded lap joints and butt strap joints by pressurizing welds to 40 pounds per square inch and painting welds with soap solution. In addition, perform 100% full circumference PT or MT test on double-lap welds and butt strap joints. Field Butt Joint Joints: Visual inspection of 100% of welds plus full circumference spot RT test on butt joint welds.	
Protective Coatings and Linings		
References	AWWA C209 AWWA C214 AWWA C216 AWWA C222.	
Pipe Coating	Tape Coating System per AWWA C217, AWWA C216, AWWA C214 and AWWA C209. Polyurethane Coating System per AWWA C222 except as modified herein: Self-priming, plural component, 100 percent solids, polyurethane, suitable for burial or immersion, and the product of one of the following approved manufacturers: • Futura Coatings (Protec II), Hazelwood, Missouri. • Chemline (Chemthane 2261/2265), St Louis, Missouri.	
Pipe Lining	Cement Mortar Lining per AWWA C205. Velocity from 0 to 15 feet per seconds (fps) meets requirements for cement mortar lining. Velocities greater than 15 fps are polyurethane lined per AWWA C222.	
Pipe Fittings	Coat buried connections, flanges, and any other irregular shapes with petrolatum or wax tape per AWWA C217. Use filler to create a smooth regular surface before applying petrolatum or wax tape.	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
	Coat buried welded joints with heat-shrinkable sleeves per AWWA C216. Wax tape coat buried accessways, per AWWA C217.	
Pipeline Appurtenances		
References	AWWA M11, 5th Edition. ASME BPVC, Section VIII, Division 1.	
General	No above ground pipeline appurtenances shall be constructed within Jurisdictional Waters of the United States or non-jurisdictional wetland.	
Manway Access	Accessways are provided every 2000 feet +/- Accessways are provided within 20 ft of vertical bends at the top of pipeline slopes that are greater than 12 percent grade. Accessways not associated with CARV vaults are buried. Accessways are combined with CARV vaults where possible to reduce number of buried access manways. Mainline accessways are minimum 30-in diameter with a blind flange top access. Accessway outlets are designed per AWWA M11.	These criteria are based on the desire of Sites JPA to have access manways. However, it is to be determined whether Sites wants access manways or not.
Pipeline Isolation Valves	There are no mainline isolation valves on the pipeline except where required for operations.	
Combination Air Valves (Air/Vacuum Release)	Design air valves for the following conditions: • To evacuate air during pipeline filling at a filling velocity of 1 fps. • To allow air to enter during pipeline draining at rates defined in the Blowoff operations sequence. • To meet the requirements defined by surge analysis. • To allow air to enter to prevent vacuum conditions during a 24-in diameter rupture. • Intermediate air valves, as described in AWWA M-51 to release air at locations other than highpoints will not be installed. Sizing the CARV is based on the following additional criteria: • Maximum differential pressure across the CARV during pipe draining or	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
	emergency pipeline rupture as recommended by valve manufacturer. • Maximum differential pressure across the CARV during filling as recommended by valve manufacturer. • Minimum seating pressure above CARV orifice as recommended by valve manufacturer.	
Blowoff Assemblies	Design flow for blowoffs are based on the smallest of: • Resulting flow if the maximum velocity in the main pipeline during draining is 2 ft/s • Resulting flow based on the discharge drainage channel not exceeding a maximum allowable downstream discharge capacity equal to the channel's 2-year storm event • Resulting flow if the maximum velocity in the blowoff piping is 12 ft/s	
	Every low point within the system is designed with a blowoff. Minimum cover above blowoff piping is 2.5 ft. Blowoff piping minimum slope from pump well is 1%.	
Earthwork and Trench		
Site Preparation	Construction activities will not be allowed outside of designated work limits as shown on the drawings.	
Trench	Method of excavation to be determined during final design using recommendations presented in the applicable geotechnical report(s). Requirements within levee prisms and berms will be determined in later stages of design following discussion with U.S. Army Corps of Engineers and Divisions of Safety of Dams. Minimum trench width: • When controlled low strength material (CLSM) is used for pipe zone material, minimum trench width is the pipe outer diameter plus 12 in clear (horizontally) on each side (typical). • When granular fill is used for pipe zone material, minimum trench width is the pipe outer diameter plus 18 in clear (horizontally) on each side (typical).	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Groundwater	Groundwater is expected to be encountered mostly at drainage crossings.	
Pipe Bedding Material	CLSM or a well-graded granular material to be used as bedding material. In areas where CLSM is required for pipe zone material, CLSM will be required as bedding material. The water pipeline will be supported beneath the haunches with sand bags or native material when CLSM is used. In areas requiring over excavation for trench stabilization, use a suitable foundation stabilization prior to placing bedding material. Requirements within levee prisms and berms will be determined in later stages of design following discussion with U.S. Army Corps of Engineers and Divisions of Safety of Dams.	
Pipe Zone Material	The pipe zone is defined as the area from the bottom of the pipe bedding to a minimum of 12 inches above the top of pipe, including the full width of the trench. CLSM or a well-graded granular material is used as backfill within the pipe zone unless otherwise specified in applicable geotechnical report(s) or hydrologic/scour report(s). CLSM is used as backfill from the bottom of the pipe bedding to a minimum of pipe springline. Requirements within levee prisms and berms will be determined in later stages of design following discussion with U.S. Army Corps of Engineers and Divisions of Safety of Dams.	
Trench Zone	The trench zone is from the top of the pipe zone to the bottom of the specified surface restoration, including the full width of the trench. Native or imported soil, loam, or other material suitable for use as backfill and is required to meet the requirements of applicable permits. Marking tape is required to be installed in the center of the trench 1 ft above the top of the pipe at the pipe centerline. Requirements within levee prisms and berms will be determined in later stages of design following discussion with U.S. Army Corps of Engineers and Divisions of Safety of Dams.	

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Minimum Depth of Pipeline	Generally minimum bury depth is 6 ft. Some locations, including drainage crossings, road crossings, and utility crossings may require an increased minimum bury depth. See Vertical Alignment criteria for minimum bury depths.	
Disposal of Excess Trench Material	Contractor to submit excavation and disposal plans per the specifications.	
Finished Grading	Restore site to pre-construction conditions; no enclosed depressions allowed and no alterations to existing drainage ways allowed. Restoration is required to meet the requirements of applicable permits.	
Revegetation Requirements	Revegetate per local jurisdictional standards, and applicable permit requirements.	
Trenchless Crossings		
References	CI/ASCE 36-01, *Standard Construction Guidelines for Microtunneling.* ASCE 27-00, *Standard Practice for Design of Precast Concrete Pipe for Jacking in Trenchless Construction.*	
Borings and Sampling	A minimum of two soil borings should be completed at each trenchless crossing: one located at the launching pit/shaft and one at the receiving pit/shaft. The need for additional borings should be evaluated based on geotechnical recommendations. Continuous standard penetration test sampling should extend from at least 10 ft above to 10 ft below the proposed pipeline zone. Provide a 5 ft minimum sample interval at all other depths within the borehole.	CI/ASCE 36-01, *Standard Construction Guidelines for Microtunneling*, suggests that a typical average final boring spacing should be on the order of 300 ft. Larger or smaller spacing may be appropriate depending on geologic variability and uncertainties remaining after initial phase borings are completed.
Piezometers	Piezometers should be installed on borings where ground water is expected. Consult geotechnical engineer regarding piezometers in saturated, clayey soils.	Groundwater levels and level fluctuations with time and seasonal precipitation and stream level changes are important to determine. Piezometers are monitored at a regular interval (at least bi-monthly) during the design phase such that at least 6 months of monitoring may be reported.

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Permeability	Slug testing is completed within installed piezometers to indicate ground mass permeability.	Ground mass permeability is very important for proper design and management of shafts, launch and reception portals and trenchless construction.
Groundwater Quality	Water samples are properly taken and sent to an analytical laboratory to test for pH, corrosiveness, and dissolved methane, hydrogen sulfide, or volatile organic compounds (VOCs).	Corrosivity data is needed for casing and pipeline design. Extent of dissolved methane, hydrogen sulfide and VOCs will provide an indication on tunnel classification as non-gassy, potentially gassy, or gassy per Occupational Safety and Health Administration (OSHA) regulations.
Laboratory Testing of Soil Samples	At a minimum, representative granular samples are tested to determine grain size distribution and distribution of fines if over 10%. Representative cohesive samples are tested to determine water content, Atterberg Limits, and Unconfined Compressive Strength. The need for additional testing will be based on initial findings and recommendations from geotechnical engineer.	Laboratory test data is needed to help with soil unified soil classification system classifications and to provide data for assessment of soil mass groutability, slurry penetration into ground mass, frac-out risk, overload factors, convergence, and Tunnelman's Ground Classifications.
Settlement Trough and Potential Impacts	A settlement trough analysis is completed in accordance with New & O'Reilly, 1992 or an equivalent method. Risk of damage is assessed for the resulting settlement predictions.	Settlement trough analyses are made for volume losses that are achievable and reasonable for the trenchless method selected. If greater than acceptable settlements and damage risk results, more restrictive trenchless methods can be specified to reduce settlement trough volumes or ground improvement or compensation grouting methods can be specified to isolate the facilities of concern from the ground movement zone.

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
Heave and Frac-Out	Calculations and assessments are completed to determine risk of heave damage or frac-out (hydraulic fracturing) from excessive slurry pressures, excavation chamber air pressures or contact grouting pressures associated with directional drilling or microtunneling operations.	A high slurry pressure during directional drilling or microtunneling can result in frac-out and flow of bentonite or polymer slurry into Fountain Creek. Excess slurry or contact ground pressures could result in unacceptable heave to the freeway pavement or railroad tracks.
Control of Water and Face Stability	An assessment is made on feasibility and potential impacts of dewatering of shaft or shaft and trenchless zones. This assessment considers the potential consequences of severe face instability and ground loss resulting in sinkholes. If dewatering is unlikely to reduce face instability risk, specifications will require a trenchless method with active face support such as achievable with microtunneling.	Trenchless methods might include directional drilling, open-face pipe jacking or microtunneling. Open-face tunneling would require dewatering to lower groundwater levels to below the tunnel zone. A dewatering viability assessment considers cost, difficulty of dewatering interfaces between low and high permeability ground, and potential impacts of dewatering such as water supply well disruptions, migration of contaminated groundwater or drawdown-settlement.
Shaft Flooding	A construction phase maximum possible flood level is determined. If one or more shafts are located within the flood zone, measures to minimize the risk of shaft and tunnel flooding are designed or specified (such as higher shaft top elevations, and temporary berms around shaft rims).	Surface flooding of shafts or tunnels can have catastrophic impacts on health and safety and tunneling equipment resulting in high impact costs and major delays.
Drive Length and Jacking Force	If pipe jacking or microtunneling is selected, a jacking force analysis is completed to help determine viable drive lengths and any requirements involving intermediate jacking stations. The analysis should use the Bennett-Cording method or similar.	Drive length should be evaluated by final designer to determine if a single drive pipe jack or microtunnel is adequate of if intermediate jacking stations are needed.
GDR and Geotechnical Baseline Report (GBR)	The initial phase site investigation (SI) work is be presented in a geotechnical data report (GDR) prepared in accordance with Underground Technology Research Council (UTRC), 1997. Essex, R.J. (ed.). *Geotechnical Baseline Reports (GBRs) for Underground Construction – Suggested Guidelines and Practices*. Reston: American Society of Civil	Proper preparation of a GDR and GBR that are consistent with the specifications and other contract documents on risk sharing is critically important for trenchless construction. The GBR is prepared by the engineer and not the SI firm responsible for the

Transmission Pipelines Design Criteria

Subject	Criteria	Comments/Reason
	Engineers. During final design a GBR is prepared by the final design team. The GBR is also prepared in accordance with UTRC, 2006.	GDR. Final design will incorporate baseline parameters (such as boulders, ground type quantities, and maximum groundwater levels).
Specifications	Specifications are prepared with a proper balance between performance and prescriptive wording for the risks involved. Trenchless specifications are likely to cover the following: • Auger boring, tunneling or microtunneling • Workshaft excavation and construction • Ground support systems • Control of water • Ground improvement (grouting) at portals and critical zones (might also include compensation grouting below freeway or railroad tracks) • Contact grouting of initial casing • Carrier pipe installation and backfilling with low density cellular grout • Geotechnical instrumentation and monitoring for protection of adjacent property	Performance specifications allow the most contractor flexibility and ingenuity and possibly the best price, but in a low-bid environment may result in excessive risk taking and a high change of construction problems from use of inappropriate equipment or methods. Fully prescription specifications essentially tell the contractor what to do and result in too much risk for the owner and engineer. Generally, a balance between performance and prescriptive requirements will result in more equitable bidding and risk sharing. Generally, more specifications on specific topics are preferable to fewer specifications covering multiple topics. Better specification clarity and conciseness is achievable with this approach.
Drawings	Trenchless and trenchless monitoring details will be provided during final design. Details will include minimum grout and lubrication port requirements for casing pipe, carrier pipe blocking and annular space requirements, shaft portal ground improvement, compensation grouting or ground improvement below roadways and railroads (if required) and geotechnical instrumentation details.	Final structural design of the carrier pipe will be conducted during final design and follow industry standards. Drawings for the casing or carrier pipe may not show final structural design depending on pipe type. A good guideline for division of responsibility and level of detail in design and submittals is given in ASCE 27-00, *Standard Practice for Design of Precast Concrete Pipe for Jacking in Trenchless Construction*.

Appendix B

Gianelli PGP Comparison to Sites PGP

Gianelli PGP Comparison to Sites PGPs
Technical Memorandum (Final)

To:	Henry Luu/HDR
Date:	August 28, 2020
From:	Jeff Smith/Jacobs
Quality Review by:	Peter Rude/Jacobs
Authority Agent Review by:	TBD
Subject:	Comparison of Gianelli PGP (San Luis Reservoir) to Sites Proposed PGPs

1.0 Purpose

The Sites Reservoir Project includes the Funks and the Terminal Regulating Reservoir (TRR) Pumping Generating Plants (PGPs), which will include large pumps and separate hydroelectric turbines. The purpose of this technical memorandum is: (1) to compare the proposed Sites PGPs to the existing Gianelli PGP located at San Luis Reservoir near Santa Nella, California; and (2) to see what can be learned from Gianelli PGP. This request was initiated at the July 1, 2020, Ad hoc Operations and Engineering Workgroup meeting of the Reservoir Committee. Information for Gianelli PGP was obtained from the U.S. Bureau of Reclamation and California Department of Water Resources websites.

2.0 Equipment Comparison

The following table compares various PGP features.

PUMPING AND GENERATING COMPARISON

Feature	Gianelli	Funks	TRR
Pumping System			
Pumping Units			
Duty	8	12	12
Standby	Unsure	1	1
Per Unit			
Power (horsepower)	63,000	8,000	9,000
Flow (cubic feet per second [cfs])	1,375	175	150

PUMPING AND GENERATING COMPARISON

Feature	Gianelli	Funks	TRR
Total (duty)			
Power (horsepower)	504,000	96,000	108,000
Flow (cfs)	11,000	2,100	1,800
Maximum Head (feet)	290	320	420
Generating System			
Generating Units			
Duty	8	2	2
Standby	Unsure	0	0
Per Unit			
Power (kilowatts)	53,000	21,000	13,500
Flow (cfs)	1,640	1,000	500
Total (duty)			
Max Power (kilowatts)	424,000	42,000	27,000
Flow (cfs)	13,120	2,000	1,000
Maximum Head (feet)	290	280	360

3.0 Discussion of Comparison

A comparison of the Gianelli PGP at San Luis Reservoir to the proposed Sites project PGPs (Funks and TRR) shows that Gianelli is considerably larger, even though the heads are comparable. For the pumping condition, each unit is seven to eight times larger than the Sites PGPs. For the generating condition, the Gianelli units are approximately three to four times larger than the Sites generating units. The source of information did not provide a distinction on whether all eight Gianelli units are duty or whether seven are duty and one is standby.

It is important to note that the Gianelli units are combination pump-turbine units that provide both pumping and generating by operating the unit's impellers either forward or reverse. Alternatively, the current Sites design has separate units for pumping and generating, with 12 units at each PGP for pumping and 2 units for generating. Pump-turbine units are very complex and required special custom engineering that is very costly and lengthy. As a result, pump-turbine units are more commonly found in facilities that generate 400 megawatts (MW) or more, which is consistent with the Gianelli facility.

Preliminary calculations indicate Funks generating 42 MW and the TRR generating 27 MW. Discussions with manufacturers and a Jacobs hydroelectric expert confirm the use of pump-turbine units on small generating facilities, like Funks and TRR, are not warranted. The use of separate pumping and generating units as currently planned and presented in our July 23, 2020, deliverable demonstrate the proper engineering approach.

Appendix C

Constant Speed versus Adjustable Speed Pumps and Motors Comparison

Constant-speed versus Adjustable-speed Pumps and Motors Comparison Technical Memorandum (Final)

To:	Henry Luu/HDR
CC:	
Date:	August 28, 2020
From:	Mike Riess/Jacobs, Jeff Smith/Jacobs
Quality Review by:	Bill Misslin/Jacobs
Authority Agent Review by:	TBD
Subject:	Constant-speed versus Adjustable-speed Pumps and Motors Comparison

1.0 Background

Sites Project Authority (Sites) adopted the recommended project (VP7) as provided in the *Sites Project Value Planning Alternatives Appraisal Report*, dated April 2020, to reduce the program cost from $5.2 billion to $3.0 billion. The VP7 project includes major changes to the pumping conditions associated with the Funks and Terminal Regulating Reservoir (TRR) Pumping Generating Plants (PGPs), notably the significantly higher pumping heads because both are now pumping directly to the Sites Reservoir. Design pumping flows and maximum pumping heads for Funks PGP are 2,100 cubic feet per second (cfs) and 317 feet; flows and maximum pumping heads for TRR PGP are 1,800 cfs and 420 feet.

2.0 Purpose

At the July 1, 2020, Ad hoc Operations and Engineering Workgroup Meeting of the Reservoir Committee, the Conveyance Team provided an overview of the proposed PGPs, including 12 duty and 1 standby pump for each PGP. The Conveyance Design Team stated that the wide range of flows and pumping heads will require the use of adjustable-speed drives for each pump. A Workgroup member requested consideration of use of constant-speed drives. The purpose of this technical memorandum is to summarize an analysis of using constant-speed versus adjustable-speed drives for the Funks and TRR PGPs.

This analysis required a modeling effort to determine where the pumps will provide coverage for all the various operating points. Good engineering practice is to operate the pumps within their preferred operating region (POR) where there is less wear and tear on the equipment. However, manufacturers also define an allowable operating region (AOR) within which operating is acceptable, but the AOR comes at the sacrifice of additional wear and tear and lower pump efficiency. Operating points outside the AOR and POR are generally deemed as not acceptable.

3.0 Modeling Analysis

Hydraulic modeling of both the Funks and TRR pumping systems was completed using AFT Fathom (v. 10) hydraulic modeling software. The current layout for the two PGPs is almost identical, so only the Funks PGP layout is shown in plan view on Figure 1. Figure 2 shows the overall system piping schematic layout used for the modeling effort from both Funks PGP and TRR PGP through to Sites Reservoir inlet/outlet tower. Figures 3 through 6 provide pump curves and pumping system curves. Attachment A contains the model data input, such as pipe diameter, pipe length, pipe number, and other information.

3.1 Pump Generating Plant Criteria

The following are common criteria used for both PGPs:

- Pipe Friction Factor (Hazen-Williams) = 130 or 150
- Sites Reservoir Maximum Water Surface Elevation = 498 feet
- Sites Reservoir Minimum Water Surface Elevation = 340 feet

3.1.1 Funks PGP

The Funks PGP modeling assumptions for the system and pump are included in Table 1.

TABLE 1: FUNKS PUMP DESIGN CRITERIA

Subject	Criteria
Maximum Flow	2,100 cfs
Number of Pumping Units	13 (12 duty + 1 standby)
Capacity at Rated Point	175 cfs @ 320 feet
Static Head, Maximum	298 feet
Static Head, Minimum	135 feet
Rated Pump Efficiency	89 percent
Pump Type and Configuration	Vertical mixed flow, multi-stage
Motor Size	8,000 horsepower
Motor Type	Induction, vertical solid shaft, high thrust
Nominal Speed	505 rotations per minute (rpm)

Figure 3 provides pump performance information for the Funks pump and includes various characteristics, such as full-speed pump curve, efficiency curve, horsepower requirements, preferred operating region (POR),and AOR.

3.1.2 TRR PGP

The TRR PGP modeling assumptions for the system and pump are included in Table 2.

TABLE 2: TRR PUMP DESIGN CRITERIA

Subject	Criteria
Maximum Flow	1,800 cfs
Number of Pumping Units	13 (12 Duty + 1 Standby)
Capacity at Rated Point	150 cfs @ 420 ft
Static Head, Maximum	379 feet
Static Head, Minimum	216 feet
Rated Pump Efficiency	88 percent
Pump Type & Configuration	Vertical Mixed Flow, Multi-Stage
Motor Size	9,000 hp
Motor Type	Induction, Vertical Solid Shaft, High Thrust
Nominal Speed	590 rpm

Figure 4 provides pump performance information for the TRR pump and includes various characteristics such as full speed pump curve, efficiency curve, horsepower requirements, POR, and allowable operating region (AOR).

3.2 Modeling Conditions

The Fathom model was used to simulate the highest and lowest static head conditions for each of the PGPs. Table 3 summarizes the conditions used in the modeling exercise. The low static and high static conditions for each PGP set the system boundaries for pump selection.

TABLE 3: SUMMARY OF MODELING CONDITIONS

	Funks PGP		TRR PGP	
Criteria	High Static	Low Static	High Static	Low Static
Sites Reservoir Level (feet)	498	340	498	340
Funks Reservoir Level (feet)	199	205	199	N/A
TRR Reservoir Level (feet)	119	N/A	124	119
Pipeline Friction Coefficient	130	150	130	150
Funks PGP Operating	Yes	Yes	Yes	No
TRR PGP Operating	Yes	No	Yes	Yes

3.3 Modeling Results

High and low static pumping scenarios were modeled to develop the system curves on each composite pump as shown in Figures 5 and 6. For each PGP, representative pump curves are superimposed over the respective system curves to display parallel pump behavior from single-pump to 12-pump operation. Isoefficiency lines corresponding to the pump POR and AOR are superimposed over the system curves to indicate the region and quality of flow coverage when each pump is operated by an adjustable-speed drive (ASD). Single-pump operation at a reduced speed, corresponding to the intersection of minimum AOR and the low head system curve, is shown to indicate the minimum recommended pump flow when considering only hydraulic criteria (other criteria may govern pump minimum speed).

Figures 5 and 6 depict the operational gaps – areas where the pumps are not operating within the POR or the AOR. The information contained in Figures 5 and 6 can be challenging to interpret, unless the reader is well versed in pump design. In simple terms, the potential operating area is vast and contained between the upper high head system curve and the lower Low Head System Curve, and between the minimum flow near zero and the maximum flow along the horizontal graph line. Each pump type has a minimum and maximum POR (see Figures 3 and 4). On Figures 5 and 6, the minimum is shown as a green line and the maximum is shown as a blue line.

Figure 5 provides the results of using ASDs to cover the entire operating range. As shown on Figure 5, the currently selected pump covers almost the entire operating region within the POR of the pumps at minimum flow (with one pump operating), to the maximum flow (with 12 pumps operating). On each end of the operating area is a very small area (shown in solid blue) where the pumps will operate in the allowable operating range to meet this design condition. There are also two areas of AOR operation between pumps 1 and 2 and between pumps 2 and 3. There is also a very small operating area (shown in solid red) at high flow and lowest head where pump operation is not allowed. Jacobs is confident that we can work with the pump manufacturers to slightly modify this pump to operate within this solid red area (not allowable operational area).

3.3.1 TRR PGP

Figure 6 shows the results of using the ASDs to cover the operating area. The results show that this pump can cover the entire area, with a small exception when flows are very low (below 100 cfs).

4.0 Constant-speed versus Adjustable-speed Drives

4.1 General Overview

The information in this memorandum has primarily focused on mechanical aspect of pump station design, but there are also differences between electrical design for ASDs and constant-speed pumps. This section presents discussion for both design disciplines.

4.1.1 Mechanical Design

For best efficiency and equipment longevity, pumps should be operated within the POR. Pumps may operate outside of the POR and within the AOR, but this course is not recommended unless unavoidable, because both efficiency and pump life will be reduced. Adjustable-speed pumping permits operators or automated control systems to more easily keep pumps within the POR for almost the entire operating area.

Using a constant-speed pump is applicable when a relatively constant operating point and somewhat constant flow exist. Both the Funks PGP and TRR PGP will have variable flow and variable head conditions that will make using constant-speed pumps essentially impossible.

Although the system and pump curves provided in Figures 5 and 6 contain many lines to interpret, they show that constant-speed pumps can only operate along the vertical curved lines; points between these lines are conditions that cannot be met by constant-speed pumps. The use of constant-speed pumps will not allow the PGP to match the flows from the Tehama-Colusa Canal and Glenn-Colusa Irrigation District Canal to pump into Sites Reservoir. At Funks PGP, constant speed pumps would operate outside the AOR when the pumps are operating at a head lower than 240 feet. At the TRR, constant speed pumps would operate outside the AOR when the pumps are operating at a head lower than 270 feet.

4.1.2 Electrical Design

The turbine generator and utility requirements will drive the method of grounding used on the switchgear. Constant-speed motors will be subject to the system grounding chosen, which may not be desirable for medium-voltage motors, where low impedance grounding is the preferred option. ASDs with isolation/phase shifting transformers will isolate the motors from the system grounding.

The two common types of motors to consider for this project include synchronous motors and induction motors. Given that using constant-speed pumps is essentially impossible, the use of induction motors is recommended because they work well with ASDs and are less expensive than synchronous motors.

Using ASDs with isolation transformers allows for flexibility with motor voltage selection, potentially saving considerable costs with coordinating a motor and pump.

4.2 Funks PGP

The pump-system curve for Funks (Figure 5) shows representative pumps operating in parallel and at a common pump speed (all pumps on ASDs and all pumps driven at the same speed), with flow coverage predominantly within the POR, from 100 cfs to approximately 1,600 cfs (design flow is 2,100 cfs). When total flow exceeds this 1,600 cfs, a region of operation is revealed within the AOR that is most pronounced at lower head conditions. Also, a small region of operation outside of the POR and AOR exists, from approximately 2,000 to 2,100 cfs; but this area is limited to extreme low head conditions. Jacobs can work with pump manufacturers to refine pump selection, having a POR envelope further “out” on the pump curve to cover up to the 2,100 cfs design flow under all head conditions.

As part of this analysis, Jacobs looked at using a combination of ASD pumps and constant-speed pumps. Applying one or more constant-speed pumps to operate in conjunction with ASD pumps, the full-speed pump head at which the minimum and maximum POR flow rates occur were evaluated relative to the system curves. The currently selected pump has a head of 350 feet at minimum POR flow, and 288 feet at the maximum POR flow. Relative to the system curves, there is a very limited range of static head conditions that would support use of a constant-speed pump operating within the POR (less than 10 percent of the static range – the area below the solid horizontal red line is outside of the AOR). If constant-speed pumps could operate in the AOR, then the range of operation would still be quite limited (less than 50 percent of the static range).

4.3 TRR PGP

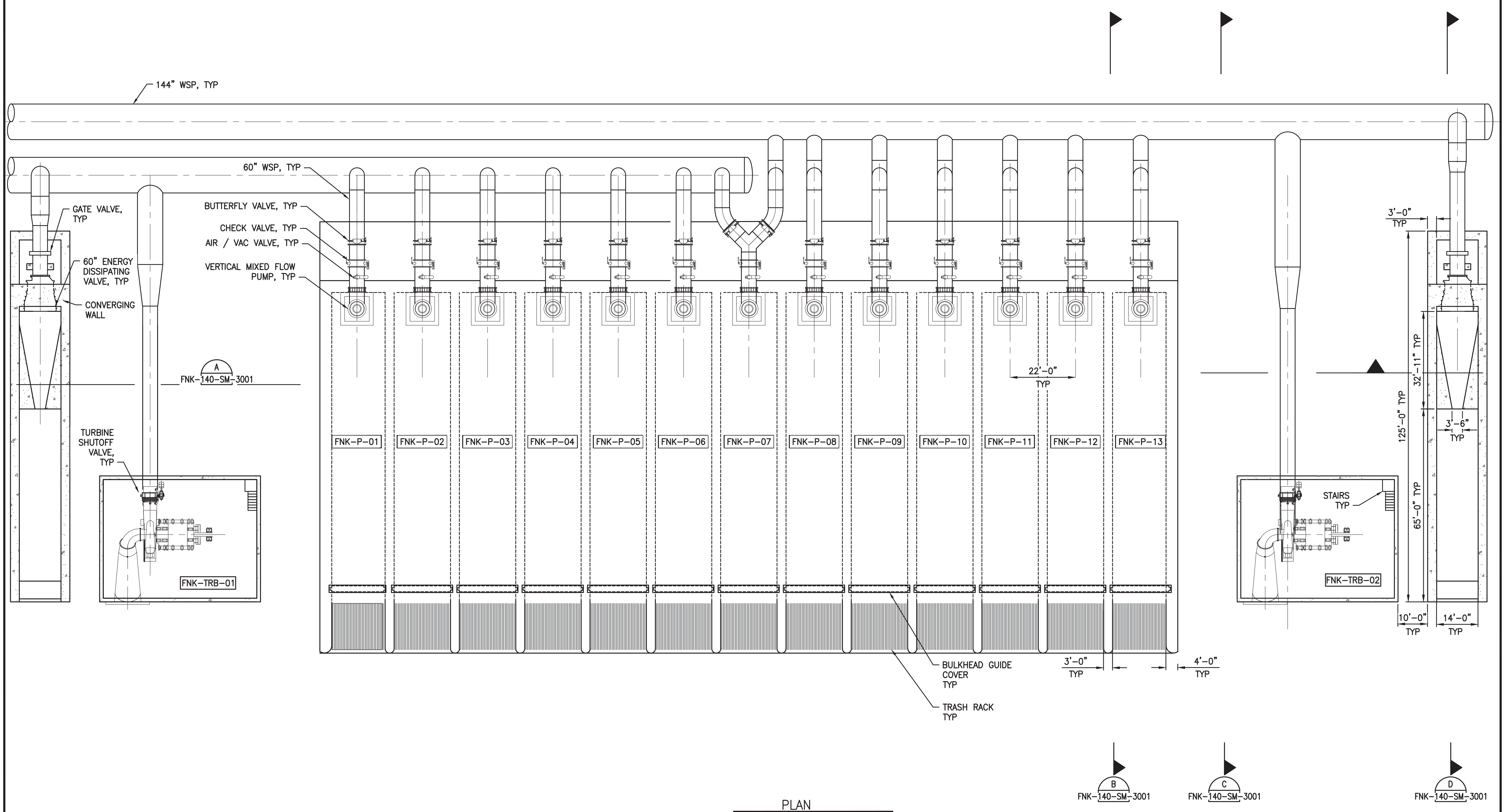
The pump-system curve (Figure 6) shows representative pumps operating in parallel and at a common pump speed (all pumps on ASDs and all pumps driven at the same speed), with flow coverage within the POR across a flow rate of 100 to 1,800 cfs.

As part of this analysis, Jacobs looked at using a combination of ASD and constant-speed pumps. Applying one or more constant-speed pumps to operate in conjunction with ASD pumps, the full-speed pump head at which the minimum and maximum POR flow rates occur were evaluated relative to the system curves. The currently selected pump has a head of 422 feet at minimum POR flow, and 338 feet at the maximum POR flow. Relative to the system curves, there is a very limited range of static head conditions that would support use of a constant-speed pump operating within the POR (less than 50 percent of the static head range – the area below the solid horizontal red line is outside of the AOR). If constant-speed pumps could operate in the AOR, then the range of operation would still be quite limited (less than 80 percent of the static range).

5.0 Recommendation

The primary purpose of this task was to evaluate whether constant-speed pumps could be used for the PGPs, as opposed to the currently recommended ASD pumps. What this exercise showed is that constant speed pumps would operate outside of the AOR and POR at lower system head conditions and therefore not recommended. Use of constant-speed pumps will limit the operational points for the system, reduce the overall pumping efficiency, provide unnecessary wear and tear on the pumps, and limit suppliers. Given the wide variation in pumping head resulting from fluctuations in Sites Reservoir water levels and variations in flow from the Tehama-Colusa Canal and Glenn-Colusa Irrigation District Canal, Jacobs recommends using all ASDs for both PGPs. Although installation of ASDs may add capital costs of approximately $10 to $12 million for both PGPs, the reduced operational cost for more efficient pumping and reduced wear and tear will lead to overall reduced costs over the life of the project.

Figures



PLAN
SCALE: 1/16" = 1'-0"

PLOTTED BY:CAVE, DAVID/RDD –July 23, 2020–3:44:42 PM
DRAWING: FNK-140-SM-2001_D3380600.dwg
JACOBS PROJECT # D3880600

I/R	DATE	BY	CHK	APPR	DESCRIPTION

DESIGNED BY: KELLOGG/SMITH
DRAWN BY: S HAUNG
CHECKED BY:
IN CHARGE: P RUDE
DATE: 07-20-2020

JACOBS
2525 AIRPARK DR
REDDING CA, 96001
PHONE: (530) 243-5831

REGISTERED PROFESSIONAL ENGINEER
STATE OF CALIFORNIA

Sites

SITES RESERVOIR PROJECT

FIGURE 1
FUNKS/TRR PGP LAYOUT

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

DRAWING NO.
FNK-140-SM-2001

DRAFT – PROJECT FEASABILITY STUDY – NOT FOR CONSTRUCTION

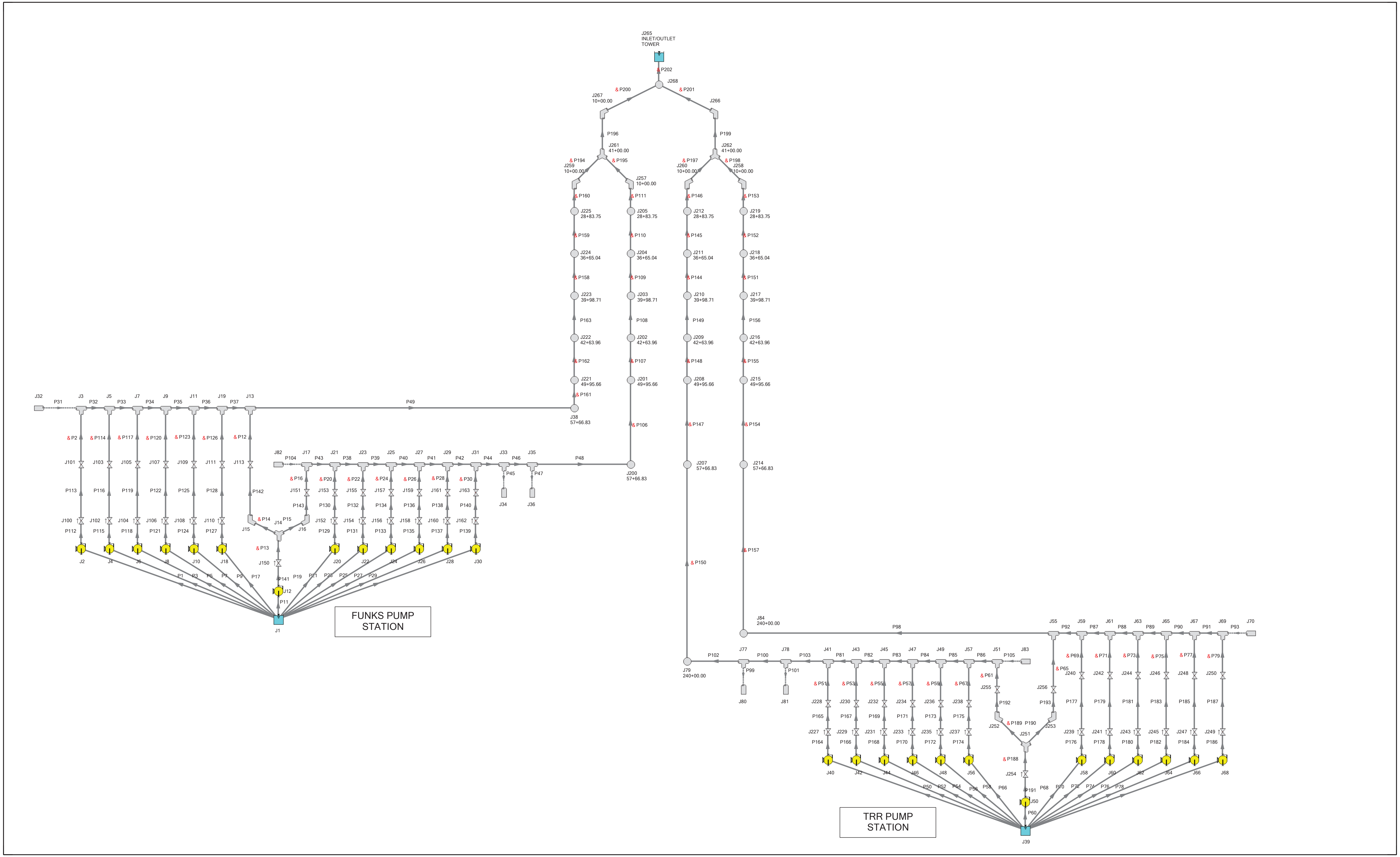


FIGURE 2: HYDRAULIC MODEL SCHEMATIC

Representative Pump - Funks Pump Station

Model: VCW	**Size: 67WMCC**	**60 Hz**	**RPM: 505**	**Stages: 3**

Job/Inq.No.: Funks Reservoir
Purchaser: SITES
End User: TBD
Item/Equip.No.: ITEM 001-012 Large
Service: Vertical Pumps

Issued by: Carlos Preciado
Quotation No.: CP2018-06-25
Rev.: 0
Date: 6/30/2020

Certified By:

Operating Conditions

Liquid: Water
Temp.: 70.0 °F
S.G.: 1.000
Flow: 78,545 GPM
TDH: 320.0 ft
NPSHa: 48.3 ft

Pump Performance

Published Efficiency: 89.0%
Rated Pump Efficiency: 89.0%
Rated Total Power: 7126.6 hp
Min. Motor Rating: 7840 hp
Imp Dia.: 40.27 in
NPSHr: 21.1 ft

Specific Speed: 3,684 (RPM,GPM,ft)
Min Hydraulic Flow: 39,273 GPM
Shut off Head: 481.2 ft
Qty: 12

GOULDS PUMPS VERTICAL PUMP DIVISION INDUSTRY, CALIFORNIA	CENTRIFUGAL PUMP CHARACTERISTICS Performance Standard: ANSI/HI 14.6-2011, grade 2B	Curve #: RPM 505	E60367WMPF
		Model:	VCW
		Size:	67WMCC - 2.82

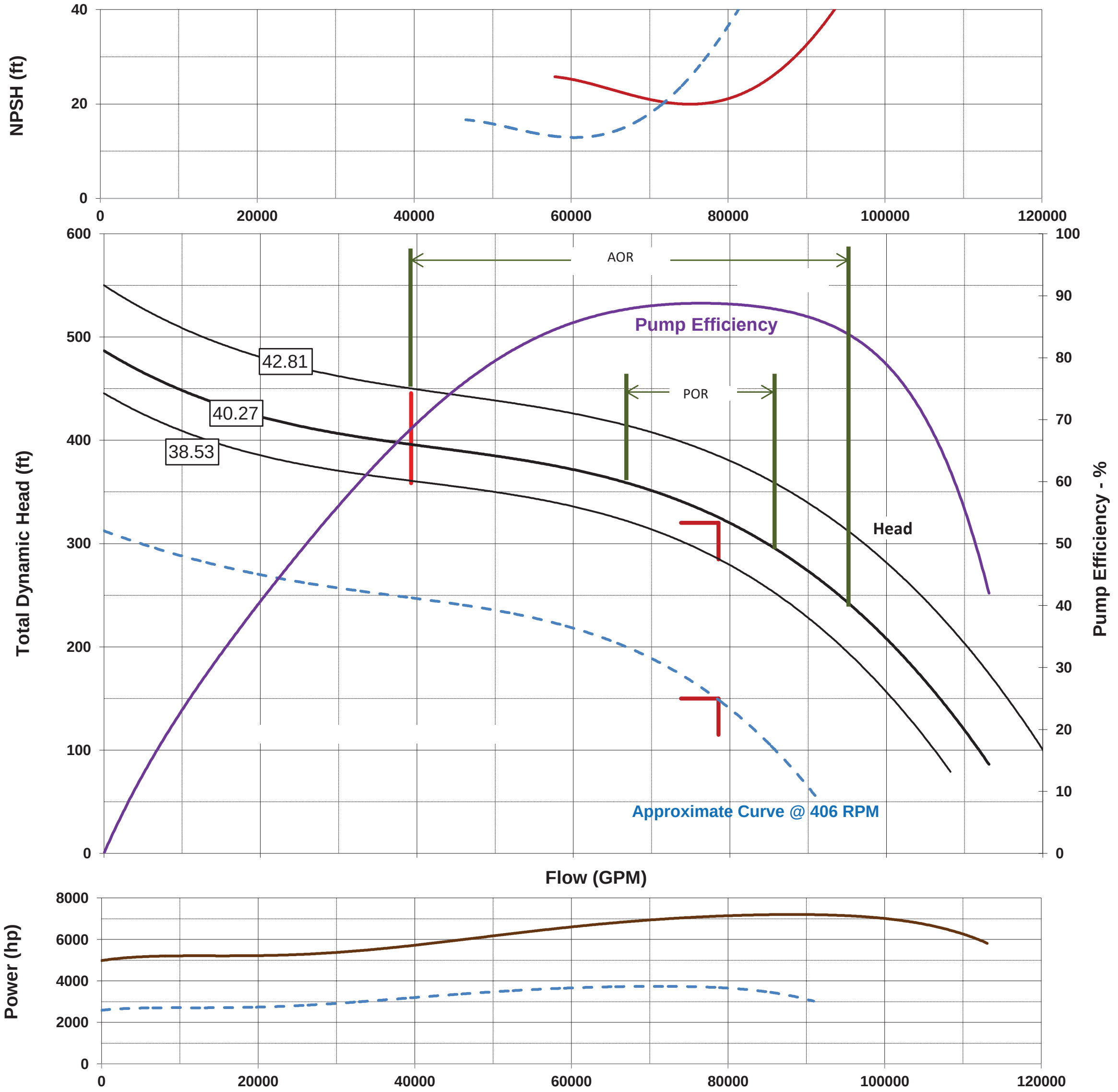


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FIGURE 3: FUNKS PUMP CURVE

Representative Pump - TRR Pump Station

Model: VCW	**Size: 63WMCC**	**60 Hz**	**RPM: 590**	**Stages: 3**

Job/Inq.No.: TRR Reservoir
Purchaser: SITES
End User: TBD
Item/Equip.No.: ITEM 001-012 Large
Service: Vertical Pumps

Issued by: Carlos Preciado
Quotation No.: CP2018-06-25
Rev.: 0
Date: 6/30/2020

Certified By:

Operating Conditions			**Pump Performance**		
Liquid:	Water	Published Efficiency:	88.7%	Specific Speed:	3,680 (RPM,GPM,ft)
Temp.:	70.0 °F	Rated Pump Efficiency:	88.7%	Min Hydraulic Flow:	40,395 GPM
S.G.:	1.000	Rated Total Power:	8044.4 hp	Shut off Head:	577.9 ft
Flow:	67,325 GPM	Min. Motor Rating:	8849 hp		
TDH:	420.0 ft	Imp Dia.:	37.77 in	Qty:	12
NPSHa:	43.5 ft	NPSHr:	24.6 ft		

GOULDS PUMPS VERTICAL PUMP DIVISION INDUSTRY, CALIFORNIA	CENTRIFUGAL PUMP CHARACTERISTICS Performance Standard: ANSI/HI 14.6-2011, grade 2B	Curve #:	E60363WMPF
		RPM 590	
		Model:	VCW
		Size:	63WMCC - 2.6463

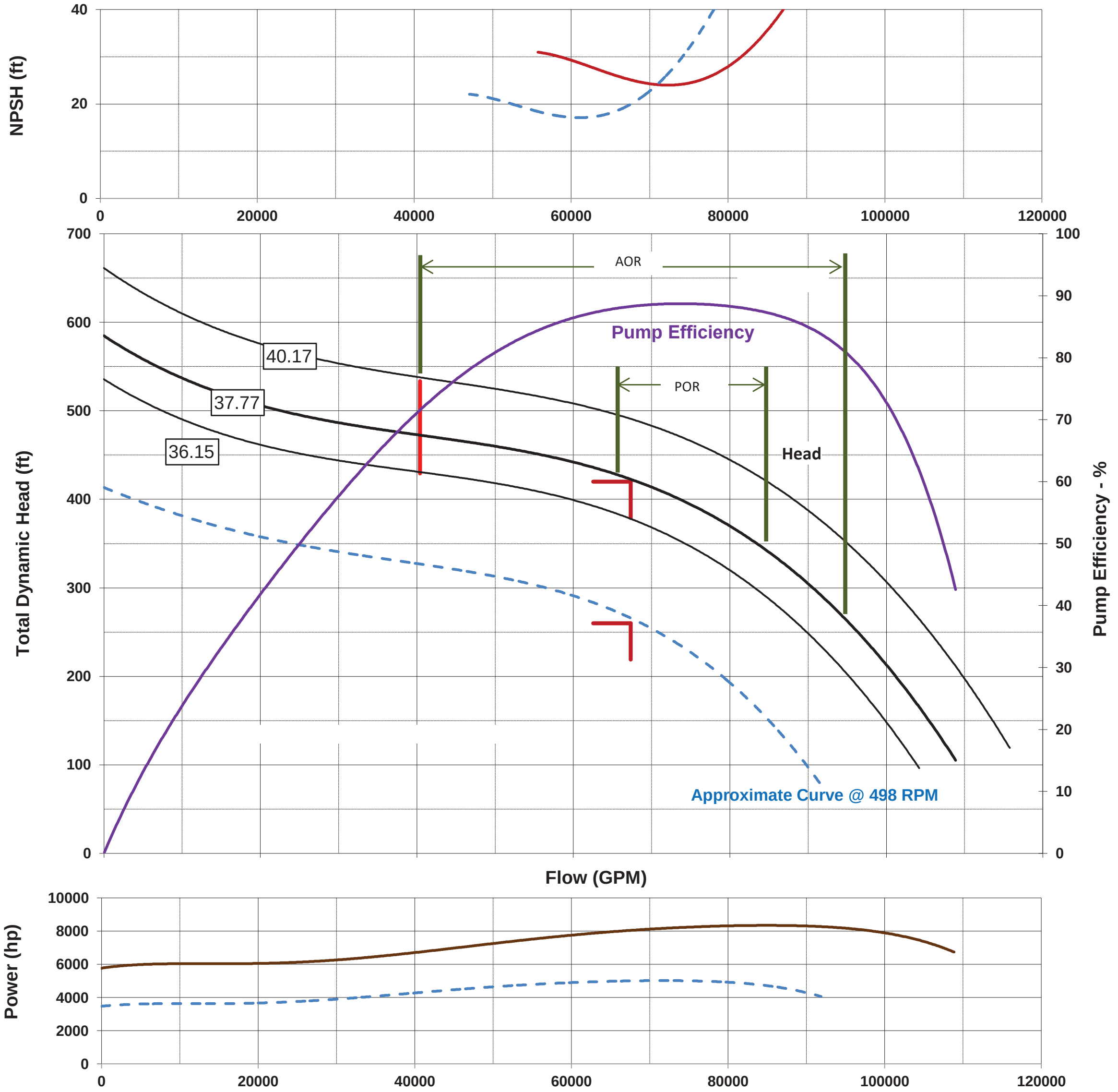

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FIGURE 4: TRR PUMP CURVE

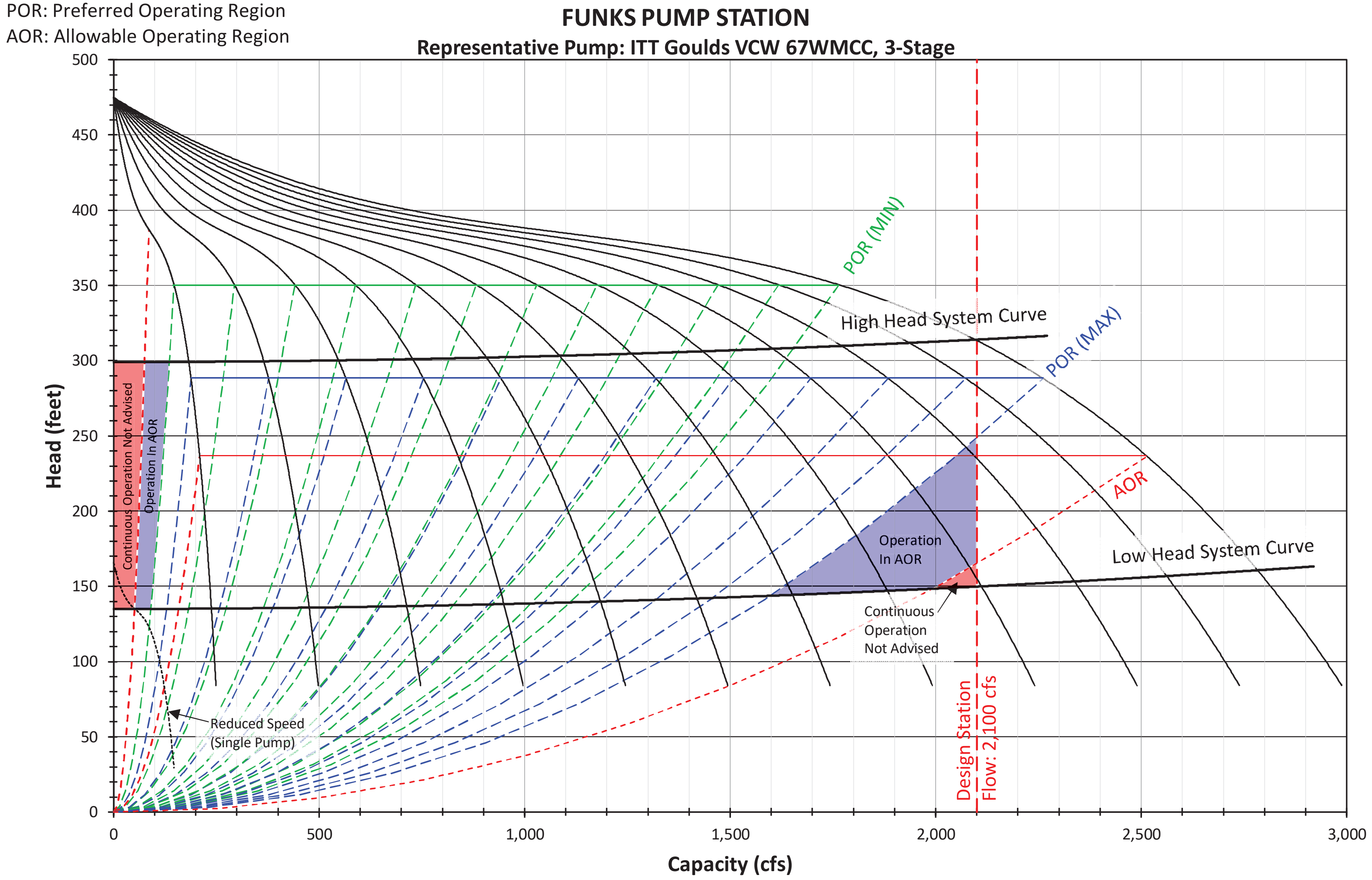
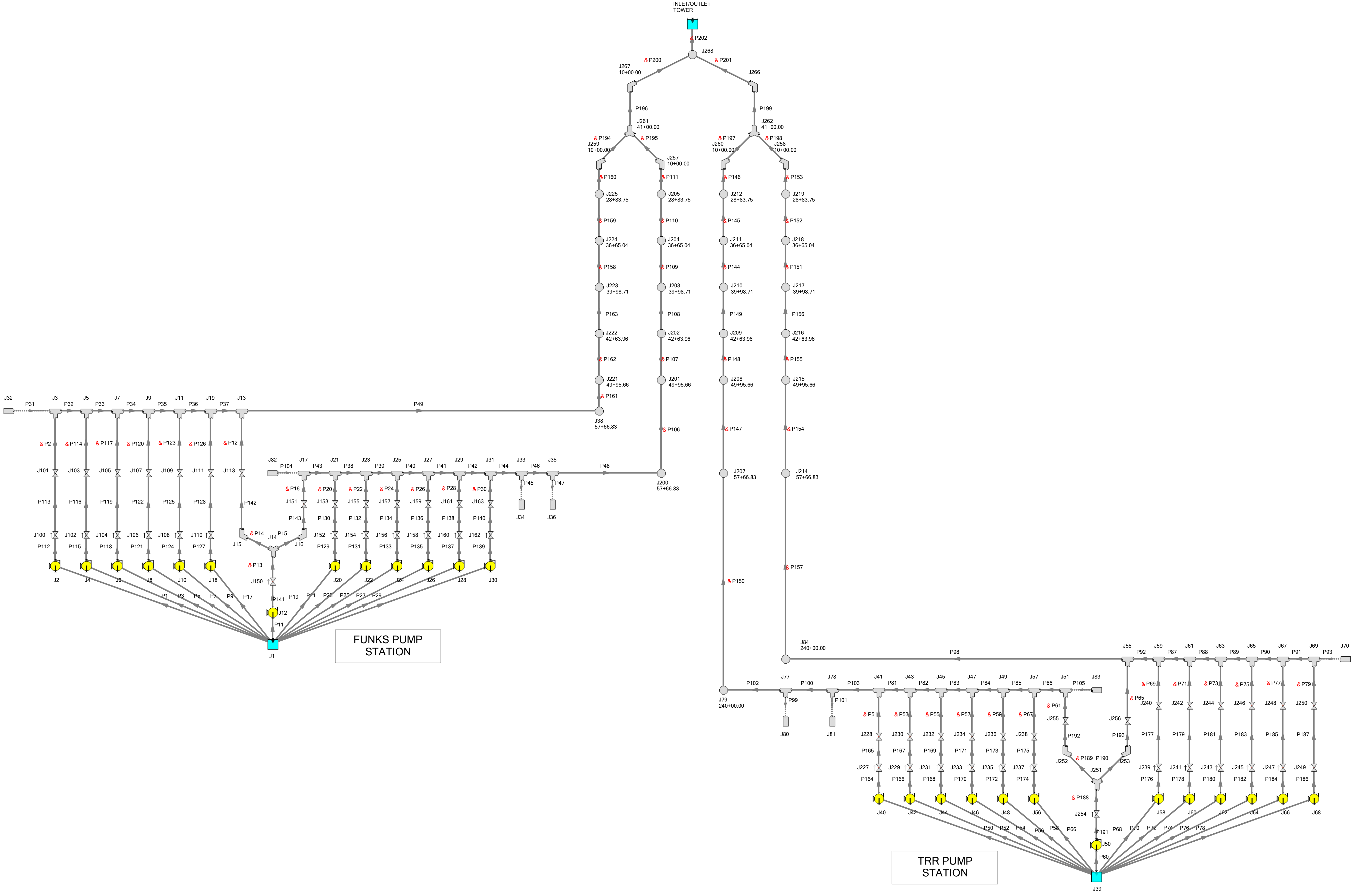


FIGURE 5: FUNKS PUMPING SYSTEM CURVES

Attachment A
Hydraulic Model Data

HYDRAULIC MODEL SCHEMATIC



HYDRAULIC MODEL INPUT DATA

General

Title: AFT Fathom Model
Input File: C:\Users\shussain.JEG\Documents\CH2MHILL\Sites Reservoir\Sites_Reservoir_PS_ Hydraulics.fth

Number Of Pipes= 189
Number Of Junctions= 164

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 70 deg. F
Density= 62.30841 lbm/ft3
Viscosity= 2.360044 lbm/hr-ft
Vapor Pressure= 0.3615736 psia
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300

Pipes

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size	Type	Special Condition
1	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 2	Cylindrical Pipe	User Specified			None
2	Pipe	Yes	36	feet	60	inches	Unspecified	130	C Hazen-Williams	0.708			101, 3	Cylindrical Pipe	User Specified			None
3	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 4	Cylindrical Pipe	User Specified			None
5	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 6	Cylindrical Pipe	User Specified			None
7	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 8	Cylindrical Pipe	User Specified			None
9	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 10	Cylindrical Pipe	User Specified			None
11	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 12	Cylindrical Pipe	User Specified			None
12	Pipe	Yes	22.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0.168			113, 13	Cylindrical Pipe	User Specified			None
13	Pipe	Yes	6	feet	60	inches	Unspecified	130	C Hazen-Williams	0.24			150, 14	Cylindrical Pipe	User Specified			Closed
14	Pipe	Yes	9.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0.3			14, 15	Cylindrical Pipe	User Specified			Closed
15	Pipe	Yes	9.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			14, 16	Cylindrical Pipe	User Specified			Closed
16	Pipe	Yes	17	feet	60	inches	Unspecified	130	C Hazen-Williams	0.168			151, 17	Cylindrical Pipe	User Specified			None
17	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 18	Cylindrical Pipe	User Specified			None
19	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 20	Cylindrical Pipe	User Specified			None
20	Pipe	Yes	26	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			153, 21	Cylindrical Pipe	User Specified			None
21	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 22	Cylindrical Pipe	User Specified			None
22	Pipe	Yes	26	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			155, 23	Cylindrical Pipe	User Specified			None
23	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 24	Cylindrical Pipe	User Specified			None
24	Pipe	Yes	26	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			157, 25	Cylindrical Pipe	User Specified			None
25	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 26	Cylindrical Pipe	User Specified			None
26	Pipe	Yes	26	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			159, 27	Cylindrical Pipe	User Specified			None
27	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 28	Cylindrical Pipe	User Specified			None
28	Pipe	Yes	26	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			161, 29	Cylindrical Pipe	User Specified			None
29	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			1, 30	Cylindrical Pipe	User Specified			None
30	Pipe	Yes	26	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			163, 31	Cylindrical Pipe	User Specified			None
31	Pipe	Yes	113	feet	144	inches	Unspecified	130	C Hazen-Williams	0			32, 3	Cylindrical Pipe	User Specified			None
32	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			3, 5	Cylindrical Pipe	User Specified			None
33	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			5, 7	Cylindrical Pipe	User Specified			None
34	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			7, 9	Cylindrical Pipe	User Specified			None
35	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			9, 11	Cylindrical Pipe	User Specified			None
36	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			11, 19	Cylindrical Pipe	User Specified			None
37	Pipe	Yes	13	feet	144	inches	Unspecified	130	C Hazen-Williams	0			19, 13	Cylindrical Pipe	User Specified			None
38	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			21, 23	Cylindrical Pipe	User Specified			None
39	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			23, 25	Cylindrical Pipe	User Specified			None
40	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			25, 27	Cylindrical Pipe	User Specified			None
41	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			27, 29	Cylindrical Pipe	User Specified			None
42	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			29, 31	Cylindrical Pipe	User Specified			None
43	Pipe	Yes	13	feet	144	inches	Unspecified	130	C Hazen-Williams	0			17, 21	Cylindrical Pipe	User Specified			None
44	Pipe	Yes	49.5	feet	144	inches	Unspecified	130	C Hazen-Williams	0			31, 33	Cylindrical Pipe	User Specified			None
45	Pipe	Yes	1	feet	144	inches	Unspecified	130	C Hazen-Williams	0			33, 34	Cylindrical Pipe	User Specified			None
46	Pipe	Yes	57	feet	144	inches	Unspecified	130	C Hazen-Williams	0			33, 35	Cylindrical Pipe	User Specified			None
47	Pipe	Yes	1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			35, 36	Cylindrical Pipe	User Specified			None
48	Pipe	Yes	375	feet	144	inches	Unspecified	130	C Hazen-Williams	0			35, 200	Cylindrical Pipe	User Specified			None
49	Pipe	Yes	612	feet	144	inches	Unspecified	130	C Hazen-Williams	0			13, 38	Cylindrical Pipe	User Specified			None
50	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 40	Cylindrical Pipe	User Specified			None

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size	Type	Special Condition
51	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			228, 41	Cylindrical Pipe	User Specified			None
52	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 42	Cylindrical Pipe	User Specified			None
53	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			230, 43	Cylindrical Pipe	User Specified			None
54	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 44	Cylindrical Pipe	User Specified			None
55	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			232, 45	Cylindrical Pipe	User Specified			None
56	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 46	Cylindrical Pipe	User Specified			None
57	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			234, 47	Cylindrical Pipe	User Specified			None
58	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 48	Cylindrical Pipe	User Specified			None
59	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			236, 49	Cylindrical Pipe	User Specified			None
60	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 50	Cylindrical Pipe	User Specified			None
61	Pipe	Yes	24.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0.168			255, 51	Cylindrical Pipe	User Specified			Closed
65	Pipe	Yes	24.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0.168			256, 55	Cylindrical Pipe	User Specified			Closed
66	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 56	Cylindrical Pipe	User Specified			None
67	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			238, 57	Cylindrical Pipe	User Specified			None
68	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 58	Cylindrical Pipe	User Specified			None
69	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			240, 59	Cylindrical Pipe	User Specified			None
70	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 60	Cylindrical Pipe	User Specified			None
71	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			242, 61	Cylindrical Pipe	User Specified			None
72	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 62	Cylindrical Pipe	User Specified			None
73	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			244, 63	Cylindrical Pipe	User Specified			None
74	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 64	Cylindrical Pipe	User Specified			None
75	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			246, 65	Cylindrical Pipe	User Specified			None
76	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 66	Cylindrical Pipe	User Specified			None
77	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			248, 67	Cylindrical Pipe	User Specified			None
78	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			39, 68	Cylindrical Pipe	User Specified			None
79	Pipe	Yes	52	feet	60	inches	Unspecified	130	C Hazen-Williams	0.54			250, 69	Cylindrical Pipe	User Specified			None
81	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			43, 41	Cylindrical Pipe	User Specified			None
82	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			45, 43	Cylindrical Pipe	User Specified			None
83	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			47, 45	Cylindrical Pipe	User Specified			None
84	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			49, 47	Cylindrical Pipe	User Specified			None
85	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			57, 49	Cylindrical Pipe	User Specified			None
86	Pipe	Yes	13	feet	144	inches	Unspecified	130	C Hazen-Williams	0			51, 57	Cylindrical Pipe	User Specified			None
87	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			61, 59	Cylindrical Pipe	User Specified			None
88	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			63, 61	Cylindrical Pipe	User Specified			None
89	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			65, 63	Cylindrical Pipe	User Specified			None
90	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			67, 65	Cylindrical Pipe	User Specified			None
91	Pipe	Yes	22	feet	144	inches	Unspecified	130	C Hazen-Williams	0			69, 67	Cylindrical Pipe	User Specified			None
92	Pipe	Yes	13	feet	144	inches	Unspecified	130	C Hazen-Williams	0			59, 55	Cylindrical Pipe	User Specified			None
93	Pipe	Yes	49.5	feet	144	inches	Unspecified	130	C Hazen-Williams	0			70, 69	Cylindrical Pipe	User Specified			None
98	Pipe	Yes	1096	feet	144	inches	Unspecified	130	C Hazen-Williams	0			55, 84	Cylindrical Pipe	User Specified			None
99	Pipe	Yes	1	feet	144	inches	Unspecified	130	C Hazen-Williams	0			77, 80	Cylindrical Pipe	User Specified			None
100	Pipe	Yes	37	feet	144	inches	Unspecified	130	C Hazen-Williams	0			78, 77	Cylindrical Pipe	User Specified			None
101	Pipe	Yes	1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			78, 81	Cylindrical Pipe	User Specified			None
102	Pipe	Yes	1078	feet	144	inches	Unspecified	130	C Hazen-Williams	0			77, 79	Cylindrical Pipe	User Specified			None
103	Pipe	Yes	70	feet	144	inches	Unspecified	130	C Hazen-Williams	0			41, 78	Cylindrical Pipe	User Specified			None
104	Pipe	Yes	1	feet	144	inches	Unspecified	130	C Hazen-Williams	0			82, 17	Cylindrical Pipe	User Specified			None
105	Pipe	Yes	0.1	feet	60	inches	Unspecified	130	C Hazen-Williams	0			83, 51	Cylindrical Pipe	User Specified			None

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size	Type	Special Condition
106	Pipe	Yes	771	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			200, 201	Cylindrical Pipe	User Specified			None
107	Pipe	Yes	732	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3505752			201, 202	Cylindrical Pipe	User Specified			None
108	Pipe	Yes	265	feet	144	inches	Unspecified	130	C Hazen-Williams	0			202, 203	Cylindrical Pipe	User Specified			None
109	Pipe	Yes	334	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1537168			203, 204	Cylindrical Pipe	User Specified			None
110	Pipe	Yes	781	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			204, 205	Cylindrical Pipe	User Specified			None
111	Pipe	Yes	1884	feet	144	inches	Unspecified	130	C Hazen-Williams	0.4827213			205, 257	Cylindrical Pipe	User Specified			None
112	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			2, 100	Cylindrical Pipe	User Specified			None
113	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			100, 101	Cylindrical Pipe	User Specified			None
114	Pipe	Yes	36	feet	60	inches	Unspecified	130	C Hazen-Williams	0.708			103, 5	Cylindrical Pipe	User Specified			None
115	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			4, 102	Cylindrical Pipe	User Specified			None
116	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			102, 103	Cylindrical Pipe	User Specified			None
117	Pipe	Yes	36	feet	60	inches	Unspecified	130	C Hazen-Williams	0.708			105, 7	Cylindrical Pipe	User Specified			None
118	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			6, 104	Cylindrical Pipe	User Specified			None
119	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			104, 105	Cylindrical Pipe	User Specified			None
120	Pipe	Yes	36	feet	60	inches	Unspecified	130	C Hazen-Williams	0.708			107, 9	Cylindrical Pipe	User Specified			None
121	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			8, 106	Cylindrical Pipe	User Specified			None
122	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			106, 107	Cylindrical Pipe	User Specified			None
123	Pipe	Yes	36	feet	60	inches	Unspecified	130	C Hazen-Williams	0.708			109, 11	Cylindrical Pipe	User Specified			None
124	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			10, 108	Cylindrical Pipe	User Specified			None
125	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			108, 109	Cylindrical Pipe	User Specified			None
126	Pipe	Yes	36	feet	60	inches	Unspecified	130	C Hazen-Williams	0.708			111, 19	Cylindrical Pipe	User Specified			None
127	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			18, 110	Cylindrical Pipe	User Specified			None
128	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			110, 111	Cylindrical Pipe	User Specified			None
129	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			20, 152	Cylindrical Pipe	User Specified			None
130	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			152, 153	Cylindrical Pipe	User Specified			None
131	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			22, 154	Cylindrical Pipe	User Specified			None
132	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			154, 155	Cylindrical Pipe	User Specified			None
133	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			24, 156	Cylindrical Pipe	User Specified			None
134	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			156, 157	Cylindrical Pipe	User Specified			None
135	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			26, 158	Cylindrical Pipe	User Specified			None
136	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			158, 159	Cylindrical Pipe	User Specified			None
137	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			28, 160	Cylindrical Pipe	User Specified			None
138	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			160, 161	Cylindrical Pipe	User Specified			None
139	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			30, 162	Cylindrical Pipe	User Specified			None
140	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			162, 163	Cylindrical Pipe	User Specified			None
141	Pipe	Yes	8	feet	60	inches	Unspecified	130	C Hazen-Williams	0			12, 150	Cylindrical Pipe	User Specified			None
142	Pipe	Yes	2	feet	60	inches	Unspecified	130	C Hazen-Williams	0			15, 113	Cylindrical Pipe	User Specified			Closed
143	Pipe	Yes	2	feet	60	inches	Unspecified	130	C Hazen-Williams	0			16, 151	Cylindrical Pipe	User Specified			None
144	Pipe	Yes	334	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1537168			210, 211	Cylindrical Pipe	User Specified			None
145	Pipe	Yes	781	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			211, 212	Cylindrical Pipe	User Specified			None
146	Pipe	Yes	1884	feet	144	inches	Unspecified	130	C Hazen-Williams	0.4827213			212, 260	Cylindrical Pipe	User Specified			None
147	Pipe	Yes	771	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			207, 208	Cylindrical Pipe	User Specified			None
148	Pipe	Yes	732	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3505752			208, 209	Cylindrical Pipe	User Specified			None
149	Pipe	Yes	265	feet	144	inches	Unspecified	130	C Hazen-Williams	0			209, 210	Cylindrical Pipe	User Specified			None
150	Pipe	Yes	18233	feet	144	inches	Unspecified	130	C Hazen-Williams	2.610465			79, 207	Cylindrical Pipe	User Specified			None
151	Pipe	Yes	334	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1537168			217, 218	Cylindrical Pipe	User Specified			None
152	Pipe	Yes	781	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			218, 219	Cylindrical Pipe	User Specified			None

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size	Type	Special Condition
153	Pipe	Yes	1884	feet	144	inches	Unspecified	130	C Hazen-Williams	0.4827213			219, 258	Cylindrical Pipe	User Specified			None
154	Pipe	Yes	771	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			214, 215	Cylindrical Pipe	User Specified			None
155	Pipe	Yes	732	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3505752			215, 216	Cylindrical Pipe	User Specified			None
156	Pipe	Yes	265	feet	144	inches	Unspecified	130	C Hazen-Williams	0			216, 217	Cylindrical Pipe	User Specified			None
157	Pipe	Yes	18233	feet	144	inches	Unspecified	130	C Hazen-Williams	2.610465			84, 214	Cylindrical Pipe	User Specified			None
158	Pipe	Yes	334	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1537168			223, 224	Cylindrical Pipe	User Specified			None
159	Pipe	Yes	781	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			224, 225	Cylindrical Pipe	User Specified			None
160	Pipe	Yes	1884	feet	144	inches	Unspecified	130	C Hazen-Williams	0.4827213			225, 259	Cylindrical Pipe	User Specified			None
161	Pipe	Yes	771	feet	144	inches	Unspecified	130	C Hazen-Williams	0.1752876			38, 221	Cylindrical Pipe	User Specified			None
162	Pipe	Yes	732	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3505752			221, 222	Cylindrical Pipe	User Specified			None
163	Pipe	Yes	265	feet	144	inches	Unspecified	130	C Hazen-Williams	0			222, 223	Cylindrical Pipe	User Specified			None
164	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			40, 227	Cylindrical Pipe	User Specified			None
165	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			227, 228	Cylindrical Pipe	User Specified			None
166	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			42, 229	Cylindrical Pipe	User Specified			None
167	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			229, 230	Cylindrical Pipe	User Specified			None
168	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			44, 231	Cylindrical Pipe	User Specified			None
169	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			231, 232	Cylindrical Pipe	User Specified			None
170	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			46, 233	Cylindrical Pipe	User Specified			None
171	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			233, 234	Cylindrical Pipe	User Specified			None
172	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			48, 235	Cylindrical Pipe	User Specified			None
173	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			235, 236	Cylindrical Pipe	User Specified			None
174	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			56, 237	Cylindrical Pipe	User Specified			None
175	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			237, 238	Cylindrical Pipe	User Specified			None
176	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			58, 239	Cylindrical Pipe	User Specified			None
177	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			239, 240	Cylindrical Pipe	User Specified			None
178	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			60, 241	Cylindrical Pipe	User Specified			None
179	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			241, 242	Cylindrical Pipe	User Specified			None
180	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			62, 243	Cylindrical Pipe	User Specified			None
181	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			243, 244	Cylindrical Pipe	User Specified			None
182	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			64, 245	Cylindrical Pipe	User Specified			None
183	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			245, 246	Cylindrical Pipe	User Specified			None
184	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			66, 247	Cylindrical Pipe	User Specified			None
185	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			247, 248	Cylindrical Pipe	User Specified			None
186	Pipe	Yes	9	feet	60	inches	Unspecified	130	C Hazen-Williams	0			68, 249	Cylindrical Pipe	User Specified			None
187	Pipe	Yes	6.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			249, 250	Cylindrical Pipe	User Specified			None
188	Pipe	Yes	6	feet	60	inches	Unspecified	130	C Hazen-Williams	0.24			254, 251	Cylindrical Pipe	User Specified			Closed
189	Pipe	Yes	9.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0.3			251, 252	Cylindrical Pipe	User Specified			Closed
190	Pipe	Yes	9.5	feet	60	inches	Unspecified	130	C Hazen-Williams	0			251, 253	Cylindrical Pipe	User Specified			Closed
191	Pipe	Yes	8	feet	60	inches	Unspecified	130	C Hazen-Williams	0			50, 254	Cylindrical Pipe	User Specified			None
192	Pipe	Yes	2	feet	60	inches	Unspecified	130	C Hazen-Williams	0			252, 255	Cylindrical Pipe	User Specified			Closed
193	Pipe	Yes	2	feet	60	inches	Unspecified	130	C Hazen-Williams	0			253, 256	Cylindrical Pipe	User Specified			Closed
194	Pipe	Yes	50	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3			259, 261	Cylindrical Pipe	User Specified			None
195	Pipe	Yes	50	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3			257, 261	Cylindrical Pipe	User Specified			None
196	Pipe	Yes	3400	feet	23	feet	Unspecified	130	C Hazen-Williams	0			261, 267	Cylindrical Pipe	User Specified			None
197	Pipe	Yes	50	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3			260, 262	Cylindrical Pipe	User Specified			None
198	Pipe	Yes	50	feet	144	inches	Unspecified	130	C Hazen-Williams	0.3			258, 262	Cylindrical Pipe	User Specified			None
199	Pipe	Yes	3400	feet	23	feet	Unspecified	130	C Hazen-Williams	0			262, 266	Cylindrical Pipe	User Specified			None

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness	Roughness Units	Losses (K)	Initial Flow	Initial Flow Units	Junctions (Up,Down)	Geometry	Material	Size	Type	Special Condition
200	Pipe	Yes	0.1	feet	23	feet	Unspecified	130	C Hazen-Williams	1			267, 268	Cylindrical Pipe	User Specified			None
201	Pipe	Yes	0.1	feet	23	feet	Unspecified	130	C Hazen-Williams	1			266, 268	Cylindrical Pipe	User Specified			None
202	Pipe	Yes	251.5	feet	40	feet	Unspecified	130	C Hazen-Williams	1			268, 265	Cylindrical Pipe	User Specified			None

Reservoir Table

Reservoir	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Database Source	Liquid Elev.	Liquid Elev. Units	Surface Pressure	Surface Pressure Units	Balance Energy	Balance Concentration	(Pipe #1) K In, K Out	(Pipe #2) K In, K Out	(Pipe #3) K In, K Out	(Pipe #4) K In, K Out	(Pipe #5) K In, K Out
1	Reservoir	Yes						205	feet	0	psig	No	No	(P1) 0, 0	(P3) 0, 0	(P5) 0, 0	(P7) 0, 0	(P9) 0, 0
39	Reservoir	Yes						119	feet	0	psig	No	No	(P50) 0, 0	(P52) 0, 0	(P54) 0, 0	(P56) 0, 0	(P58) 0, 0
265	INLET/OUTLET TOWER	Yes						340	feet	0	psig	No	No	(P202) 0, 0				

Reservoir	(Pipe #6) K In, K Out	(Pipe #7) K In, K Out	(Pipe #8) K In, K Out	(Pipe #9) K In, K Out	(Pipe #10) K In, K Out	(Pipe #11) K In, K Out	(Pipe #12) K In, K Out	(Pipe #13) K In, K Out	(Pipe #14) K In, K Out	(Pipe #15) K In, K Out	(Pipe #16) K In, K Out	(Pipe #17) K In, K Out	(Pipe #18) K In, K Out	(Pipe #19) K In, K Out	(Pipe #20) K In, K Out	(Pipe #21) K In, K Out	(Pipe #22) K In, K Out	(Pipe #23) K In, K Out	(Pipe #24) K In, K Out	(Pipe #25) K In, K Out
1	(P11) 0, 0	(P17) 0, 0	(P19) 0, 0	(P21) 0, 0	(P23) 0, 0	(P25) 0, 0	(P27) 0, 0	(P29) 0, 0												
39	(P60) 0, 0	(P66) 0, 0	(P68) 0, 0	(P70) 0, 0	(P72) 0, 0	(P74) 0, 0	(P76) 0, 0	(P78) 0, 0												
265																				

Reservoir	(Pipe #1) Depth	(Pipe #2) Depth	(Pipe #3) Depth	(Pipe #4) Depth	(Pipe #5) Depth	(Pipe #6) Depth	(Pipe #7) Depth	(Pipe #8) Depth	(Pipe #9) Depth	(Pipe #10) Depth	(Pipe #11) Depth	(Pipe #12) Depth	(Pipe #13) Depth	(Pipe #14) Depth	(Pipe #15) Depth	(Pipe #16) Depth	(Pipe #17) Depth	(Pipe #18) Depth	(Pipe #19) Depth	(Pipe #20) Depth
1	(P1) 179.6	(P3) 179.6	(P5) 179.6	(P7) 179.6	(P9) 179.6	(P11) 179.6	(P17) 179.6	(P19) 179.6	(P21) 179.6	(P23) 179.6	(P25) 179.6	(P27) 179.6	(P29) 179.6							
39	(P50) 89.9	(P52) 89.9	(P54) 89.9	(P56) 89.9	(P58) 89.9	(P60) 89.9	(P66) 89.9	(P68) 89.9	(P70) 89.9	(P72) 89.9	(P74) 89.9	(P76) 89.9	(P78) 89.9							
265	(P202) 300																			

Reservoir	(Pipe #21) Depth	(Pipe #22) Depth	(Pipe #23) Depth	(Pipe #24) Depth	(Pipe #25) Depth	Pipe Depth Units
1						feet
39						feet
265						feet

Appendix D

Harrington Pipeline Alignment Analysis

Harrington Pipeline Alignment Analysis
Technical Memorandum (Final)

To:	Henry Luu/HDR
CC:	
Date:	August 28, 2020
From:	Jeff Smith/Jacobs
Quality Review by:	Brad Memeo/Jacobs
Authority Agent Review by:	TBD
Subject:	Analysis of Harrington Pipeline Route

1.0 Background

The Sites Project Authority (Authority) adopted the recommended project (VP7) as provided in the *Sites Project Value Planning Alternatives Appraisal Report,* dated April 2020, to reduce the program cost from $5.2 billion to $3.0 billion. One of the new conveyance components of VP7, uses the Tehama-Colusa Canal (TCC) to convey water from Funks Reservoir, approximately 40 miles south, to near the end of the TCC. At this point, a new discharge outlet and pipeline would convey water for discharge to either the Colusa Basin Drain (CBD) or the Sacramento River. Since the discharge point is near the end of the TCC, close to Dunnigan, this pipeline has been referred to as the “Dunnigan pipeline.” The Dunnigan pipeline is a 4-mile-long, 9-foot-diameter pipe to the CBD, or a 10-mile-long, 10.5-foot-diameter pipeline if it flows to the Sacramento River.

2.0 Purpose

Recently, the Authority asked the Conveyance Team to investigate the possibility of using an alternative alignment to the Dunnigan pipeline alignment. This alternative alignment, called the Harrington alignment, is parallel and approximately 9 miles north of the Dunnigan alignment. The Harrington alignment is associated with an existing main pipeline used by Colusa County Water District (CCWD). This potential alignment would either use the existing CCWD pipeline’s unused capacity and/or construct a parallel pipe to convey the 1,000 cubic feet per second (cfs) from the TCC to the CBD using, to the extent possible, CCWD’s existing right-of-way. If the Harrington alignment has merit, then further analysis would be completed to take the pipeline to the Sacramento River.

3.0 Analysis

Information regarding the existing pipeline was obtained from CCWD’s General Manager, Shelly Murphy, and other sources. This information included the following:

- Parcel lines
- Existing pipeline as-built drawings
- Pipeline flow of 125 cfs peak design capacity

- Water surface elevations:
  - TCC – 180 feet
  - CBD – 40 feet

3.1 Alignment and Sizing

The as-built drawing for the main pipeline (Lateral 2A) shows it begins at the TCC and goes directly east for 5 miles to West Road, where it discharges to a canal that flows north. Lateral 2A is aligned along the southern side of White Road in an east-west direction, but ends about 1.25 miles short of the CBD, where it crosses under White Road and then discharges into the canal.

As it leaves the TCC, Lateral 2A consists of 1 mile of 60-inch-diameter pipe, followed by 3 miles of 54-inch-diameter pipe, and a final last mile of 48-inch-diameter pipe. The pipe was installed in 1965 and consist of reinforced concrete pipe (60-inch diameter) and concrete cylinder pipe (54- and 48-inch diameter).

Figure 1 shows the approximate location of Lateral 2A in relation to the TCC and CBD.

3.2 Flow Calculations

Calculations were completed to determine: (1) if there was unused capacity in Lateral 2A; and (2) new pipeline diameter required to convey 1,000 cfs to the 6.25 miles from the TCC to CBD.

3.2.1 CCWD Lateral 2A

Based on information provided by Jeff Sutton (TCC Authority General Manager), the turnout on the TCC to CCWD Lateral 2A is designed for a maximum capacity of 125 cfs. Actual design flows of the lateral was not available, but a hydraulic analysis of Lateral 2A in the initial mile of 60-inch-diameter pipe indicates it can accommodate a maximum flow of about 210 cfs under gravity flow condition with approximate known head conditions. There is not enough information to determine the available capacity of the downstream 54- and 48-inch-diameter pipes because lateral demand flows are unknown. Regardless, of the capacity of the downstream smaller pipes, the roughly 210 cfs calculated for the 60-inch pipe would be the maximum this lateral could convey. It could be less if the downstream pipes have further constraints. This analysis shows that there may be some additional capacity in lateral 2A of about 85 cfs (210 cfs calculated – 125 cfs current turnout limitation) in the 60-inch-diameter pipe, but this is only a fraction of the 1,000 cfs needed to convey the Sites Project water to the CBD. Therefore, it was determined that using the existing CCWD Lateral 2A was not practical because a new, large-diameter pipe is required regardless.

3.2.2 New Pipeline

Hydraulic calculations were preformed to determine the pipeline size needed for a new pipeline for 6.25 miles, from the TCC to the CBD, using a parallel alignment to Lateral 2A. The location of this alternative pipeline alignment is shown on Figure 2. Following are the criteria used for to calculate the pipe diameter:

- The water surface elevation of the upper end at TCC is about 180 feet
- The downstream end of the proposed pipeline at the CBD is roughly 40 feet.
- Hazen-Williams C-value of 130

Results of this analysis indicates a roughly 9.5-foot-diameter pipeline would be required using gravity flow. This results in a velocity of about 14 feet per second, which is higher than the normal 7 feet per second. However, since this pipe is gravity flow, the approach to sizing the pipe was to make the pipe as small as possible while using all the available driving head differential. Since an energy dissipater would be required at the end of the pipe at the CBD, flowing at this velocity was not a concern.

3.3 Utilizing Existing Lateral 2A Right-of-Way for New Pipe Installation

One of the reasons for studying this potential alignment for a new discharge pipeline was to take advantage of using the existing right-of-way for Lateral 2A for a shared installation of the new pipeline. This analysis used the as-built drawing information to determine:

- The overall right-of-way width and location of the existing Lateral 2A within the right-of-way
- If there is enough space to install the new 9.5-foot-diameter pipeline
- The location of the right-of-way with respect to White Road and whether encroachments have occurred within this right-of-way since Lateral 2A was constructed 55 years ago

3.3.1 Right-of-Way Width

Analysis of the Lateral 2A as-built drawings showed the width of the right-of-way varies from 70 to 90 feet. The general location of the pipe within the right-of-way is 40 to 50 feet north of the southern line of right-of way. this would leave about 20 to 50 feet of room on each side of new pipeline alignment for installation. This is a very narrow corridor to install the 9.5-foot-diameter pipe, but the space is possible, assuming a vertical trench wall would be possible (at a higher cost than laying back) and an additional temporary construction easement of about 50 feet can be obtained.

3.3.2 Encroachments in Existing Right-of-Way

Parcel line information was obtained from the Real Estate Team and overlaid with Google Earth to assist in determining where the existing pipe may be located. The parcel information did not correlate well to roads and other features shown in Google Earth, especially the last 2 miles along White Road. The presumed White Road right-of-way lines were shown south of the road in the orchard and did not include any of the physical road.

The Google Earth image did seem to indicate a corridor and a few features that help to roughly locate the existing pipeline, but this was not clearly definitive. What the image did show is that orchards have encroached within the existing pipeline right-of-way, especially on the section between the TCC and Grieve Road (3 miles). In this segment, there is a farm access road where the existing pipeline is likely located, but the distance between the orchard and this road is only about 30 to 40 feet. In other words, there are mature trees currently located within the existing pipeline right-of-way, given the right-of-way is 80 to 90 feet wide in this segment.

In the other 2-mile segment, between Grieve Road and the end of Lateral 2A, the existing pipeline parallels White Road and is located about 40 to 45 feet south of the road centerline. This places the existing pipeline roughly in the farm road adjacent to the orchard. The space between the southern edge of road and the existing pipeline contains power poles and a buried communication cable that could interfere with using as a work area for construction of a new pipeline.

The Jacobs team also looked at placing the new pipeline in White Road, but determined this would also be challenging because of a narrow road width that is often bordered by ditches or other features on both sides. The work area within the road is approximately 50 feet at best. Additionally, there are numerous turnouts that cross the road that would result in a 16-18-foot-deep trench to avoid the lateral crossings.

4.0 Comparison

An analysis of the existing right-of-way and pipeline corridor indicate that there is insufficient space available to install the new pipeline without requiring removal of orchards. A rough approximation of the area of orchards to be removed to accommodate construction is 90 acres (assuming 150 feet of easements, which includes removing trees in the existing right-of-way, plus a temporary construction easement). The total width of work area required for construction is about 200 feet, assuming some layback area for the deep trench; which is roughly the same as anticipated for the Dunnigan pipeline. Use of a vertical trench may only require about 125 feet of work area, but maintaining a deep vertical trench in these wet soils (because of high groundwater) is expected to be almost impossible.

Another consideration associated with this alignment includes discharging to the CBD roughly 8 miles upstream of the proposed Dunnigan Pipeline discharge point , which may result in additional losses resulting from seepage and other possible water losses. In other words, more than 1,000 cfs of flow may be required to ensure 1,000 cfs ends up in the Sacramento River. This is also true for the Dunnigan Pipeline, but fewer losses are expected with the Dunnigan pipeline because the length of conveyance in the CBD is shorter by about 8 miles (10 miles versus 18 miles).

Installation of a pipeline to the CBD for this alignment requires 6.25 miles, versus about 4 miles for the Dunnigan pipeline, from the TCC to the CBD. This pipeline requires a 9.5-foot-diameter pipe, versus the 9-foot-diameter pipe anticipated for Dunnigan. Although the Dunnigan Pipeline is significantly shorter, there is less head differential available to convey the 1,000 cfs. Both the Harrington and Dunnigan pipelines require tunneling under I-5, Old Hwy 99, and Union Pacific Railroad tracks.

A Class 5 cost estimate was prepared for both the Harrington and Dunnigan pipelines. The expected accuracy ranges for this class estimate are –20 to –50 percent on the low side, and +30 to +100 percent on the high side. This estimate includes a contractor's overhead and profit, a 10 percent contingency, and 17 percent for soft costs (administrative, design, construction management). It does not include any costs for real estate acquisition. Estimate costs are as follows:

Construction Cost for Dunnigan Pipeline to Colusa Basin Drain = $64.5 million

Construction Cost for Harrington Pipeline to Colusa Basin Drain = $112.4 million

The comparison of construction costs shows the Harrington pipeline to be almost twice the cost of the Dunnigan pipeline. This is explained given the Dunnigan Pipeline is much shorter and a slightly smaller diameter pipeline. Although land acquisition costs are not included in this construction cost, the Harrington pipeline will likely require removal of approximately 90 acres of orchards, while the Dunnigan pipeline is anticipated to require removal of roughly 40 acres of orchards and vineyards. Therefore, the cost differential is expected to increase further if land acquisition costs are included in the comparison.

5.0 Recommendation

Based on the analysis presented in this technical memorandum, we recommend using the Dunnigan pipeline alignment to convey water from the TCC to the CBD. The Harrington alignment does not warrant further study.

Figures

FIGURE 1
Existing CCWD Pipeline

FIGURE 2
Harrington Alternate

Legend

🟩 Harrington Alternative Alignment

Appendix E

Emergency Drawdown Facilities Evaluation

Emergency Drawdown Facilities Evaluation Technical Memorandum (Final)

To:	Henry Luu
CC:	Michael Forest/AECOM, Jeff Herrin/AECOM
Date:	August 28, 2020
From:	Jeff Smith/Jacobs
Quality Review by:	Peter Rude/Jacobs
Authority Agent Review by:	TBD
Subject:	Site Reservoir Emergency Drawdown Facilities Requirements and Alternatives

1.0 Background and Purpose

The Sites Joint Powers Authority (Authority) has embarked on the implementation of a 1.5-million-acre-foot reservoir, known as the Sites Reservoir. Other major facilities include two pump generating plants, two smaller regulating reservoirs, and several miles of 12-foot-diameter pipelines used to pump water from the Tehama Colusa Canal (TCC) and Glenn-Colusa Irrigation District (GCID) Canal to and from the Sites Reservoir. The Funks Reservoir is located on the TCC and serves currently as a regulating reservoir, and the Terminal Regulating Reservoir (TRR) will be a new regulating reservoir on the GCID Canal.

The Sites Reservoir will require a procedure to provide emergency drawdown, as described in more detail in a technical memorandum (TM) entitled “Funks and Stone Corral Creeks - Reservoir Operating Elevations and Emergency Release Management,” prepared by AECOM and dated May 27, 2020. Results provided in this TM show that about 16,000 cubic feet per second (cfs) of flow will need to be discharge through the inlet/outlet tunnels that ultimately are connected to Funks and TRR reservoirs, as well as Funks Creek. How this 16,000 cfs flow will be distributed is not provided, but the flow is assumed to be able to be conveyed to Funks Reservoir, the TRR, and ultimately Funks Creek. Some flow may also be sent into the TCC and GCID Canal for dispersion away from the project site.

The purpose of this TM is to provide calculations showing how much flow the proposed pipelines connected to the Funks Reservoir and TRR can accommodate during an emergency drawdown condition.

2.0 Flow Calculations

The Site Reservoir inlet/outlet (I/O) tunnel consists of two 23-foot diameter penstocks that end at the foot of Sites Reservoir. It is proposed to connect the I/O tunnel to both the Funks Reservoir and the TRR. These connections are made using two 12-foot-diameter pipelines for each reservoir. At each reservoir, the pipelines are connected to a pumping/generating plant (PGP) that pumps water from the regulating reservoir to Sites Reservoir, as well as turbines that will generate power when flow is released from Sites Reservoir. There will also be energy-dissipation equipment, such as a fixed cone valve(s), adjacent to each PGP to throttle the flow of water into each regulating reservoir when the turbines are not being used.

For the emergency drawdown condition, calculations were performed to determine the maximum flow that can be conveyed through the 12-foot-diameter pipes to each regulating reservoir using the fixed-cone valves. Flow through these pipes will be based on gravity flow.

2.1 Funks Regulating Reservoir

Following are design criteria used to perform flow calculations:

- Sites Reservoir Levels
  - Maximum = 498 feet
  - 10% drawdown level = 478 feet
- Pipeline
  - Two 12-foot internal diameter
  - Length = 6,000 feet
  - Hazen-Williams C-factor = 120
  - Maximum velocity = 40 feet per second
- Energy-dissipation Valve Elevation = 215 feet

Based on this information, calculations show that there is more than enough water surface elevation differential to provide a high volume of flow during the drawdown condition. Specifically, there is enough head to achieve a flow of 12,500 cfs through the two pipes, but velocities in these pipes would be around 55 feet per second. At the upper limit of 40 feet per second, the flow would be about 9,000 cfs, or roughly about 56% of the total drawdown flow.

We understand the U.S. Bureau of Reclamation (Reclamation) restricts the maximum allowable velocity in a pipeline to 20 feet per second. If this criterion was used, then the maximum flow through the two pipelines would be 4,500 cfs, or roughly 23% of the total drawdown flow.

2.2 Terminal Regulating Reservoir

Following are design criteria used to perform flow calculations:

- Sites Reservoir Levels
  - Maximum = 498 feet
  - 10% drawdown level = 478 feet
- Pipeline
  - Two 12-foot internal diameter
  - Length = 25,000 feet
  - Hazen-Williams C-factor = 120
  - Maximum velocity = 40 feet per second
  - Energy-dissipation Valve Elevation = 130 feet

Based on this information, calculations show more than enough water surface elevation differential to provide a high volume of flow during the drawdown condition. Because of the higher friction losses associated with the longer pipes, this system could achieve a flow of about 7,000 cfs through the two pipes, resulting in a velocity of about 30 feet per second. The flow of 7,000 cfs is roughly about 44% of the total drawdown flow.

Using Reclamation's design criteria of 20 feet per second, the maximum flow through the two pipelines would be 4,500 cfs, or roughly 23% of the total drawdown flow.

3.0 Discussion of Results

Based on the calculations performed as part of this analysis, using the proposed pipelines to carry flow during an emergency drawdown condition could achieve the entire flow of 16,000 cfs, with 9,000 being discharged to Funks Reservoir and 7,000 cfs to the new TRR. This is all predicated on allowing a maximum velocity of 40 feet per second in the pipelines and both reservoirs accommodating these flows.

Funks Reservoir has a spillway that can accommodate a flow of 22,000 cfs or more than the total emergency drawdown flow of 16,000 cfs. The TRR is lower in the system and is not anticipated to have a spillway that could accommodate the 7,000 cfs emergency drawdown flow the system is capable of conveying. Although a high-capacity spillway could be added at the TRR, there is concern that excessive flow from the TRR could pose a flooding threat to residents downstream. In the event the TRR is found to not be able to accommodate the emergency drawdown flows, one option is to install additional energy-dissipation valves at Funks Reservoir and connect to the TRR pipelines, which would increase the flow into Funks where the flow could possibly be accommodated.

If the Authority adhered to Reclamation’s criteria of a maximum of 20 feet per second in the pipelines, then the maximum drawdown flow that could be sent through the pipelines would be 4,500 cfs for each system, or a total of 9,000 cfs. The additional 7,000 cfs would need to be discharged by other facilities, such as: 1) an energy-dissipation structure at the tunnel outlet that discharges to Funks Creek; or 2) the addition of more pipelines from the outlet to Funks Reservoir with additional energy dissipation to Funks Reservoir.

4.0 Recommendations

This analysis has shown that the proposed Sites Project facilities at Funks and the TRR could convey the entire emergency drawdown flow of 16,000 cfs. However, before this would be allowed, there are several recommended actions:

1. Determine what the Authority will allow for a maximum velocity in the pipes during the very rare operating condition of an emergency drawdown. A maximum velocity of 40 feet per second is allowed in similar situations, but Reclamation only allows 20 feet per second under all conditions.
2. Complete a flood analysis of this general area to determine the impacts of a 7-day discharge of 16,000 cfs in the area of the Funks Reservoir and TRR. This analysis should provide results that would indicate the maximum allowable flow to both regulating reservoirs, as well as a general summary of flooding conditions and impacts in the area.

The Jacobs design team is continuing with design of facilities to accommodate the normal operation of the Site Project and will not include additional facilities, such as additional energy-dissipating valves, which would be required for an emergency drawdown condition. However, once a flood analysis is performed as requested above in item 2, the design team can modify the facilities per direction from the Authority.

Appendix F

Funks Creek Environmental Water Source Analysis

Funks Creek Environmental Water Source Analysis Technical Memorandum (Final)

To:	Henry Luu
CC:	Michael Forest/AECOM, Jeff Herrin/AECOM
Date:	October 12, 2020
From:	Jeff Smith/Jacobs
Quality Review by:	Peter Rude/Jacobs
Authority Agent Review by:	TBD
Subject:	Site Reservoir – Funks Creek Environmental Water Source Analysis

1.0 Purpose

The Sites Reservoir Project may require providing supplemental environmental water to Funks Creek at the base of Golden Gate Dam. The reason for this possibility is that construction of this dam will isolate flow into the creek, rendering Funks Creek dry during for most of the year. To mitigate this change, a concept to introduce 10 cubic feet per second (cfs) to Funks Creek at the base of Golden Gate Dam has been suggested by the Environmental Team.

The purpose of this technical memorandum is to provide hydraulic calculations and a simple economic analysis to evaluate two different systems to deliver the 10 cfs to Funks Creek. If a change occurs in the flow rate, then this memorandum will need to be revised.

2.0 Description of Systems

Two alternative systems have been identified to deliver 10 cfs to the head of Funks Creek at the base of Golden Gate Dam. The first alternative is to provide a dedicated pumped system that includes a pump at the Funks Pumping Generating Plant (PGP), a small pipeline from Funks PGP to Funks Creek, and an outlet into Funks Creek. The second alternative system is to provide a gravity system that includes a connection at the Sites inlet/outlet (I/O) tunnels manifold (where Funks and Terminal Regulating Reservoir (TRR) 12-foot-diameter pipelines connect to the I/O tunnels), a small pipeline from this manifold to Funks Creek, and an energy-dissipation structure/outlet into Funks Creek. Figure 1 provides a basic overview of the locations of the two alternatives.

Alternative 1 will have, at Funks Reservoir, a pumping station that is dedicated to supplying water only to Funks Creek. This pump station will draw water from one of the PGP pump bays. The pipeline alignment from Funks PGP to Funks Creek will initially follow the proposed Funks and TRR 12-foot-diameter transmission pipes, but then diverge in a northwesterly direction, crossing Funks Creek, and skirting the edge of hills to keep the pipeline at a lower elevation than the Funks Creek discharge point. Keeping the pipeline lower reduces pumping head requirements. The total pipeline length is roughly 7,000 feet.

Alternative 2 begins at the I/O tunnel manifold and then travels about 2,800 feet north to the Funks Creek discharge point. This pipeline will have a higher pressure than Alternative 1. The pressure will be equal to the Sites Reservoir elevation; therefore, the pipeline will require a pressure-reducing valve to dissipate energy before the water is discharged into Funks Creek.

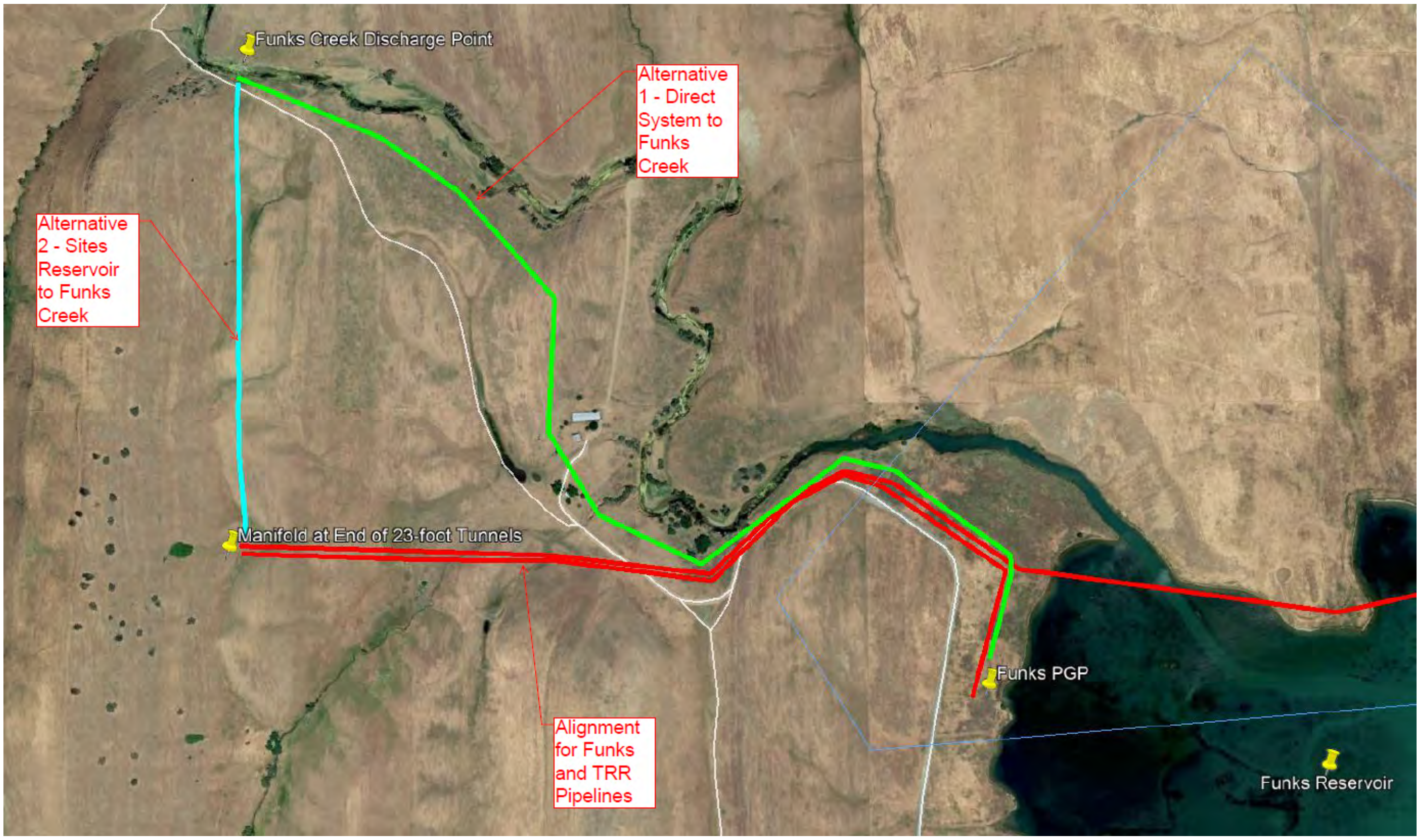


FIGURE 1: FUNKS CREEK ALTERNATIVES

3.0 System Sizing Calculations

Calculations were performed to determine pipeline and pump station (Alternative 1 only) sizes. Following are design criteria used to perform the hydraulic calculations:

- Sites Reservoir water surface elevation = 450 feet
- Funks Reservoir water surface elevation = 200 feet
- Funks Creek discharge point elevation = 260 feet
- Use of PVC pipe that can handle the pressure requirements of this system
- Hazen-Williams C-factor = 135
- Maximum velocity = 15 feet per second

Alternative 1 will require a roughly 150 horsepower pump, along with an 18-inch-diameter pipe. The pipe will be flowing at roughly 5 feet per second.

Alternative 2 will require a 12-inch-diameter pipe that will be flowing at about 13 feet per second. Because of the higher pressure in this pipeline, a pressure-reducing valve station will be required where it discharges to Funks Creek.

4.0 Economic Analysis

An economic analysis was performed, looking at a 20-year life cycle cost that included capital and operational costs for both alternatives. Following are the assumptions used for this economic analysis:

- Pumping days = 200 per year for 24 hours per day
- Pipe unit cost = $20/diameter-inch/liner foot
- Pump station = $100,000
- Pressure control valve station = $30,000
- Electricity cost = $0.12 per kilowatt-hour
- Annual electricity cost escalation = 4%
- Discount rate = 2.5%
- Return Period – 20 years

Even though the Funks PGP will pump the 10 cfs up to Sites Reservoir, this incremental pumping above the normal 2,100 cfs for which Funks is designed to pump still has a cost associated with it. In other words, the requirement to pump an additional 10 cfs to the higher Sites Reservoir water surface elevation adds operational power costs that would not be included if water did not need to be discharged to Funks Creek. Therefore, this analysis includes operational power costs to pump to Sites Reservoir at the 10 cfs rate for 200 days each year.

A 20-year time period was selected because this is both common for this type of analysis and coincides with a general life of a pump before replacement is required. No additional cost for the Funks PGP pumping unit was assumed because adding 10 cfs of capacity to the design capacity of 2,100 cfs is very small and essentially minor.

Table 1 summarizes the economic calculations.

TABLE 1: RESULTS OF ECONOMIC ANALYSIS

Cost	Alternative 1 Pumped to Funks Creek	Alternative 2 Gravity From Sites Reservoir to Funks Creek
Capital	$2,620,000	$702,000
Operational Power	$1,178,000	$2,897,000
Net Present Value	$3,880,000	$3,941,000

The power costs are a function of the lift the pump needs to provide for each alternative. For Alternative 1, the pumping head is approximately 100 feet (60 feet static lift and 40 feet in pipe friction losses), while the pumping head for Alternative 2 is about 250 feet.

The results of this analysis show that Alternative 1 has a significantly higher capital cost ($2.6 M) due to adding an additional dedicated pump station at Funks Reservoir and for a dedicated pipeline from Funks Reservoir to the Funks Creek discharge point. The higher 20-year operational cost for Alternative 2 ($2.9 M) results from the increase cost to pump to the higher water surface at Sites Reservoir and then to allow for ‘gravity flow’ to Funks Creek. On a net present value over a 20-year period, these two alternatives are essentially the same cost.

5.0 Recommendation

Given the 20-year costs are about the same, it is recommended to use Alternative 2 due to the lower initial capital costs.

Appendix G

Draft Hydropower Flow Release Assessment

Draft Hydropower Flow Release Assessment Technical Memorandum

To:	Sites Project Authority
CC:	Henry Luu, P.E., HDR
Date:	June 14, 2021
From:	Christine Vangelatos, ZGlobal Wayne Dyok, H2O EcoPower
Quality Review by:	Peter Rude, P.E., Jacobs
Authority Agent Review by:	Henry Luu, P.E., HDR
Subject:	Sites Hydropower Flow Release Assessment

1.0 Introduction

1.1 Project Description and Objectives

The Sites Reservoir Project is a water supply project. The Sites Reservoir is a 1.5 million acre-feet (MAF), offstream storage reservoir. The project requires water to be pumped from the Sacramento River during periods of high flow to two smaller reservoirs (Funks and the Terminal Regulating Reservoir [TRR]) via two canals. From Funks and the TRR, water will be pumped into the Sites Reservoir. The Sites Project Authority (SPA) desires to recapture the pumping energy during periods of water supply release. The objectives of the current hydropower task are to: (1) update and quantify energy and capacity values based on CAL SIM II flow modeling, and (2) reassess turbine specifications.

1.2 Background

Over the past 2 years, the Sites Project has been reconfigured to provide 1.5 MAF of water supply storage. Previously, the SPA had considered a 1.8 MAF Sites Reservoir, but determined that a 1.5 MAF reservoir or smaller size better meets their needs.

In the previous studies for the 1.8 MAF Sites Reservoir, it was presumed that there would be both energy recovery facilities at Funks and TRR, and additional pumped storage capability either at Funks or an alternative reservoir named Fletcher. The generation capacity was estimated to be on the order of 120 megawatts (MW). However, studies conducted for the U.S. Bureau of Reclamation (Reclamation) and the SPA indicated that the pumped storage component was marginal based on capacity and energy values assumed at the time.[1] Pumped storage is not currently considered a component of the project. However, as described in this technical memorandum (TM), there are potential opportunities for the SPA to make adjustments to project operations to earn significant additional revenue without compromising pumping or water supply releases.

Studies for the 1.8 MAF Sites Reservoir assumed a maximum pumping rate of 5,900 cubic feet per second (cfs) and a maximum generation rate of 5,100 cfs. For the 1.5 MAF Sites Reservoir, the maximum pumping rate is set at 3,900 cfs (2,100 cfs from Funks Reservoir and 1,800 cfs from the TRR). The maximum Sites Reservoir elevation is 497.6 feet (mean sea level), which corresponds to 1.5 MAF of total storage. The minimum reservoir level is at about elevation 340 feet, corresponding to a capacity of about 120,000 acre-feet (ac-ft).[2] Maximum release flows are established at 2,000 cfs to Funks Reservoir and 1,000 cfs to the TRR. Two 12-foot-diameter pipes connect Sites Reservoir with Funks; two additional 12-foot-diameter pipes connect Sites Reservoir with the TRR.

Funks Reservoir has a usable capacity of 1,170 ac-ft between elevations 199.5 and 205.2 feet and a dead storage of 1,080 ac-ft below elevation 199.5 feet.[3] The TRR has a maximum water level of 124 feet. Typically, the TRR is operated between elevation 123 and 123.2 feet in the summer and 121.8 feet in the winter. It is assumed to have a storage capacity of 446 ac-ft. The SPA is considering relocating the TRR because of geotechnical concerns. The live storage volume may be adjusted. For this TM, the TRR storage is assumed to be sufficient to operate the TRR project in a manner that maximizes the value of the flow release energy.

Each of the two 12-foot-diameter pipes connecting Sites to Funks will have a maximum release flow of 1,000 cfs. Jacobs has calculated the total head loss at 18.1 feet during periods of maximum head and maximum release flow. The head loss between Sites and the TRR is estimated to be 14.1 feet at maximum head and maximum release flow. Release flows from Funks and the TRR will be discharged to the Tehama-Colusa Canal and the Glenn-Colusa Irrigation District (GCID) Main Canal, respectively. These flows will be continuously released to meet release targets.

2.0 Initial Turbine Sizing

Based on the head differential at Funks and TRR, maximum pipeline flows and associated head loss, two 21.4 MW turbines (totaling 42.8 MW) were preliminarily sized for Funks energy recovery At the TRR, two 13.8 MW turbines (totaling 27.6 MW) could be installed for an approximate total maximum generating capacity of about 70 MW.[4]

Three turbine suppliers provided technical assistance on turbine design details and cost information: Mavel, General Electric, and Voith. Other suppliers will be contacted as the design progresses. Table 1 provides the information on which the turbine suppliers were asked to size the turbines.

At Funks early in the analysis, it was determined that one turbine cannot operate over the full range of Sites Reservoir fluctuations. Therefore, either two different turbines will be needed at Funks with an overlap in operating heads, or two identical turbines will need to be selected and energy recovery unavailable at Sites

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[1] The results of the pumped storage study were based upon capacity valuation requirements adopted by California Independent Service Operators (CAISO) at the time the study was conducted. Considerable literature now exists suggesting capacity values are substantial under existing regulations and could become even higher in the future.

[2] Monthly and daily flow modeling by Jacobs indicates that there are times when the Sites Reservoir is drawn below elevation 340 feet.

[3] The storage at Funks may be further adjusted as the design process unfolds.

[4] The turbine design head is normally set at the head at which the project most frequently operates and provides the best operational efficiency. However, the turbine design also includes the maximum and minimum operating parameters.

Reservoir levels below the turbine operating range. For the former case, if releases are greater than 1,000 cfs and outside the head overlap band, then some energy may not be recaptured.[5]

TABLE 1. PROJECT OPERATION DATA[6]

	Funks Reservoir	TRR
Max. Sites Water Elev. (ft)	497.6	497.6
Min. Sites Water Elev. (ft)	340	340
Max Water Lower Res. Elev. (ft)	205	124
Min Water Lower Res. Elev. (ft)	199.5	119
Max Static Head (ft)	298.1	378.6
Min Static Head (ft)	135	216
No. Inflow Pipelines (12-ft diam.)	2	2
Total Generation Flow (cfs)	2,000	1,000
Flow per Turbine (cfs)	1,000	500
Pipe and Minor Head Loss (ft)	18.5	18
Turbine efficiency (percent)	90	90
Max Generation (MW)	42.8	27.6
Max Generation at Min Head (MW)	17.7	15.0
Design Head (ft)	210	290

The suppliers provided turbine design data for both Funks and TRR based on operation at the maximum head and maximum generation flow (that is, identical units at Funks and identical units at TRR). Two additional cases were also examined: (1) a turbine that would operate at a lower head most of the time[7], and (2) a turbine that would operate down to the lowest Sites Reservoir level of 340 feet. The latter design indicates how much overlap would be between units. These two cases were identified to recover as much of the pumping energy as possible without adding a third turbine. Suppliers also provided information on generators, controls, electrical interconnections, turbine submergence for civil design, and cost.

This TM provides information necessary to update turbine designs of the units at both Funks Reservoir and TRR. This information includes monthly water level exceedance curves during the primary release period and potential capacity values based on existing California Independent Systems Operations (CAISO) regulations. Both the Funks and TRR turbines are expected to operate at their maximum hydraulic capacities during flow releases to maximize energy and capacity revenues. This operational strategy maximizes daily revenue because the energy price differential during the peak demand hours is much greater than at other times of the

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[5] Jacobs has contacted the turbine suppliers and requested that they incorporate updated energy and capacity modeling information at different operational heads to optimize turbine sizes. A revised TM may be provided in July 2021 if the turbine suppliers recommend slightly different sizes based on updated modeling information.

[6] The head loss values at full capacity flows for both Funks and TRR in Table 1 have since been slightly modified to 18.1 and 14.1 feet, respectively.

[7] Based on review of the modeling results for the 1.8 MAF Sites Reservoir alternative, the water level in Sites Reservoir appeared to be well above the minimum water level for most years most of the time. Therefore, the period when the energy would not be recoverable is expected to be small.

day, despite higher energy losses resulting from the higher flows (such as, during the month of August, when energy prices vary from a maximum of $93.93 per megawatt-hour [MWh] to a minimum of $7.86 per MWh). For example, providing 1,000 cfs for 2 hours is better than providing 500 cfs for 4 hours (or lower flows for longer periods) because the average price for 2 hours multiplied by the amount of energy generated exceeds the average price for 4 hours multiplied by the amount of energy generated. During the detailed design phase, operations may be adjusted somewhat, but the primary operating premise generally will be to operate at maximum flow capacity.

For TRR operations, the maximum generation at the maximum 1,000 cfs flow capacity and maximum net head will be about 27.6 MW. The design head will be selected to provide about 1,000 cfs of flow over a large range of heads. Therefore, the design capacity for each unit is likely to be 10 to 12 MW at the rated design head.

At Funks, because the maximum capacity for a conduit exemption is 40 MW, the two turbines will have a maximum total design capacity no greater than 40 MW. The maximum output of either turbine will be about 21.4 MW (that is, 1,000 cfs at a head of 278 feet). (Note that these units can produce more than the unit design capacity at maximum head and maximum flow.) Therefore, the total capacity for the 4 turbines could vary between 64 and 58.5 MW. For the 58.5 MW option, energy could be recaptured over the entire head range, but when release flows exceed 1,000 cfs at Funks the energy associated with the excess release might not be recoverable.

The suppliers should provide updated design drawings in July 2021. Previously provided dimensions for the initial sizing of turbines should be reasonably close to the final design dimensions for the turbines and generators.

Available literature for turbines, generators, and controls suggests that costs for the electromechanical components can vary significantly. Price data provided by the suppliers included only costs for specific components. At this stage of design, a wide price band with an upper limit cost of $2,000 per kilowatt was established for the turbines, generators, controls, civil works costs for the turbine/generator installation and other related costs. The resulting upper limit capital cost would be $128 million. Based on Jacobs' experience, the costs could be as low as $60 million (that is, $1,000 per kilowatt). For the economic analysis, the higher cost was used, so as to be conservative.

Suppliers generally agreed that a 2-year schedule for manufacture and delivery of the turbines and generators was reasonable. The procurement schedule will be refined as the design proceeds.

3.0 Methodology

In 2020 and the first quarter of 2021, Jacobs conducted a detailed modeling assessment of pumping and water conveyance through the feeder canals into and out of Funks, TRR, and Sites Reservoir. Initial results of the modeling were a monthly array of inflows and outflows in the canals and reservoirs, and a monthly Sites Reservoir level. Jacobs then converted the monthly data into daily data for the 82 years modeled. This information was provided to H2O EcoPower to estimate the energy and revenue.

H2O EcoPower used and expanded the Jacobs spreadsheet. In addition to the daily flow releases to Funks and TRR, and the end of day Sites Reservoir elevations, columns were added for turbine efficiencies, Funks reservoir levels, TRR reservoirs level, net heads, the average daily Sites Reservoir level, power and energy, power at full flow capacity, hours of operation at full flow capacity, average price for the daily hours of operation, and revenue. Turbine efficiency was assumed at 90 percent.[8] Although not used for the initial energy and revenue calculations or exceedance values, Table 2 provides Jacobs' estimates for efficiency at Funks and TRR PGPs at different heads. For this analysis, because the Funks turbines have not been

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[8] Modern turbines have efficiencies greater than 90 percent at best gate and design head, but efficiencies will vary with head. Based on available design information, preliminary turbine sizing was undertaken to estimate energy and capacity and to develop turbine/generator cost estimates. Turbine sizes may be modified in consultation with turbine suppliers based on the results in this TM.

optimized and the second turbine might have a lower design head, estimating an approximate upper limit for energy generation was determined to be useful; this estimate also enables turbine alternatives to be evaluated against this maximum. At TRR, the turbines can cover the entire head range. However, because of the lower efficiency between heads of 116 and 188 feet, it may be advantageous to use a lower design head for the second turbine, if the flow releases during the lower operating heads justify the change. Also, the capacity values for which Funks and TRR power generation might qualify will also influence the turbine selection.

TABLE 2. TURBINE EFFICIENCY VERSUS NET HEAD AT FUNKS AND TRR PGPs

Funks Head (feet)	Efficiency	TRR Head (feet)	Efficiency
84	47%	116	47%
94.5	61%	130.5	61%
105	75%	145	74%
115.5	80%	159.5	80%
126	86%	174	85%
136.5	88%	188.5	87%
147	90%	203	89%
157.5	91%	217.5	90%
168	92%	232	91%
178.5	92%	246.5	91%
189	93%	261	92%
199.5	92%	275.5	91%
210	91%	290	90%
220.5	89%	304.5	89%
231	88%	319	87%
246.75	87%	340.75	86%
262.5	86%	362.5	85%

The net heads at Funks and TRR were calculated by subtracting: (1) the average daily water level at Funks and TRR from the Sites water level; and (2) the energy losses at maximum flow. Funks Reservoir elevation and head losses were assumed to be 202 feet and 18.1 feet, respectively, and at TRR the elevation and head losses were assumed to be 121.5 feet and 14.1 feet.

Several project operational strategies were considered. Often, flow releases are below the operating limits of the turbines. One operational strategy is to operate the turbines at the minimum operational flow level, when that level is greater than the flow release, and at the flow release level, when the flow release is greater than the minimal turbine operating flow level. Under this strategy, when the daily flow release (in cfs) is less than the minimum turbine flow, the hours of operation would be less than 24 hours. Accordingly, operations would occur over the higher-value energy hours. This strategy would minimize the head losses between Sites and Funks or TRR, and require a minimal storage amount in Funks and TRR reservoirs.

A second strategy is to operate at the full hydraulic capacity of the turbines during the highest-value hours. Because average hourly energy values vary significantly over the course of a day, more revenue is likely to be derived from this approach, despite the higher energy losses associated with the higher flows. This approach would require the most storge in both Funks and TRR. A third approach is to consider incremental energy values and associated energy losses at lesser generation flows in the 24-hour period, and then maximize the total revenue. If the net revenue is greater for the successive hour (that is, less average flow and less energy loss, but lower average energy rates), then the following hour would be included for scheduled generation. The next hour would then be included, and so on, until the net revenue is maximized. It is likely that this will be the strategy contemplated for real time operations. However, through simple inspection of the hourly changes in revenue, it appears that operating at maximum flows provides close to the maximum revenue.

For this analysis, both the Funks and TRR turbines were assumed to operate at their maximum hydraulic capacities during flow releases, to maximize energy and capacity revenues. This operational strategy maximizes daily revenue because the energy price differential during the peak demand hours is much greater than at other times of the day, despite higher energy losses resulting from the higher flows. For example, providing 1,000 cfs for 2 hours is better than 500 cfs for 4 hours (or lower flows for longer periods) because the average price for 2 hours multiplied by the amount of energy generated exceeds the average price for 4 hours multiplied by the amount of energy generated.

Power and energy calculations were based on daily flows, net heads, and efficiency. The hours of operation were estimated by taking the daily flow and prorating it to the maximum release flow, then multiplying by 24 hours. For example, a Funks flow of 500 cfs would equate to 6 hours of operation at full capacity.

ZGlobal provided projected 2030 energy prices for each hour of the day, for each month. These prices were averaged for each successional hour to provide average prices for hours of operation from 1 to 24 hours. The average price of energy for the hours of generation was determined. For fractional hours of generation, the average price determined by the lesser hours of operation. For example, under 2.4 hours of operation, the average price was for 2 hours of operation. This resulted in a slight overestimation in revenue for that increment of an hour. Revenue was estimated by multiplying the power at maximum flow (MW) by the number of hours of generation (hours), by the average price for those hours.

The next step was to partition the 82 years of data for each month of the year (for example, 2,642 data rows for a 31-day month). This enabled the data to be sorted by parameter (such as, flow, head, power, hours of generation, energy, and revenue) and exceedance curves to be developed to better understand the sequence, timing, and value of the energy, as well as to use for refining the turbine sizes. Note that the exceedances are not coincidental. Flow and hours of operation are directly correlated, but head and flow have little correlation. The average price of energy is inversely proportional to number of hours of operation. This inverse proportion is logical because as the number of hours of operation are increased, the generation spans more lower priced hours. It is also worth noting that head and flow do not correlate well. Flow releases can be required at virtually any head. Therefore, being able to maintain high flows at lower heads may be important.

4.0 Results

Table 3 summarizes the monthly and annual energy and revenue for the 82-year hydrological sequence. On average, the project generates about 49,200 MWh of release energy annually and an annual revenue of about $2,525,000 (2020 dollars) based on the 2030 price forecast. If a 40 MW capacity is assumed at Funks and 24 MW at TRR, the annual capacity factor would be less than 10 percent. By itself, this revenue would not be enough to justify installing the turbines. To justify installing turbines, capacity payments would also need to be included. ZGlobal has investigated the capacity value of the project, considering the potential power generation during critical times and the associated availability of providing this power when it is needed. ZGlobal's TM, *Resource Adequacy (RA) Valuation for Sites*, dated May 11, 2021, indicates that the Sites capacity value would vary between $1.98 and $2.28 million annually. This value suggests that annual energy and capacity values under current CAISO capacity rules would be about $4.5 million.

In a June 2, 2021, conference call with the National Hydropower Association, Mr. Milos Basanac of the CAISO summarized the California Public Utility Commission's recent methodology for qualifying capacity for hydropower. In June 2020, the Commission adopted two options for counting hydropower:

- **OPTION 1 –** Historical data. Using 10 years of historical bid data, the qualifying capacity amount is calculated monthly for the 50 and 10 percent exceedance values. The 50 percent value is weighed at 80 percent, and the 10 precent value is weighed at 20 percent. Using these weightings is the default, voluntary methodology. This approach is intended to provide flexibility to hydro owners and account for the various constraints of hydro facilities.
- **OPTION 2** – Nameplate capacity with penalties. Alternatively, dispatchable hydro generators can set their qualifying capacities to the nameplate capacity and must offer obligations in the day-ahead market. But in selecting this option, generators would be subject penalties for non-performance during shortage events.

TABLE 3 - MONTHLY AND ANNUAL ENERGY AND REVENUE

	Energy (MWh)			**Revenue ($)**		
	Funks	**TRR**	**Total**	**Funks**	**TRR**	**Total**
January	46.04114	35.73141	81.77255	3,800	3,071	6,872
February	64.19736	20.84716	85.04452	4,975	1,699	6,674
March	235.8581	13.78262	249.6408	17,568	1,138	18,706
April	1,821.974	200.3905	2,022.364	68,773	9,028	77,802
May	3,086.779	1,338.98	4,425.759	99,740	32,791	132,531
June	6,251.923	1,325.525	7,577.448	216,671	47,248	263,920
July	6,416.295	3,078.12	9,494.415	283,635	112,917	396,553
August	7,588.822	2,374.908	9,963.73	438,139	115,452	553,592
September	5,820.043	960.2757	6,780.318	375,685	76,053	451,739
October	3,558.847	1,514.645	5,073.493	253,221	114,680	367,902
November	1,515.23	1,031.521	2,546.751	98,117	67,538	165,656
December	606.1835	291.9818	898.1653	54,228	28,563	82,791
Totals	37,012.19	12,186.71	49,198.9	1,914,560	610,184	2,524,744

Mr. Basanac also noted that in May 2021, California Public Utility Commission deferred the June 2020 resource adequacy (RA) rule changes to the existing RA methodology to further evaluate the impact of the changes. As CAISO obtains additional information, the changed RA rules may be implemented.

Since the Sites Project is not yet constructed, 10 years of historical data do not exist. However, in response to a generic question from H2O EcoPower, Mr. Basanac responded that for a new project, a project developer could propose a methodology that CAISO would consider. H2O EcoPower believes that for the initial RA valuation, CAISO would accept Sites' 82 years of modeled data to determine RA values.

At this time, Sites has elected not to pursue the project as a pump storage project. However, based on the hours of operation for pumping and releases, there is a great opportunity for energy arbitrage. If a decision is made to pursue energy arbitrage, Sites could earn significant additional revenue. Although the net heads at Funks and TRR are lower than other proposed pump storage projects in California, Sites has a huge advantage over these other projects: only infrastructure for the Sites turbines and generators is needed, whereas the other proposed pump storge projects typically require construction of upper and lower reservoirs, transmission lines, and associated facilities, all of which are already included in the non-hydropower cost for the Sites Project. Because these projects appear to be economic, some type of pump storage operation that is consistent with water supply releases makes economic sense.

The energy arbitrage can easily be calculated based on the number of hours that are not needed for release flows or pumping, as occurred for the 1.8 MAF Sites Reservoir alternative. Once updated turbine sizes are available from the turbine suppliers, Jacobs recommend that Sites investigate the opportunity to maximize revenue from capacity and energy operations that are not part of the pumping or flow release schedules for water supply, and do not interfere with the base purpose of the project.[9] H2O EcoPower's analysis also does not include additional dynamic benefits that might be obtained by the project. These dynamic benefits can be incorporated in a future phase of the project.

Jacobs conducted a recent analysis that indicates the average annual pumping is 81,100 MWh. In comparing the average annual generation of 49,200 MW, the overall system efficiency is about 61 percent. Given there is significant net evaporation and friction losses, the round-trip efficiency appears to reasonable.

Release flows in June through October period would account for over 80 percent of the annual project revenue (see Attachment 1). Of this, 21.9 percent of the revenue is generated in August, 17.9 percent in September, 15.7 percent in July, 14.6 percent in October, and 10.5 percent in June. The remaining seven months account for slightly less than 20 percent of the annual revenue.

Attachment 1 presents the exceedances for each month, ranging from the maximum to minimum values and 10 percent increments for the following parameters for both Funks and TRR: (1) average daily release in cfs; (2) generation hours at the maximum generation level; (3) net head on the turbines after subtracting pipeline energy losses; (4) power generated; (5) daily energy in MWh; (6) the 2030 average daily energy price for the number of generation hours; and (7) the daily revenue. Note that these values were sorted from largest to smallest and are not coincidental, except for releases and generation hours. The energy price is inversely proportional to the number of hours of generation because with 1 hour or less of generation, the price is the peak hour price, whereas for 24 hours of operation, the price is the energy price for each hour averaged over the entire day, including off-peak energy prices. Of particular importance for capacity value calculations are the 50 percent and 10 percent exceedance levels for power generation.

For the month of August, the maximum release flow at Funks is 1,480 cfs, well below the 2,000 cfs capacity of the turbines. Therefore, the project would generate for about 17.8 hours on that day. Twenty percent of the time, the release flow is less than 296 cfs, or less than 3.55 hours of operation. This suggests that, even in the highest revenue month, about 20 percent of the time, an opportunity exists to pump water up to the Sites Reservoir for about 5 hours and then release that water during the higher value hours.

The Funks head ranges from 277.7 to 107 feet; however, 90 percent of the time, the head is greater than 135 feet. At 262 feet, the efficiency is less than 86 percent, so at the maximum head, efficiency would be less. At a head of 135 feet the efficiency would be 88 percent, but at 107 feet, it would only be 75 percent; at the design head of 189 feet, the efficiency would be 93 percent. Thus, for this analysis an average efficiency of 90 percent is a reasonable estimate until the suppliers provide the actual efficiencies.

The combination of head and flow is critical for the turbine design. Because there is little correlation between head and flow (that is, significant releases can occur at any head within the flow range and the project is likely to operate at or near maximum flow for the hours of operation), the head duration curve will be the primary parameter used by the manufacturers to size the turbines. In August, 50 percent of the time the head is greater than 229 feet. The initial design contemplated a design head of 210 feet, which may be a reasonable head because decreasing head corresponds to decreasing maximum flow through the turbines. It is important to obtain as much power as possible for the capacity payments; the key to doing so is selecting turbine sizes that maximize project revenues within the pumping and flow release constraints.

In assessing the turbine heads for Funks, two different turbine sizes appear to make sense, but considering how capacity values change if the second unit is sized for a lower head (and generation) is important. Because

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[9] This analysis can be undertaken in subsequent phases of the project.

flows and heads are not correlated, design of the second unit head may require an iterative process to firm the design head. It will depend on how existing and future capacity payments are derived (that is, will future RA values be based on 50 percent and 10 percent exceedance levels) and what energy revenue can be derived from the project based on only recovering the pumping energy or including some component of pumped storage operations.

In August, Funks power ranges from a maximum of about 42 MW to a minimum of 16 MW, but 50 percent of the time it is about 35 MW. Therefore, 80 percent of the August capacity payment will be based on 35 MW and 20 percent will be based on 42 MW (the 10 percent exceedance value).

The August energy prices vary from $46 to a maximum of $91 per MWh. The $46 price is the average price over the maximum of 17.8 hours of operation. This range shows the large disparity in energy prices over a day. The average for the top 5 hours in August is $69.51, while the average price for the lowest off-peak hours is $10.14. To pump water into Sites Reservoir for 5 hours would require about 50.5 MW at the median head of 229 feet, and pumping rate of 2,000 cfs. The equivalent generation would be 34.5 MW, for an overall system efficiency of 68 percent. However, pumping cost would only be $2,535, and generation revenue would be $11,990, for a daily net revenue of about $9,455 for those days when there are no flow releases scheduled. Because this happens on average about 6 days per month in August, revenue for those 5 hours would be about $57,000. Given the price differentials in hourly energy, pumping and releasing for more than 5 hours per day would be most cost effective. For example, in looking at the average price for the highest 10 hours of generation, the average price would be $55.51, whereas for the lowest-priced, off-peak hours, the average price would be $18.63. It continues to make sense if flow releases are less than 8 hours to pump and release for those extra hours. For example, if no releases are scheduled (as occurs for 6 days per month on average), the cost of pumping for 8 hours would be $6,060 and the revenue would be $16,648 per day, for a total net revenue ($10,588 x 6) of $63,630. More days would occur when less than 8 hours of flow are released.

In Attachment 1, the last column for Funks shows that the daily release energy revenue varies from $0 to a maximum of $31,019 , with a median of $15,059 per day. For those days with 0 leases, pump storage operations could yield additional daily revenue of over $10,000.

At Funks Reservoir, flow releases vary from 0 to a maximum of 972 cfs (that is, close to the hydraulic maximum of 1,000 cfs). Importantly, over 40 percent of the time, there are no flow releases, making pump storage more valuable for TRR in August. The head varies from 362 feet down to 192 feet. Corresponding efficiencies are 85 percent and 87 percent, with a maximum efficiency of 92 percent at a head of 261 feet. Power varies from 14.7 MW at the lowest head to 27.6 MW at the high heads. Because there are more hours of operation, the minimum average daily price for the energy is $39, or less than at Funks. Similarly, there is less daily revenue at TRR because the flow releases are less than at Funks.

The months of July, July, September, and October show similar patterns as August, except for the following. The maximum and minimum releases are similar, but the percent of time in which there are no releases is greater in these months. For example in June, there is little or no flow for about 40 percent of the days, making pump storage operations more valuable. The head and power generation variations exhibit little differences between the months. However, energy prices for the months vary significantly, along with large variances in hourly energy values. For example, the energy price in June varies from a maximum of $56.40 per MWh during the peak hour to almost 0 during the lowest off-peak time. Maximum prices increase through September, when they reach their maximum of $113 per MWh before falling in October.

5.0 Comparing this TM to August 2020 Analysis

In August, H2O EcoPower analyzed the energy and revenue using 2030 prices as forecast at that time for the years 1930, 1993, and 1971. These years were selected as dry, average, and wet years. The average release during these three years was the equivalent of about 764 cfs per day based on assumptions made at the time. Annual energy varied from a low of 33,723 MWh to 191,403 MWh. The current modeling effort resulted in an average daily release flow of 320 cfs from Sites Reservoir, with an annual generation of 49,200 MWh for all 82 years simulated. ZGlobal updated the 2030 energy price forecasts, which were used in the current analysis. Therefore, the annual value of energy is significantly less than in the previous analysis, which accounted for only three years. Also, some of the assumptions of pumping rates were optimistic when compared to the current modeling effort conducted by Jacobs. The driver in the revenue analysis is the total average annual release. In essence, this is the pumping volume less the net evaporation.

6.0 Permitting

Through informal communications with Federal Energy Regulatory Commission staff, the SPA was advised that the Sites Project would qualify for 40 MW conduit exemptions at both Funks and TRR because they operate independently and are separated by more than 1 mile. Federal Energy Regulatory Commission staff also stated the Sites Project would be jurisdictional, most likely because of interstate commerce and possibly because of the project's dependence on Sacramento River (that is, a navigable water way) flow for its existence. Because the Sites Project is on off-stream project, the conduit exemption process is straightforward and can be completed in a matter of months. The application itself can be prepared in a matter of days.

7.0 Recommendations

Based on energy recovery alone, neither the Funks nor TRR generation would justify recovering the pumped energy because the capacity factor of less than 10 percent indicates that energy recovery would not be economic. This differs from the analysis with the larger 1.8 MAF Sites Reservoir, where heads were higher and the flow releases much greater. Despite this, the hydropower portion of the project seems to be cost effective when capacity values are included, especially if pumped storage operations are included.

Jacobs has remained in contact with turbine suppliers. The suppliers are in the process of updating the turbine designs based on the exceedance values (particularly head) resulting from the current energy modeling. As part of the turbine selection process, the capacity values also will be integrated into the design.

Jacobs also recommends that the SPA strongly consider including energy arbitrage and associated capacity values in the analysis, once the updated turbine characteristics become available. It will take some effort to include a pump storage component into the spreadsheet, but that process is straightforward. The spreadsheet has been set up to include specific turbine characteristics in the energy model. Once these efficiencies are received from the suppliers, the energy model can be re-run and the economics re-evaluated.

As part of the current communications with the suppliers, updated cost information is also being sought. The updated costs should be factored into the project economics.

Storage at Funks and TRR is important for both pumping and flow releases to minimize pumping costs and maximize revenue from generation. Before final decisions are made on sizing of Funks and TRR, the effect of storage changes on pumping costs and generation revenue, if any, should be determined.

Energy prices beyond 2030 have not been forecast because of uncertainty. If batteries and electric cars become a big part of the California electric system, that could increase the value of the off-peak energy, reducing the spread in hourly costs for each day. However, if solar energy continues to grow as it has, this could exacerbate the spread in hourly energy prices making it more valuable to pump as much as possible in off-peak hours and generate during the peak hours. Jacobs recommends that a sensitivity analysis be conducted to assist SPA in their decision-making with respect to energy recovery.

Sites should continue to monitor and work with CALISO to ensure that its interests are integrated in any future decision on how capacity is valued. Further, the energy generation and capacity values from the flow releases and possibly pump storage operations should be factored into discussions, with coordinated operations with solar projects and utilities like PG&E.

Once SPA completes its National Environmental Policy Act analysis, SPA should submit the exemption application to the Federal Energy Regulatory Commission.

Attachment 1

Funks and TRR Release Exceedance Curves

Attachment 1 - FUNKS AND TRR RELEASE EXCEEDENCE CURVES

Month JANUARY Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0003934	207.3199	2.487838	277.5727	42.34161	67.09638	90.57871	5807.695	97.79	2.34696	362.0727	27.61572	48.43093	90.57871	4164.996
0.0503541	0.000216	2.59E-06	277.2945	42.29917	0.00011	90.57871	0.009919	7.45	0.1788	361.7945	27.5945	4.456905	90.57871	403.7007
0.1003147	0	0	275.6059	42.04158	0	90.57871	0	0	0	360.1059	27.4657	0	90.57871	0
0.200236	0	0	267.7954	40.85015	0	90.57871	0	0	0	352.2954	26.86999	0	90.57871	0
0.3001574	0	0	259.4848	39.58242	0	90.57871	0	0	0	343.9848	26.23613	0	90.57871	0
0.4000787	0	0	241.7468	36.87662	0	90.57871	0	0	0	326.2468	24.88323	0	90.57871	0
0.5	0	0	219.6478	33.5056	0	90.57871	0	0	0	304.1478	23.19771	0	90.57871	0
0.6003147	0	0	209.972	32.02962	0	90.57871	0	0	0	294.472	22.45973	0	90.57871	0
0.700236	0	0	169.0065	25.78065	0	90.57871	0	0	0	253.5065	19.33524	0	90.57871	0
0.8001574	0	0	151.3531	23.08776	0	90.57871	0	0	0	235.8531	17.9888	0	90.57871	0
0.9000787	0	0	132.294	20.18044	0	90.57871	0	0	0	216.794	16.53513	0	90.57871	0
1	0	0	110.3102	16.82699	0	79.06629	0	0	0	194.8102	14.85841	0	79.06629	0

FEBRUARY Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0004318	268.6403	3.223684	277.6329	42.35079	128.0216	81.50857	9413.136	62.18	1.49232	362.1329	27.62031	39.24999	81.50857	3199.211
0.0500864	10.23975	0.122877	277.5312	42.33527	3.586815	81.50857	292.3561	0	0	362.0312	27.61255	0	81.50857	0
0.1001727	0.310547	0.003727	277.3554	42.30846	0.142342	81.50857	11.6021	0	0	361.8554	27.59914	0	81.50857	0
0.2003454	0	0	275.1298	41.96895	0	81.50857	0	0	0	359.6298	27.42939	0	81.50857	0
0.3000864	0	0	265.3157	40.47189	0	81.50857	0	0	0	349.8157	26.68086	0	81.50857	0
0.4002591	0	0	244.5131	37.2986	0	81.50857	0	0	0	329.0131	25.09422	0	81.50857	0
0.5	0	0	226.2732	34.51625	0	81.50857	0	0	0	310.7732	23.70304	0	81.50857	0
0.6001727	0	0	215.7242	32.90708	0	81.50857	0	0	0	300.2242	22.89846	0	81.50857	0
0.7003454	0	0	180.5298	27.53844	0	81.50857	0	0	0	265.0298	20.21413	0	81.50857	0
0.8000864	0	0	165.5639	25.25551	0	81.50857	0	0	0	250.0639	19.07267	0	81.50857	0
0.9002591	0	0	141.3717	21.56517	0	81.50857	0	0	0	225.8717	17.2275	0	81.50857	0
1	0	0	120.1571	18.32905	0	73.52774	0	0	0	204.6571	15.60944	0	81.50857	0

MARCH Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0003934	623.2001	7.478401	277.6828	42.35839	250.6445	82.91097	13941.37	85.6	2.0544	362.1828	27.62411	33.32919	82.91097	2392.16
0.0503541	152.2395	1.826874	277.5563	42.3391	55.10683	82.91097	4490.794	3.36	0.08064	362.0563	27.61446	1.731696	82.91097	143.5766
0.1003147	60.63959	0.727675	277.4898	42.32895	19.83454	82.91097	1644.501	0	0	361.9898	27.60939	0	82.91097	0
0.200236	6.52002	0.07824	277.2954	42.2993	2.626488	82.91097	217.7646	0	0	361.7954	27.59457	0	82.91097	0
0.3001574	0	0	272.0726	41.5026	0	82.91097	0	0	0	356.5726	27.19622	0	82.91097	0
0.4000787	0	0	254.4694	38.81737	0	82.91097	0	0	0	338.9694	25.8536	0	82.91097	0
0.5	0	0	231.8129	35.36129	0	82.91097	0	0	0	316.3129	24.12556	0	82.91097	0
0.6003147	0	0	219.8563	33.53741	0	82.91097	0	0	0	304.3563	23.21362	0	82.91097	0
0.700236	0	0	198.3708	30.25995	0	82.91097	0	0	0	282.8708	21.57489	0	82.91097	0
0.8001574	0	0	180.1509	27.48064	0	82.91097	0	0	0	264.6509	20.18524	0	82.91097	0
0.9000787	0	0	151.9097	23.17267	0	82.91097	0	0	0	236.4097	18.03125	0	82.91097	0
1	0	0	128.2058	19.55682	0	55.62207	0	0	0	212.7058	16.22332	0	71.77371	0

APRIL Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price ($/MWh)	TRR Revenue ($)
0.0004065	1540.96	18.49152	277.7211	42.36423	708.4929	55.14533	17510.59	516.02	12.38448	362.2211	27.62703	273.6743	55.14533	9437.521
0.05	693.9204	8.327045	277.5467	42.33763	292.0416	55.14533	10386.74	75.95	1.8228	362.0467	27.61373	33.30895	55.14533	1625.166
0.1	414.3398	4.972077	277.4347	42.32054	147.5832	55.14533	6320.434	38.44	0.92256	361.9347	27.60519	17.0247	55.14533	938.8325
0.2	225.75	2.709	277.2584	42.29366	83.5749	55.14533	3990.788	0	0	361.7584	27.59175	0	55.14533	0
0.3	131.9102	1.582922	275.2038	41.98024	50.61791	55.14533	2666.123	0	0	359.7038	27.43504	0	55.14533	0
0.4	74.49023	0.893883	260.2032	39.69201	32.50437	55.14533	1792.464	0	0	344.7032	26.29092	0	55.14533	0
0.5	26.11963	0.313436	233.5088	35.61999	10.325	55.14533	569.3757	0	0	318.0088	24.25491	0	55.14533	0
0.6	0.97998	0.01176	220.5522	33.64356	0.428098	55.14533	23.60761	0	0	305.0522	23.2667	0	55.14533	0
0.7	0	0	209.9315	32.02345	0	55.14533	0	0	0	294.4315	22.45664	0	55.14533	0
0.8	0	0	190.8011	29.10526	0	48.79067	0	0	0	275.3011	20.99754	0	55.14533	0
0.9	0	0	164.6233	25.11202	0	42.5515	0	0	0	249.1233	19.00093	0	55.14533	0
1	0	0	123.1539	18.78619	0	22.69637	0	0	0	207.6539	15.83801	0	29.87081	0

MAY Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0003934	1566.63	18.79956	277.6995	42.36093	770.1294	51.54581	16584.45	1049.26	25.18224	362.1995	27.62538	651.8318	51.54581	11109.01
0.0503541	1225.901	14.71081	277.4524	42.32325	435.964	51.54581	11432.83	669.23	16.06152	361.9524	27.60654	380.764	51.54581	8581.481
0.1003147	692.66	8.31192	277.2613	42.2941	305.8224	51.54581	9372.551	276.05	6.6252	361.7613	27.59196	162.4608	51.54581	5879.389
0.200236	504.3297	6.051957	276.771	42.21931	178.7871	51.54581	6423.81	19.6	0.4704	361.271	27.55457	10.8835	51.54581	560.9987
0.3001574	313.0401	3.756481	273.0866	41.65728	107.4656	51.54581	4576.632	1.55	0.0372	357.5866	27.27355	0.868514	51.54581	44.76823
0.4000787	165.2499	1.982999	259.6587	39.60896	62.28347	51.54581	3114.727	0	0	344.1587	26.24939	0	51.54581	0
0.5	71.34961	0.856195	233.9571	35.68838	25.04863	51.54581	1291.152	0	0	318.4571	24.2891	0	51.54581	0
0.6003147	3.870117	0.046441	223.0208	34.02012	1.956668	51.54581	100.858	0	0	307.5208	23.45498	0	51.54581	0
0.700236	0	0	212.4553	32.40843	0	43.08882	0	0	0	296.9553	22.64913	0	51.54581	0
0.8001574	0	0	190.7497	29.09741	0	34.84903	0	0	0	275.2497	20.99362	0	51.54581	0
0.9000787	0	0	161.2286	24.5942	0	31.58347	0	0	0	245.7286	18.74201	0	34.84903	0
1	0	0	112.1204	17.10311	0	21.53462	0	0	0	196.6204	14.99647	0	15.922	0

JUNE Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price ($/MWh)	TRR Revenue ($)
0.0004065	1751.67	21.02004	277.6533	42.35389	829.4952	56.39933	23218.07	1032.51	24.78024	362.1533	27.62186	650.3701	56.39933	14826.95
0.05	1524.52	18.29424	277.3291	42.30444	715.8623	56.39933	21561.78	444.32	10.66368	361.8291	27.59714	254.542	56.39933	9586.765
0.1	1365.8	16.3896	277.1202	42.27257	616.7107	56.39933	19838.53	202.25	4.854	361.6202	27.5812	119.7144	56.39933	5509.175
0.2	1209.3	14.5116	275.9035	42.08697	444.777	56.39933	14875.65	76.54	1.83696	360.4035	27.4884	46.4504	56.39933	2619.772
0.3	836.7103	10.04052	268.6403	40.97903	334.1559	56.39933	12458.6	10.42	0.25008	353.1403	26.93443	6.310486	56.39933	355.9072
0.4	475.5098	5.706118	257.0669	39.2136	171.0638	56.39933	8102.578	7.81	0.18744	341.5669	26.05171	4.060235	56.39933	228.9946
0.5	223.1002	2.677202	240.8456	36.73915	71.86348	54.03067	3829.706	4.01	0.09624	325.3456	24.81449	1.997303	56.39933	112.6466
0.6	46.5498	0.558598	220.5565	33.64422	22.05191	45.70647	1243.713	0	0	305.0565	23.26702	0	56.39933	0
0.7	32.3501	0.388201	207.1583	31.60041	14.17288	36.9833	799.3409	0	0	291.6583	22.24512	0	56.39933	0
0.8	0	0	185.1448	28.24242	0	33.3811	0	0	0	269.6448	20.56613	0	56.39933	0
0.9	0	0	157.5394	24.03143	0	32.06075	0	0	0	242.0394	18.46063	0	48.97642	0
1	0	0	110.2271	16.8143	0	25.56017	0	0	0	194.7271	14.85206	0	22.49257	0

JULY Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0003934	1840.01	22.08012	277.6123	42.34764	749.6323	76.21645	27285.95	1005.07	24.12168	362.1123	27.61874	609.7725	76.21645	19057.25
0.0503541	1488.96	17.86752	277.2038	42.28533	639.8336	76.21645	24556.66	972.07	23.32968	361.7038	27.58758	513.5685	76.21645	16393.14
0.1003147	1398.12	16.77744	276.6752	42.2047	530.8805	76.21645	19885.48	935.03	22.44072	361.1752	27.54726	464.0114	76.21645	15165.97
0.200236	1152.66	13.83192	275.0315	41.95396	394.7784	76.21645	16631.71	275.17	6.60408	359.5315	27.42189	158.488	76.21645	8448.016
0.3001574	988.0102	11.85612	266.2559	40.61531	313.3027	76.21645	13972.51	21.13	0.50712	350.7559	26.75257	12.38018	76.21645	943.5737
0.4000787	681.7404	8.180885	251.0462	38.29518	240.0477	76.21645	12003.82	14.88	0.35712	335.5462	25.59251	7.97464	76.21645	607.7988
0.5	395.7998	4.749598	237.4969	36.22834	153.6435	61.78081	8760.252	9.85	0.2364	321.9969	24.55908	4.903519	76.21645	373.7288
0.6003147	88.3501	1.060201	214.4474	32.71232	42.64686	48.34351	3250.392	0	0	298.9474	22.80108	0	76.21645	0
0.700236	43.44971	0.521396	197.5047	30.12783	20.91768	43.66308	1594.272	0	0	282.0047	21.50883	0	76.21645	0
0.8001574	39.6499	0.475799	174.781	26.66151	17.22401	41.55573	1312.753	0	0	259.281	19.77567	0	53.04887	0
0.9000787	0	0	147.0092	22.42513	0	38.84903	0	0	0	231.5092	17.65748	0	32.28855	0
1	0	0	109.0967	16.64187	0	32.28855	0	0	0	193.5967	14.76585	0	30.24983	0

AUGUST Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price ($/MWh)	TRR Revenue ($)
0.0003934	1480.47	17.76564	277.6565	42.35438	672.7228	90.93194	31019.82	921.53	22.11672	362.1565	27.62211	549.626	90.93194	22208.72
0.0503541	1391.93	16.70316	275.7789	42.06797	600.5009	90.93194	28217.17	830.01	19.92024	360.2789	27.4789	402.6172	90.93194	17752.95
0.1003147	1196.82	14.36184	274.8675	41.92894	488.6169	90.93194	25011.82	753.77	18.09048	359.3675	27.40939	362.1065	90.93194	16059.64
0.200236	1097.76	13.17312	273.1917	41.6733	363.1105	79.99344	18704.27	335.42	8.05008	357.6917	27.28157	144.4016	90.93194	8985.118
0.3001574	1037.34	12.44808	263.0217	40.12195	299.2926	69.5109	17077.13	22.02	0.52848	347.5217	26.50589	13.03134	90.93194	1184.965
0.4000787	565.33	6.78396	244.1028	37.23602	256.2978	69.5109	16269.57	19.31	0.46344	328.6028	25.06292	10.51792	90.93194	956.4152
0.5	498.4395	5.981273	229.6942	35.0381	230.7299	69.5109	15058.89	15.96	0.38304	314.1942	23.96397	8.207167	90.93194	746.2935
0.6003147	462.0103	5.544123	212.648	32.43783	207.4031	66.19763	13999.54	0.14	0.00336	297.148	22.66383	0.079215	90.93194	7.203204
0.700236	417.2505	5.007006	185.0688	28.23083	171.1735	51.9021	12403.35	0	0	269.5688	20.56033	0	90.93194	0
0.8001574	296.0401	3.552481	159.7595	24.37009	106.404	50.48933	8046.906	0	0	244.2595	18.62996	0	60.32794	0
0.9000787	35.10986	0.421318	135.109	20.60984	8.237355	49.2406	749.0386	0	0	219.609	16.74984	0	44.76821	0
1	0	0	107.5962	16.41299	0	46.11085	0	0	0	192.0962	14.65141	0	39.00633	0

SEPTEMBER Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price ($/MWh)	TRR Revenue ($)
0.0004065	1363.41	16.36092	277.3805	42.31228	597.1678	111.3137	29586.92	600.67	14.41608	361.8805	27.60105	345.7701	111.3137	17864.95
0.05	1227.625	14.7315	273.3184	41.69263	489.5898	111.3137	25893.56	277.37	6.65688	357.8184	27.29123	158.7974	111.3137	10363.73
0.1	1127.48	13.52976	272.3741	41.54859	398.2621	111.3137	21257.5	239.3	5.7432	356.8741	27.21921	122.3767	111.3137	9164.578
0.2	950.5005	11.40601	270.6484	41.28535	294.4466	111.3137	17953.42	113.44	2.72256	355.1484	27.08759	56.97612	111.3137	4870.408
0.3	559.5601	6.714721	259.6997	39.61521	247.2521	83.11856	17037.36	36.69	0.88056	344.1997	26.25252	19.16369	111.3137	2133.181
0.4	482.3604	5.788324	239.7348	36.56971	229.0743	77.12008	16113.54	28.82	0.69168	324.2348	24.72977	15.57471	111.3137	1733.678
0.5	457.0572	5.484686	222.617	33.95852	209.9126	73.03033	14846.54	20.91	0.50184	307.117	23.42418	11.5023	111.3137	1280.363
0.6	403.1899	4.838279	208.9243	31.86981	162.2869	73.03033	11645.03	0	0	293.4243	22.37982	0	111.3137	0
0.7	257.8106	3.093727	173.5663	26.47622	89.53646	69.59211	8126.903	0	0	258.0663	19.68303	0	111.3137	0
0.8	75.49988	0.905999	148.056	22.58481	25.9185	56.3163	2885.083	0	0	232.556	17.73732	0	92.14017	0
0.9	20.12988	0.241559	130.0593	19.83956	6.737413	53.01351	749.9661	0	0	214.5593	16.3647	0	73.03033	0
1	0	0	106.3829	16.2279	0	49.00894	0	0	0	190.8829	14.55886	0	51.66712	0

OCTOBER Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0003934	1151.15	13.8138	277.4096	42.31672	481.5081	96.44742	27280.59	358.3	8.5992	361.9096	27.60328	221.2987	96.44742	14666.13
0.0503541	1016.269	12.19523	272.157	41.51548	383.9336	96.44742	23133.23	304.04	7.29696	356.657	27.20265	173.4282	96.44742	12040.56
0.1003147	754.9597	9.059517	270.4948	41.26191	274.9731	96.44742	18193.36	296.15	7.1076	354.9948	27.07587	162.9415	96.44742	11390.93
0.200236	467.4404	5.609285	268.4208	40.94555	225.0705	96.44742	16593.95	238.81	5.73144	352.9208	26.91769	114.0032	96.44742	8654.858
0.3001574	442.2998	5.307598	256.6048	39.14311	210.5974	96.44742	15741.73	138.66	3.32784	341.1048	26.01647	64.903	96.44742	5365.233
0.4000787	342.0801	4.104961	237.3802	36.21054	149.2876	96.44742	12339.46	65.52	1.57248	321.8802	24.55018	27.89776	96.44742	2690.667
0.5	166.7905	2.001486	217.8283	33.22805	48.81739	91.34435	4583.356	39.41	0.94584	302.3283	23.05894	19.97308	96.44742	1926.352
0.6003147	47.0903	0.565084	209.2111	31.91356	13.83527	79.18524	1334.376	0	0	293.7111	22.40169	0	96.44742	0
0.700236	6.140194	0.073682	162.53	24.79271	2.416432	74.88716	233.0587	0	0	247.03	18.84127	0	85.50591	0
0.8001574	0	0	143.2245	21.8478	0	74.88716	0	0	0	227.7245	17.36882	0	74.88716	0
0.9000787	0	0	127.9804	19.52243	0	63.73875	0	0	0	212.4804	16.20613	0	69.42677	0
1	0	0	106.099	16.18459	0	56.65655	0	0	0	190.599	14.53721	0	66.27298	0

NOVEMBER Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0004065	1011.25	12.135	277.6508	42.35351	400.8727	82.21467	21457.14	388.42	9.32208	362.1508	27.62167	239.1269	82.21467	13661.33
0.05	972.1595	11.66591	275.359	42.00392	263.9939	82.21467	14135.59	332.69	7.98456	359.859	27.44688	184.1324	82.21467	11190.68
0.1	405.1996	4.862396	271.0205	41.34211	160.0553	82.21467	11817.56	293.74	7.04976	355.5205	27.11597	162.8531	82.21467	9975.336
0.2	283.8597	3.406316	267.3736	40.78581	107.3249	82.21467	7878.682	102.83	2.46792	351.8736	26.83782	55.88291	82.21467	4430.965
0.3	97.80048	1.173606	254.3662	38.80162	37.19315	82.21467	3057.823	30.72	0.73728	338.8662	25.84573	15.63311	82.21467	1285.271
0.4	4.590214	0.055083	235.3477	35.90049	1.475112	82.21467	121.2758	18.7	0.4488	319.8477	24.39516	7.487966	82.21467	615.6206
0.5	1.840515	0.022086	215.774	32.91468	0.743796	82.21467	61.15098	0	0	300.274	22.90226	0	82.21467	0
0.6	0.919922	0.011039	207.4296	31.6418	0.282353	82.21467	23.21352	0	0	291.9296	22.26582	0	82.21467	0
0.7	0	0	161.8844	24.69422	0	79.29017	0	0	0	246.3844	18.79203	0	82.21467	0
0.8	0	0	138.2592	21.09038	0	75.32789	0	0	0	222.7592	16.99011	0	79.29017	0
0.9	0	0	127.777	19.4914	0	53.52606	0	0	0	212.277	16.19062	0	61.46838	0
1	0	0	105.9681	16.16463	0	0	0	0	0	190.4681	14.52723	0	57.13004	0

DECEMBER Exceedence	Release Into Funk (cfs)	Funks Generatior (hours)	Funks Head (ft)	Funks Power (MW)	Funks Rel Energy (MWh)	Funks Op Period Avg Price ($/MWh)	Funks Revenue ($)	Release into TRR (cfs)	TRR Generatior (hours)	TRR Head (ft)	TRR Power (MW)	TRR Rel Energy (MWh)	TRR Op Period Avg Price (S/MWh)	TRR Revenue ($)
0.0003934	1000	12	277.5636	42.34022	505.208	101.2035	37288.18	293.55	7.0452	362.0636	27.61502	184.0474	101.2035	15664.95
0.0503541	284.23	3.41076	276.1445	42.12374	116.4832	101.2035	11591.95	128.58	3.08592	360.6445	27.50678	68.17017	101.2035	6784.031
0.1003147	137.6999	1.652399	274.0546	41.80494	53.09384	101.2035	5373.285	31.08	0.74592	358.5546	27.34739	18.60177	101.2035	1882.565
0.200236	1.459961	0.01752	267.0865	40.74201	0.512524	101.2035	51.86921	24.82	0.59568	351.5865	26.81592	13.87997	101.2035	1404.702
0.3001574	0.000137	1.65E-06	254.2232	38.77981	5.15E-05	101.2035	0.005217	4.44	0.10656	338.7232	25.83482	1.941164	101.2035	196.4527
0.4000787	0	0	237.7018	36.2596	0	101.2035	0	0	0	322.2018	24.57471	0	101.2035	0
0.5	0	0	215.5582	32.88176	0	101.2035	0	0	0	300.0582	22.8858	0	101.2035	0
0.6003147	0	0	207.3511	31.62983	0	101.2035	0	0	0	291.8511	22.25983	0	101.2035	0
0.700236	0	0	162.1672	24.73738	0	101.2035	0	0	0	246.6672	18.8136	0	101.2035	0
0.8001574	0	0	141.788	21.62868	0	101.2035	0	0	0	226.288	17.25926	0	101.2035	0
0.9000787	0	0	130.2775	19.87284	0	101.2035	0	0	0	214.7775	16.38133	0	101.2035	0
1	0	0	106.7353	16.28166	0	73.12145	0	0	0	191.2353	14.58574	0	85.11369	0

Appendix H
GCID Facility Improvements

GCID Facility Improvements Technical Memorandum (Draft)

To:	Henry Luu/HDR
CC:	
Date:	October 15, 2020
From:	Jeff Smith/Jacobs
Quality Review by:	Peter Rude/Jacobs
Authority Agent Review by:	Reviewer
Subject:	List of GCID Facility Improvements required for conveyance of water to TRR

1.0 Background

Sites Project Authority (Sites) adopted the recommended project (VP7) as provided in the “Sites Project Value Planning Alternatives Appraisal Report” dated April 2020 to reduce the program cost from approximately $5.2 billion to $3.0 billion. One of the conveyance components of VP7, uses the Glenn Colusa Irrigation District (GCID) main canal to convey water from the Sacramento River to the Terminal Regulating Reservoir (TRR). From the TRR water is pumped up into Sites Reservoir. VP7 assumes that the GCID main canal can convey a maximum of 1,800 cfs to the TRR during the winter with only a two-week maintenance shutdown which compares to the current six-week maintenance shutdown from about January 1 to February 15.

The GCID Main Canal is a 65-mile unlined earthen channel that delivers water from the Sacramento River to water users along its route, from its diversion point approximately 5 miles northwest of Hamilton City to southeast of the City of Williams. The canal has a capacity varying from 3,000 cfs at the upstream end to 300 cfs at the southern terminus. The Hamilton City Main Pump Station (3,000 cfs capacity) lifts water from the Sacramento River into the GCID Main Canal.

2.0 Purpose

Sites has asked the HC team to coordinate with GCID to understand upgrades required for the GCID Main Canal (Canal) infrastructure to allow a maximum of 1,800 cfs to flow from the Hamilton City Main Pump Station at Canal Mile Post (MP)1.40 to the current location of the TRR just upstream of the Funks Creek Siphon at MP 41.3. In addition, the Canal capacity of 1,800 cfs to the TRR needs to be verified. Understanding these required upgrades and incorporating them into the feasibility level design is necessary to prepare the EIR/EIS document, as well as to provide the basis for a Level IV construction cost estimate.

3.0 Facility Upgrade List

GCID provided an initial list of facilities in late August 2020 and then was confirmed by a meeting on September 15, 2020 and a Field Trip with GCID staff on September 28, 2020. The following revised list of facilities is a result of the two September meetings. This list may change as both GCID and the HC team continue to coordinate during the feasibility level design that will include development of a hydraulic model of the canal to help determine the structure and canal capacities and also a condition assessment of older facilities slated for January/February 2021. Results of both of these tasks may change this current list of improvements.

- Headgates MP 1.73 – replace with a new structure just upstream of the existing structure. The existing headgate structure (capacity 3,000 cfs) will be left in place after removing the gates. The structure will not be demolished since it is connected to a County maintained bridge. No drawings are available for this structure. Drawings will be developed for the new structure by Jacobs for feasibility design and cost estimating purposes.

- Walker Creek Siphon MP 24.48 - may need to be replaced but will depend on results of hydraulic capacity model and condition assessment. Have record drawings from circa 1910 and 1974. Drawings will be developed for the new structure by Jacobs for feasibility design and cost estimating purposes.

- Willow Creek Siphon MP 24.68 – may need to be replaced but will depend on results of hydraulic capacity model and condition assessment. Have record drawings from circa 1910 and 1974. Drawings will be developed for the new structure by Jacobs for feasibility design and cost estimating purposes.

- Railroad Siphon MP 26.60 – may need to be replaced but will depend on results of hydraulic capacity model and condition assessment. Have record drawings from circa 1910. Drawings will be developed for the new structure by Jacobs for feasibility design and cost estimating purposes.

- Baker Creek Siphon MP 34.04 - Newer structure built in 1995/1996. Replacement is only needed if there are capacity concerns resulting from hydraulic model analysis. Have record drawings. Per measurement taken in 1996 the Siphon passed 2,000 cfs with less than 0.3 ft head differential. Therefore, Jacobs is not planning on developing new drawings for feasibility design nor cost estimating.

- Main Canal (Milepost 26 to 41.3)
    a. Earthwork – Based on GCID survey work, there are a number of low canal bank sections between Willows and the TRR that will require adding earthwork to obtain the minimum 2.5-foot freeboard requirement established by GCID. Below is a table that provides the locations, lengths and rough calculated earthwork quantities needed to obtain the minimum freeboard. Approximately 5,000 cubic yards of material are expected to be required to fill these low areas. A drawing of canal cross section and typical improvements will be developed by Jacobs for feasibility design and cost estimating purposes.

Milepost Marker		Freeboard (ft)		Fill Measurements (ft)			Volume	
Start	**End**	**Current**	**Required**	**Height**	**Length**	**Width**	**Cubic Feet**	**Cubic Yards**
26.44	26.46	1.55	2.5	0.95	129	19	2,328	86
29.89	29.97	1.70	2.5	0.80	409	30	9,816	363
30.69	30.98	2.00	2.5	0.50	1516	43	32,594	1,207
31.37	31.43	1.60	2.5	0.90	259	26	6,060	224
33.17	33.37	2.00	2.5	0.50	1033	29	14,978	554
34.22	34.36	2.00	2.5	0.50	762	26	9,906	366
34.42	34.55	1.60	2.5	0.90	662	23	13,703	507
34.46	34.54	1.30	2.5	1.20	429	23	11,840	438
34.55	34.57	1.60	2.5	0.90	74	24	1,598	59
34.57	34.67	1.60	2.5	0.90	501	18	8,116	300
34.66	34.79	1.00	2.5	1.50	640	24	23,040	853
							Total	**4,957**

- Road topping – Approximately 16.6 miles of left bank canal road between the Willow Creek Siphon and the Funks Siphon may potentially need 6-inches of aggregate base material added to make all weather road surface. Rough calculations show a need for about 27,000 cubic yards of aggregate base will be needed. Jacobs will include this road improvement in the feasibility design cost estimate.

Appendix I

Alternatives to the Terminal Regulating Reservoir

Alternatives to the Terminal Regulating Reservoir (TRR) DRAFT Technical Memorandum

DRAFT – PREDECISIONAL WORKING DOCUMENT – FOR DISCUSSION PURPOSES ONLY

To: Pete Rude, PE, Jacobs
Jeff Smith, PE, Jacobs
CC: Henry Luu, PE, HDR
Date: December 1, 2020
From: Brian Martinez, PhD, PE
Quality Review by: Derek Morley, PE
Authority Agent Review by: Reviewer
Subject: Alternatives to the Terminal Regulating Reservoir (TRR)

Executive Summary

The purpose of this technical memorandum is to (i) discuss implications of geotechnical exploration findings for the Terminal Regulating Reservoir - East (TRR-East); (ii) present preliminary reservoir locations and configurations that may be suitable alternatives to the TRR-East; and (iii) discuss initial evaluations of advantages and disadvantages of the alternative reservoir locations and configurations.

Five alternative locations and configurations have been identified, four of which are situated between the Glen Colusa Irrigation District (GCID) Main Canal and Tehama Colusa (TC) Canal, to the northwest of the TRR-East site. Three of these alternatives, shown in Figures 2 through 4, are referred to as the Between Canal Management (BCM) reservoirs or BCM-1, BCM-2, and BCM-3. Another alternative, referred to as TRR-West, is located in approximately the same area as BCM-1, but with a revised layout based on real-estate feedback. The last alternative is referred to as Stone Corral Creek (SCC) reservoir and is located along the western side of the GCID Canal approximately two miles southeast of Funks Reservoir (Figure 5). The results of initial engineering evaluation of these alternatives relative to TRR-East are discussed herein.

Initial engineering evaluation compared the BCMs, TRR-West, and SCC alternatives to the TRR-East with respect to real estate impacts, construction costs, optimization potential (i.e., potential to optimize the configuration), resilience to changes, environmental considerations, and DSOD jurisdiction. The findings are summarized in Table 1.

1.0 Background and Purpose

Sites Reservoir is a 1.5-million-acre-foot reservoir project undergoing feasibility evaluations led by the Sites Joint Powers Authority (Authority). The project will be designed to support California's water infrastructure and includes the main reservoir and conveyance features. Conveyance features will include two pumping/generating plants, two regulating reservoirs, and pipelines which hydraulically connect the new Sites Reservoir to the existing Funks reservoir, the existing TC Canal, the existing GCID Canal, and the new TRR-East or its alternative.

The TRR-East is currently planned to be located on the east side of the GCID Canal roughly due east of Funks Reservoir within a flatland area currently used for agriculture. Figure 1 provides a map showing the location of TRR-East relative to the GCID Canal, and the TC Canal. In 2019, geotechnical explorations were performed in two locations around the TRR-East, adding to historical borings from 1975, to inform the feasibility of design and construction of the TRR-East. No other subsurface exploration data relevant to the TRR-East is known to exist at this time.

The following sections of this memorandum are organized to: (a) provide interpretation of the recent and historic borings; (b) discuss the implications of those findings for TRR-East; (c) present preliminary reservoir locations and configurations that may be suitable alternatives to TRR-East; (d) discuss advantages and disadvantages of the alternative reservoir locations and configurations relative to TRR-East based on the criteria previously listed; and (e) summarize conclusions from these evaluations.

2.0 Summary of Geotechnical Data

The soils underlying the TRR-East are predominantly soft clay with thick layers of loose sand. This characterization is based on the four soil borings surrounding the facility. Attachment A provides the data relied upon for this evaluation, including draft locations and recorded logs of borings performed as part of (i) recently collected data by the United States Bureau of Reclamation (USBR) from 2019 feasibility-level explorations; and (ii) excerpt drawings from a historic plan set (1975) for structural improvement of the Funks Siphon and Check at the GCID Canal near TRR-East with plan and log of test borings for two locations on the west side of the canal.

The boring identified as Delevan Pipeline 1 (DH-19-DP1-A) is located on the northeast corner of TRR-East in the flatlands of an adjacent agriculture area, approximately 2000 ft northeast from the nearest point of the GCID Canal. The boring was situated on the shoulder of McDermott Road. The boring log indicates that groundwater was encountered at a depth of approximately 6 feet (approximately 3 feet below the top of native soils), and the following general stratigraphic layering was observed from top to bottom:

- ~3 feet of silty fill;
- ~12 feet of soft to very soft, lean to fat clays with a very loose 3-ft silty sand layer;
- ~11 feet of loose to very loose poorly graded sands with low fines content (<15%);
- ~11 feet of soft to very soft lean clay to elastic silt;
- ~9 feet of loose to medium dense silty sands with higher fines content (>15%) and trace gravel;
- ~12 feet of medium stiff lean clays with sand and sandy clays; and
- ~42 feet of stiff to very stiff lean clays with trace sands and gravels intermixed.

The boring identified as TRR-PGP (DH-19-TRRPGP-A) is located near the northwest corner of the TRR-East on the northeast embankment of the GCID Canal. The boring log indicates that groundwater was encountered at a depth of approximately 12 feet (approximately 5 feet below the top of native soils), and the following general stratigraphic layering was observed from top to bottom:

- ~7 feet of canal embankment fill, consisting mostly of very soft to soft sandy lean clay;
- ~10 feet of a mixture of soft to medium stiff lean clays and silts with thin layers of silty sand;
- ~4 feet of loose to medium dense poorly graded sand with silt and low fines content (<15%);
- ~26 feet of stiff lean clays with trace gravels and sands; and
- ~52 feet of stiff to very stiff lean clays with a few 1-3 ft seams of dense silty or clayey sands.

In addition to the two recent borings, there are logs of test borings available from the plan set for a structural improvement to the Funks Siphon and Check located near the southern tip of the planned TRR-East. These borings are shown as B-1 and B-2 on the General Plan for the Funks Slough Siphon in Attachment A. The boring log of B-1 extends to a depth of approximately 34 feet and indicates that groundwater was encountered at a depth of approximately 9 feet, with stiff silty clay above the water table, underlain by ~15 feet of soft to very soft silty clays, underlain by stiff clay with sand layers. The boring log of B-2 extends to a depth of approximately 40 feet and indicates a groundwater depth of approximately 9 feet, with stiff silty clay above the water table, underlain by ~10 feet of soft to very soft silty clay, underlain by ~7 feet of stiff clay with sand layers, underlain by ~11 feet of loose poorly graded sand, underlain by stiff sandy clay and clayey sand.

A geomorphology study[1] performed in October 2020 in the area of the TRR-East corroborates the findings from the geotechnical data observed in the above borings and based on the geomorphology (flatland basin deposits), suggests that there is likely the same adverse conditions across the entire TRR-East site. Further detail can be found in the referenced technical memorandum.

3.0 Implications of Findings

The subsurface conditions encountered in the borings indicate the presence of adverse foundation conditions for the TRR-East. The soils observed suggest geotechnical design issues are the soft clays and the loose poorly graded sands below the water table.

The soft clays are compressible and prone to substantial settlement under the weight of the new embankment. These settlements would impact the TRR-East embankment, hydraulics infrastructure, the existing GCID Canal embankment, and other new and existing infrastructure adjacent to the TRR-East. These settlements may occur non-uniformly across the site given the various thickness of clay deposits encountered.

The loose sands are prone to liquefaction, considering the anticipated seismic hazard of the area[2], the shallow depth to groundwater, and the relatively shallow depth of the sand layers. The consequences of liquefaction of these layers during an earthquake may include embankment instability and lateral deformations of the embankments, including embankment instability and lateral deformations adjacent to and toward the GCID Canal, and seismically-induced settlements and differential settlements of overlying embankments and other TRR-East hydraulics infrastructure.

Note that the adverse soils conditions were observed in all four borings – situated near all three corners of the TRR-East – including either soft clay, loose sands, or both in each boring. The depths of layers varied from boring to boring, including between the two borings situated relatively close to each other at the southern end of the TRR-East site. At both the southern end of the site (close to Funks Creek) and northern end of the site (distant from Funks Creek), adverse soil conditions were encountered to depths of about 40 feet. Considering these observations, and that the entire TRR-East site is located within the same geologic context, it is likely that adverse soil conditions are present underneath most (if not all) of the length of the TRR-East embankment. The adverse conditions have been observed down to about 40 feet deep in 2 of 3 locations explored along the TRR-East embankment, including liquefiable sands at this depth. Commonly, liquefaction is considered of concern for liquefaction-prone soils down to a depth of 50 feet. Given the variation in depth of liquefiable sands encountered in borings recorded to date, the observation of such sands as deep as about 40 feet, and that there is not a geologic constraint limiting such sands to this depth, it is reasonable to expect that liquefiable sands also exist at depths between 40 and 50 feet at various locations at the site.

These adverse soil conditions – both the soft clays and loose sands – will need to be mitigated in order to develop the TRR-East at this site. Given the mixed nature of the soils, cement deep soil mixing (CDSM) is likely the most viable method of ground improvement. For feasibility-level planning, it is prudent to estimate quantities/cost based on ground improvement of the entire depth of adverse soil conditions, under the width of the footprint of the embankment and widened embankment/infrastructure areas. However, in order to develop a best estimate of costs, we anticipate that some refinement of the depth of improvement may be achieved after detailed site investigation is completed. Also, ground improvement using CDSM may be performed in a way that doesn't modify 100% of the foundation area – a tight grid pattern of treatment can be performed to mitigate the soils while limiting the amount of materials/work needed to accomplish the mitigation (this is factored into the estimate as a replacement ratio).

Considering the footprint of improvement, depth of improvement, replacement ratio, and the unit cost of CDSM, our **best estimate cost is approximately $132M**. Assuming the footprint of improvement does not vary (approximately 30 acres around the perimeter of the berm), each aspect factored into the cost was evaluated to

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[1] Fugro, 2020. Geology and Geomorphology Studies Funks Reservoir and Proposed TRR Areas. October

[2] DWR DOE. 2003a. Sites Reservoir Engineering Feasibility Study – Golden Gate, Sites, and Saddle Dams. February.

a relatively tight range. The best estimates and ranges of depth of improvement, replacement ratio, and unit cost were, respectively, 45 ft (-20% to +10%), 40% (-15% to 25%), and $150 per cubic yard (-10% to +20%). While the ranges for these parameters were tight, together they add up to a significant range on the total cost of CDSM, from about -40% to +70%. The overall cost could be estimated with greater certainty with appropriate geologic and geomorphic mapping in conjunction with design-level exploration, but the refined cost is likely to fall within this range. This accounts for only the ground improvement and would be an additional cost beyond already-planned costs for grading to construct the TRR-East or any of the various facilities and improvements. This cost also does not account for ground improvement staging or disposal/handling of spoils generated during CDSM (up to 20% of volume treated) if these materials cannot be re-used on site.

This need for ground improvement at TRR-East represents a significant cost and introduces additional risk to the project cost and schedule. Also, it is unlikely that additional subsurface exploration will result in a finding that ground improvement is not needed at the TRR-East site (i.e., additional exploration will refine the estimate of ground improvement cost, but not preclude the need for ground improvement).

4.0 Alternative Locations for a Reservoir

An alternative to incurring this significant additional cost may be to relocate this reservoir to a location that reduces CDSM requirements to construct the reservoir. Five preliminary alternative locations for the reservoir have been identified. The alternative locations for this reservoir are referred to as BCM-1, BCM-2, BCM-3, TRR-West, and SCC; the locations of these alternative locations are shown on Figures 2 through 6. These alternatives were sized to provide the same storage capacity as TRR-East within the same operational range required for the GCID Canal.

Four of these alternative locations are in the topographically higher area between the GCID Canal and TC Canal, to the northwest of the TRR-East site, to avoid or reduce CDSM requirements. Figures 2 through 5 show the layout of these alternatives, where there is anticipated to be more favorable geology/soil conditions (i.e., avoiding/minimizing the thickness of flatland basin deposits, which include the soft clays and loose sands).

Two historic borings (B-1 and B-2) on the southern edge of this region near the proposed TRR pipeline (see excerpt boring logs in Attachment A) were performed in 2001 by the Department of Water Resources (DWR). These borings suggest more favorable soils for reservoir construction to the west of the GCID canal, including medium stiff to stiff lean clays with some silts and sands intermixed. These stiffer soils likely comprise the majority of the topographic high between the GCID and TC canals. The geomorphology study[3] performed in October 2020 corroborates these findings and suggests various deposits that differ from the flatland basin deposits of the TRR-East. Adverse soils may still be encountered in some of the other geomorphologic blocks identified in the referenced memorandum but would likely be excavated to minimize their thicknesses.

The SCC location that has been identified (previously by others) for consideration is located to the west of the GCID Canal approximately two miles southeast of Funks reservoir. Figure 6 shows the layout of this alternative. Historic geotechnical data are not available in this area.

The five alternative locations were evaluated and compared based on several key factors; principal among these factors was real estate. The five alternative locations were all selected to reduce the impacts to orchards and explore different impacts to property owners than TRR-East and each other. For example, TRR-East impacts irrigated and orchard property (permanent need and additional temporary construction easements) while BCM-1 impacts a significantly reduced acreage of orchard property, because the reservoir itself is located on rangeland. BCM-2 and BCM-3 also were located/configured such that the reservoir is on rangeland, and their impacts to orchard property affect a different property owner than TRR-East and BCM-1. The TRR-West reservoir is located similarly to BCM-1 and impacts only one property owner. The SCC reservoir is also located

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[3] Fugro, 2020. Geology and Geomorphology Studies Funks Reservoir and Proposed TRR Areas. October

such that it affects property held by only one owner but would have pipeline/canal impacts to different properties and different from those affected by the TRR-East or the BCMs.

Each of the five alternatives were configured to meet the TRR-East hydraulic design criteria[4], including a storage capacity of approximately 600 acre-ft within the operational range of the GCID Canal. Additionally, the five alternatives were configured to have approximately the same plan-view footprint as the impoundment portion of the TRR-East (with some differences to accommodate alternative-specific configuration needs) and 12 acres (of the total footprint) immediately adjacent to the GCID Canal for routing and controlling flows in and out of the reservoir and bypassing the reservoir through a re-constructed bypass canal (i.e., inlet/outlet/bypass infrastructure).

5.0 Initial Engineering Evaluation of Alternatives

Selection of a preferred alternative (i.e., either continuing with TRR-East or selecting one of the five alternatives) will involve a range of considerations. For the current TM, the five alternatives were developed and compared based on engineering judgment of the conveyance systems functionality and in consideration of information from discussions with the original TRR-East designers, GCID operations personnel, TC Canal operations personnel, real estate evaluators, and the Sites JPA. Key criteria identified based on these discussions include:

- Real estate impacts
- Construction cost
- Optimization potential
- Resilience to changes
- Environmental impacts
- DSOD jurisdiction

A description of each of these criteria is provided as follows.

Real Estate Impacts

For this TM, real estate impacts were evaluated principally in terms of property ownership and land use. Land use evaluation focused on permanent need of orchards and on temporary construction easement (TCE) through orchards. Based on conversations with the Sites JPA and real estate evaluators, a primary concern for placement of these alternatives is to avoid or minimize impact to any private orchards, as well as to irrigated lands, particularly on the borders of the GCID Canal in the vicinity of TRR-East. Similarly, the alternatives were compared regarding impacts to orchards where a TCE would likely be needed to install pipelines, improve channels, stage equipment and materials, etc. These lands would be returned to the owners affected after construction, but the orchards within these TCE areas would be removed during construction.

An additional constraint for all BCM and TRR-West alternatives is the presence of Pacific Gas and Electric transmission towers along an alignment roughly parallel and to the east of the TC Canal and an underground transmission line near the intersection of the GCID and Noel Evan Road.

Construction Cost

Construction cost of each alternative is different from TRR-East for the reservoir itself, for the pipelines (and power lines) from the reservoir to Sites Reservoir, and for site access and stockpiling/staging during construction.

Principally, this evaluation compares the reservoir feature of each alternative, as opposed to other features, such as the pump generating plants (PGP) and inlet/outlet works, which are considered similar across all alternatives. This TM focuses on construction costs only; costs for real estate acquisition, environmental mitigation, etc. are

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[4] For further information about hydraulic criteria for the TRR-East, refer to the Understanding of TRR Operations Technical Memorandum, dated September 25, 2020.

not included in the estimates presented within this TM. This TM also does not include costs for electrical transmission; electrical transmission is anticipated to correspond partly to the pipelines corridor, but the tie-in location (to PG&E or WAPA) is not yet known, so the remainder of the electrical corridor is unknown at this time. Therefore, the costs presented in this TM are focused on the construction of the reservoir and pipeline facilities, and these costs should not be considered the total cost of the alternative.

The largest differences in construction cost for the reservoir itself are due to the differing geotechnical and topographic conditions of TRR-East in contrast to those at each of the five alternatives. The BCM and TRR-West alternatives were placed principally to avoid likely adverse soil conditions as found near the TRR-East, thus avoiding or reducing CDSM. Conversely, due to the higher topographic conditions at the locations of each BCM and TRR-West alternative, each of the BCM and TRR-West alternatives would necessitate significantly more earthwork (predominantly excavation) than is needed for TRR-East to construct the reservoir. Excavation volumes were estimated based on the area of each layout, the topography available, and the target base elevation for the reservoir. Earthwork construction costs are estimated assuming $20-25 per cubic yard. This estimate considers double-handling of material due to construction scheduling (phasing of different project features) and the very large quantities of excavation to be performed.

SCC is located in an area topographically similar to TRR-East and will require similar earthwork quantities (i.e., primarily embankment construction). However, based on the regional geology and geomorphic setting of the SCC, it is likely to have similar geotechnical conditions to the TRR-East, and therefore would require a similar CDSM construction element and associated cost.

Additionally, shallow groundwater elevations near the surface in the vicinity of the TRR-East will likely require dewatering during construction. The BCM and TRR-West alternatives were sited in locations with potentially lower (i.e. deeper) groundwater levels due to the geology and likelihood of higher runoff toward the valley. The SCC alternative is likely to have shallow groundwater, similar to TRR-East, based on the geomorphic setting and land use (i.e., rice fields) in the area.

For associated pipeline (and powerline) costs, three of the alternatives (BCM-1, BCM-3, and TRR-West) have significantly shorter lengths of pipelines than TRR-East. In all alternatives, tunneling beneath the TC Canal will need to be performed. The SCC alternative has a significantly longer pipeline length compared to TRR-East.

Site access for construction equipment, materials delivery, and construction personnel was considered for each alternative based on discussions with the project team and potential access locations through public and accessible private roads. The BCM and TRR-West alternatives each have more limited or challenging site access than TRR-East for construction of the reservoir itself because there are no public roads/bridges to access the areas between the canals. The BCM alternatives have better access to stockpiling and staging areas than TRR-East; however, the BCM and TRR-West alternatives may require more area for stockpiling and staging than TRR-East. SCC is likely to have similar relative ease of access as TRR-East due to the public roads adjacent to the site.

Comparing the BCM, TRR-West, and SCC alternatives to TRR-East, there are numerous features associated with the construction that drive construction costs either up or down for each alternative relative to the others. Construction costs estimated in this TM are limited to those associated with pipeline length and with excavation quantities for reservoir construction. Earthwork quantities associated with the PGP and inlet/outlet/bypass infrastructure are assumed to be comparable between all alternatives and are not considered herein.

Optimization Potential

Whichever alternative is selected, the configuration and design will be optimized as the project progresses from feasibility to design. Some optimization ideas have already been implemented by the project team upon receiving additional topography data and the preliminary environmental impacts report. Each alternative, however, is likely to benefit from optimization due to its configuration and constraints. For example, for each of the BCM and TRR-West alternatives, the opportunity exists to optimize a tradeoff between length of pipelines vs volume of excavation for open reservoir/channel leading to the PGP. This optimization is not available for TRR-East because it is situated on the east side of the GCID Canal and the pipeline must begin at this location. Certain alternatives will have a greater rate-of-change (i.e., rate of decrease in construction costs) than others in response to this optimization, due to differences in configuration and constraints (e.g., alternatives situated in steeper topography will have greater decreases in cost than those in flatter topography).

Resilience to Changes

One of the most critical aspects of feasibility-level layouts, locations, and configurations is the ability of these to accommodate changes that arise. At the feasibility level, many uncertainties and project risks exist. As some of these uncertainties become clarified and some of these project risks are realized, resilient project configurations can accommodate the changes with relatively minor impacts, whereas less resilient project configurations may be severely impacted or need to be abandoned altogether. For example, it is unknown at this time whether certain property owners ultimately will be willing to allow permanent need or TCE on their lands. Some alternatives can accommodate a negative outcome to this question, while other alternatives become infeasible (i.e., cannot be constructed). Another example is environmental constraints, where locations of particular environmental concern are identified, necessitating avoidance to prevent significant impacts and mitigation requirements. Some alternatives can accommodate this constraint, being readily adjusted to avoid the environmental concern, while other alternatives cannot be readily adjusted, and thus would cause significant impacts and mitigation requirements.

Environmental Impacts

Potential environmental impacts were not evaluated as part of this engineering evaluation; however, information from three preliminary environmental studies[5], and one cultural resources study were provided for synopsis-level reporting in this TM by the Sites Environmental/Permitting team. Two of these studies (for the BCMs, TRR-West, and SCC) presented the information in the form of Google Earth kmz files, which were received by email on September 4 and 25, 2020, respectively. The synopsis-level reporting in this TM should be verified by the project Environmental consultant if this information is to be relied upon for decision making.

Each environmental study focused primarily on either the area of the BCM and TRR-West alternatives, the existing TRR-East area, or the SCC alternative area. However, there is some overlap of the different study areas considered in each study, and there appear to be some inconsistencies in the potential environmental impacts identified in these overlapping areas. Potential environmental impacts of each alternative are qualitatively discussed herein based on the perceived most relevant information (and in consideration of apparent inconsistencies). The potential environmental impacts shown in Figures 1-6 are based on the provided Preliminary studies.

Habitat for various species of concern exists in the areas of the proposed reservoirs. Principal species of concern appear to be fairy shrimp, red-legged frogs, and giant garter snakes; their habitats include:

- Fairy shrimp: vernal pools and seasonal wetlands
- Red-legged frogs: creeks and ponds
- Giant garter snakes: sloughs, canals, low gradient streams, freshwater marshes and wetlands, irrigation ditches, canals, and rice fields.

One or more of these potential habitats are affected by each of the alternative reservoir locations considered in this TM. The presence of the habitat does not necessarily mean the associated species are present.

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[5] (1) ICF (2020). TRR_LandCover_DRAFT_20190904.kmz, Attachment to email "RE: Sites HC: TRR Alternatives suggested EIS/EIR survey area" from Ellen Berryman to John Spranza, September 4, 2020.
(2) ICF (2020). StoneCorralCreekTRR_LandCover_DRAFT_20190924.kmz, Attachment to email "Stone Corral Creek TRR Potential Location: Sites Reservoir – Bio and Cultural", from Monique Briard to Pete Rude, September 25, 2020.
(3) ICF (2020). "Memorandum: Preliminary biological constraints analyses for the 2020-2021 Sites Project Authority's geotechnical investigations of the proposed TRR and Dunnigan pipelines". June 29, 2020. Received by email September 25, 2020.

DSOD Jurisdiction

Currently, it is understood that the TRR-East will fall under the jurisdiction of the California Division of Safety of Dams (DSOD), and that DSOD will be heavily involved in the determination of design criteria, the design process, and construction oversight, as well as ongoing jurisdictional oversight of the operation and maintenance of the constructed reservoir. Interest has been expressed in pursuing the possibility of adjusting the reservoir configuration such that it is not DSOD-jurisdictional. Each of the reservoir configurations has a differing level of potential for realizing this objective.

The following subsections present an initial assessment of each alternative from an engineering perspective. For comparison and use as a baseline, the TRR-East is summarized herein as it relates to the evaluation criteria outlined above. In conjunction with the following subsections, refer to Table 1 (next page) and Figures 1 to 6, which show comparisons of the alternatives versus TRR-East and each other.

TABLE 1 - COMPARISONS OF TRR-East, BCMs, TRR-West, AND SCC ALTERNATIVES

KEY CRITERIA/EXAMPLES	TRR-East	BCM-1	BCM-2	BCM-3	TRR-West	SCC
Real Estate Impacts (not including pipeline)						
Primary Properties Affected	4 private land holdings	2 private land holdings	2 private land holdings	2 private land holdings	2 private land holdings	1 private land holding and GCID (see Note 1)
Current Land Use of Planned Reservoir Facility (Predominantly)	Irrigated land	Rangeland	Rangeland	Rangeland	Rangeland	Irrigated land
Permanent Orchard Need (±20%)	22 acres (1 private land holding)	22 acres (1 private land holding)	22 acres (1 private land holding)	22 acres (1 private land holding)	22 acres (1 private land holding)	0 acres
Additional TCE through Orchards (±20%)	21 acres (1 private land holding)	0 acres	0 acres	0 acres	0 acres	30 acres
Additional real estate for stockpiling, staging, and laydown	20 acres non-adjacent	20 acres adjacent	20 acres adjacent	20 acres adjacent	20 acres adjacent	20 acres adjacent
Construction Cost Impacts (see Note 2)						
Extensive Ground Improvement (Cement Deep Soil Mixing) Required?	Yes	Unlikely	Unlikely	Unlikely	Unlikely	Likely
Additional Earthwork Volume	N/A (see Note 3)	7.3 MCY	5.4 MCY	3.7 MCY	8.5 MCY	N/A (see Note 3)
Pipeline Corridor Length	4.3 miles	2.8 miles	4.0 miles	3.5 miles	2.3 miles	6.0 miles
Reservoir Facilities Cost (see Note 4)	$51 million	$51 million	$51 million	$51 million	$51 million	$51 million
Additional Excavation Cost	$0	$164 million	$122 million	$83 million	$191 million	$0
Additional CDSM Cost	$132 million	$0	$0	$0	$0	$132 million
Widening GCID Main Canal Cost	$0	$0	$0	$0	$0	$3 million (see Note 5)
Pipeline Cost	$97 million	$65 million	$90 million	$80 million	$55 million	$133 million

KEY CRITERIA/EXAMPLES	TRR-East	BCM-1	BCM-2	BCM-3	TRR-West	SCC
Total Cost of Main Components per Alternative for Comparison	$280 million	$280 million	$263 million	$214 million	$297 million	$319 million
Schedule Impacts	Long and Constrained (+1-2 yrs)	Short and Flexible	Short and Flexible	Short and Flexible	Short and Flexible	Long and Constrained (+1-2 yrs)
Degree of Optimization Potential	Low	Moderate	High	High	Moderate	Moderate
Resilience to Changes						
Resilient to Negative Response from Adjacent Orchards Owners?	No	No	Yes	Yes	No	Yes
Resilient to Negative Response to Orchard Need near Noel Evan Road?	Yes	Yes	No/Maybe	No/Maybe	Yes	Yes
Resilience to Other Changes (e.g., storage capacity, environmental, etc.)	Low	High	Moderate	Moderate	Moderate	Low
Significant Environmental Impacts	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Degree of Reconfiguring to Avoid DSOD Jurisdiction	Significant	Minor	None	None	Minor	Significant

Notes:

1. Additionally, this alternative impacts properties along the entire length of the GCID Canal from Funks Creek to the SCC reservoir due to widening
2. Construction quantities and cost estimates reported in the table are best estimate values; refer to text in the TM for ranges and uncertainty in these values
3. All excavation for TRR-East and SCC assumed to be included in the base cost estimate from the Value Planning Alternatives Appraisal Report (April 2020)
4. The cost for reservoir facilities is assumed to be equal to the cost of TRR-East facility from the Value Planning Alternatives Appraisal Report, page 75 of 153 (April 2020)
5. Cost assumes increased capacity of the canal only

5.1 TRR-East

Real Estate

The TRR-East is situated on the east side of the GCID Canal roughly due east of Funks Reservoir within a flatland area currently used for agriculture. The plan area including the reservoir, PGP, inlet/outlet structures, infrastructure gates and channels, pipeline and TCE, etc. resides on at least four private properties, including the private orchards on either side of the GCID Canal. Figure 1 shows the current plan area for TRR-East with light cyan area showing permanent land need, dark cyan area showing the TCE, and the shaded area showing impact to private property near the GCID Canal. Most of the area that the reservoir facility occupies is irrigated lands. Approximately 22 acres of orchard would be designated for permanent need and an additional 21 acres of orchard for TCE.

For stockpiling fill materials for processing and staging (e.g., moisture control of excavated materials prior to placement as embankment fill), an area roughly the size of the TRR-East area is needed. Processing and staging could be performed in the interior of the TRR-East site and would require an additional roughly 20 acres of a non-adjacent property (e.g. in the area of BCM-1). Candidate locations include north or east of the proposed TRR-East, or on the other side of the GCID Canal, along the pipelines TCE or in the topographically higher area to the northwest.

Construction Cost

As discussed in previous sections of this TM, the geotechnical conditions at TRR-East are adverse and mitigation would add significant cost to the project. The TRR-East site is essentially flat, so the reservoir consists of an earthen embankment around its perimeter and relatively shallow excavation across the interior (with a few areas of somewhat deeper excavation). Earthwork for TRR-East is a combination of excavation (across the reservoir footprint) and fill placement (for the embankments).

The schedule impact to performing CDSM is long and constrained due to the specific order of construction required and the time to implement ground improvement. No other construction work can likely start before CDSM is implemented and based on the volumes estimated for improvement, the CDSM effort alone could take between 1 and 2 years to complete (e.g. the Perris Dam project involving CDSM for the California Department of Water Resources lasted 6 months and improvement approximately half of the volume anticipated for this project).

The TRR-East alternative includes a little more than 4 miles of pipeline corridor (i.e., a corridor with two parallel pipelines, each more than 4 miles long, as measured to Funks Reservoir).

Groundwater elevations in the vicinity of TRR-East are shallow (a few feet below ground surface, according to the geotechnical data), which will likely lead to a dewatering requirement for excavations. Access to the TRR-East site should be relatively simple, through public roads; however, stockpiling and staging will be challenging if an adjacent site cannot be identified.

Optimization Potential

TRR-East is considered to have a low degree of optimization potential. It is anticipated that the size of the reservoir may be slightly reduced relative to the current feasibility-level configuration because the required storage capacity may also be able to be reduced. Ability to reduce reservoir footprint area depends in part on the elevation range of storage within the reservoir; full evaluation of required storage elevation range is yet to be performed. If the size of the reservoir can be reduced, there would be a corresponding reduction in earthwork, geotechnical mitigation, and real estate requirements. Due to the location of properties relative to the GCID Canal and pipelines corridor, reduction in reservoir size may not be as beneficial for real estate concerns as might be anticipated. For example, if the reservoir is downsized by moving its northern perimeter southward, less orchard area would be impacted on the east side of the GCID Canal, but more orchard area would be impacted on the west side of the GCID Canal.

The primary constraint to optimization of the TRR-East is its location to the eastern side of the GCID Canal. Siting of TRR-East at this location requires that water from TRR-East must be drawn into the PGP and pumped through pipelines that must pass under the GCID Canal. This location and configuration are essentially fixed; water must be piped from this location all the way to Funks and Sites. Also, due to this constraint, impacts to real estate (both permanent need and TCE) on both sides of the canal cannot be avoided, regardless of reservoir downsizing or other optimization efforts. Another potential constraint to optimization at TRR-East is the presence of shallow groundwater. This condition hampers ability to excavate deeper for optimization efforts that might otherwise benefit from deeper excavation. TRR-East is considered to have a low degree of optimization potential.

Resilience to Changes

TRR-East is not especially resilient to changes that may occur, especially with respect to real estate. TRR-East is constrained laterally along its western/southern margin by the GCID Canal, and it is constrained along its eastern margin by McDermott Road and the canal running adjacent to the western side of the road. If a change were to occur that necessitated an increase in footprint, the reservoir would need to be expanded northward, impacting additional property, including more orchard land. The viability of TRR-East – as currently configured or after optimization, even without any adverse changes that may occur – is strictly dependent on the ability to obtain specific orchard lands for permanent need and TCE. If it turns out that these orchard lands are not able to be obtained, the TRR-East configuration cannot be constructed.

Environmental Impacts

The potential environmental impacts shown in Figure 1 are based on the provided environmental studies covering this area[6],[7]. Though no environmental impacts were mapped within the immediate reservoir footprint, based on the text of the report, giant garter snakes are potentially present in TRR-East area. Based on the report text, giant garter snake habitat exists along the entire length of the southwestern embankment of the TRR (proximity to canal) and along the entire length of the eastern embankment of TRR-East (proximity to canal). Also, approximately half the length of the pipeline corridor is within potential giant garter snake habitat (proximity to canal and to wetland). According to the provided studies, the pipelines may affect additional special-status species (e.g., San Joaquin spearscale). The synopsis-level reporting in this TM should be verified by the project Environmental consultant.

DSOD Jurisdiction

As currently configured, TRR-East is DSOD jurisdictional. Considering the operational requirements for TRR-East and the elevations of the site, it is likely that TRR-East will remain DSOD jurisdictional.

5.2 BCM-1

Real Estate

BCM-1 is the closest location to the current TRR-East and pipeline alignment. BCM-1 is situated along the southeastern portion of the topographic high separated from the GCID Canal by private orchard lands. The plan area of BCM-1, similar to that of TRR-East, resides on at least two properties. Most of the reservoir facility area occupies rangeland. Figure 2 shows the plan for BCM-1, including permanent land need in light blue, TCE in dark blue, and shaded area showing impact to private property near the GCID Canal. As planned, BCM-1 would require approximately 22 acres of permanent need on private property with orchards, primarily for the same infrastructure as TRR-East (inlet/outlet, gates, channels, etc.) needed to tie-in to the GCID Canal.

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[6] ICF (2020). “Memorandum: Preliminary biological constraints analyses for the 2020-2021 Sites Project Authority’s geotechnical investigations of the proposed TRR and Dunnigan pipelines”. June 29, 2020. Received by email September 25, 2020.

[7] ICF (2020). TRR_LandCover_DRAFT_20190904.kmz, Attachment to email “RE: Sites HC: TRR Alternatives suggested EIS/EIR survey area” from Ellen Berryman to John Spranza, September 4, 2020.

As for TRR-East, an area roughly equal to the size of the BCM-1 is likely needed for stockpiling fill materials for processing and staging (e.g., moisture control of excavated materials prior to placement as embankment fill). Processing and staging could be performed in the interior of the proposed BCM-1 site plus an additional roughly 20 acres.

Construction Cost

Apart from the area of the inlet/outlet/channel infrastructure, the geotechnical conditions for the BCM-1 alternative avoid the adverse geotechnical conditions found at TRR-East, based on the assumed geology and the historic geotechnical data previously discussed. BCM-1 would not incur the expensive ground mitigation costs that TRR-East would incur. However, relative to TRR-East, BCM-1 involves significantly more earthwork – about 7.3 MCY, predominantly excavation – as its western margin is controlled by increasing elevation of the topography. This volume of earthwork represents a significant construction cost.

The schedule impacts of all the BCMs are short and flexible due to potentially performing excavation in phases as materials are need for other parts of the project (e.g. Golden Gate Dam if materials are suitable). Since the BCMs are mostly excavation driven features, there are also fewer constraints on the order in which excavation is performed relative to the other features of the alternatives.

Relative to TRR-East, BCM-1 shortens the length of pipeline corridor needed to less than 3 miles, since the PGP can be located at the southwestern corner of the reservoir.

There are a few options for access to the BCM-1 site. Since BCM-1 involves permanent need of some private property near the GCID Canal, one option for site access is through this property. A site access option that does not involve private property in this vicinity is access from the north, from Noel Evan road and southward via a TCE across rangeland private property. Another option for site access is from the west, from USBR property and eastward via a TCE across rangeland private property. Stockpiling and staging for BCM-1 would occur (a) within the area of the BCM-1 reservoir footprint, and (b) adjacent to the northern margin of the BCM-1 reservoir footprint.

Optimization Potential

BCM-1 is considered to have a moderate degree of optimization potential. Similar to TRR-East, it is anticipated that the size of the BCM-1 reservoir may be able to be reduced somewhat relative to the current feasibility-level configuration, because the required storage capacity may be able to be reduced. Ability to reduce reservoir footprint area depends in part on the elevation range of storage within the reservoir; full evaluation of required storage elevation range is yet to be performed. If the size of the reservoir can be reduced, there would be a corresponding reduction in earthwork and real estate requirements. Due to the sloping nature of the BCM-1 reservoir site, a reduction in reservoir footprint area would result in significant reduction in earthwork volume (and significant reduction in cost), because the reservoir footprint can be reduced in the areas of deepest excavation (potentially providing greater percentage cost decrease than percentage reservoir footprint decrease).

For BCM-1, the opportunity exists to optimize a tradeoff between length of pipelines vs. volume of excavation for open reservoir/channel leading to the PGP. At the reservoir's southwestern end (where the PGP will be sited), the reservoir can be narrowed to a canal that extends westward, shortening the length of pipelines needed (and power lines). As the reservoir/canal is extended westward, more significant excavation is needed; at some point, it becomes advantageous to terminate the open canal and switch to pipelines. This optimization also might be used to locate the PGP in a most-favorable location or footprint of other variations in site conditions (e.g., various geologic conditions).

The primary constraint to optimization of BCM-1 is its eastern and southern margins are bounded by orchard lands. This prevents flexibility in configuration of the facility along its eastern and southern sides. Additionally, BCM-1 necessitates modification and permanent use of the canal on private property that extends westward from the GCID Canal. This constraint limits how much this alternative can be optimized with respect to minimizing impact to orchards. Conversely, if the inlet/outlet/canal infrastructure can be optimized to reduce its footprint area, this provides an opportunity to reduce the impact to orchards relative to what is currently shown and relative to TRR-East. PG&E transmission towers provide an additional constraint in the western region of the reservoir. This constraint limits how far the western region can be extended north without modification (e.g. creation of an island or cutout).

Resilience to Changes

Relative to TRR-East, BCM-1 is more resilient to changes that may occur, with some exception. BCM-1, while bounded on its eastern and southern margins by real estate constraints, is not bounded on its western and northern margins by such constraints (excepting the PG&E transmission towers). There is flexibility to make changes in the configuration to accommodate changes that may arise (e.g., increased capacity need, avoiding certain locations of environmental concern, etc.). The western and northern margins are not optimal for adjusting, since these areas would involve significant excavation cuts.

However, as for TRR-East, the viability of BCM-1 – as currently configured or after optimization, even without any adverse changes that may occur – is strictly dependent on the ability to obtain specific orchard property for permanent need. If it turns out that these private orchard lands are not able to be obtained, the BCM-1 configuration cannot be constructed.

Environmental Impacts

The potential environmental impacts shown in Figure 2 are based on the provided environmental studies covering this area[8],[9]. The southern margin of the reservoir footprint includes freshwater marsh, ephemeral stream, and a canal, which are potential habitat for giant garter snake and red-legged frog. Some additional species also may be impacted (e.g., San Joaquin spearscale and burrowing owls). The synopsis-level reporting in this TM should be verified by the project Environmental consultant.

DSOD Jurisdiction

As currently configured, BCM-1 may or may not be DSOD jurisdictional. The BCM-1 reservoir would be mostly contained within an excavated area, but it’s southeastern margin would involve an embankment, which might result in BCM-1 being DSOD jurisdictional. It is likely that BCM-1 can be configured to remove it from DSOD jurisdiction.

5.3 BCM-2

Real Estate

BCM-2 is situated along the northern portion of the topographic high, just south of the PG&E Colusa Substation. Most of the reservoir facility occupies rangeland. This alternative would reside on at two properties, including the orchards to the west of the GCID Canal just south of Noel Evan road. Figure 3 shows the plan for BCM-2 including permanent land need in light yellow and TCE in dark yellow. As planned, BCM-2 would require approximately 22 acres of orchard, intentionally planned to be along the southern and eastern edges of the property to avoid bisection of the property.

As for TRR-East, an area roughly equal to the size of the BCM-2 is likely needed for stockpiling fill materials for processing and staging (e.g., moisture control of excavated materials prior to placement as embankment fill). Processing and staging could be performed in the interior of the proposed BCM-2 site plus an additional roughly 20 acres.

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[8] ICF (2020). TRR_LandCover_DRAFT_20190904.kmz, Attachment to email “RE: Sites HC: TRR Alternatives suggested EIS/EIR survey area” from Ellen Berryman to John Spranza, September 4, 2020.

[9] ICF (2020). “Memorandum: Preliminary biological constraints analyses for the 2020-2021 Sites Project Authority’s geotechnical investigations of the proposed TRR and Dunnigan pipelines”. June 29, 2020. Received by email September 25, 2020.

Construction Cost

This alternative is situated intentionally within the lower/flatter area of assumed good geology to avoid the adverse geotechnical conditions that would necessitate extensive CDSM ground improvement. BCM-2 would not incur the expensive ground mitigation costs that TRR-East would incur. However, relative to TRR-East, BCM-2 involves significantly more earthwork – about 5.4 MCY, predominantly excavation – as its southwestern margin is controlled by increasing elevation of the topography. This volume of earthwork, while about 2 MCY less than BCM-1, still represents a significant construction cost.

The schedule impacts of all the BCMs are short and flexible due to potentially performing excavation in phases as materials are need for other parts of the project (e.g. Golden Gate Dam if materials are suitable). Since the BCMs are mostly excavation driven features, there are also fewer constraints on the order in which excavation is performed relative to the other features of the alternatives.

Relative to TRR-East, BCM-2 somewhat shortens the length of pipeline corridor needed, to approximately 4 miles. As shown in Figure 3, this length is situated along a different alignment route than the pipelines corridor for TRR-East and BCM-1. The BCM-2 pipeline alignment runs westward from the BCM-2 reservoir site, extending under the TC Canal (at an embankment section of the canal) and then turns southward to extend to the Funks Reservoir area.

Site access is likely achievable from the north via Noel Evan road and accessible private roads extending south from Noel Evan road. Another option for site access is from the west, from USBR property and eastward via a TCE across rangeland private property. Stockpiling and staging for BCM-2 would occur (a) within the area of the BCM-2 reservoir footprint, and (b) adjacent to the western and southern margins of the BCM-2 reservoir footprint, on the same property as the reservoir.

Optimization Potential

BCM-2 is considered to have a high degree of optimization potential. As for TRR-East, it is anticipated that the size of the reservoir may be able to be reduced somewhat relative to the current feasibility-level configuration, because the required storage capacity may be able to be reduced. Ability to reduce reservoir footprint area depends in part on the elevation range of storage within the reservoir; full evaluation of required storage elevation range is yet to be performed. If the size of the reservoir can be reduced, there would be a corresponding reduction in earthwork and real estate requirements. Due to the sloping nature of the BCM-2 reservoir site, a reduction in reservoir footprint area would result in significant reduction in earthwork volume (and significant reduction in cost), because the reservoir footprint can be reduced in the areas of deepest excavation (potentially providing greater percentage cost decrease than percentage reservoir footprint decrease).

As for BCM-1, the opportunity exists at BCM-2 to optimize a tradeoff between length of pipelines vs volume of excavation for open reservoir/channel leading to the PGP. At the reservoir's western end (where the PGP will be sited), the reservoir can be narrowed to a canal that extends westward, shortening the length of pipelines needed. As the reservoir/canal is extended westward, more significant excavation is needed; at some point, it becomes advantageous to terminate the open canal and switch to pipelines. This optimization also might be used to locate the PGP in a most-favorable location or footprint of other variations in site conditions (e.g., various geologic conditions).

The primary constraint to optimization of BCM-2 is its eastern margin is bounded by orchard lands. This prevents flexibility in configuration of the facility along its eastern side. Additionally, BCM-2 necessitates construction of a canal and inlet/outlet/canal infrastructure that extends westward from the GCID Canal to BCM-2. This constraint limits how much this alternative can be optimized with respect to minimizing impact to orchards. Conversely, if the inlet/outlet/canal infrastructure can be optimized to reduce its footprint area, this provides an opportunity to reduce the impact to orchards relative to what is currently shown and relative to TRR-East. Additionally, the footprint of this connector canal (i.e., the amount of orchard need) can be reduced substantially if relocated along the northern margin of the property; this configuration would involve constructing a new bridge just south of Noel Evan road to provide access to the orchard, and would need concurrence from the property owner.

Another possible constraint to optimization of BCM-2 is the PG&E tower locations within and adjacent to the footprint of BCM-2. The reservoir would be designed to avoid alteration of these facilities, but their presence may inhibit some optimization of the reservoir configuration.

The pipeline alignment extending from BCM-2 westward and then southward may also provide opportunity for optimization (considering tradeoffs between alignment, earthwork, and pumping demands).

Resilience to Changes

Relative to TRR-East, BCM-2 is more resilient to changes that may occur, with some exception. BCM-2, while bounded on its eastern margin by real estate constraints, is not bounded on its western, northern, or southern margins by real estate constraints (with the exception of isolated features such as the PG&E towers). There are, however, various environmental constraints in the BCM-2 area. Still, there is flexibility to make changes in the configuration to accommodate changes that may arise (e.g., increased capacity need, avoiding certain locations of environmental concern, etc.). The southwestern margins are not optimal for adjusting, since these areas would involve more significant excavation cuts. But changes can be made here without too much impact, and changes along the northern margin would be even more economical.

The viability of BCM-2 – as currently configured or after optimization, even without any adverse changes that may occur – is dependent on the ability to obtain orchard lands for permanent need. If it turns out that these orchard lands are not able to be obtained, the BCM-2 configuration cannot be constructed unless another property just north (PG&E and others) or south (irrigated lands) can be obtained.

Environmental Impacts

The potential environmental impacts shown in Figure 3 are based on the provided environmental studies covering the area[10],[11]. Potential environmental impacts within the reservoir footprint include multiple small seasonal wetlands, ephemeral streams, and a pond, potentially impacting fairy shrimp and red-legged frogs. The inlet/outlet infrastructure, adjacent to the GCID Canal, is situated partly within area considered habitat for giant garter snake (proximity to canal). Some additional species also may be impacted (e.g., burrowing owls), and the pipeline corridor may impact additional ephemeral streams. The synopsis-level reporting in this TM should be verified by the project Environmental consultant.

DSOD Jurisdiction

As currently configured, BCM-2 is unlikely to be DSOD jurisdictional. The BCM-2 reservoir would be contained within an excavated area, separated hydraulically from the GCID Canal and lower areas via gates (as opposed to an embankment).

5.4 BCM-3

Real Estate

BCM-3 is situated in the central/northern portion of the topographic high, and oriented generally north-to-south. Most of the reservoir facility occupies rangeland. The plan area for this alternative would reside on at least two properties, including the orchards to the west of the GCID Canal just south of Noel Evan road. Figure 4 shows the plan for BCM-3, including permanent land need in light red and TCE in dark red. Similar to BCM-2, BCM-3 would require the same area for inlet/outlet, channels, gates, etc. on the private property south of Noel Evan road (~22 acres).

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[10] ICF (2020). TRR_LandCover_DRAFT_20190904.kmz, Attachment to email "RE: Sites HC: TRR Alternatives suggested EIS/EIR survey area" from Ellen Berryman to John Spranza, September 4, 2020.

[11] ICF (2020). "Memorandum: Preliminary biological constraints analyses for the 2020-2021 Sites Project Authority's geotechnical investigations of the proposed TRR and Dunnigan pipelines". June 29, 2020. Received by email September 25, 2020.

As for TRR-East, an area roughly equal to the size of the BCM-3 is likely needed for stockpiling fill materials for processing and staging (e.g., moisture control of excavated materials prior to placement as embankment fill). Processing and staging could be performed in the interior of the proposed BCM-3 site plus an additional roughly 20 acres.

Construction Cost

BCM-3 is sited in the area of good geology and to achieve relatively short pipeline length while providing connection to the GCID Canal near Noel Evan road. BCM-3 would not incur the expensive ground mitigation costs that TRR-East would incur. However, relative to TRR-East, BCM-3 involves significantly more earthwork – about 3.7 MCY, predominantly excavation – as its western margin is controlled by increasing elevation of the topography. This volume of earthwork, while about 2 MCY less than BCM-2, still represents a significant construction cost.

The schedule impacts of all the BCMs are short and flexible due to potentially performing excavation in phases as materials are need for other parts of the project (e.g. Golden Gate Dam if materials are suitable). Since the BCMs are mostly excavation driven features, there are also fewer constraints on the order in which excavation is performed relative to the other features of the alternatives.

Relative to TRR-East, BCM-3 shortens the length of pipeline corridor needed, to approximately 3-½ miles. As shown in Figure 4, this length is situated along a different alignment route than the pipelines corridor for TRR-East, BCM-1, and BCM-2. The BCM-3 pipeline alignment runs southwest from the BCM-3 reservoir site before turning west to go under the TC Canal and connect to Funks.

Site access is likely achievable from the north via Noel Evan road and accessible private roads extending south from Noel Evan road. Another option for site access is from the west, from USBR property and eastward via a TCE across rangeland private property. Stockpiling and staging for BCM-3 would occur (a) within the area of the BCM-3 reservoir footprint, and (b) adjacent to the western margins of the BCM-3 reservoir footprint, on the same property as the reservoir.

Optimization Potential

BCM-3 is considered to have a high degree of optimization potential. As for TRR-East, it is anticipated that the size of the reservoir may be able to be reduced somewhat relative to the current feasibility-level configuration, because the required storage capacity may be able to be reduced. Ability to reduce reservoir footprint area depends in part on the elevation range of storage within the reservoir; full evaluation of required storage elevation range is yet to be performed. If the size of the reservoir can be reduced, there would be a corresponding reduction in earthwork and real estate requirements. Due to the sloping nature of the BCM-3 reservoir site, a reduction in reservoir footprint area would result in significant reduction in earthwork volume (and significant reduction in cost), because the reservoir footprint can be reduced in the areas of deepest excavation (potentially providing greater percentage cost decrease than percentage reservoir footprint decrease).

The primary constraint to optimization of BCM-3 is its eastern margin is bounded by orchard lands. This prevents flexibility in configuration of the facility along its eastern side. Additionally, BCM-3 necessitates construction of a canal and inlet/outlet/canal infrastructure that extends westward from the GCID Canal to BCM-3. This constraint limits how much this alternative can be optimized with respect to minimizing impact to orchards. Conversely, if the inlet/outlet/canal infrastructure can be optimized to reduce its footprint area, this provides an opportunity to reduce the impact to orchards relative to what is currently shown and relative to TRR-East. Additionally, the footprint of this connector canal (i.e., the amount of orchard need) can be reduced substantially if relocated along the northern margin of the property; this configuration would involve constructing a new bridge just south of Noel Evan road to provide access to the orchard, and would need concurrence from the property owner.

PG&E transmission towers provide an additional constraint in the northwestern region of the reservoir. This constraint limits the how far the northern region can be extended west without modification (e.g. creation of an island or cutout).

Resilience to Changes

Relative to TRR-East, BCM-3 is more resilient to changes that may occur, with some exception. BCM-3, while bounded on its eastern margin by real estate constraints, is not bounded on its western margin by such constraints. There is flexibility to make changes in the configuration to accommodate changes that may arise (e.g., increased capacity need, avoiding certain locations of environmental concern, etc.). Portions of the western margins are not optimal for adjusting, since these areas would involve more significant excavation cuts. But changes can be made here without too much impact, and changes along other portions of the western margin would be even more economical.

The viability of BCM-3 – as currently configured or after optimization, even without any adverse changes that may occur – is dependent on the ability to obtain orchard lands for permanent need. If it turns out that these orchard lands are not able to be obtained, the BCM-3 configuration cannot be constructed unless another property just north (PG&E and others) or south (irrigated lands) can be obtained.

Environmental Impacts

The potential environmental impacts shown in Figure 4 are based on the provided environmental studies covering this area[12],[13]. Potential environmental impacts within the reservoir footprint include one large seasonal wetland, a relatively short length of ephemeral and intermittent stream, and a pond. These are potential habitat for fairy shrimp and for red-legged frogs. The inlet/outlet infrastructure, adjacent to the GCID Canal, is situated partly within area considered habitat for giant garter snake (proximity to canal). Some additional species also may be impacted (e.g., burrowing owls), and the pipeline corridor may impact additional ephemeral streams. The synopsis-level reporting in this TM should be verified by the project Environmental consultant.

DSOD Jurisdiction

As currently configured, BCM-3 is unlikely to be DSOD jurisdictional. The BCM-3 reservoir would be contained within an excavated area, separated hydraulically from the GCID Canal and lower areas via gates (as opposed to an embankment).

5.5 TRR-West

Real Estate

The TRR-West reservoir is west of the GCID canal, similar to BCM-1, but with a revised layout to respect a parcel boundary as requested by the property owner. The TRR-West pipeline alignment is shorter but follows the same alignment as those for TRR-East and BCM-1. Similar to BCM-1, TRR-West is situated along the southeastern portion of the topographic high separated from the GCID Canal by private orchard lands, with the majority of the reservoir facility area on rangeland. The plan area of TRR-West, similar to that of TRR-East, resides on at least two properties. Figure 5 shows the plan for TRR-West, including permanent land requirements in light green, TCE in dark green, and shaded area showing impact to private property near the GCID Canal. As planned, TRR-West would require approximately 22 acres of permanent land need on private property with orchards, primarily for the same infrastructure as TRR-East (inlet/outlet, gates, channels, etc.) needed to tie-in to the GCID Canal. A version of the TRR-West layout shown in Figure 5 was initially proposed by the property owners; the layout was modified (extended further west) considering topographical constraints, PG&E transmission tower constraints, and project requirements for reservoir storage capacity.

An area is likely needed for stockpiling excavated materials and another area for processing and staging (e.g., moisture control of excavated materials prior to placement as embankment fill). Processing and staging could

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[12] ICF (2020). TRR_LandCover_DRAFT_20190904.kmz, Attachment to email "RE: Sites HC: TRR Alternatives suggested EIS/EIR survey area" from Ellen Berryman to John Spranza, September 4, 2020.

[13] ICF (2020). "Memorandum: Preliminary biological constraints analyses for the 2020-2021 Sites Project Authority's geotechnical investigations of the proposed TRR and Dunnigan pipelines". June 29, 2020. Received by email September 25, 2020.

be performed in the interior of the proposed TRR-West site, but a significant stockpile area (approximately 20 acres) outside of the reservoir footprint will be required to manage the excavated material.

Construction Cost

Similar to BCM-1, apart from the area of the inlet/outlet/channel infrastructure, the geotechnical conditions for the TRR-West alternative likely avoid the adverse geotechnical conditions found at TRR-East, based on the assumed geology and the historic geotechnical data previously discussed. Therefore, we have not included ground improvement costs for TRR-West. However, relative to TRR-East and BCM-1, TRR-West involves more earthwork – about 8.5 MCY (1.2 MCY more than BCM-1) of excavation – as the additional northern constraint necessitates use of the higher topography western area. This volume of earthwork represents a significant construction cost.

The schedule impacts of TRR-West are short and flexible due to the potential for performing the excavation in phases as materials are needed for other parts of the project (e.g. at Golden Gate Dam if materials are suitable). Since TRR-West is mostly excavation driven, there are also fewer constraints on the order in which excavation is performed relative to the other features of the alternative.

Relative to TRR-East, TRR-West shortens the length of pipeline corridor needed to less than 2.5 miles because the PGP would be located at the western end of the reservoir.

There are a few options for access to the TRR-West site. Since TRR-West involves permanent need of some private property near the GCID Canal, one option for site access is through this property. A site access option that does not involve private property in this vicinity is access from the north, from Noel Evan road and southward via a TCE across rangeland private property. Another option for site access is from the west, from USBR property and eastward via a TCE across rangeland private property. Stockpiling and staging for TRR-West would occur (a) within the area of the TRR-West reservoir footprint, and (b) outside the TRR-West reservoir footprint within the parcels approved for use by the landowners.

Optimization Potential

TRR-West is considered to have a moderate degree of optimization potential. Similar to TRR-East, it is anticipated that the size of the TRR-West reservoir may be able to be reduced somewhat relative to the current feasibility-level configuration, because the required storage capacity may be able to be reduced. Ability to reduce reservoir footprint area depends in part on the elevation range of storage within the reservoir; full evaluation of required storage elevation range is yet to be performed. If the size of the reservoir can be reduced, there would be a corresponding reduction in earthwork and real estate requirements. Due to the sloping nature of the TRR-West reservoir site, a reduction in reservoir footprint area would result in significant reduction in earthwork volume and associated cost because the reservoir footprint can be reduced in the areas of deepest excavation (potentially providing greater percentage cost decrease than percentage reservoir footprint decrease).

Similar to BCM-1, the opportunity exists at TRR-West to optimize a tradeoff between length of pipelines vs. volume of excavation for open reservoir/channel leading to the PGP. At the reservoir's western end where the PGP will be sited, the reservoir has been narrowed and could be extended even further westward, further shortening the length of pipelines and power lines needed. As the reservoir/canal is extended westward, more significant excavation is needed; at some point, it becomes advantageous to terminate the open canal and switch to pipelines. This optimization also might be used to locate the PGP in a most-favorable location relative to the project and/or site conditions (e.g., various geologic conditions).

The primary constraints to optimization of TRR-West are (1) its eastern and southern margins are bounded by orchard lands, which prevents flexibility in configuration of the facility along these sides, and (2) its northern margin is bounded by a parcel boundary requested by the landowners. Additionally, TRR-West necessitates modification and permanent use of the canal on private property that extends westward from the GCID Canal. This constraint limits how much this alternative can be optimized with respect to minimizing impact to orchards.

Conversely, if the inlet/outlet/canal infrastructure can be optimized to reduce its footprint area, this provides an opportunity to reduce the impact to orchards relative to what is currently shown and relative to TRR.

PG&E transmission towers located within and adjacent to the TRR-West footprint provide an additional constraint. The reservoir would be designed to avoid alteration of these facilities, and so their presence inhibits some optimization of the reservoir configuration. Additional constraints posed by potential underground utilities were not considered in the development of the current TRR-West layout.

Resilience to Changes

Relative to TRR-East, TRR-West is somewhat more resilient to changes that may occur, with some exception. TRR-West, while bounded on its eastern, southern, and northern margins by real estate constraints, is not bounded on its western margin by real estate. There is flexibility to make changes in the configuration to accommodate changes that may arise (e.g., increased capacity need, avoiding certain locations of environmental concern, etc.). The western margin is not optimal for adjusting, since this area would involve significant excavation cuts.

However, as for TRR-East, the viability of TRR-West – as currently configured or after optimization, even without any adverse changes that may occur – is strictly dependent on the ability to obtain specific orchard property for permanent need. If it turns out that these private orchard lands are not able to be obtained, the TRR-West configuration will not be feasible.

Environmental Impacts

The potential environmental impacts shown in Figure 5 are based on the provided environmental studies covering this area[14],[15]. The southern margin of the reservoir footprint includes freshwater marsh, ephemeral stream, a canal, and a seasonal wetland, which are potential habitat for giant garter snakes, red-legged frogs, and fairy shrimp. Some additional species also may be impacted (e.g., San Joaquin spearscale and burrowing owls). The synopsis-level reporting in this TM should be verified by the project Environmental consultant.

DSOD Jurisdiction

As currently configured, TRR-West may or may not be DSOD jurisdictional. The TRR-West reservoir would be mostly contained within an excavated area, but it's southeastern margin would involve construction of an embankment, which might result in TRR-West being DSOD jurisdictional. It is likely that TRR-West can be configured to remove it from DSOD jurisdiction.

5.6 Stone Corral Creek (SCC)

Real Estate

SCC is located south of TRR-East along the western boundary of the GCID Canal, bounded by the Stone Corral Creek on the south and Danley Road on the west. The plan area of the SCC reservoir resides on one property, currently occupied by irrigated lands. Figure 6 shows the plan for SCC, including permanent land need in light purple, and TCE in dark purple. No orchards would be impacted by the SCC reservoir, though approximately 30 acres of orchard would be impacted for TCE to construction the pipelines. The pipelines could be rerouted to avoid orchard TCE, but this change would increase the pipeline corridor length.

As for TRR-East, TRR-West, and the BCM alternatives, an area roughly equal to the size of the SCC is likely needed for stockpiling fill materials for processing and staging (e.g., moisture control of excavated materials prior

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[14] ICF (2020). TRR_LandCover_DRAFT_20190904.kmz, Attachment to email "RE: Sites HC: TRR Alternatives suggested EIS/EIR survey area" from Ellen Berryman to John Spranza, September 4, 2020.

[15] ICF (2020). "Memorandum: Preliminary biological constraints analyses for the 2020-2021 Sites Project Authority's geotechnical investigations of the proposed TRR and Dunnigan pipelines". June 29, 2020. Received by email September 25, 2020.

to placement as embankment fill). Processing and staging could be performed in the interior of the proposed SCC site plus an additional roughly 20 acres.

Construction Cost

The geotechnical conditions for the SCC alternative are anticipated to be similar to the adverse geotechnical conditions found at TRR-East, based on the similar geologic and geomorphic setting between the two sites. While no site-specific geotechnical data is available for SCC, it is anticipated that a reservoir constructed at this location would incur expensive CDSM costs similar to those for TRR-East. Relative to TRR-East, SCC also would involve more earthwork as compared to TRR-East due to the realignment of the GCID Canal that is necessary at the location of the reservoir.

Also, significant work is required along the entire length of the GCID Canal from Funks Creek to the SCC location, to increase the capacity of the canal. Along this length of the canal, the capacity of the canal (currently on the order of 1200 cfs) needs to be increased to meet the requirements of the project (1800 cfs) and for the SCC alternative to be equivalent to the TRR-East alternative. This increase in capacity along the GCID Canal represents added construction cost, as well as significant real estate needs and environmental impacts (e.g., entire length is giant garter snake habitat).

The schedule impact to performing CDSM is long and constrained due to the specific order of construction required and the time to implement ground improvement. No other construction work can likely start before CDSM is implemented and based on the volumes estimated for improvement, the CDSM effort alone could take between 1 and 2 years to complete (e.g. the Perris Dam project involving CDSM for the California Department of Water Resources lasted 6 months and improvement approximately half of the volume anticipated for this project).

Relative to TRR-East, SCC increases the length of pipeline corridor needed to approximately 6 miles.

Groundwater elevations in the vicinity of the SCC are expected to be similar to those at TRR-East (a few feet below ground surface), which will likely lead to a dewatering requirement for excavations. There are a few options for access to the SCC site. The primary access option is from Danley road along the western boundary. Site access may also be available from McDermott road on the east across farmland private property. Stockpiling and staging for SCC would occur (a) within the area of the SCC reservoir footprint, and (b) adjacent to the eastern margin of the SCC reservoir footprint, on the same property as the reservoir.

Optimization Potential

SCC is considered to have a moderate degree of optimization potential. Similar to TRR, it is anticipated that the size of the SCC reservoir may be able to be reduced somewhat relative to the current feasibility-level configuration, because the required storage capacity may be able to be reduced. Ability to reduce reservoir footprint area depends in part on the elevation range of storage within the reservoir; full evaluation of required storage elevation range is yet to be performed. If the size of the reservoir can be reduced, there would be a corresponding reduction in earthwork and real estate requirements. Due to the relatively level nature of the SCC reservoir site, a reduction in reservoir footprint area would not result in significant reduction in earthwork volume; however, reduction in reservoir footprint area would result in reduction in ground improvement area and costs.

For SCC, there is opportunity to shorten the pipeline corridor length by extending the reservoir into a channel leading to the PGP. However, unlike for the BCM alternatives, this conversion of pipeline corridor into canal would impact agricultural lands instead of rangeland, i.e., would exchange TCE of agricultural lands for permanent need instead for those lands. Therefore, this potential construction cost optimization is less likely to be leveraged for SCC than for the BCM alternatives.

The primary constraints to optimization of SCC are its western margin is bounded by Danley road, its southern margin is bounded by a creek and orchard land, and its northern margin is bounded by other private property. This prevents flexibility in configuration of the facility along its western, southern, and northern sides. Additionally, SCC necessitates relocation of the GCID Canal where it intersects the reservoir, which constrains how the facility can be configured.

Resilience to Changes

Relative to TRR-East, SCC is somewhat more resilient to changes that may occur. SCC, while bounded on its western, southern, and northern margins by real estate constraints, is not bounded on its eastern margin by such constraints. However, the current configuration requires relocation of the GCID Canal, which limits the flexibility of the eastern margin.

As for TRR-East, the viability of SCC – as currently configured or after optimization, even without any adverse changes that may occur – is dependent on the ability to obtain specific property for permanent need. If it turns out that these private lands are not able to be obtained, the SCC configuration cannot be constructed unless other adjacent lands can be obtained.

Environmental Impacts

The potential environmental impacts shown in Figure 6 are based on the provided environmental studies covering this area[16],[17]. The reservoir footprint has potential environmental impacts to rice fields, canals, and ditches, which are potential habitat for giant garter snakes. According to the provided studies, the pipeline corridor has potential environmental impacts to ditches and canals (giant garter snake habitat), intermittent streams (red-legged frog habitat), and seasonal wetlands (fairy shrimp habitat). Some additional species also may be impacted (e.g., tricolored blackbirds and San Joaquin pocket mouse). The synopsis-level reporting in this TM should be verified by the project Environmental consultant.

DSOD Jurisdiction

As currently configured, SCC is expected to be DSOD jurisdictional.

6.0 Other Considerations and Recommendations

Two of the alternative locations – identified as BCM-2 and BCM-3 – result in significantly lower project cost than the currently planned TRR-East location (based on the level of effort provided for this evaluation). BCM-1, TRR-West, and SCC result in higher additional costs than TRR-East (but may offer other advantages). Principally, the expensive CDSM ground improvement that is needed at TRR would be avoided at the BCM locations, and excavation at the BCMs and TRR-West may introduce flexibility in the overall construction schedule of the project. The requirement to perform CDSM at TRR-East and SCC will likely have implications on the overall project schedule both in terms of overall length and predictability. There may also be additional cost savings at some of these locations, associated with pipeline length, real estate, etc.

It is likely that the TRR-West and one or more of the BCM locations are much more resilient (i.e., less prone to risk) with respect to project changes than the TRR-East location. TRR-East is tightly constrained by real estate requirements; changes to hydraulic design needs could result in significant real estate conflicts. TRR-West and one or more of the BCM alternatives are likely much more flexible in configuration and constraints and could accommodate changes to hydraulic requirements or other changes that might alter the capacity requirements.

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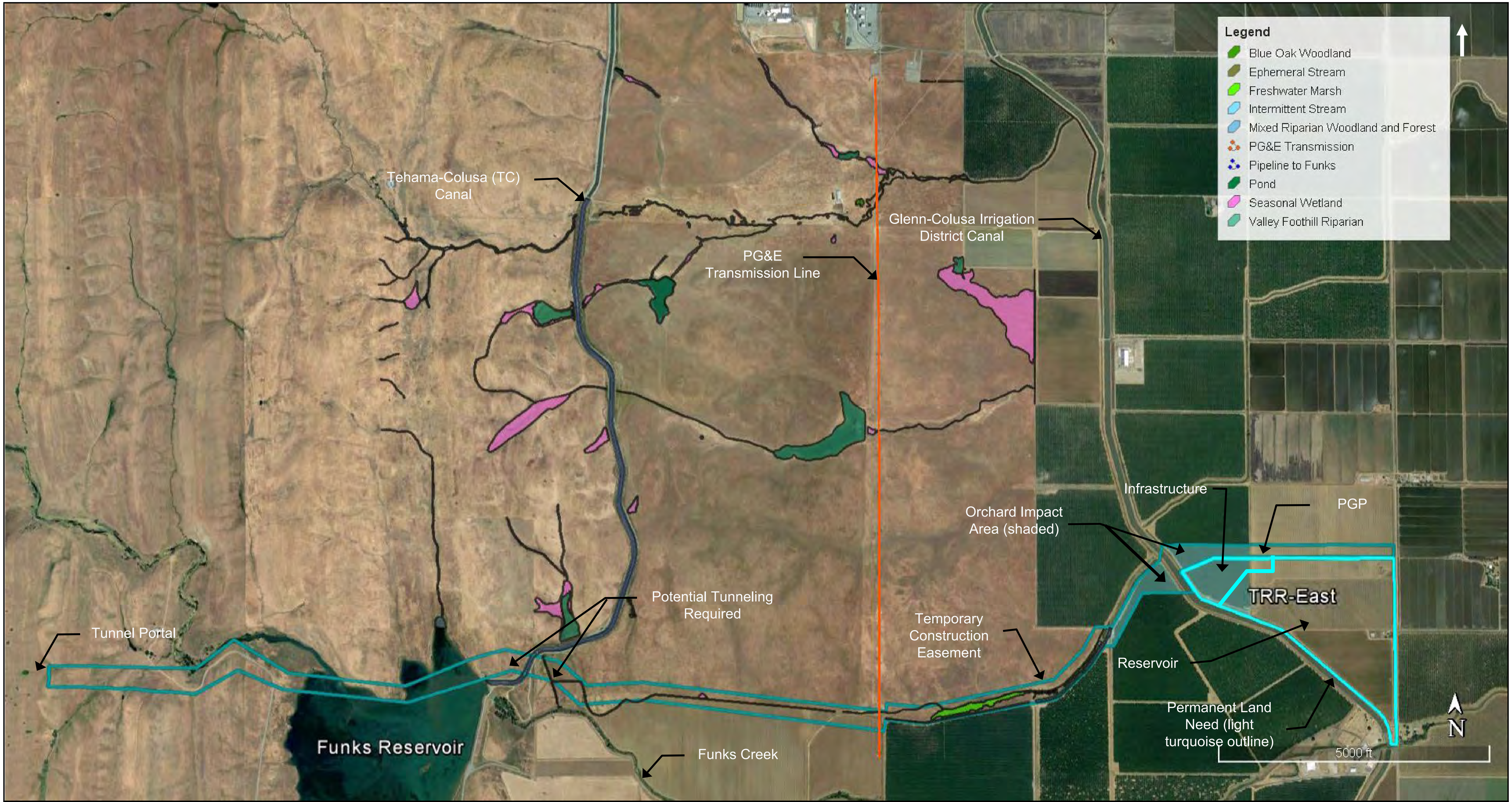
[16] ICF (2020). StoneCorralCreekTRR_LandCover_DRAFT_20190924.kmz, Attachment to email "Stone Corral Creek TRR Potential Location: Sites Reservoir – Bio and Cultural", from Monique Briard to Pete Rude, September 25, 2020.

[17] ICF (2020). "Memorandum: Preliminary biological constraints analyses for the 2020-2021 Sites Project Authority's geotechnical investigations of the proposed TRR and Dunnigan pipelines". June 29, 2020. Received by email September 25, 2020.



Notes:
1. Linework boundaries approximate and should be interpreted only at the scale shown.
2. Base Map Source : Google Earth Pro, © 2016.

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TRR-East Footprint

Sites Reservoir Project
Sites, California

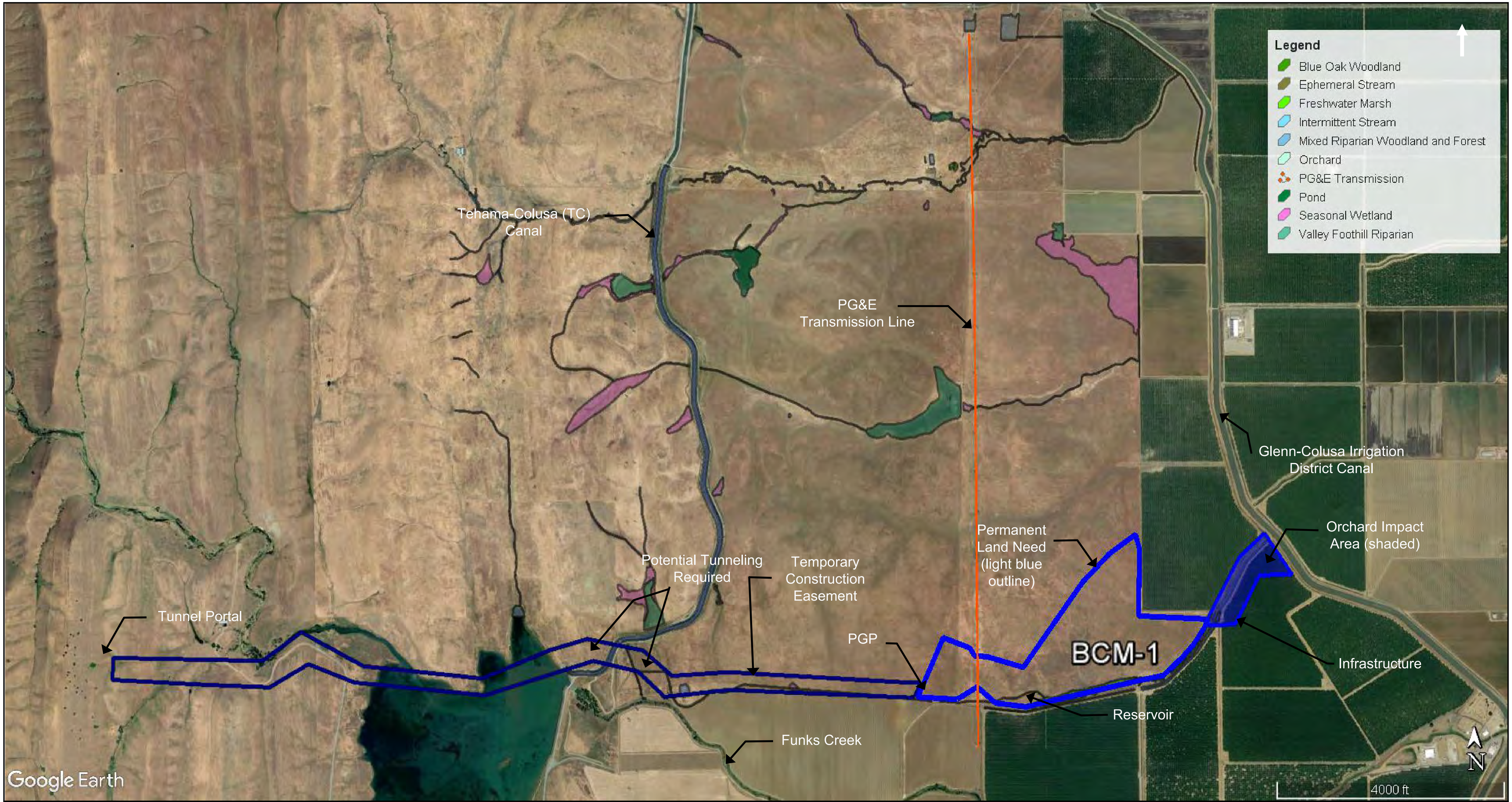
Geosyntec
consultants

Davis, CA | November 2020

Figure

1

P:\PRJ2003Geo\Jacobs\WG2877 - Sites Reservoir\06. Deliverables\Working Versions-Delete when finalized\20200619 TRR Alternatives



Notes:

1. Linework boundaries approximate and should be interpreted only at the scale shown.
2. Base Map Source : Google Earth Pro, © 2016.

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BCM-1 Footprint

Sites Reservoir Project
Sites, California

Geosyntec
consultants

Davis, CA

November 2020

Figure

2

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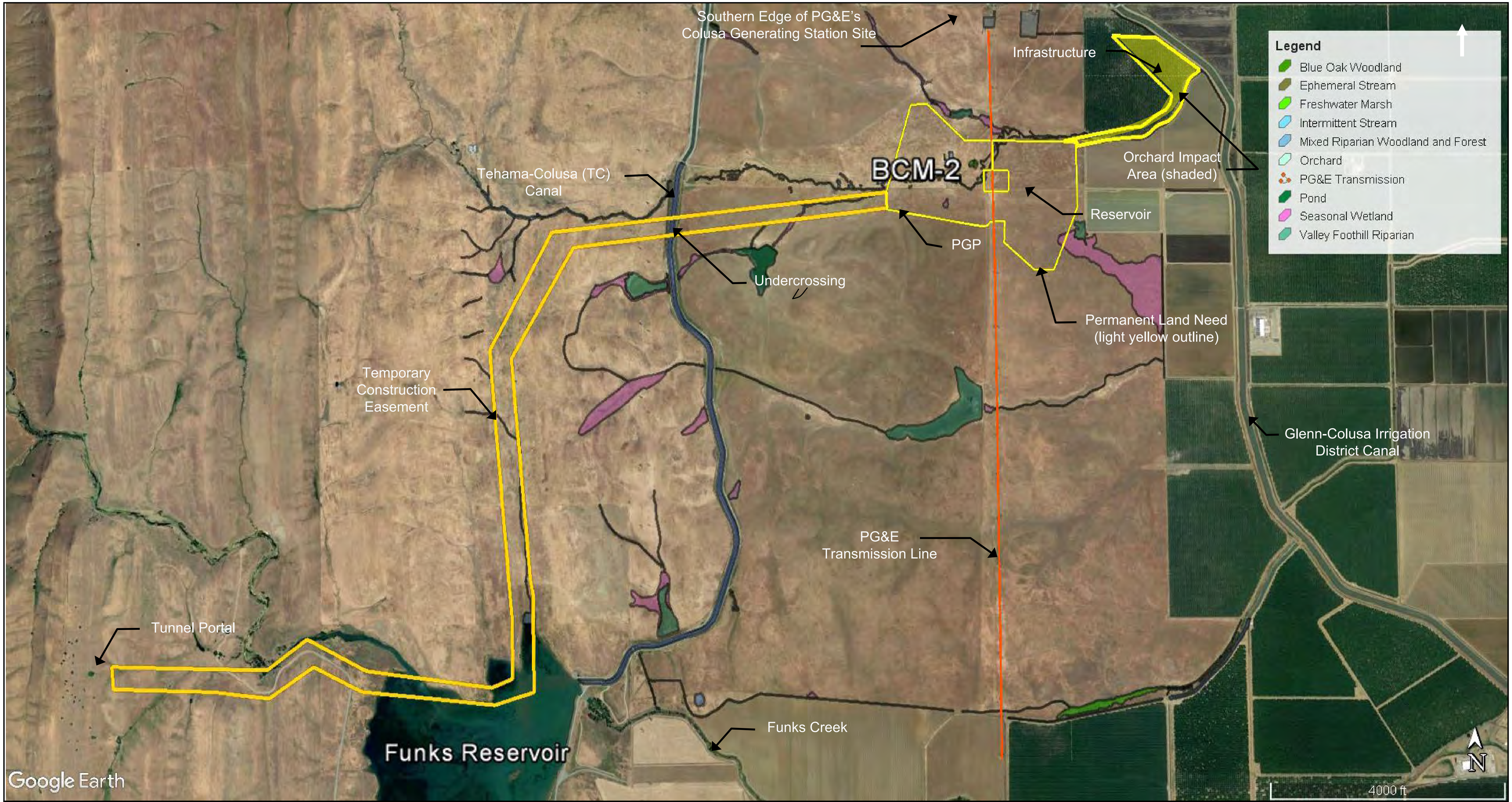

Notes:
1. Linework boundaries approximate and should be interpreted only at the scale shown.
2. Base Map Source : Google Earth Pro, © 2016.

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BCM-2 Footprint

Sites Reservoir Project
Sites, California

Geosyntec consultants

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Figure

3

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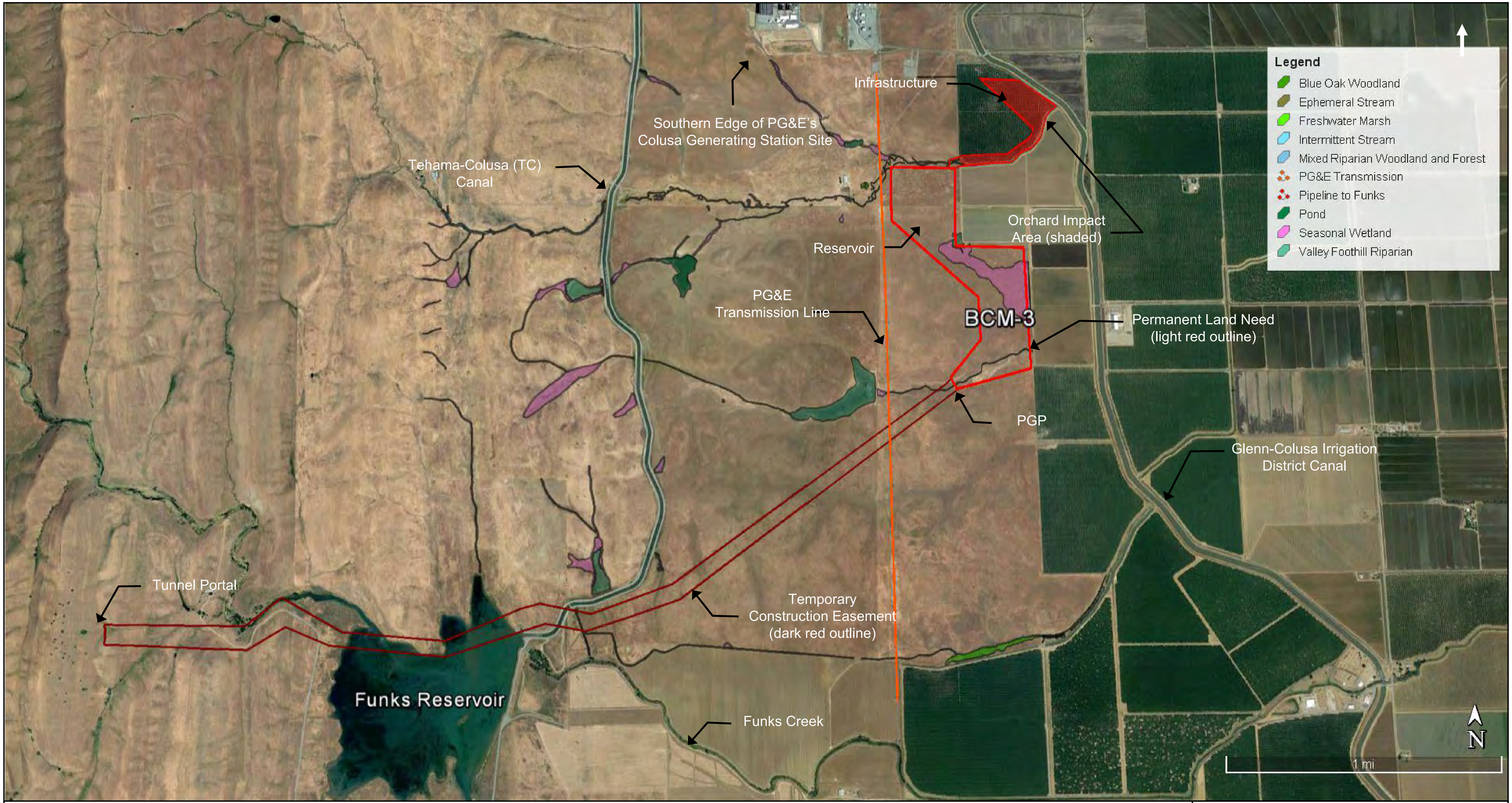

Notes:
1. Linework boundaries approximate and should be interpreted only at the scale shown.
2. Base Map Source : Google Earth Pro, © 2016.

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BCM-3 Footprint

Sites Reservoir Project
Sites, California

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November 2020

Figure

4

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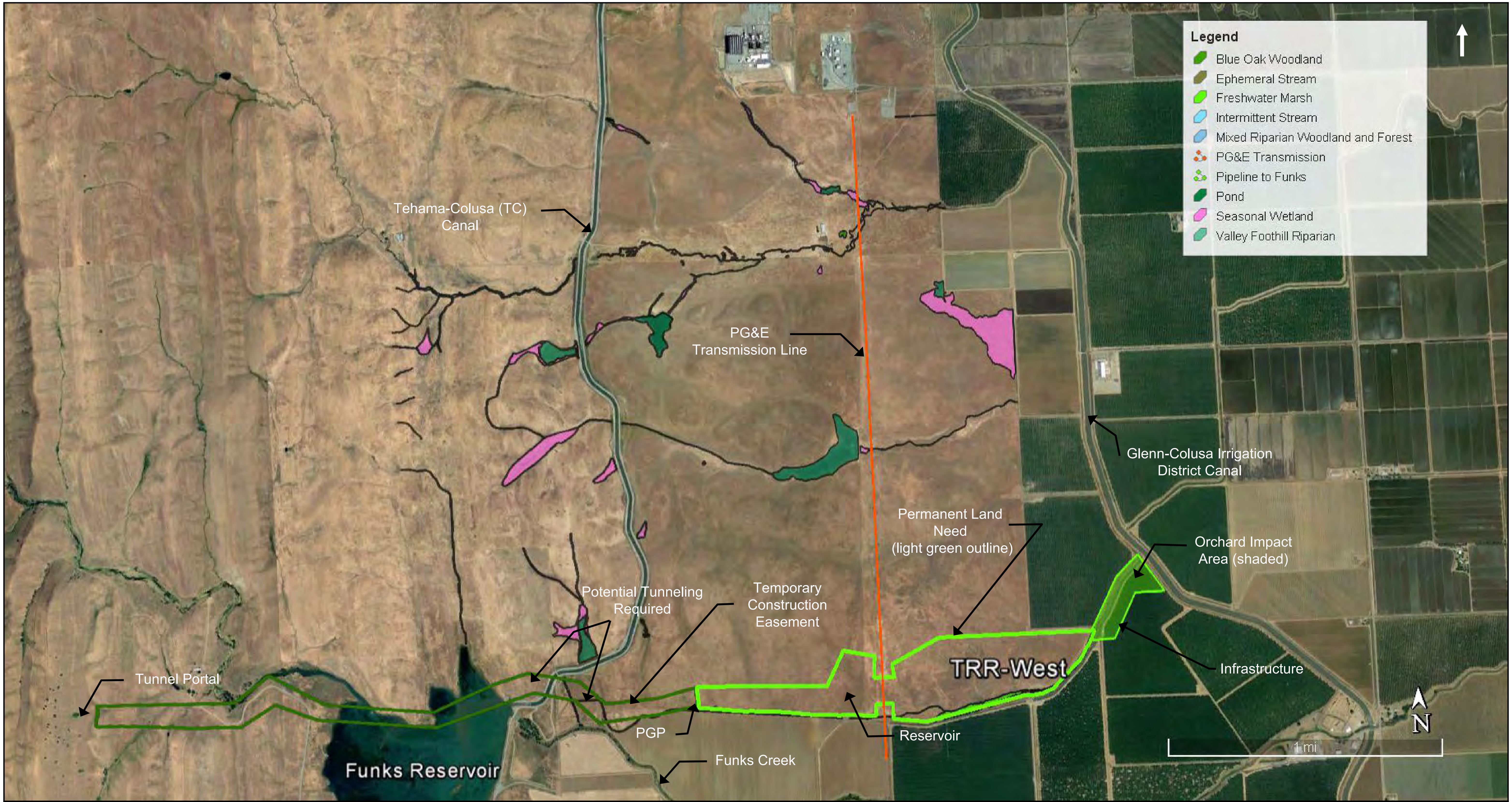

Notes:
1. Linework boundaries approximate and should be interpreted only at the scale shown.
2. Base Map Source : Google Earth Pro, © 2016.
3. Reservoir footprint configured to work around and maintain offsets from PG&E transmission towers.
4. Potential underground utilities were not considered in the development of the reservoir layout.

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TRR-West Footprint

Sites Reservoir Project
Sites, California

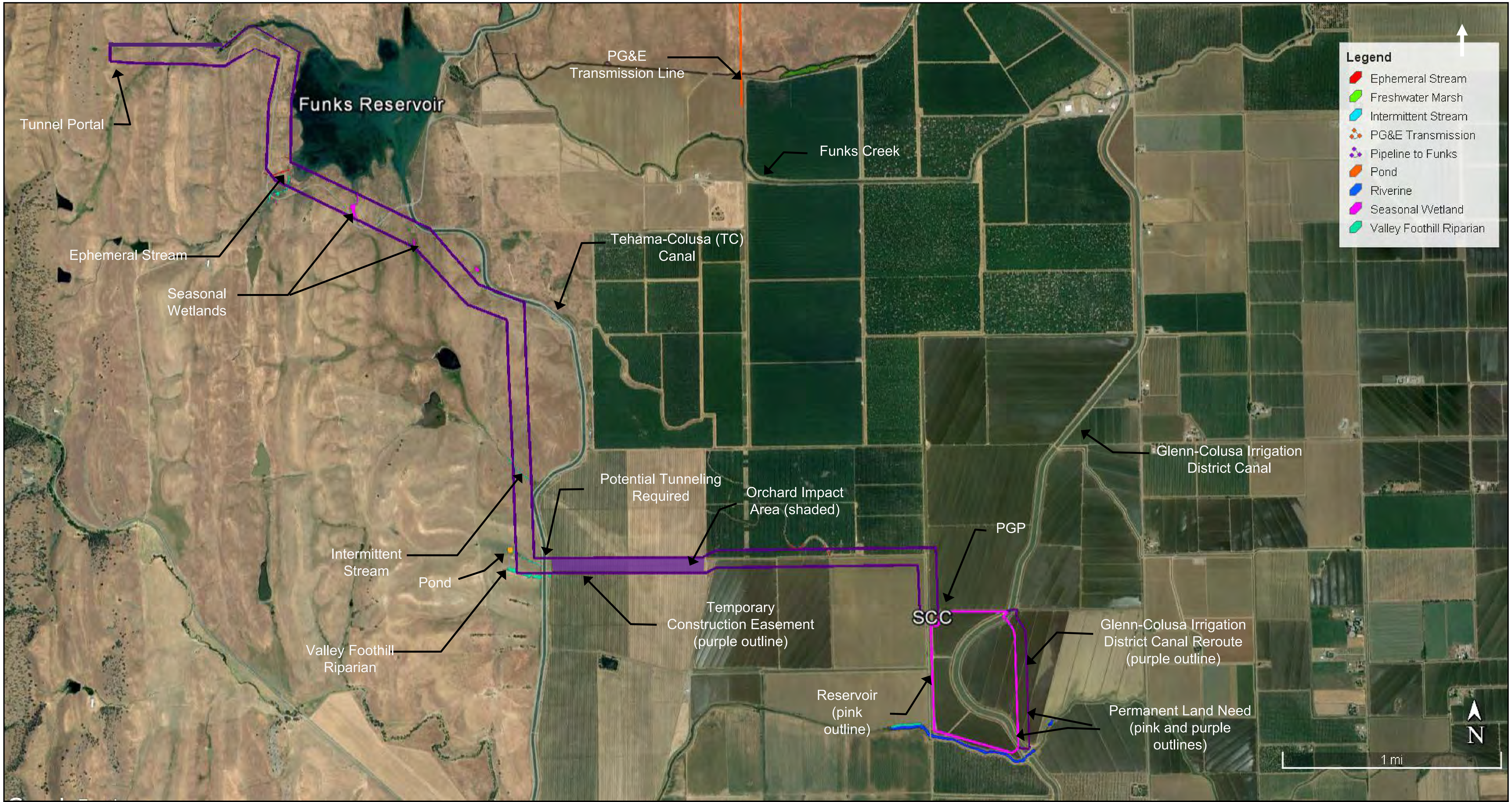
Geosyntec
consultants

Davis, CA
November 2020

Figure

5

P:\PRJ2003Geo\Jacobs\WG2877 - Sites Reservoir\06. Deliverables\Working Versions-Delete when finalized\20200619 TRR Alternatives



Notes:
1. Linework boundaries approximate and should be interpreted only at the scale shown.
2. Base Map Source : Google Earth Pro, © 2016.

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SCC Footprint

Sites Reservoir Project
Sites, California

Geosyntec consultants

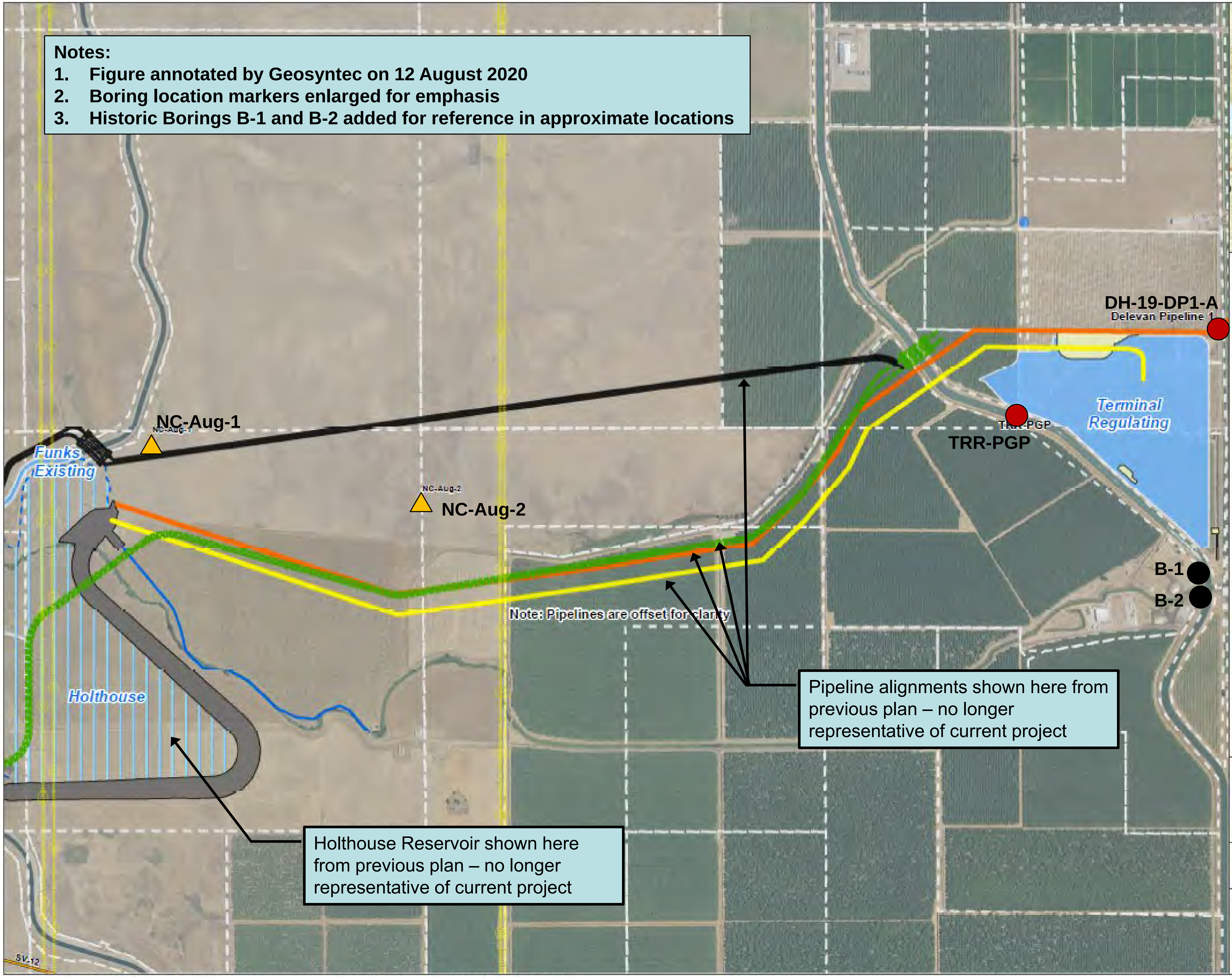
Davis, CA | November 2020

Figure

6

ATTACHMENT A

Geotechnical Boring Locations and Logs

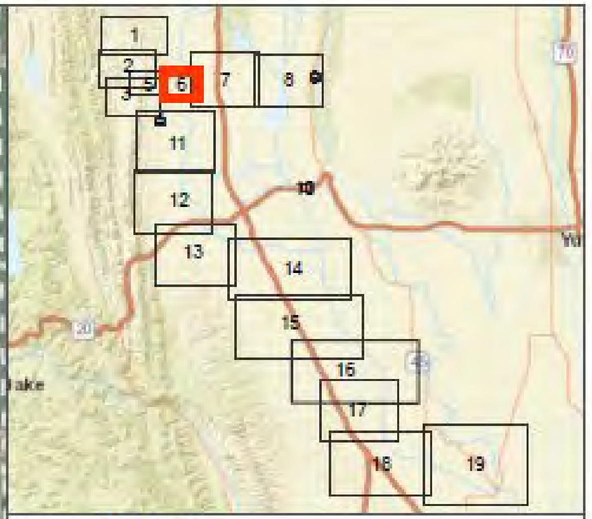


Notes:
1. Figure annotated by Geosyntec on 12 August 2020
2. Boring location markers enlarged for emphasis
3. Historic Borings B-1 and B-2 added for reference in approximate locations

Pipeline alignments shown here from previous plan – no longer representative of current project

Holthouse Reservoir shown here from previous plan – no longer representative of current project

Note: Pipelines are offset for clarity



LEGEND
- ● NODOS Explorations Surveyed
- ▲ Historic Boring Locations
- — Historic Geophysic Survey Lines
- ● Water Wells
- — Overhead T-Line
- — Delevan Pipeline
- — Fletcher Pipeline North
- — Fletcher Pipeline South
- — Funks Creek Pipeline
- — TRR Pipeline
- ■ Dam
- ☐ Intake Outlet
- Reservoir
- Holthouse
- Terminal Regulating

DRAFT

DATA SOURCES: Historic Borings/Geophysic Survey Lines -DWR (1969-2010), Proposed Borings/Geophysic Survey Lines - ICF (2019), Fugro (2019), Faults - WLA (2002), Water Wells - DWR (2019), Gas Wells - CDC (2019), Substations, Transmission Lines - CEC (2019), Flowlines - NHD (2019), Other Data - HDR (2019).

DISCLAIMER: This exhibit is preliminary and is subject to change. All locations are approximate.

MAP DATE: 4.05.2020

GEOTECHNICAL BORINGS AND ASSOCIATED DATA - OPTION 1
SITES RESERVOIR

N

1,240
Feet

Sites

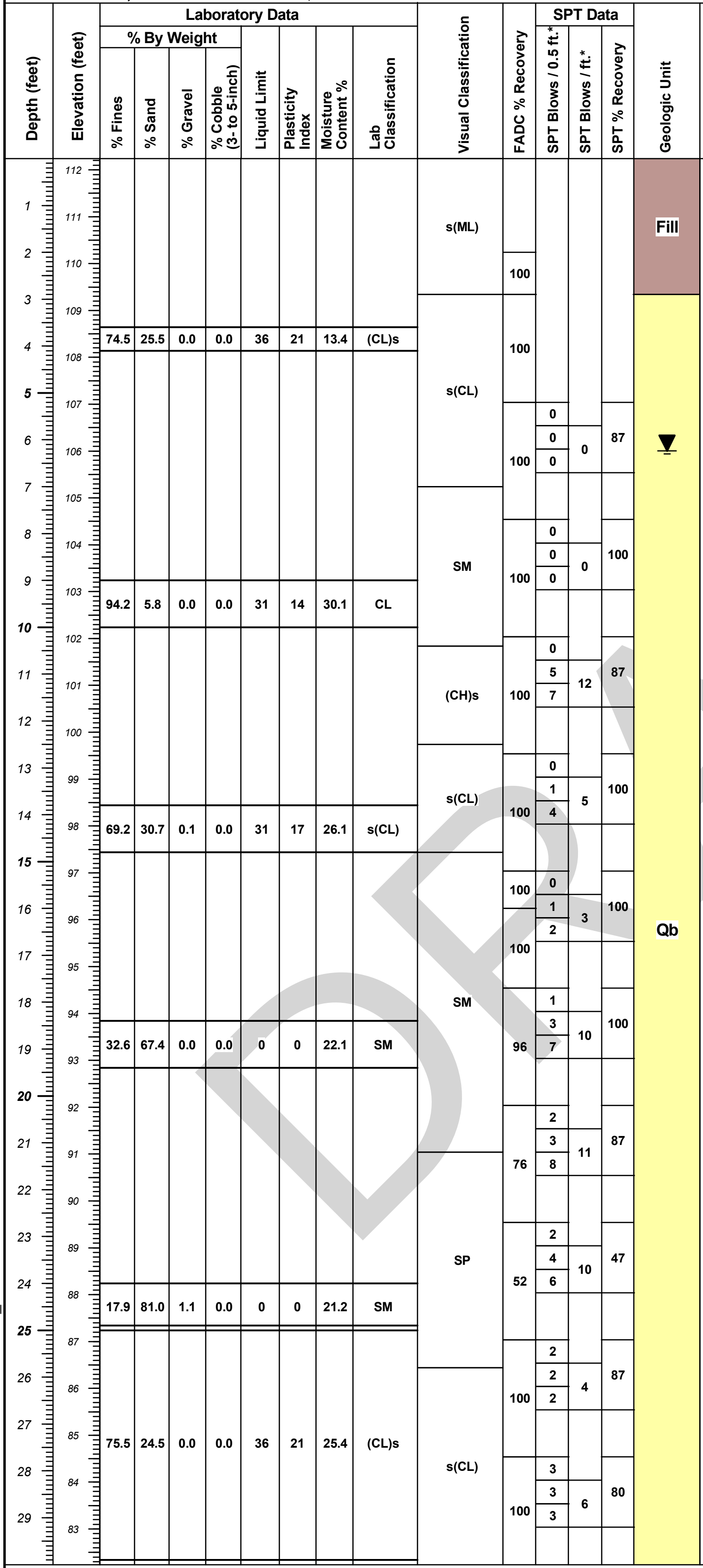
GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

SHEET 1 OF 6

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:



Laboratory Data

% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
74.5	25.5	0.0	0.0	36	21	13.4	(CL)s
94.2	5.8	0.0	0.0	31	14	30.1	CL
69.2	30.7	0.1	0.0	31	17	26.1	s(CL)
32.6	67.4	0.0	0.0	0	0	22.1	SM
17.9	81.0	1.1	0.0	0	0	21.2	SM
75.5	24.5	0.0	0.0	36	21	25.4	(CL)s

Visual Classification: s(ML), s(CL), SM, (CH)s, s(CL), SM, SP, s(CL)

FADC % Recovery: 100, 100, 100, 100, 100, 100, 100, 100, 100, 96, 76, 52, 100, 100

SPT Data

SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
0 0 0	0	87
0 0 0	0	100
0 5 7	12	87
0 1 4	5	100
0 1 2	3	100
1 3 7	10	100
2 3 8	11	87
2 4 6	10	47
2 2 2	4	87
3 3 3	6	80

Visual Classification and Physical Condition

0.0 to 2.9 ft.
Fill

0.0 to 2.0 ft.: FAPB. Logged auger flight drill cuttings.

0.0 to 2.9 ft.: SANDY SILT, s(ML):
About 70% fines with low plasticity, high to very high dry strength, low toughness, slow dilatancy; about 30% predominantly fine with medium and coarse, hard, angular to subangular sand; maximum size, coarse sand; soft consistency; dry; brown; no reaction with HCl.

2.9 to 100.2 ft.
Quaternary: Basin Deposits, Qb

2.9 to 7.0 ft.: SANDY LEAN CLAY, s(CL):
About 60% fines with medium plasticity, very high dry strength, medium toughness, no dilatancy; about 40% predominantly fine with medium sand; maximum size, medium sand; firm consistency; moist; brown; no reaction with HCl.

7.0 to 10.4 ft.: SILTY SAND, SM:
About 60% fine sand; about 40% non-plastic fines with very high dry strength, slow dilatancy; maximum size, fine sand; wet; brown; no reaction with HCl.

10.4 to 12.5 ft.: FAT CLAY WITH SAND, (CH)s:
About 80% fines with high plasticity, very high dry strength, high toughness, no dilatancy; about 20% predominantly fine with trace medium sand; maximum size, medium sand; firm to hard consistency; moist; brown; upper contact difficult to discern due to swelling of material in sampler; no reaction with HCl.

12.5 to 14.8 ft.: SANDY LEAN CLAY, s(CL):
About 55% fines with medium to high plasticity, high to very high dry strength, medium toughness, no to slow dilatancy; about 45% predominantly fine with medium sand; maximum size, medium sand; soft to firm consistency; moist to wet; brown; grades coarser with depth from 14.0 to 14.8 ft.; no reaction with HCl.

14.8 to 21.2 ft.: SILTY SAND, SM:
About 85% predominantly fine to medium with trace coarse, hard, subangular to subrounded sand; about 15% non-plastic fines with no dry strength, rapid dilatancy; trace fine, hard, subrounded gravel; maximum size, 3/4 inch; wet; brown; no reaction with HCl.

21.2 to 25.8 ft.: POORLY GRADED SAND, SP:
About 95% predominantly fine to medium with trace coarse, hard, angular to subangular sand; about 5% fines; maximum size, coarse sand; wet; brown; no reaction with HCl.

25.8 to 30.2 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, very high dry strength, medium toughness, no dilatancy; about 30% predominantly fine with medium sand; maximum size, medium sand; firm consistency; moist; brown; grades finer with depth; no reaction with HCl.

30.2 to 36.8 ft.: SANDY ELASTIC SILT, s(MH):
About 65% fines with medium plasticity, very high dry strength, low toughness, no dilatancy; about 35% fine sand; maximum size, fine sand; soft consistency; moist to wet; light brown ; sticky; sand is fine to very fine; grades coarser with depth; no reaction with HCl.

36.8 to 41.1 ft.: SILTY SAND, SM:
About 65% predominantly fine to medium with trace coarse, hard, angular to subangular sand; about 35% non-plastic fines with high dry strength, slow dilatancy; maximum size, coarse sand; wet; brown; grades coarser with depth; no reaction with HCl.

41.1 to 45.2 ft.: SILTY SAND WITH GRAVEL, (SM)g:
About 40% fine, hard, subrounded gravel; 40% fine to coarse, hard, subangular to subrounded sand; about 20% non-plastic fines; maximum size, 1/2 inch; moist to wet; brown; gravels are concentrated in thin layers (about 0.1 to 0.3 inches thick); no reaction with HCl.

45.2 to 45.5 ft.: POORLY GRADED GRAVEL WITH SILT AND SAND, (GP-GM)s:
About 60% fine, hard, subrounded gravel; about 30% fine to coarse, hard, subangular to subrounded sand; about 10% fines; maximum size, 1/2 inch; moist to wet; brown; no reaction with HCl.

45.5 to 51.5 ft.: SANDY LEAN CLAY, s(CL):
About 65% fines with medium plasticity, high dry strength, low toughness, slow

Geologic Units

Roadbase	
Fill	
Qb	Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

Depth (feet): 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59

Elevation (feet): 82, 81, 80, 79, 78, 77, 76, 75, 74, 73, 72, 71, 70, 69, 68, 67, 66, 65, 64, 63, 62, 61, 60, 59, 58, 57, 56, 55, 54, 53

Laboratory Data

% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
88.8	11.2	0.0	0.0	31	15	29.9	CL
20.3	48.6	31.1	0.0	46	26	18.2	(SC)g
79.8	17.5	2.7	0.0	28	8	25.3	(CL)s
67.0	31.3	1.7	0.0	27	11	23.1	s(CL)

Visual Classification: s(MH), SM, (SM)g, (GP-GM)s, s(CL), SC, (SC)g

FADC % Recovery	SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
100 100	0 0 0	0	100
100	0 0 3	3	100
100	0 2 4	6	100
72	0 3 4	7	100
48	2 7 9	16	100
96	3 4 9	13	73
100	4 4 4	8	60
80	3 4 5	9	93
96	4 4 6	10	100
100	2 4 5	9	100
100	2 4 6	10	100
100	7 13 21	34	100

Geologic Unit: Qb

Visual Classification and Physical Condition

dilatancy; about 35% predominantly fine with medium and trace coarse, hard, angular to subangular sand; maximum size, coarse sand; soft to firm consistency; moist; mottled light brown with gray; grades coarser with depth; no reaction with HCl.

51.5 to 58.2 ft.: CLAYEY SAND, SC:
About 55% fine to coarse, hard, angular to subangular sand; about 45% fines with medium plasticity, high dry strength, medium toughness, no to slow dilatancy; maximum size, coarse sand; moist; mottled brown with gray; no reaction with HCl.

58.2 to 60.9 ft.: CLAYEY SAND WITH GRAVEL, (SC)g:
About 50% fine to coarse, hard, angular to subangular sand; about 35% fines with medium plasticity, high dry strength, medium toughness, no to slow dilatancy; about 15% fine, hard, subangular to subrounded gravel; moist; brown with gray, orange, and black; no reaction with HCl.

60.9 to 63.0 ft. NO RECOVERY

63.0 to 64.1 ft.: SILTY SAND, SM:
About 80% fine sand; about 20% fines with no to low plasticity, rapid dilatancy; trace fine, hard, subrounded gravel; maximum size, 3/8 inch; wet; mottled predominantly brown with minor pale green-gray and red-brown; no reaction with HCl.

64.1 to 64.8 ft.: CLAYEY SAND WITH GRAVEL, (SC)g:
About 50% fine to coarse, hard, angular to subangular sand; about 35% fines with medium plasticity, high dry strength, medium toughness, no to slow dilatancy; about 15% fine, hard, subangular to subrounded gravel; maximum size, 3/8 inch; moist; brown with gray, orange, and black; no reaction with HCl.

64.8 to 66.5 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with low to medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 30 to 35% fine sand; trace fine, hard, angular to subangular gravel; maximum size, 5/8 inch; soft to firm consistency; moist; mottled brown, green-gray, red-brown (FeOx), and minor black (MnO2); gravels have strong reaction with HCl; no reaction with HCl.

66.5 to 67.1 ft.: LEAN CLAY WITH SAND, (CL)s:
About 80 to 85% fines with low to medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 15 to 20% fine sand; trace fine, hard, angular to subangular gravel; maximum size, 5/8 inch; soft to firm consistency; moist; mottled brown, green-gray, red-brown (FeOx), and minor black (MnO2); no reaction with HCl.

67.1 to 70.2 ft.: LEAN CLAY WITH SAND TO SANDY LEAN CLAY, (CL)s / s(CL):
About 65 to 85% fines with low to medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 15 to 35% fine sand; trace fine, hard, angular to subangular gravel; maximum size, 5/8 inch; soft to firm consistency; moist; mottled brown, green-gray, red-brown (FeOx), and minor black (MnO2); alternating layers of (CL)s and s(CL); difficult to discern layer contacts; interbed from 68.1 to 68.3 feet consisting of calcareous cemented, fine to coarse gravel size, moderately hard, angular fragments (strong reaction with HCl; maximum size, 1-inch) ; no reaction with HCl.

70.2 to 70.7 ft.: SANDY SILT TO SILTY SAND, s(ML) / SM:
About 50% fine sand; about 50% non-plastic fines with rapid dilatancy; maximum size, fine sand; soft consistency; wet; mottled brown, red-brown, and green-gray; no reaction with HCl.

70.7 to 70.8 ft.: Interbed of calcareous cemented, fine to coarse gravel, moderately hard, angular, strong reaction with HCl.

70.8 to 74.7 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 85 to 90% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 10 to 15% fine with trace coarse, moderately hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

74.7 to 75.2 ft. NO RECOVERY

75.2 to 75.5 ft.: SILTY SAND, SM:
About 80% fine sand; about 20% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; wet; brown; no reaction with HCl.

75.5 to 76.5 ft.: Gradational contact with next layer.

Geologic Units

Roadbase	
Fill	
Qb	Quaternary: Basin Deposits

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

Depth (feet): 61–89; Elevation (feet): 52–23; Geologic Unit: Qb

Laboratory Data

% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
29.8	69.5	0.7	0.0	0	0	21.1	SM
89.1	10.1	0.8	0.0	31	16	19.9	CL
50.5	20.7	28.8	0.0	39	23	19.8	g(CL)s

Visual Classification: (SC)g; NR; SM; (SC)g; s(CL); (CL)s; (CL)s / s(CL); s(ML) / SM; CL / (CL)s; NR; SM; (CL)s; s(ML) / SM; (CL)s; NR; s(CL) / SC; CL; g(CL)s; CL; (CL)s; CL; s(CL); (CL)s

SPT Data

FADC % Recovery	SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
43	23 37 40	77	100
95	5 7 16	23	80
100	8 11 13	24	100
92	14 13 15	28	100
100	3 6 14	20	100
80	7 12 16	28	100
100	3 6 10	16	100
80	5 14 15	29	100
100	9 21 39	60	100
100	11 13 17	30	100
100	10 15 22	37	100
100	8 11 13	24	100

Visual Classification and Physical Condition

76.5 to 77.7 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15 to 25% predominantly fine with trace coarse, moderately hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

77.7 to 78.1 ft.: SANDY SILT TO SILTY SAND, s(ML) / SM:
About 50% fine sand; about 50% non-plastic fines with rapid dilatancy; maximum size, fine sand; soft consistency; wet; mottled brown, red-brown, and green-gray; no reaction with HCl.

78.1 to 79.7 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 80% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 20 to 25% predominantly fine with trace coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

79.7 to 80.2 ft. NO RECOVERY

80.2 to 80.6 ft.: SANDY LEAN CLAY TO CLAYEY SAND, s(CL) / SC:
About 50% fine with trace coarse, subangular, moderately hard sand (strong reaction with HCl); about 50% fines with medium plasticity, high dry strength, low to medium toughness, no to slow dilatancy; maximum size, fine sand; soft to firm consistency; moist to wet; mottled brown, green-gray, and red-brown (FeOx); no reaction with HCl in body of soil.

80.6 to 81.0 ft.: LEAN CLAY, CL:
About 90% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 10% fine sand; maximum size, fine sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil.

81.0 to 83.4 ft.: GRAVELLY LEAN CLAY WITH SAND, g(CL)s:
About 65% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 20% fine to coarse, moderately hard, subangular gravel; about 15% fine to coarse, moderately hard, subangular sand; maximum size, 2.5 inches; firm to hard consistency; moist to wet; mottled brown with minor green-gray and red-brown (FeOx); no reaction with HCl in body of soil, strong reaction with HCL in gravels.

83.4 to 84.6 ft.: LEAN CLAY, CL:
About 90 to 95% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 5 to 10% coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

84.6 to 85.4 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 80% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 20 to 25% predominantly fine with trace coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

85.4 to 87.7 ft.: LEAN CLAY, CL:
About 90 to 95% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 5 to 10% coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

87.7 to 89.7 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine with trace coarse, hard, subangular sand; maximum size, coarse sand; firm consistency; moist; mottled brown with minor gray-green; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

89.7 to 92.7 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% fine with trace coarse, moderately hard, subangular sand; trace fine, moderately hard, subangular gravel (strong reaction with HCl); maximum size, 1/2 inch; firm to hard consistency; moist; mottled brown with minor gray-green; no reaction with HCl in body of soil.

92.7 to 93.6 ft.: SANDY LEAN CLAY, s(CL):

Geologic Units

Roadbase
Fill
Qb Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)	Laboratory Data								Visual Classification	FADC % Recovery	SPT Data			Geologic Unit
		% By Weight													
		% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification			SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	
91 92	22 21 20	88.7	10.0	1.3	0.0	46	28	19.1	CL	(CL)s	100	10 15 20	35	100	Qb
93 94	19 18									s(CL) SC (CL)s SC-SM	100	9 11 13	24	100	
95 96	17 16									CL / (CL)s	100	5 8 11	19	100	
97	15	97.1	2.9	0.0	0.0	49	30	27.6	CL						
98 99 100	14 13										100	4 9 11	20	100	

BOTTOM OF HOLE: T.D. 100.2 ft. (el. 12.0)

Visual Classification and Physical Condition

About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine with trace coarse, hard, subangular sand; maximum size, coarse sand; firm consistency; moist; mottled brown with minor gray-green; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

93.6 to 93.8 ft.: CLAYEY SAND, SC:
About 55% fine sand; about 45% fines with low to medium plasticity, medium to high dry strength, low toughness, slow dilatancy; maximum size, fine sand; moist to wet; brown ; no reaction with HCl.

93.8 to 94.4 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, 1/2 inch; firm to hard consistency; moist; mottled brown with minor gray-green; no reaction with HCl.

94.4 to 94.9 ft.: CLAYEY TO SILTY SAND, SC-SM:
About 70 to 80% predominantly fine to medium with trace coarse, hard, subangular to subrounded sand; about 20 to 30% fines with no to low plasticity, slow to rapid dilatancy; maximum size, coarse sand; moist to wet; brown; no reaction with HCl.

94.9 to 100.2 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 85 to 95% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 5 to 15% fine sand; firm to hard consistency; moist; mottled brown with minor gray-green; no reaction with HCl.

Geologic Units

- Roadbase
- Fill
- Qb Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

SHEET 5 OF 6

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

NOTES

PURPOSE OF HOLE:
To determine geotechnical properties of soil and depth to groundwater bearing soils (foundation conditions) for the proposed Delevan Pipeline. Data will be used to prepare feasibility level design of excavation slopes, a dewatering system, and structural support.

LOCATION:
About 0.25 miles north of the intersection between McDermott Road and Lenahan Road. Drill hole is located on the east shoulder of McDermott Road, about 16 feet from the edge of the road and about 8 feet from an unlined irrigation canal to the east (parallel to McDermott Road).

DRILLED BY:
Bureau of Reclamation: Pacific Northwest (PN) Region drill crew:
Rick Knott, driller
Austin Anderson, helper

DRILL RIG:
Central Mining Equipment (CME) 850 track mounted rig

DRILLING AND SAMPLING METHODS :
Drill hole was advanced using flight auger pilot bit (FAPB) and flight auger dry core (FADC) systems.

FAPB was to advance the lead auger between depths of 0.0 to 2.0 feet, which then allowed for FADC advancement. FAPB consisted of 4-1/4 inch i.d. by 8 inch o.d. hollow flight augers equipped with an 8.5-inch o.d. lead drill bit containing six carbide bullet bit teeth around the rim, and a 4-1/4 inch o.d. pilot bit with six carbide bullet teeth attached to NWJ rods and set inside the lead drill bit using. FAPB is a closed system and does not allow for collection of core.

FADC was used to advance the drill hole and collect soil core from 2.0 to 100.2 feet. FADC utilizes the same augers as FAPB. Instead of using a pilot bit, FADC uses a 3-3/8 inch i.d. by 4 inch o.d. by 5-foot-long split barrel dry coring system. NWJ rods were attached to a free spinning bearing assembly, which is attached to the FADC barrel. The bearing assembly allows for the FADC barrel to remain stationary while the augers rotate and advance the hole. The barrel's cutting shoe was 0.1 foot beyond the lead drill bit between 2.0 and 100.2 feet. A metal "basket" was used in the cutting shoe to assist with retention of core.

SPT was performed at 2.5 foot intervals (1-foot spacing between SPT intervals), unless otherwise noted. SPT consisted of a 1-3/8 inch i.d. by 2 inch o.d. by 2.0 foot long split spoon sampler driven 1.5 feet. Sampler was attached to NWJ rods that weigh about 57.5 lbs/10 ft. The sampler was advanced with an auto-hammer (140 pound weight with a 30 inch drop) at a rate of about 54 blows per minute (drill rig engine at about 1550 rpm). The auto-hammer energy was measured in companion hole DH-19-TRRPGP-B on November 1, 2019, resulting in a 87.4% energy correction. Blow count data presented in this log is uncorrected "N"-values.

DRILLING CONDITIONS:
0.0 to 5.2 ft.: FADC. Smooth and easy auger advancement.

5.2 to 6.7 ft.: SPT. No blow counts; sampler advanced under weight of the rods and hammer.

5.2 to 7.7 ft.: FADC. Very soft drilling. Wet zone observed from 6.3 to 6.6 feet. Driller noted lots of heave prior to drilling this interval.

7.7 to 9.2 ft.: SPT. No blow counts; sampler advanced under weight of the rods and hammer.

7.7 to 10.2 ft.: FADC. Smooth and easy auger advancement. Driller noted some heave.

10.2 to 11.7 ft.: SPT. Sampler sank about 0.4 feet before test. Driller noted about 0.2 ft. of heave.

10.2 to 12.7 ft.: FADC. Smooth and easy auger advancement. Driller noted heave.

12.7 to 14.2 ft.: SPT. Sampler sank about 0.7 feet before test. Driller noted about 0.3 ft. of heave.

12.7 to 16.0 ft.: FADC. Smooth and easy auger advancement. Ended the day with a short run (15.2 to 16.0 ft.) to set the augers flush with the ground surface (in accordance with the county encroachment permit).

16.0 to 17.7 ft.: FADC. Driller noted about 0.4 ft. of heave.

17.7 to 19.2 ft.: SPT was not performed due to about 1.5 ft. of heave. More water was added to the augers.

16.2 to 17.7 ft.: Pilot bit was used to cleanout heave down to 17.7 feet.

17.7 to 22.7 ft.: Smooth and easy auger advancement.

22.2 to 22.7 ft.: Pilot bit was used to clean out about 0.5 ft. of heave.

22.7 to 25.2 ft.: Smooth and easy auger advancement.

25.2 to 26.7 ft.: SPT. Driller noted 0.2 ft. of heave. Sampler sank through the 0.2 ft. of heave.

25.2 to 30.8 ft.: Smooth and easy auger advancement. Ended the day with a short run (30.2 to 30.8 ft.) to set the augers flush with the ground surface.

30.8 to 40.2 ft.: Smooth and easy auger advancement.

40.2 to 42.7 ft.: Driller notes "scratchy" drilling (slightly rough).

42.7 to 45.2 ft.: Smooth drilling with slightly rough spots.

45.2 to 57.7 ft.: Smooth and easy auger advancement.

57.7 to 60.2 ft.: Driller notes drilling became very hard at about 59.7 feet and had to switch to manual down pressure.

60.2 to 60.9 ft.: Hit refusal with augers at 60.9 feet.

60.9 to 63.0 ft.: Pilot bit interval.

Geologic Units

Roadbase
Fill
Qb **Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected
("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

NOTES

63.0 to 65.2 ft.: Smooth and easy auger advancement. Minor cuttings return.

65.2 to 67.7 ft.: Alternating hard and soft drilling.

74.7 to 75.2 ft.: No recovery.

79.7 to 80.2 ft.: No recovery.

80.2 to 82.7 ft.: Slow auger advancement due to clay/gravel.

85.2 to 100.2 ft.: Smooth and easy auger advancement.

DRILLING FLUID, RETURN AND COLOR:
Drilling fluid was not used to advance the hole.

REASON FOR HOLE TERMINATION:
Drill hole terminated at target depth.

HOLE COMPLETION:
The hole was backfilled with bentonite from total depth to ground surface.

GROUNDWATER LEVELS:
The following water levels were measured at the start of each day, prior to drilling:

11/3/2019: Groundwater initially encountered at 6.3 feet.
11/4/2019: 5.0 feet with lead auger at 16.0 feet.
11/5/2019: 4.1 feet with lead auger at 30.8 feet.
11/6/2019: 4.6 feet with lead auger at 50.2 feet.
11/13/2019: 4.8 feet with lead auger at 60.9 feet.
11/14/2019: 4.8 feet with lead auger at 77.7 feet.

NEARBY SURFACE WATER LEVELS:
11/03-14/2019: About 2.0 feet below ground surface elevation at the drill hole in an unlined canal located approximately 15 feet to the east.

GENERAL NOTE:
Lab and visual classifications are described according to the Unified Soil Classification System (USCS) as presented in Bureau of Reclamation (Reclamation) standards USBR 5000 and 5005. Reclamation's standards are consistent with the American Society for Testing Materials (ASTM) D2487 and D2488.

SURVEY NOTE:
Geologic explorations were surveyed February 19, 2020 by Surveys and Mapping Branch, Division of Design and Construction California-Great Basin Region. Horizontal datum is NAD 1983 (2007) State Plane Coordinates, CA State Plane Zone 2, US Survey Feet. Vertical datum is NAVD 1988 (Based on NGS Benchmark DL92228 "CANAL 1").

Geologic Units
Roadbase
Fill
Qb Quaternary: Basin Deposits

Symbols
▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Laboratory Data

Depth (feet)	Elevation (feet)	% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
5	123	70.2	29.8	0.0	0.0	28	17	15.9	(CL)s
10	118	74.3	25.7	0.0	0.0	38	24	16.8	(CL)s
15	113	65.0	34.9	0.1	0.0	27	13	23.6	s(CL)
20	108	15.4	70.6	14.0	0.0	0	0	17.9	SM

Visual Classification

- Roadbase
- s(CL)
- SC
- s(CL)
- (CL)s
- s(CL)
- s(ML) / SM
- s(CL-ML)
- SM
- SP-SM
- s(CL-ML)
- SP-SM
- (CL)s

FADC % Recovery and SPT Data

FADC % Recovery	SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
92			
100	0 0 0	0	80
100	0 3 5	8	93
92	1 5 7	12	100
100	0 3 4	7	100
100	2 2 4	6	100
84	3 5 3	8	73
92	4 13 25	38	100
100	5 13 16	29	100
100	6		100

Geologic Unit

Fill

▼

Qb

Visual Classification and Physical Condition

0.0 to 1.9 ft.: FAPB. Logged auger flight drill cuttings.

0.0 to 7.3 ft.
Embankment Fill

0.0 to 1.0 ft.: **Aggregate Roadbase:** Lower contact is estimated. SILTY GRAVEL WITH SAND, (GM)s.

1.0 to 5.9 ft.: **SANDY LEAN CLAY, s(CL):** Upper contact is estimated. About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine sand; trace fine, hard, subrounded gravel; maximum size, 1/4 inch; firm consistency; moist; brown to dark brown; no reaction with HCl.

5.9 to 6.4 ft.: **CLAYEY SAND, SC:** About 55% predominantly fine with medium sand; about 45% fines with low to medium plasticity, medium dry strength, low toughness, slow to rapid dilatancy; moist to wet; brown; no reaction with HCl.

6.4 to 7.3 ft.: **SANDY LEAN CLAY, s(CL):** Upper contact is estimated. About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine sand; trace fine, hard, subrounded gravel; maximum size, 1/4 inch; firm consistency; moist; brown to dark brown; no reaction with HCl.

7.3 to 100.9 ft. Upper contact is approximated, based on drill cuttings.
Quaternary: Basin Deposits, Qb

7.3 to 10.9 ft.: **LEAN CLAY WITH SAND, (CL)s:** About 85% fines with medium plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; brown; no reaction with HCl.

10.1 to 10.4 ft.: Trace off-white, medium sand size fragments; strong reaction with HCl.

10.9 to 12.0 ft.: **SANDY LEAN CLAY, s(CL):** About 65% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; about 35% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

12.0 to 12.2 ft.: **SANDY SILT TO SILTY SAND, s(ML) / SM:** About 50% fine sand; about 50% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; very soft consistency; wet; dark gray; no reaction with HCl.

12.2 to 16.9 ft.: **SANDY LEAN CLAY TO SILT, s(CL-ML):** About 55 to 65% fines with no to low plasticity, low dry strength, no to low toughness, slow to rapid dilatancy; about 35 to 45% fine sand; maximum size, fine sand; soft consistency; wet; brown; minor silty sand (SM) interbeds (<0.1-ft. thick) with about 75% fine sand and about 25% non-plastic fines; no reaction with HCl.

16.9 to 17.5 ft.: **SILTY SAND, SM:** About 60 to 70% fine sand; about 30 to 40% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; wet; brown; no reaction with HCl.

17.5 to 18.1 ft.: **POORLY GRADED SAND WITH SILT, SP-SM:** About 90% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 10% non-plastic fines; trace fine, hard, subangular to subrounded gravel; maximum size, 3/8 inch; wet; dark brown to olive brown; no reaction with HCl.

18.1 to 18.6 ft.: **SANDY LEAN CLAY TO SILT, s(CL-ML):** About 55 to 65% fines with no to low plasticity, low dry strength, no to low toughness, slow to rapid dilatancy; about 35 to 45% fine sand; maximum size, fine sand; soft consistency; wet; brown; minor silty sand (SM) interbeds (<0.1-ft. thick) with about 75% fine sand and about 25% non-plastic fines; no reaction with HCl.

18.6 to 21.9 ft.: **POORLY GRADED SAND WITH SILT, SP-SM:** About 90% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 10% non-plastic fines; trace fine, hard, subangular to subrounded gravel; maximum size, 1/2 inch; wet; dark brown to olive brown; some interbeds of silty sand (SM) up to 0.4-ft. thick, about 85% predominantly fine with medium sand and about 15% non-plastic fines; no reaction with HCl.

21.9 to 25.0 ft.: **LEAN CLAY WITH SAND, (CL)s:** About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency;

Geologic Units

Roadbase	
🟫 Fill	
🟨 Qb	Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

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FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)	% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification	Visual Classification	FADC % Recovery	SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	Geologic Unit
26	103 102										100	10 10 14	24 24	100	Qb
27 28	101 100										100	5 11 13	24	100	
29 30 31	99 98 97										100	5 15 17	32	87	
32 33	96 95	86.8	13.2	0.0	0.0	39	21	21.6	CL	(CL)s	100	6 12 16	28	100	
34 35 36	94 93 92										100	6 14 16	30	100	
37 38 39	91 90 89										100	6 14 16	30	100	
40 41	88 87	71.9	15.0	13.1	0.0	42	24	22.1	(CL)s	g(CL)s	100	4 13 15	28	100	
42 43 44	86 85 84										100	5 12 16	28	100	
45 46	83 82									(CL)s	100	8 16 16	32	100	
47 48 49	81 80 79									s(CL) / SC	100	8 15 18	33	100	
										(CL)s	100	10		100	

Visual Classification and Physical Condition

moist; brown with localized minor green-gray; trace off-white fine to coarse sand and fine gravel size fragments throughout (strong reaction with HCl); trace black MnO2 specks throughout (medium sand size); no reaction with HCl.

25.0 to 25.6 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 25% fine sand; maximum size, fine sand; firm consistency; moist; brown with localized minor green-gray; no reaction with HCl.

25.6 to 38.8 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; brown with localized minor green-gray; fairly consistent gradation, slight (5%) variation in sand percentage; no reaction with HCl.

29.4 to 30.0 ft.: slight decrease in plasticity (approaching ML, but still rolls a thread), soft consistency.

29.4 to 38.8 ft.: brown to red-brown with minor green-gray

38.8 to 41.0 ft.: GRAVELLY LEAN CLAY WITH SAND, g(CL)s:
About 60% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% CaCO3 cemented nodules/fragments consisting of fine to coarse sand and fine to coarse gravel, hard, angular to subangular (surfaces coated with black MnO2, strong reaction with HCl); about 10% fine sand; moist; light brown; presence of CaCO3 fragments caused soil to break apart (crumbly); no reaction with HCl in body of soil.

41.0 to 42.1 ft.: LEAN CLAY WITH SAND, (CL)s:
About 80% fines with low to medium plasticity, high dry strength, low to medium toughness, no to slow dilatancy; about 20% fine sand; maximum size, fine sand; firm consistency; moist; brown to red-brown with minor green-gray; black MnO2 specks throughout (medium sand size); trace off-white, fine to coarse sand size fragments (strong reaction with HCl); no reaction with HCl.

42.1 to 43.5 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; brown with localized minor green-gray; fairly consistent gradation, slight (5%) variation in sand percentage; no reaction with HCl.

43.5 to 48.6 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with low to medium plasticity, high dry strength, low to medium toughness, no to slow dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm consistency; moist; brown to red-brown with minor green-gray; no reaction with HCl.

48.6 to 49.4 ft.: SANDY LEAN CLAY TO CLAYEY SAND, s(CL) / SC:
About 50% predominantly fine to medium with trace coarse, hard, subangular to subrounded sand; about 50% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, coarse sand; moist to wet; brown; weakly consolidated (breaks apart with light manual pressure); no reaction with HCl.

49.4 to 52.0 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 25% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

52.0 to 52.5 ft.: SANDY LEAN CLAY TO CLAYEY SAND, s(CL) / SC:
About 50% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 50% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, coarse sand; moist to wet; brown; weakly consolidated (breaks apart with light manual pressure); no reaction with HCl.

52.5 to 57.6 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 25% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

57.6 to 61.2 ft.: LEAN CLAY WITH SAND TO SANDY LEAN CLAY, (CL)s / s(CL):
About 70 to 80% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 20 to 30% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

61.2 to 63.1 ft.: SILTY SAND, SM:

Geologic Units

Roadbase
Fill
Qb **Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)	Laboratory Data % By Weight % Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification	Visual Classification	FADC % Recovery	SPT Data SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	Geologic Unit	Visual Classification and Physical Condition
	78											22 22 23	45 45	100		
51	77									(CL)s	100					
52	76									s(CL) / SC		9 13	27	100		
53	75	92.4	7.0	0.6	0.0	41	22	23.0	CL		100	14				
54	74															
55	73									(CL)s		9 16	34	100		
56	72										100	18				
57	71											4 12	27	100		
58	70										100	15				
59	69									(CL)s / s(CL)						
60	68											4 7	17	100		
61	67										100	10				
62	66	50.1	49.9	0.0	0.0	24	8	15.2	s(CL)	SM		5 14	32	100	Qb	
63	65										84	18				
64	64	34.3	65.4	0.3	0.0	31	17	15.1	SC							
65	63											7 18	39	100		
66	62									CL / (CL)s	100	21				
67	61											5 12	26	100		
68	60										100	14				
69	59									s(CL)		6				
70	58									SC		13	34	100		
71	57										100	21				
72	56	80.2	19.8	0.0	0.0	42	32	14.2	(CL)s	CL / (CL)s		11 25	57	100		
73	55										100	32				
74	54									s(CL)	100	9		100		

About 60% fine sand; about 40% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; moist; brown; black MnO2 throughout; trace off-white, fine to coarse sand size, CaCO3 fragments (strong reaction with HCl); no reaction with HCl in body of soil.

63.1 to 64.4 ft.: SILTY SAND, SM:
About 85% predominantly fine with trace medium sand; about 15% non-plastic fines; maximum size, medium sand; moist to wet; brown; no reaction with HCl.

64.4 to 69.2 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 75 to 90% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 10 to 25% fine sand; maximum size, fine sand; hard consistency; moist; brown with minor green-gray; trace off-white, fine to coarse sand size fragments with strong reaction with HCl; minor black MnO2 specks throughout; no reaction with HCl in body of soil.

69.2 to 70.0 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30 to 35% fine sand; maximum size, fine sand; hard consistency; moist; brown with minor green-gray; no reaction with HCl.

70.0 to 70.5 ft.: CLAYEY SAND, SC:
About 70% fine sand; about 30% fines with low to medium plasticity, medium dry strength, low toughness, slow to rapid dilatancy; maximum size, fine sand; moist to wet; brown; minor black MnO2 specks; no reaction with HCl.

70.5 to 74.1 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 85 to 90% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 10 to 15% fine sand; maximum size, fine sand; hard consistency; moist; brown with minor green-gray; trace off-white, fine to coarse sand size fragments with strong reaction with HCl; minor black MnO2 specks throughout; no reaction with HCl in body of soil.

74.1 to 74.4 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30 to 35% fine sand; maximum size, fine sand; firm to hard consistency; moist to wet; brown with minor green-gray; no reaction with HCl.

74.4 to 75.2 ft.: SANDY LEAN CLAY, s(CL):
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist to wet; brown with minor green-gray; no reaction with HCl.

75.2 to 76.5 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30 to 35% fine sand; maximum size, fine sand; firm to hard consistency; moist to wet; brown with minor green-gray; no reaction with HCl.

76.5 to 76.9 ft.: SANDY LEAN CLAY, s(CL):
About 50% fine sand; about 50% fines with low plasticity, medium to high dry strength, no to low toughness, slow dilatancy; maximum size, fine sand; firm consistency; moist; brown with minor red-brown and dark brown (spotty); no reaction with HCl.

76.9 to 77.2 ft.: SILTY SAND, SM:
About 85% fine sand; about 15% non-plastic fines; maximum size, fine sand; wet; brown to red-brown; no reaction with HCl.

77.2 to 77.9 ft.: CLAYEY SAND, SC:
About 65% predominantly fine with trace medium sand; about 35% fines with low plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, medium sand; moist to wet; brown with minor red-brown and dark brown in patches; no reaction with HCl.

77.9 to 80.8 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium to high plasticity, high to very high dry strength, medium to high toughness, no dilatancy; about 30 to 35% predominantly fine to medium with coarse, hard, subrounded sand; maximum size, coarse sand; hard consistency; moist; green-gray; trace off-white, fine to coarse sand size fragments (strong reaction with HCl); no reaction with HCl.

80.8 to 81.4 ft.: CLAYEY SAND, SC:
About 75% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 25% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, coarse sand; moist to wet; olive-brown; minor spotty FeOx; no reaction with HCl.

Geologic Units

Roadbase	
Fill	
Qb	Quaternary: Basin Deposits

Symbols

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Abbreviations

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GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Depth (feet): 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99

Elevation (feet): 53, 52, 51, 50, 49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29

Laboratory Data

% By Weight							
% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
70.3	20.7	9.0	0.0	59	29	32.5	(CH)s
80.1	19.3	0.6	0.0	41	20	27.0	(CL)s

Visual Classification: s(CL), SM, SC, s(CL), SC, (CL)s, s(CL), s(ML), s(CL), CL, (CL)s, s(CL), (CL)s, s(CL), (CL)s, s(CL), (CL)s, NR, (CL)s

FADC % Recovery: 100, 93, 100, 84, 100, 96, 100, 100, 100, 100

SPT Data

SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
16	34	
16 18	34	100
6 15 16	31	100
11 22 27	49	100
10 11 17	28	100
12 16 21	37	100
7 14 20	34	100
9 15 18	33	100
11 26 38	64	100
9 15 21	36	100
14 23 44	67	100
14		100

Geologic Unit: Qb

Visual Classification and Physical Condition

81.4 to 83.0 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% predominantly fine with medium sand; maximum size, medium sand; hard to very hard consistency; moist; light green-gray; weakly cemented with CaCO3; strong reaction with HCl in off-white, fine to coarse sand and fine gravel (up to 3/8-inch) size fragments; displays claystone-like appearance and properties, breaks apart with light to moderate manual pressure, crumbly; clay is somewhat dispersive and air slakes/dessication cracks; weak reaction with HCl.

83.0 to 84.2 ft.: SANDY LEAN CLAY, s(CL):
About 65% fines with medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 35% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; trace clay nodules (CaCO3 cemented, strong reaction with HCl); no reaction with HCl.

84.2 to 84.9 ft.: SANDY SILT, s(ML):
About 60% fines with no to low plasticity, slow dilatancy; about 40% fine sand; maximum size, fine sand; hard to very hard consistency; moist to wet; dark brown; weakly to moderately cemented with non-calcareous material, break apart with manual pressure and with some effort between fingernails; no reaction with HCl.

84.9 to 86.4 ft.: SANDY LEAN CLAY, s(CL):
About 65% fines with medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 35% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; about 5% clay nodules (CaCO3 cemented, strong reaction with HCl), fine to coarse sand and fine to coarse gravel size; no reaction with HCl.

86.4 to 88.5 ft.: LEAN CLAY, CL:
About 90 to 95% fines with high plasticity, very high dry strength, medium to high toughness, no dilatancy; about 5 to 10% fine sand; maximum size, fine sand; very hard consistency; moist; light green-gray; trace FeOx thread-like rootlets; no reaction with HCl.

88.5 to 91.4 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; trace off-white fragments (strong reaction with HCl); band of FeOx (about 3/8-inch thick) at the upper contact ; no reaction with HCl in body of soil.

91.4 to 93.5 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

93.5 to 94.9 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

94.9 to 95.8 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

95.8 to 96.9 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

96.6 to 96.9 ft.: contains weakly to moderately cemented s(CL) and SM, appears like claystone/siltstone/sandstone

96.9 to 97.5 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; contains weakly to moderately cemented s(CL) and SM; no reaction with HCl.

97.5 to 98.2 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; contains weakly to moderately cemented s(CL) and SM at 98.2 ft.; no reaction with HCl.

98.2 to 99.4 ft. NO RECOVERY

Geologic Units

Roadbase	
Fill	
Qb	**Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)	Laboratory Data								Visual Classification	FADC % Recovery	SPT Data			Geologic Unit	Visual Classification and Physical Condition
		% By Weight														
		% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification			SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery		
	28									(CL)s		21 21 29	50 50	100	Qb	**99.4 to 100.9 ft.: LEAN CLAY WITH SAND, (CL)s:** About 75 to 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

BOTTOM OF HOLE: T.D. 100.9 ft. (el. 27.3)

Geologic Units

Roadbase
Fill
Qb Quaternary: Basin Deposits

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected
("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

SHEET 6 OF 7

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

NOTES

PURPOSE OF HOLE:
To perform Standard Penetration Test (SPT), visually classify, and collect/test samples in order to determine geotechnical properties of soil and depth to groundwater bearing soils (foundation conditions) for a proposed pumping plant associated with proposed Terminal Regulating Reservoir (TRR). Data will be used to prepare feasibility level design of excavation slopes, a dewatering system, and structural support.

LOCATION:
About 0.7 mile northwest where McDermott Road crosses Funks Creek. Drill hole is located on the north (left side) embankment of GCID's unlined canal, about 12 feet north-northeast (perpendicular) from the top edge of the canal's water-side slope.

Approximately 5 feet northwest of companion undisturbed/intact sample hole, DH-19-TRRPGP-B.

DRILLED BY:
Bureau of Reclamation: Pacific Northwest (PN) Region drill crew:
Rick Knott, driller
Austin Anderson, helper

DRILL RIG:
Central Mining Equipment (CME) 850 track mounted rig

DRILLING AND SAMPLING METHODS :
Drill hole was advanced using flight auger pilot bit (FAPB) and flight auger dry core (FADC) systems.

FAPB was to advance the lead auger between depths of 0.0 to 1.9 feet, which then allowed for FADC advancement. FADC refusal was encountered at a depth of 98.2 feet, so FAPB was advanced from 98.2 to 99.4 feet. FAPB consisted of 4-1/4 inch i.d. by 8 inch o.d. hollow flight augers equipped with an 8.5-inch o.d. lead drill bit containing six carbide bullet bit teeth around the rim, and a 4-1/4 inch o.d. pilot bit with six carbide bullet teeth attached to NWJ rods and set inside the lead drill bit using. FAPB is a closed system and does not allow for collection of core.

FADC was used to advance the drill hole and collect soil core from 1.9 to 98.2 feet. FADC utilizes the same augers as FAPB. Instead of using a pilot bit, FADC uses a 3-3/8 inch i.d. by 4 inch o.d. by 5-foot-long split barrel dry coring system. NWJ rods were attached to a free spinning bearing assembly, which is attached to the FADC barrel. The bearing assembly allows for the FADC barrel to remain stationary while the augers rotate and advance the hole. The barrel's cutting shoe was 0.1 foot beyond the lead drill bit between 1.9 and 96.9 feet. The cutting shoe was retracted even with the lead drill bit between 96.9 and 98.2 feet, where FADC refusal was encountered in hard consistency clay that lifted the rig off its supports. A metal "basket" was used in the cutting shoe to assist with retention of core.

SPT was performed at 2.5 foot intervals (1-foot spacing between SPT intervals), unless otherwise noted. SPT consisted of a 1-3/8 inch i.d. by 2 inch o.d. by 2.0 foot long split spoon sampler driven 1.5 feet. Sampler was attached to NWJ rods that weigh about 57.5 lbs/10 ft. The sampler was advanced with an auto-hammer (140 pound weight with a 30 inch drop) at a rate of about 54 blows per minute (drill rig engine at about 1550 rpm). The auto-hammer energy was measured in companion hole DH-19-TRRPGP-B on November 1, 2019, resulting in a 87.4% energy correction. Blow count data presented in this log is uncorrected "N"-values.

DRILLING CONDITIONS:
0.0 to 16.9 ft.: Smooth and easy auger advancement.

16.9 to 18.4 ft.: SPT. Wet SM and SP-SM in sampler. Appears to have potential to be flowing sand (potential for heaving).

16.9 to 19.4 ft.: FADC. Filled augers with water prior to pulling sampler. Heaving did not occur.

19.4 to 20.9 ft.: SPT. Filled augers with water prior to pulling sampler. Wet, flowing sand heaved 2 ft. into augers after pulling sampler.

19.4 to 21.9 ft.: FADC. Lifted augers a few feet to flush sand out bottom of augers and to allow FADC sampler to seat in lead auger. Advanced auger/sampler. Filled augers with water prior to pulling sampler. Heaving did not occur (measured hole depth to confirm). Upper 0.5 ft. in sampler is SP-SM and appears to be flowing/heaved sand.

21.9 to 24.4 ft.: FADC. Firm to hard clay, which sealed off heaving sand with augers socketed into it.

21.9 to 100.9 ft.: Minor drill cuttings generated, which slowed auger advancement. Smooth, but slow drilling.

29.4 to 36.9 ft.: FADC. Abundant water displaced to surface. Driller rate significantly reduced so drillers could shovel water into Bobcat bucket (permit disallows water discharge to surface and adjacent canal).

61.9 to 64.4 ft.: FADC. No material in sampler cutting shoe (fell downhole). Auger refusal (drill rig lifted off ground). Due to minimal drill cuttings, auger flights are believed to be plugged with compacted soil. Pulled back augers 5 ft., backspun augers to remove material from auger flights (downhole), and drilled out material with FAPB. Minimal success in generating drill cuttings.

64.4 to 74.4 ft. and 79.9 to 98.2 ft.: FADC. 0.2 to 1 ft. of slough (wet, loose sand) in top and on outside of FADC sample tube. Sand originating from 16.9 to 21.9 ft. Slight wobble of augers created a small annular space between the borehole sidewall and augers, allowing sand to move down the outside of the augers and then in through bottom of augers.

74.4 to 76.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).

76.9 to 79.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).

79.9 to 82.4 ft.: FADC. Auger refusal (drill rig lifted off ground and shifted over). Refusal encountered on a thin layer of very hard compacted clay (claystone-like appearance). Driller was able to slowly advance through clay layer.

82.4 to 84.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).
87.4 to 89.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).

89.9 to 92.4 ft.: FADC. No material in sampler cutting shoe (fell downhole).

94.9 to 96.9 ft.: FADC. Auger refusal. Driller was able to slowly advance augers.

96.9 to 98.2 ft.: FADC. Driller was able to slowly advance augers after retracting FADC sampler cutting shoe even with lead auger drill bit. Auger refusal at 98.2 ft.

98.2 to 99.4 ft.: FAPB. Pilot bit required to advance hole to final SPT interval (99.4 to 100.9 ft.)

Geologic Units

Roadbase
Fill
Qb **Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

SHEET 7 OF 7

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

NOTES

DRILLING FLUID, RETURN AND COLOR:
Drilling fluid was not used to advance the hole.

REASON FOR HOLE TERMINATION:
Drill hole terminated at target depth.

HOLE COMPLETION:
The hole was backfilled with bentonite from total depth to 1 ft. bgs, and with gravel road base from 1 to ground surface.

GROUNDWATER LEVELS:
The following water levels were measured at the start of each day, prior to drilling:

10/18/2019: Groundwater initially encountered at 12.0 feet in SPT interval 11.9 to 13.4 ft.
10/19/2019: 15.6 feet with lead auger at 29.4 feet.
10/20/2019: 20.4 feet with lead auger at 59.4 feet.
10/21/2019: 30.2 feet with lead auger at 79.9 feet.
10/22/2019: 23.4 feet with lead auger at 94.9 feet.

NEARBY SURFACE WATER LEVELS:
10/18-22/2019: About 2.5 feet below ground surface elevation at the drill hole in GCID's canal located approximately 14 feet to the south-southwest. Surface water is also present in a ditch located about 45 feet north. Water in the ditch is about 9.5 feet below ground surface elevation at the drill hole.

GENERAL NOTE:
Lab and visual classifications are described according to the Unified Soil Classification System (USCS) as presented in Bureau of Reclamation (Reclamation) standards USBR 5000 and 5005. Reclamation's standards are consistent with the American Society for Testing Materials (ASTM) D2487 and D2488.

SURVEY NOTE:
Geologic explorations were surveyed February 19, 2020 by Surveys and Mapping Branch, Division of Design and Construction California-Great Basin Region. Horizontal datum is NAD 1983 (2007) State Plane Coordinates, CA State Plane Zone 2, US Survey Feet. Vertical datum is NAVD 1988 (Based on NGS Benchmark DL92228 "CANAL 1").

Geologic Units

Roadbase
Fill
Qb **Quaternary: Basin Deposits**

Symbols

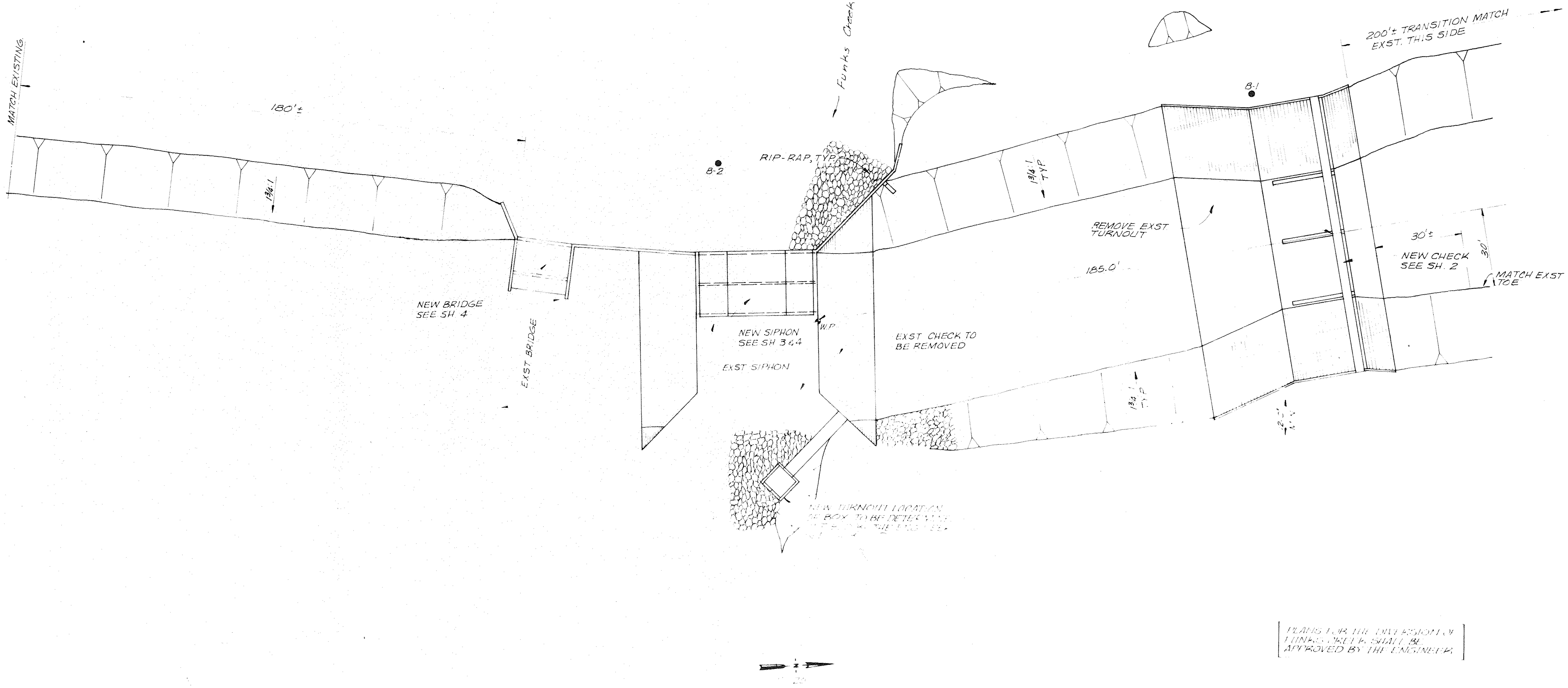
▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West



PLANS FOR THE DIVERSION OF
FUNKS CREEK SHALL BE
APPROVED BY THE ENGINEER.

JACK E. CALL
RSE 1542

CH2M HILL

DES. J.E.C.						
DR. ELM						
CHK. GRK						
APPD.	NO.	DATE	REVISION	BY	APPD.	

GLENN - COLUSA
IRRIGATION DISTRICT
WILLOWS CALIFORNIA

SIPHON AND CHECK

GENERAL PLAN

SHEET 1
OF 8
DATE
DWG. NO. R-3013.24

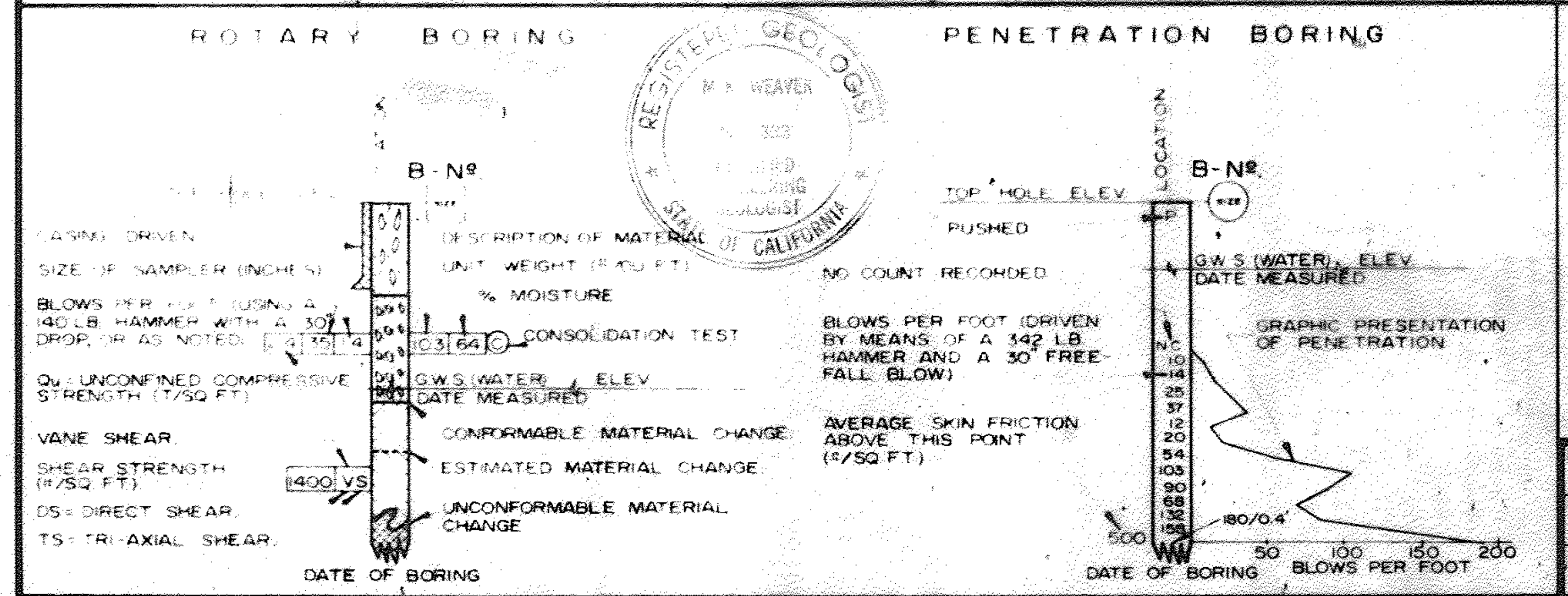
23-A

BORING PROFILES

Scale: 1" = 5' vertical

Note: For plan of borings see Sheet 1 & 2

LEGEND OF DRILLING, SAMPLING & TESTING OPERATIONS



REGISTERED GEOLOGIST M. K. WEAVER 333 STATE OF CALIFORNIA

- ● PLAN OF ANY BORING
- PENETROMETER (FLUSH-COUPLED)
- ● 2 ¼" CONE PENETROMETER
- SAMPLER BORING (DRY)
- ROTARY BORING (WET)
- AUGER BORING (DRY)
- JET BORING
- DIAMOND CORE BORING
- TEST PIT

BIT SIZES; (O.D.) "AX" = 1 13/16", "BX" = 2 9/32", "NX" = 2 29/32".

CASING SIZES, (O.D.) "BX" = 2 7/8", "NX" = 3 ½".

THE UNIFIED SOIL CLASSIFICATION SYSTEM

MAJ. DIV.		LETTER	SYMBOL	NAME
COARSE GRAINED MATERIAL	GRAVEL AND GRAVELLY SOIL	GW		WELL GRADED GRAVEL OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GP		POORLY GRADED GRAVEL OR GRAVEL SAND MIXTURES, LITTLE OR NO FINES
		GM		SILTY GRAVEL, GRAVEL-SAND SILT MIXTURES
		GC		CLAYEY GRAVEL, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOIL	SW		WELL GRADED SAND OR GRAVELLY SAND, LITTLE OR NO FINES
		SP		POORLY-GRADED SAND OR GRAVELLY SAND, LITTLE OR NO FINES
		SM		SILTY SAND, SAND SILT MIXTURES
		SC		CLAYEY SAND, SAND-SILT MIXTURES
FINE GRAINED SOIL	SILTS AND CLAYS LL <50	ML		INORGANIC SILT AND VERY FINE SAND, ROCK FLOUR, SILTY OR CLAYEY FINE SAND OR CLAYEY SILT WITH SLIGHT PLASTICITY
		CL		INORGANIC CLAY OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAY, SANDY CLAY, SILTY CLAY, LEAN CLAY
		OL		ORGANIC SILT AND ORGANIC SILTY CLAY OF LOW PLASTICITY
	SILTS AND CLAYS LL >50	MH		INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILT
		CH		INORGANIC CLAY OF HIGH PLASTICITY, FAT CLAY
		OH		ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILT
HIGHLY ORGANIC SOILS		PT		PEAT AND OTHER HIGHLY ORGANIC SOILS

ROCK CLASSIFICATION

SYMBOL	NAME
	[illegible]
	SEDIMENTARY ROCK
	METAMORPHIC ROCK

NOTE:
CLASSIFICATION OF EARTH MATERIAL SHOWN ON THIS SHEET IS BASED UPON FIELD INSPECTION UNLESS NOTED OTHERWISE

SOIL CONSISTENCY CLASSIFICATION

CONSISTENCY		* BLOWS PER FT.
GRANULAR	COHESIVE	
VERY LOOSE	VERY SOFT	[illegible]
LOOSE	SOFT	[illegible] TO 10
SLIGHTLY COMPACT	STIFF	[illegible] TO 20
COMPACT	VERY STIFF	[illegible] TO 35
DENSE	HARD	35 TO 70
VERY DENSE	VERY HARD	70

* (STANDARD PENETRATION TEST) BLOWS PER FT (140 LB HAMMER, 30" FREE-FALL BLOW USING A 2" O.D. x 1 3/8" I.D. SAMPLER)

DWN. BB
CHK
DATE

M. K. Weaver
ENGINEERING GEOLOGIST
333
REGISTRATION NUMBER

CH2M HILL
1525 COURT STREET
REDDING, CALIFORNIA

LOG OF TEST BORINGS

GLEN - COLUSA IRRIGATION DISTRICT

DWG. NO. 8

JOB NO. R-3013.26 H

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 3
HOLE NO. NC-AUG-1
ELEV. 200* FEET
DEPTH 51.5 FEET

PROJECT SITES RESERVOIR PROJECT
FEATURE NEW CANAL ALIGNMENT
LOCATION CAL COORDS: N- 2247683; E- 6482710
CONTR. LAYNE-CHRISTENSEN DRILL RIG CME-850
DATE DRILLED 05/05/01
ATTITUDE VERTICAL
LOGGED BY D. FOREWALTER, G. GORDON
DEPTH TO WATER NOT DETERMINED

*As measured off of contour maps prepared by DWR (contour interval=10 feet).

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (200)		<u>PLIOCENE TEHAMA FORMATION</u> 0.0 to ~16.0'		AD	8" hollow stem auger used for drilling.
2.0		2.0 to 4.5' <u>Clay (CL)</u>; silty; light yellowish-brown (10YR 6/4); dry, high plasticity; medium toughness; very high dry strength.	1	PS	Shelby Tube 800 psi Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
4.0				AD	
6.0	CL	5.0 to 7.5' <u>Clay (CL)</u>; silty; olive brown (2.5Y 6/6); dry, high plasticity; very high dry strength.	2	PS	Shelby Tube 1000 psi Shear Strength = 4.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
8.0 (192)				AD	
10.0		10.0 to 11.5' <u>Clay (CL)</u>; silty; yellowish-brown (10YR 5/6); dry; very stiff to hard; low to medium plasticity; very high dry strength.	3	DR	California Modified Blow Count- 16,42,50 for 5" Shear Strength = 5.0 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
12.0 14.0				AD	
		15.0 to 16.5' <u>Clay (CL)</u>; silty; yellowish-brown (10YR5/6); dry, very stiff to hard; medium plasticity; very high dry strength; severely weathered bedrock; remaining bedrock, mudstone; light olive brown (2.5Y5/3).	4	DR	California Modified Blow Count- 18,50,50+ cont. next page.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 of 3
HOLE NO. NC-AUG-1

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0 (184)					Shear Strength = 5.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
18.0		<u>GREAT VALLEY SEQUENCE</u> <u>CRETACEOUS CORTINA FORMATION</u> ~16.0 to 51.5'		AD	
20.0		20.0 to 51.5' Weathered mudstone.	5	DR	California Modified Blow Count- 12,29,45 Shear Strength = 8.125 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
22.0 24.0 (176)				AD	
26.0			6	DR	California Modified Blow Count- 27,50 for 5" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
28.0				AD	
30.0			7	DR	California Modified Blow Count- 46,50 for 3" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
32.0 34.0				AD	
			8	DR	California Modified Blow Count- 48,50 for 3"

State of California
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SHEET 3 of 3
HOLE NO. NC-AUG-1

DRILL HOLE LOG

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0 (154)					Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^{2}
38.0				AD	
40.0			9	DR	California Modified Blow Count- 30,50 for 3" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^{2}
42.0 44.0 (156)				AD	
46.0			10	DR	California Modified Blow Count- 50,50 for 3" Shear Strength = N/A Unconfined Strength = >4.5 ton/ft^{2}
48.0				AD	
50.0		BOH = 51.5'	11	DR	California Modified Blow Count- 100 for 5" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^{2}
52.0 54.0					Hole completed by back filling with cuttings.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 1 of 3
HOLE NO. NC-AUG-2
ELEV. 170* FEET
DEPTH 51.5 FEET

DRILL HOLE LOG

PROJECT SITES RESERVOIR PROJECT
FEATURE NEW CANAL ALIGNMENT
LOCATION CAL COORDS: N- 2246895; E- 6486288
CONTR. LAYNE-CHRISTENSEN DRILL RIG CME-850
DATE DRILLED 05/05/01
ATTITUDE VERTICAL
LOGGED BY D. FOREWALTER, G. GORDON
DEPTH TO WATER 6.0'

*As measured off of contour maps prepared by DWR (contour Interval=10 feet).

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (170)		PLIOCENE TEHAMA FORMATION 0.0 to 51.5'		AD	8" hollow stem auger used for drilling.
2.0 4.0	CL	2.0' Clay (CL); silty; dark brown (10YR 3/3); hard, dry; medium to high plasticity; high dry strength; few grass rootlets.	1	PS	Shelby Tube 500 psi Shear Strength = N/A Unconfined Strength = N/A
	SC	4.5' Sand (SC), very fine sand, clayey, silty; yellowish brown (10YR 5/4); dry, very dense; low to medium plasticity, low toughness; high dry strength; some calcareous blebs (white 2.5 Y 8/2).		AD	
6.0		5.0' Clay (CL); sandy, silty; yellowish brown (10YR 5/4); dry, hard; high plasticity; high toughness; high dry strength.	2	PS	Shelby Tube 1200 psi Shear Strength = 13.75 kg/cm^{2} Unconfined Strength = 4.6 tons/ft^{2}
8.0 (162)	CL	7.5' Clay (CL); sandy, silty; yellow (2.5YR 7/6); dry, hard; medium plasticity; medium toughness; high dry strength.		AD	
10.0		10.0 to 11.5' Sand (SM); silty; light yellowish-brown (10YR 6/4); fine sand, sub-angular to sub-rounded; medium dense to dense, dry; nonplastic; low toughness.	3	DR	California Modified Blow Count- 10,19,42 Shear Strength = 2.5 kg/cm^{2} Unconfined Strength = >4.5 tons/ft^{2}
12.0 14.0				AD	
	CL	15.0 to 16.5' Clay (CL); silty; yellowish brown (10YR 5/4), stiff to hard, dry; high plasticity; medium toughness; high dry strength.	4	DR	California Modified Blow Count- 13,20,33 cont. next page.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 2 of 3
HOLE NO. NC-AUG-2

DRILL HOLE LOG

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0 (154)					Shear Strength = 2.5 kg/cm^2 Unconfined Strength = >4.5 $tons/ft^2$
				AD	
18.0					
20.0		20.0 to 21.5' <u>Clay (CL)</u>; silty; light olive brown (2.5 Y 5/4); stiff to very stiff, slighlty moist; high plasticity; low dry strength.	5	DR	California Modified Blow Count- 9,13,28 Shear Strength = 1.25 kg/cm^2 Unconfined Strength = >4.5 $tons/ft^2$
22.0				AD	
24.0 (146)					
		25.0 to 26.5' <u>Clay (CL)</u>; sandy, silty; brownish-yellow (10YR 6/6); minor fine sand, moist.	6	DR	California Modified Blow Count- 11,18,24 Shear Strength = 11.25 kg/cm^2 Unconfined Strength = >4.5 $tons/ft^2$
26.0	CL				
28.0				AD	
30.0		30.0 to 31.5' <u>Clay (CL)</u>; silty, sandy; yellowish-brown (10 YR 5/4); fine sand; stiff, slighlty moist; low plasticity; low toughness; minor iron staining.	7	DR	California Modified Blow Count- 8,15,19 Shear Strength = 10.625 kg/cm^2 Unconfined Strength = >4.5 $tons/ft^2$
32.0				AD	
34.0					
		35.0 to 36.5' <u>Clay (CL)</u>; sandy, silty; brownish-yellow (10YR 6/6); fine to medium sand; stiff to hard, slightly moist; low plasticity; low toughness; abundant iron staining.	8	DR	California Modified Blow Count- 6,9,43

State of California
The Resources Agency
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SHEET 3 of 3
HOLE NO. NC-AUG-2

DRILL HOLE LOG

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0 (134)					Shear Strength = 1.25 kg/cm^2 Unconfined Strength = >4.5 $tons/ft^2$
38.0				AD	
40.0		40.0 to 41.5' <u>Clay (CL)</u>; gravelly, silty; olive brown (2.5Y4/3); fine gravel; firm to very stiff, slightly moist; high plasticity; medium toughness; nodules of greenish-brown clay.	9	DR	California Modified Blow Count- 8,17,22 Shear Strength = 9.375 kg/cm^2 Unconfined Strength = 3.0 $tons/ft^2$
42.0				AD	
44.0 (126)	CL				
46.0		45.0 to 46.5' <u>Clay (CL)</u>; silty; light olive brown (2.5Y 5/4); stiff to hard, slightly moist; high plasticity; low to medium toughness.	10	DR	California Modified Blow Count- 11,17,31 Shear Strength = 8.75 kg/cm^2 Unconfined Strength = >4.5 ton/ft^2
48.0				AD	
50.0		50.0 to 51.5' <u>Clay (CL)</u>; silty; olive brown (2.5Y 4/3); firm to very stiff, slightly moist; high plasticity; medium to high toughness; iron staining and mottling. BOH = 51.5'	11	DR	California Modified Blow Count- 8,15,28 Shear Strength = 11.25 kg/cm^2 Unconfined Strength = >4.5 $tons/ft^2$
52.0					Hole completed by back filling with cuttings.
54.0					

Appendix J

GCID Siphon Condition Assessment

GCID Siphon Condition Assessment Final Technical Memorandum

To:	Henry Luu/HDR
CC:	Holly Dawley/GCID and Zac Dickens/GCID
Date:	June 16, 2021
From:	Jeremy Kellogg, S.E./Jacobs
Quality Review by:	Howie Henrikson, P E./Jacobs and Peter Rude, P.E./Jacobs
Subject:	Glen Colusa Irrigation District Siphon Condition Assessment

1.0 Summary

The purpose of this technical memorandum (TM) is to summarize the findings of the structural condition assessment of three existing siphons in the Glen Colusa Irrigation District (GCID) main canal near the town of Willows, California. The siphons assessed included Walker Creek Siphon, Willow Creek Siphon, and the Railroad Siphon. These siphons were deemed to be potential critical infrastructure in their ability to convey water through the GCID main canal for the Sites Project (Project) due to their age and hydraulic conveyance capacity.

On February 4, 2021, Jeremy Kellogg and Jason Blum, from Jacobs, conducted a site visit to perform visual observations in accordance with the recommendations of American Concrete Institute (ACI) 201.1R. The observations included inspections of the concrete surfaces that were visually accessible. The goal of the assessment was to develop an initial understanding of the structures' behavior and characterize the performance and durability of the structures. Nondestructive hammer sounding was also implemented at accessible areas to verify the concrete conditions. The site visit was supplemented by a review of the siphon record drawings. Differences and variations between the record drawings and actual structures were documented. In general, the overall condition of the siphon structures was classified as satisfactory to good, with no major deficiencies or distress observed. The following sections outline the findings at each siphon.

1.1 Willow Creek Siphon

Willow Creek Siphon is a cast-in-place, concrete structure, approximately 55 feet wide (not including the wing walls) and 180 feet long which conveys water under Willow Creek. The siphon consists of six individual bays. Four original bays are approximately 6.5 feet wide; two retrofit bays are approximately 10 feet wide. The height of the siphon bays varies at the inlet and outlet with a minimum height of 8.5 feet tall through the middle of the structure. No visible movement joints were observed within the siphon bays. Record drawings for the existing original siphon construction were not obtained. However, record drawings were provided for an inlet and outlet modification project from the mid-1970s. The main siphon structure is assumed to have been constructed in the early-1900s when the canal was originally constructed.

Prior to the February site visit, GCID personnel had dewatered Willow Creek Siphon. Approximately 12 inches of water remained in the bottom of the siphon at the time of the site visit. The floor of the siphon was not assessed in detail because it was covered with water and sediment. The depth of sediment varied throughout the structure and was generally not more than a couple inches thick, at most. Based on observations that were made while walking along the floor, there were no indications of distress at the floor slab. In general, the structure appeared to be in good condition. There were no significant areas of concern or concrete degradation. Accessible portions of the structure were sounded with a hammer. All concrete sounded with a hammer appeared dense and structurally sound. No significant cracks or corroded reinforcing were observed. The following photos document the observations and surface conditions.

Figure 1. Willow Creek Siphon Outlet

Figure 2. Willow Creek Siphon Inlet

Figure 3. Typical Siphon Bay from the 1970s Project

Figure 4. Typical Siphon Bay from the Original Siphon Project

1.1.1 Willow Creek Siphon Observed Defects

As with most aging structures, there are areas which could benefit from preventative maintenance. The following items were observed and documented in the corresponding photos:

- Concrete erosion from abrasion was observed at the base of the original divider walls at the siphon inlet. The depth of erosion was approximately 6 inches from the original upstream divider wall nose. No reinforcing or evidence of corroded reinforcing were observed in the areas with concrete erosion. Given the lack of observed reinforcing in the concrete erosion, future assessments should consider verifying that the walls are not unreinforced. The concrete surfaces surrounding the erosion was observed to be sound. Therefore, rebuilding the walls to their original shape would be possible when the canal is empty.

Figure 5. Concrete Erosion

- Canal bank erosion was observed at both ends of the siphon. The loss of material was not significant enough to pose a structural risk to the siphon structure. However, rebuilding the canal banks as material is lost over time would be beneficial to prevent signification issues in the future.

Figure 6. Canal Bank at Siphon Inlet

1.2 Walker Creek Siphon

Walker Creek Siphon is very similar to Willow Creek Siphon in its geometry and condition. Walker Creek Siphon is a cast-in-place, concrete structure, approximately 55 feet wide (not including the wing walls) and 250 feet long which conveys water under Walker Creek. The siphon consists of six individual bays. Four original bays are approximately 6.5 feet wide; two retrofit bays are approximately 10 feet wide. The height of the siphon bays varies at the inlet and outlet with a minimum height of 8.5 feet tall through the middle of the structure. No visible movement joints were observed within the siphon bays. Record drawings for the existing original siphon construction were not obtained. However, record drawings were provided for an inlet and outlet modification project from the mid-1970s. The main siphon structure is assumed to have been constructed in the early-1900s when the canal was originally constructed.

Prior to the site visit in February, GCID personnel had dewatered Willow Creek Siphon. There were approximately 12 inches of water in the bottom of the siphon at the time of the site visit. The floor of the siphon was not assessed in detail because it was covered with water and sediment. The depth of sediment varied throughout the structure and was generally not more than a couple inches thick, at most. Based on observations that were made while walking along the floor, there were no indications of distress at the floor slab. In general, the structure appeared to be in good condition, with no significant areas of concern or concrete degradation. Accessible portions of the structure were sounded with a hammer. All concrete sounded with a hammer appeared dense and structurally sound. No significant cracks or corroded reinforcing were observed. The following photos document the observations and surface conditions.

Figure 7. Walker Creek Siphon Outlet

Figure 8. Walker Creek Siphon Inlet

Figure 9. Typical Siphon Bay from the 1970s Project

Figure 10. Typical Siphon Bay from the Original Siphon Project

1.2.1 Walker Creek Siphon Observed Defects

Walker Creek Siphon experienced similar areas of potential maintenance as Willow Creek Siphon, including concrete erosion and canal bank erosion/scour. The following images documented the areas which could receive future maintenance:

- Concrete erosion from abrasion was observed at the base of the original divider walls at the siphon inlet. The depth of erosion was approximately 6 inches. No reinforcing or evidence of corroded reinforcing were observed in the areas with concrete erosion. Given the lack of observed reinforcing in the concrete erosion, future assessments should consider verifying that the walls are not unreinforced. The concrete surfaces surrounding the erosion was observed to be sound. Therefore, rebuilding the walls to their original shape would be possible when the canal is empty.

Figure 11. Concrete Erosion

- Canal bank erosion and scour were observed at both ends of the siphon. The loss of material was not significant enough to pose an immediate structural risk to the siphon structure. However, rebuilding the canal banks as material is lost over time would be beneficial to prevent signification issues in the future.

Figure 12. Canal Bank at Siphon Outlet

1.3 Railroad Siphon

Railroad Siphon is a cast-in-place, concrete structure constructed in 1911 (according to the date on the structure). The overall structure is approximately 90 feet wide and 50 feet long. The siphon consists of five rectangular bays and two circular bays. The circular siphon bays appeared to be constructed from precast concrete pipe cast into the structure. The siphon conveys water under the railroad. The top slab of the siphon structure supports the railroad tracks. A one-page record drawing was reviewed prior to the site visit. There were significant discrepancies between the record drawings and the actual structure. For example, the record drawings did not include the two circular portions of the siphon, and the depth of the siphon bays did not match the record drawings.

GCID did not dewater the siphon structure prior to the condition assessment because of the challenges of isolating the siphon from the water in the main canal and limitations on pumping the water to another location. The depth of water varied in the main canal and siphon structure, from anywhere between 1 and 4 feet deep. Accessible portions of the structure were assessed. This included the above grade components and the areas where the depth of water was less than approximately 2 feet.

When compared to Walker and Willow siphons, overall, Railroad Siphon was observed to be in poorer condition, with degradation as noted. The portions of the structure below the normal water level were observed to be in good to satisfactory conditions. The guardrail, which is mostly above the normal water level, were observed to be in satisfactory to poor condition. The concrete canal liner at the slopes adjacent to the inlet and outlet were observed to be in poor condition. The following photos document the observations and surface conditions.

Figure 13. Railroad Siphon Outlet

Figure 14. Railroad Siphon Inlet

Figure 15. Typical Circular Siphon Bay

Figure 16. Typical Rectangular Siphon Bay

1.3.1 Railroad Siphon Observed Defects

Railroad Siphon revealed a few defects and some degree of distress. The observed defects are more extensive than defects observed at Walker and Willow siphons. The observations of the areas of distress are as follows.

- Canal bank erosion was observed at both ends of the siphon. Portions of the canal bank are shotcrete lined where the erosion has removed significant quantities of material from below/behind the liner.

Figure 17. Canal Bank Erosion at Eastern Side of Inlet

Figure 18. Canal Bank Erosion at Eastern Side of Outlet

Figure 19. Canal Bank Erosion at Western Side of Inlet

Figure 20. Canal Bank Erosion at Western Side of Outlet

- Spalled concrete and corroded reinforcing were noted at the outlet bays on the western side of the structure. The depth of water was too deep to access the spalled concrete; therefore, these areas were only documented in photos. It appeared that the concrete spalling was minor and could be repaired relatively easily when the canal is empty.

Figure 21. Spalled Concrete

Figure 22. Spalled Concrete

- Minor concrete erosion was observed on the inlet side of the of the siphon pier walls. Because of the depth of water in the siphon, the depth of the erosion was not precisely measured, but was estimated to be less than 1 inch. The concrete erosion documented does not pose a significant near-term concern. However, the surfaces could be rebuilt during future maintenance activities, when more significant defects are addressed.

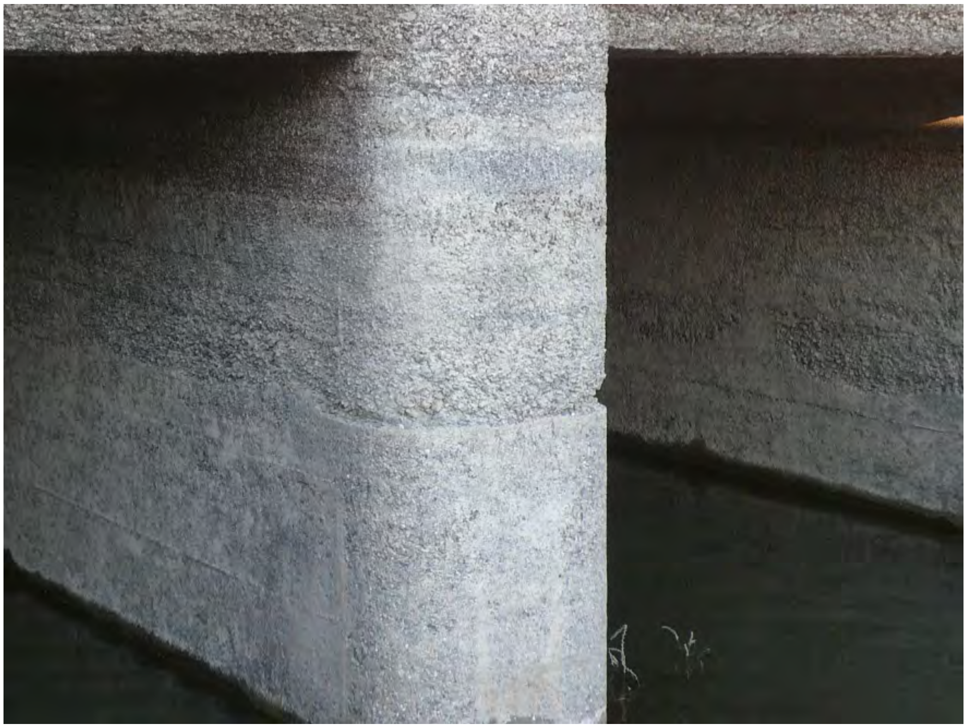


Figure 23. Concrete Erosion at Siphon Inlet

- Numerous concrete cracks were documented in the guardrail portion of the structure. The width of the cracks varied from hairline cracks to 0.25 inch. Some cracks were documented to extend through the full thickness of the concrete guardrail section. Very few cracks were noted below the guardrail. Two significant cracks were observed between the circular and rectangular siphon bays on the inlet side. These cracks were filled with a repair material that appeared to have been installed long ago. The crack repair material appeared to be sufficiently sealing the cracks. In the future, repairing the cracks throughout the structure will help to preserve the structure's integrity and extend its useful life.

Figure 24. Crack Through Guardrail Wall

Figure 25. Extensive Cracks at Guardrail Wall

Figure 26. Crack Through Guardrail Wall and Spalled Concrete

Figure 27. Crack Through Guardrail Wall

Figure 28. Crack at Western Side of Inlet

Figure 29. Crack at Eastern Side of Inlet

2.0 Conclusion

The overall condition of the siphons can be defined as good to satisfactory. However, Railroad Siphon included localized areas in poor condition above grade. Deficiencies were noted at each facility. The deficiencies observed appear to be items that can be addressed through future maintenance projects and do not pose an immediate risk to the siphons. Implementing maintenance repair projects will help to preserve the structures' integrity and extend their useful service life.

Walker Creek Siphon and Willow Creek Siphon do not have any immediate maintenance service needs. Therefore, we believe that they have a long useful service life. Railroad Siphon has localized above grade deficiencies that could benefit from maintenance activities. The above grade deficiencies which would benefit from maintenance would fall into the railroad's jurisdiction and are somewhat independent on the ability of the siphon to convey water. Given the minor degradation observed at the below grade components of the Railroad Siphon, we would conclude that the below grade components that convey water would have a long useful service life.

This TM provides the results of the preliminary visual condition assessment. While a service life prediction is beyond the scope of a visual assessment, should the need arise, additional analysis could be performed to define a predicted service life of the structures. A service life analysis would consider decisions concerning the end of service life related to safety, serviceability, functionality, and economic considerations. To make service life predictions, information is required on the present condition of concrete and reinforcement, concrete material properties, rates of degradation, past and future loading, structural analysis, and definition of the end of life. Based on remaining life predictions, economic decisions can be made on whether a structure should be repaired, rehabilitated, or replaced.

The service life prediction would need to define the quantity of data to be accumulated, laboratory testing procedures, desired accuracy of the predictions, and available budget for the predictive effort. Performing a service life prediction is an in-depth numerical analysis that uses input parameters, based on field data, laboratory testing, and environmental effects, to extrapolate the time from the present state to the condition constituting the end of service life. Theoretical models should be developed in addition to empirical models to give realistic predictions of the remaining service life.

3.0 Citations

ACI 201.1R-08. 2008. *Guide for Conducting a Visual Inspection of Concrete in Service*.

Appendix K

Final HC Constructability

Final HC Constructability Technical Memorandum

To:	Sites Project Authority
CC:	Henry Luu, P.E. (HDR)
Date:	April 19, 2021
From:	Jeff Smith, P.E. (Jacobs), Isabell Barrios (Jacobs), Brian Martinez, P.E (Geosyntec), Derek Morly, P.E. (Geosyntec), Larry Fishman, P.E. (Vanderweil)
Quality Review by:	Peter Rude, P.E.(Jacobs)
Authority Agent Review by:	Henry Luu, P.E. (HDR)
Subject:	Constructability Analysis for Conveyance Facilities Task Order No. 2

1.0 Executive Summary

The purpose of this exercise was to investigate and confirm the Sites Conveyance Facilities (HC facilities) can be constructed given the complexity, schedule, as well as the availability of materials and labor.

1.1 Schedule

The construction schedule to have the HC facilities complete by end of 2028 is reasonable, but will require careful planning to ensure long-lead time equipment is specified and ordered early. This equipment includes the pumps, generator turbines, and switchgear for substations. The timing of completing work at existing facilities such as installing new pumps at the Red Bluff Pumping Plant, dredging of the Funks Reservoir and tying into the GCID Main Canal will be performed over several seasons given the short duration when these facilities may be taken out of service.

1.2 Construction materials

Construction materials are primarily composed of earthwork and concrete, both of which are readily available in the timeframe allowed for the quantity required. Earthwork may require moving excavated spoils for reuse on other project features such as the large reservoirs and for construction of the TRR East. However, there should be sufficient spoils material available given the large volume generated from the pipelines construction.

1.3 Workforce

Providing for a sufficient labor force for this project poses a challenge, but is manageable. It is anticipated that much of the labor force would come from the surrounding region, with contractors also bringing some skilled work force from other areas. The surrounding counties, including Placer, Sacramento and Yolo Counties, have a regional population of over two million. It may be advantageous to consider project labor agreements with trade unions as a means of accommodating the project labor requirements, as well as avoiding labor disputes. This strategy has been used successfully on other large civil works projects in California.

1.4 Equipment Availability

The required equipment consists of standard heavy earthmoving and excavation equipment. Although the quantity of equipment may be large, especially for reservoir construction, this type of equipment is commonly found in the region and elsewhere. Large contractors would use their own equipment, lease or purchase new equipment.

1.5 Summary

In summary, although there are risks to the scheduled four-year completion of construction, the HC facilities of the Sites Reservoir Project can be constructed with existing technology and available construction materials, work force and equipment.

2.0 Introduction

The Sites Reservoir Project (Project) consists of a large reservoir, ancillary roads, and conveyance facilities near Maxwell, California. The Site Joint Power Authority (Authority) decided to segregate the design of these facilities into two segments. The first, Segment H Reservoir (HR), includes design of the reservoir features (including several dams and inlet/outlet (I/O) tunnels at Golden Gate Dam) and relocation of roads displaced by the reservoir. The second segment, Segment H Conveyance (HC), includes improvements to: the two existing diversion canals from the Sacramento River to the project area (Tehama-Colusa Canal [TCC] and Glenn-Colusa Irrigation District [GCID] Main Canal); regulating reservoirs (existing Funks Reservoir and a new Terminal Regulating Reservoir); two pumping generating plants (PGP) and their respective substations; electrical interconnection transmission lines; large-diameter pipelines from each PGP to Sites Reservoir; and a large-diameter pipeline to convey water from the TCC to the Colusa Basin Drain (CBD) or Sacramento River near Dunnigan, California.

This technical memorandum addresses the constructability of the Conveyance HC segment. Detailed descriptions of each facility are provided in the next section. An overall site plan of the project area is provided on Figure 1.

2.1 General Description of Facilities

Following is a list of the individual new facilities and existing facilities associated with only the Conveyance portion of the Sites Project that require improvements:

- Improvements to the Tehama-Colusa Canal Authority (TCCA) Red Bluff Pumping Plant on the Sacramento River
- GCID canal improvements upstream of the Terminal Regulating Reservoir (TRR)
- TRR-East Alternative
- TRR-West Alternative
- TRR PGP with respective substation
- TRR pipelines
- Funks Reservoir – sediment removal
- Funks PGP with respective substation
- Funks pipelines
- Western Area Power Administration (WAPA) or Pacific Gas and Electric (PG&E) substation/switchyard
- Power transmission lines
- Dunnigan Pipeline (Alternatives 1 and 2)

- Administration and operations building
- Maintenance and storage building
- Access roads

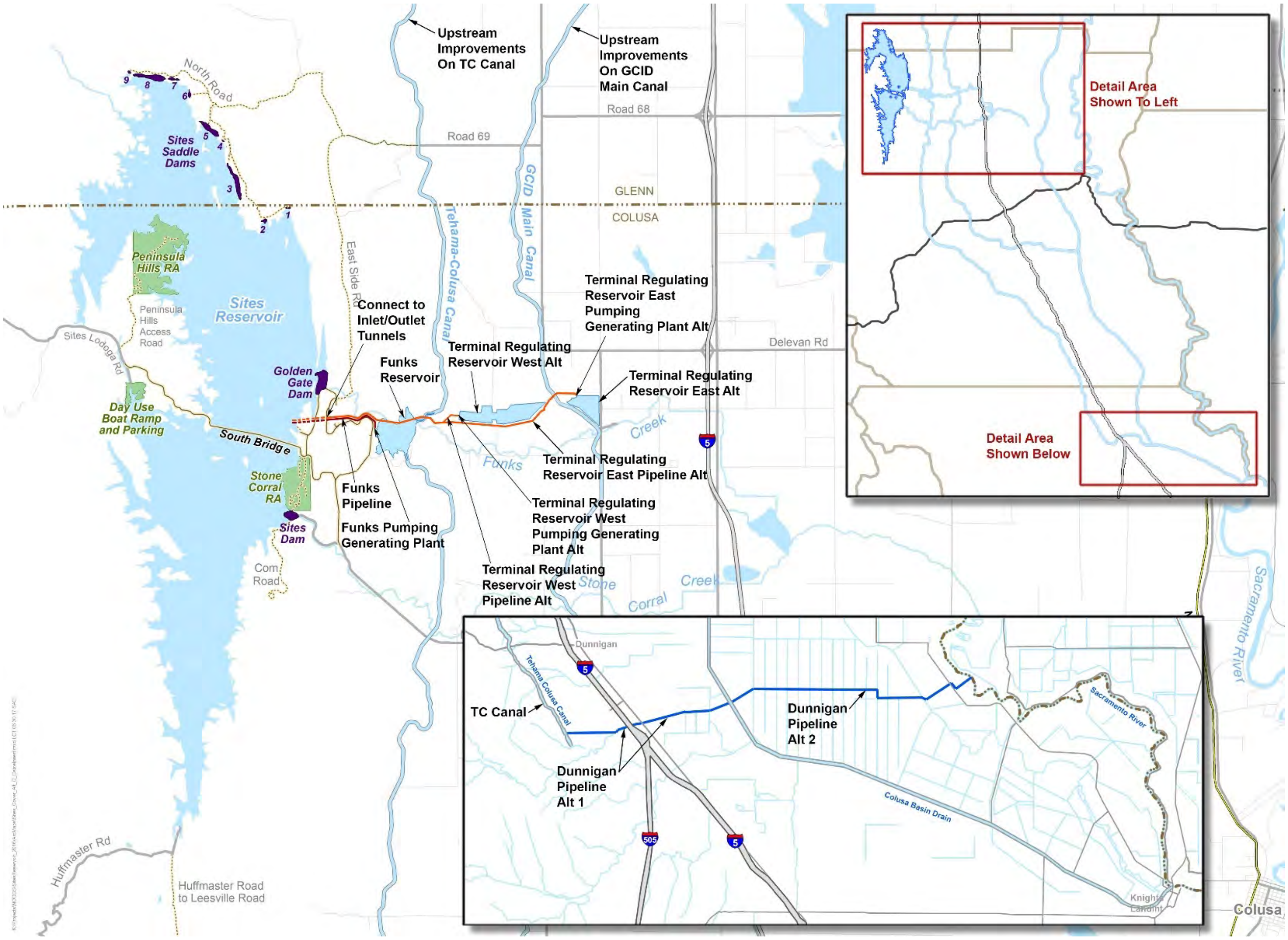


Figure 1: Project Area Site Plan

2.1.1 Improvements to the TCCA Red Bluff Pumping Plant

The Red Bluff Diversion is located on the Sacramento River in Red Bluff, California. The facility includes a 2,500 cubic feet per second (cfs) capacity, 1,180-foot-long fish screen structure, forebay, pumping plant (current capacity 2,000 cfs), electrical switchyard, and a 660-foot-long access bridge, canal, and siphon under Red Bank Creek, to deliver water from the Sacramento River into the TCC and Corning Canal. This facility was constructed and put into operation in October 2012. The pumping plant was designed to accommodate the Sites Project. The plant includes space to add two additional 250 cfs 600-horsepower pumping units, bringing the total pumping capacity to 2,500 cfs.

2.1.2 GCID Main Canal Improvements

The GCID Main Canal delivers water from the Sacramento River to water users along its route, from its diversion point approximately 5 miles northwest of Hamilton City to southeast of the City of Williams. The canal is a 65-mile-long, unlined, earthen channel, with capacity varying from 3,000 cfs at the upstream end to 300 cfs at the southern terminus. Water conveyed by the canal is pumped by the Hamilton City Main Pump Station into the GCID Main Canal.

Improvements to the GCID Main Canal will include a new 3,000 cfs headworks structure just downstream of the Hamilton City Diversion, two new siphon structures (Willow Creek and Walker Creek), modifications to a railroad siphon at Willows, canal earthwork, and some canal bank gravel road improvements. The need for replacing the siphons and railroad crossing will be determined after a canal hydraulic model and condition assessment are completed, which is anticipated to be in Spring 2021.

2.1.3 TRR

This is a new reservoir that will be hydraulically connected to the GCID Main Canal, about 3 miles east of Funks Reservoir and just upstream of the Funks Creek Siphon at milepost 41.3 on the GCID Main Canal. The footprint of the TRR will be approximately 130 acres, with a storage volume of approximately 600 acre-feet. The TRR will also include gates to control water flow in and out of the GCID Main Canal. There are two alternative locations for the TRR: one on the eastern side of the GCID Main Canal (TRR-East) and one on the western side of the GCID Main Canal (TRR-West).

2.1.4 TRR PGP

This is a PGP that will be used to pump water from the TRR to the Sites Reservoir. This facility will also include hydroelectric turbines to generate electricity when flow is released from Sites Reservoir to the TRR and GCID Main Canal. As part of this PGP facility, there will also be an energy-dissipation facility to allow releases back to the TRR as backup to the hydroelectric turbine facilities. The pumping plant will have a capacity of 1,800 cfs; the generating plant will have a capacity of 1,000 cfs.

2.1.5 TRR Pipelines

These are two, parallel, 12-foot-diameter pipelines used to convey water between the TRR PGP and the Sites Reservoir. These pipelines will connect from the piping manifold at TRR PGP to the downstream side of the proposed 32-foot-diameter tunnel connected to the Site Reservoir I/O structure. The approximate length of these pipelines for TRR-East is 4.4 miles (23,200 feet) each. The approximate length of these pipelines for TRR-West is 2.5 miles(13,000 feet) each. Just downstream of the piping manifold that connects the TRR pipelines with the I/O tunnel, there is a 42-inch-diameter Environmental Water Pipeline that is approximately 2,550 feet long and discharges into Funks Creek. This pipeline is not to be used for construction purposes, but is a long-term solution to provide water to Funks Creek just downstream of the proposed Golden Gate Dam.

2.1.6 Funks Reservoir

The U.S. Bureau of Reclamation (Reclamation) constructed the Funks Reservoir in the mid-1970s, with the intent of providing operational flexibility for the TCC. There are check structures on the TCC just upstream and downstream of the reservoir. The TCC is located about 1 mile east of the proposed Sites Reservoir. At the time of construction, the reservoir had a useable capacity of 1,170 acre-feet between operating levels of 199.5 and 205.2 feet elevation, and 1,080 acre-feet of inactive storage below elevation 199.5 feet, for a total capacity of 2,250 acre-feet. However, the addition of sediment from Funks Creek and the TCC have likely reduced the total storage volume. Additionally, a cofferdam will be constructed within Funks Reservoir to facilitate construction of the TRR pipelines. The resulting storage volume reductions will be offset by sediment removal and excavation where storage capacity can be regained. The spillway has a capacity of 2,500 cfs. The Project will remove accumulated sediment to recapture the design storage volume.

2.1.7 Funks PGP

This is a PGP that will be used to pump water from Funks Reservoir to the Sites Reservoir. This facility will also include hydroelectric turbines to generate electricity when flow is released from Sites Reservoir to Funks Reservoir and, ultimately, to the TCC. Part of this PGP facility will be an energy-dissipation facility that will allow releases back to Funks Reservoir as backup to the hydroelectric turbine facilities. The pumping plant will have a capacity of 2,100 cfs; the generating plant will have a capacity of 2,000 cfs.

2.1.8 Funks Pipelines

These are 2 parallel, 12-foot-diameter pipelines used to convey water between the Funks PGP and the Sites Reservoir. These pipelines will connect from the piping manifold at Funks PGP to the downstream side of the proposed, 32-foot-diameter, tunnel connected to the Site Reservoir I/O structure. The approximate lengths of these pipelines are 1 mile (5,200 feet) each.

2.1.9 Dunnigan Pipeline

The Dunnigan pipeline consists of either a 9-foot-diameter or 10.5-foot-diameter pipeline that will be used to release water from the TCC to the Sacramento River. The concept is to release flow from Sites Reservoir to Funks Reservoir, where the flow will then go south about 40 miles to near the end of the TCC. At this point, flow will be diverted into the Dunnigan pipeline, where flow will head either to the CBD, which flows to Sacramento River, or directly to the Sacramento River. If the pipeline discharges directly into the Sacramento River, then a portion of the water will also be diverted and discharged in the CBD. Alternative 1 consists of a 9-foot-diameter pipeline that is about 4 miles (20,900 feet) long and discharges into the CBD. Alternative 2 consists of a 10.5-foot-diameter pipeline that is about 9.4 miles (49,500 feet) long and discharges directly into the Sacramento River.

2.1.10 Electrical Transmission Lines and Substations

Electrical transmission lines will be required to connect the existing WAPA or PG&E 230 kV transmission lines to the TRR PGP and the Funks PGP. There are 230 kilovolt (kV) electrical transmission lines running near the proposed project area. Specifically, the WAPA transmission lines run very close to Funks Reservoir in a north-south direction, with a parallel 230 kV line owned by PG&E a few miles east of the WAPA transmission lines. It is anticipated that one of these transmission lines will be connected to provide power for the Project, and receive generated electrical power from the hydroelectric turbines. Substations will be needed to provide power to and receive power from both the TRR and Funks PGP's.

2.1.11 Administration and Operations Building

At this time, staffing requirements for operating and maintaining the Sites facilities have not been defined, but an administration and operations building is provided, based on a drawing obtained from Reclamation. This building is anticipated to be next to the Funks PGP.

2.1.12 Maintenance and Storage Building

A building will be required to provide maintenance and storage associated with the Project. A drawing from Reclamation of the building was used in the feasibility design. This building is anticipated to be next to the Funks PGP.

2.1.13 Access Roads

Access to the proposed TRR-East site would likely be from McDermott Road, which lies adjacent to the proposed reservoir. Access to the Funks complex (PGP and reservoir) is currently accomplished using the operations and maintenance road, along the TCC. Access to the proposed TRR-West site would come off the Access to the Funks complex. A new access road will be required that allows larger equipment and year-round access. It is also anticipated that roads will be constructed within the TRR-East or TRR-West and Funks Pipeline easements, not only to provide access to the pipelines and electrical power transmission lines, but also to act as a secondary access road to the project facilities. Access roads are more fully described in Section 4 and in Appendix A.

2.2 Purpose and Scope

The purpose of this task is to demonstrate that the HC portion of the Project can be constructed with existing technology and availability of construction materials, work force, and equipment. This task includes the following:

- General construction conditions on conveyance activities, including site access, weather and environmental considerations, and staging use
- Characterization of material balance for TRR-East and TRR-West, considering borrow material sources, locations of placement within the TRR and their required volumes, and disposal
- Equipment use tables (including schedule and durations of use)
- Construction sequencing plan, risks, and construction schedule for the facilities within the HC contract (The constructability analysis will demonstrate the ability to provide public benefits by 2030.)
- Work force staff and equipment needs estimated over the construction period, for facilities within the HC contract

2.3 Limitations

The scope of work for this technical memorandum (TM) is restricted to the development of the constructability activities for the Sites Reservoir under the HC contract. Constructability activities for the reservoir facilities are separately considered in a companion TM for the HR contract.

Jacobs represents that our services have been conducted in a manner that is consistent with the standards of care ordinarily applied as the state of practice in the profession, within the limits prescribed by our client.

This TM is intended for the sole use of the Sites Project Authority. The scope of services performed may not be appropriate to satisfy the needs of other users. Any use or reuse of this document or of the findings, conclusions, or recommendations presented herein is at the sole risk of said user.

3.0 Public Interface and Site Safety

3.1 Public Interface and Traffic Routing

Construction of conveyance facilities will involve approximately 4 years of regularly transporting construction equipment and materials on public roadways leading to the site. The anticipated increase in traffic in the rural area of the Project warrants special planning. The Authority is taking measures for the appropriate conveyance of construction traffic, considering the safety and convenience of the traveling public. Construction access routes to the site have been defined to avoid the Town of Maxwell.

Objectives of the traffic handling strategy will be: avoiding the comingling the traveling public with construction activities, avoiding public interface with heavy off-road equipment, and minimizing public interface with other construction equipment required on public roadways.

Construction access figures are provided in Appendix A.

3.2 Site Safety

The contractor is responsible for means and methods to complete the work safely. The contractor also is required to provide for public safety and safe access for inspection and to Authority employees.

California Code of Regulations (CCR), Title 8 and California Department of Industrial Relations, Division of Occupational Safety and Health (Cal/OSHA) will have overall jurisdiction regarding project safety, including tunneling. Additionally, the interconnected utility (WAPA or PG&E) Health and Safety Standards and Protocols will be included in the works for the contractor to follow and implement.

Work around construction equipment requires special precautions and the contractor will be required to provide and maintain equipment in accordance with CCR Title 8.

4.0 General Considerations

4.1 Procurement and Work Packages

Procurement packages should divide the work in a manner that considers market conditions, resource availability, and bonding, and is conducive to concurrent construction of conveyance facilities. The construction procurement strategy and program should also recognize the need for participation from large, national, and international contractors with adequate resources to complete the anticipated work. The procurement strategy should consider contractor prequalification and proposals, as necessary, to provide for contracting with constructors who are qualified for the work involved; the strategy should anticipate adequate time in the procurement schedule.

For this constructability analysis, and considering the site arrangement, contractor resources, and work type, potential contract packages are anticipated as follows:

- Design-bid-build (traditional) contracts:
  - TCCA Red Bluff Pumping Plant improvements
  - GCID Main Canal improvements
  - TRR Alternatives
    - TRR-East
      - Contract 1: Ground improvement (cement deep soil mixing [CDSM]), also includes haul roads, GCID Canal bridge, material handling, stockpile
      - Contract 2: PGP and reservoir earthwork, also includes base liner, spillway, I/O works, GCID Canal plug
    - TRR-West
      - Contract 1: Earthwork (reservoir excavations), also includes haul roads, surface water diversion, stockpile (Note: Because this earthwork does not have to be done all at one time or any particular time, this contract can be broken into multiple contracts and/or can be part of HR Reservoir contract[s] to optimize material usage)
      - Contract 2: PGP and I/O works, also includes reservoir base liners, tunnels between main and extension reservoirs, existing canal lateral relocation, GCID Canal plug
  - Funks Reservoir
      - Contract 1: Dredging, also includes haul roads, surface water diversion (including Funks Creek), material handling, dewatering, stockpile
      - Contract 2: PGP and reservoir earthwork, includes Funks Creek diversion, approach channel excavation, temporary cofferdams
- Design-Build Contracts:
  - TRR/Funks pipelines
  - Dunnigan pipeline Alternative 1 or 2
  - Transmission power lines
  - Electrical substations
  - Interconnection substation for WAPA or PG&E

4.2 Site Access

4.2.1 Improvements to the TCCA Red Bluff Pumping Plant

Site access plan and details for the GCID Main Canal upgrade locations are provided on the figures in Appendix A.

4.2.2 GCID Main Canal Improvements Area

Site access plan and details for the GCID Main Canal improvement locations are provided on the figures in Appendix A.

4.2.3 Funks and TRR Area

The proposed Funks PGP and TRR PGP sites are located in Colusa County, about 7 miles west of Maxwell, California. Access is shown on the figures in Appendix A.

Some roadway improvements will be required within the Funks area. The Funks PGP site will be accessed via a 30-foot-wide all weather gravel road from Maxwell Sites Road to the south. Paved parking will be provided at the PGP. Existing gravel roads will be improved to be 30 feet wide; these roads will be relocated through the PGP site. A 30-foot-wide all weather gravel bypass road may be provided to the west of the site. On the northern side of the site, the existing dirt road will be improved to be a 30-foot-wide all weather gravel road that will follow the existing road alignment until it reaches the TRR pipeline. At that location, a new 30-foot-wide all weather gravel access road will be built alongside the Funks and TRR pipelines to the connection with the Sites tunnels.

Most of the proposed Funks PGP site is in a Federal Emergency Management Agency (FEMA) Area of Minimal Flood Hazard, Zone X, but a portion of the existing gravel road to the northwest of the PGP site and adjacent to the existing creek is located within a FEMA Special Hazard Flood Area without Base Flood Elevation, Zone A. This portion may need to be raised, if all-season access from that direction will be required.

The proposed TRR-East is located in Colusa County, east of the GCID Main Canal, north of Funks Creek, and just West of McDermott Road. The site will be accessed via a maximum 30-foot-wide all weather gravel road from McDermott Road. Paved parking will be provided near the pumping generating plant.

The proposed TRR-East site is located within a designated FEMA Special Flood Hazard Areas, Zone A, Without Based Flood Elevation. A base flood elevation will need to be determined prior to project approval.

The proposed TRR-West is located in Colusa County, west of the GCID Main Canal, east of Funks Reservoir, and north of Funks Creek. The site will be accessed via an all-weather gravel road off Funks Reservoir. Paved parking will be provided near the PGP.

The proposed TRR-West site is not located within a flood zone.

4.2.4 Dunnigan Pipeline Area

Site access plans and details for the Dunnigan pipeline Alternatives 1 and 2 are on the figures in Appendix A.

4.3 Weather Considerations

Wet weather may affect construction activities, although not significantly. Potential impacts may occur for a few specific work components, as detailed in the following paragraphs.

Wet weather has potential to delay the placement of the welded geomembrane liner on the cofferdams at Funks Reservoir. This activity is to be performed during the drawdown of the reservoir during the TCC Canal non-operational period, from December to March. The liner needs to be heat-welded together and will not seal if it is wet. In rainy weather, time-consuming drying could delay completion. Alternatively, rain shelters can be used to avoid such delays.

Both the TRR-East and TRR-West reservoir options involve I/O connections to the GCID Main Canal, with this construction to be performed within the GCID Main Canal non-operational window (January through February). Moving heavy equipment around during times that are too wet can cause delays and other construction challenges.

Stormwater control and stream diversions (particularly Funks Creek) will need to be handled in accordance with the Project's stormwater pollution prevention plan during construction activities.

Wet weather will have an impact on the construction of the Dunnigan pipeline, Alternatives 1 and 2, once the pipelines are east of the Highway (Hwy) 99 and railroad crossing. This area has silty/clay soils that make it very difficult for pipeline construction during extended wet weather.

4.4 Environmental Impacts and Impacts on Construction

It is beyond the scope of work for this TM to provide a detailed evaluation of environmental impacts resulting from construction; these impacts are addressed by others. Project planning will need to consider protection of species, such as nesting birds. A strategy of brush and tree clearing or netting of trees prior to nesting season could be employed to deter nesting birds, which otherwise could impact construction. Giant garter snake habitat is present along the Dunnigan pipeline; work adjacent to creeks and drains will need to be considered as well.

Dust control measures, similar to those employed on similar civil construction works, will be implemented. These will include gravel plating of haul roads, use of dust suppressants or surfactants on haul roads, water applied to haul roads, spray bars and dust catchment systems on aggregate processing equipment and batch plants, and other measures. Stockpiles and other open sources of fugitive dust will likely require temporary seeding. Air monitoring stations will be used.

4.5 Geotechnical Considerations

All of the planned conveyance facilities are considered constructable, using standard construction procedures and current geotechnical engineering practices.

4.5.1 TRR Alternatives

4.5.1.1 TRR-East

TRR-East features include embankment berms, canal I/O works, and a bridge over the GCID Main Canal. An important geotechnical consideration prior to the construction of TRR-East embankments involves ground improvement activities. Previous explorations within the footprint of the reservoir indicate adverse subsurface conditions that may be susceptible to liquefaction, lateral spreading, and ground settlement. To address these concerns, ground improvement will be performed and is anticipated to consist of CDSM methods.

Prior to mobilizing equipment for bridge construction, current site conditions along the eastern and western edges of the GCID Main Canal and available access routes should be considered. Limited available workspace for construction activities (such as pile driving and pile cap construction) and permissible access roads crossing the GCID Main Canal may limit mobilization or delay construction. Equipment mobilization should be initiated based on anticipated construction sequencing to the extent feasible.

Because of shallow or seasonal perched groundwater conditions, temporary dewatering may be required during excavation across the base of the reservoir. Groundwater removed during TRR-East construction activities would be managed and stored in accordance with state and local regulations.

Embankment berms associated with TRR-East will be under Division of Safety of Dams' (DSOD's) jurisdictional oversight. Anticipated turnaround times for required DSOD permitting and inspections must be accounted for to facilitate appropriate construction scheduling and help avoid delays in construction.

4.5.1.2 TRR-West

TRR-West features include two reservoir excavations (main and extension), the canal I/O works, and the extension reservoir connecting tunnel.

One of the geotechnical considerations includes high-cut slopes that could experience groundwater seepage, seasonal surface water erosion, and sediment transport. These considerations are routine and can be managed by implementing best management practices, as described in the Project’s stormwater pollution prevention plan.

Excavations for each reservoir and the I/O works will produce topographically low areas that will concentrate groundwater, surface water, and construction water during construction activities. This concentration of water is considered routine and can be managed by a site-specific pumping plan to prevent conflicts with construction activities.

TRR-West features also cross existing corridor facilities (including overhead electrical transmission, underground gas lines, the GCID Main Canal, and a local landowner canal lateral). These crossings should be considered during construction to facilitate appropriate scheduling time for permitting, depth and distance to associated feature, and operating closure constraints (for the GCID Main Canal). In particular, the tunnel connecting the reservoirs crosses below the gas lines and considerations must be made to ensure tunnel roof stability and ground control (see Section 3.9 for more details).

Unlike TRR-East, TRR-West does not fall within DSOD’s jurisdiction (because no dam will be constructed), which will remove the time associated with DSOD permitting and inspections.

4.5.2 Funks

Funks Reservoir features include sediment removal by dredging, temporary cofferdams construction and removal, and PGP approach channel excavation. Geotechnical considerations include soil characteristics of the dredge material to be reused as a material for construction.

For the dredged sediments to be used throughout the Project, they will need to be dewatered. Some soils from dredging are anticipated to be predominantly finer material and, therefore, likely to require more time to dry enough to be used for construction. Suitable materials for the temporary cofferdams are proposed to come from both the dredging and other areas of excavation. The cofferdam material will need to be sourced prior to the cofferdam construction, which would occur in the December through February non-operational period of Funk/TCC.

4.5.3 Other Conveyance Features

Other conveyance features that involve earthwork and geotechnical considerations, and for which limited geotechnical information is currently available include:

- The GCID Main Canal improvements. Geotechnical considerations include structural stability and uplift for the main head gate and siphon structures, and dewatering at those locations so the structures can be built in the dry.
- The TRR-East pipelines. Geotechnical considerations include dewatering the pipe trench near the GCID Main Canal, crossing the GCID Main Canal, pipe trench stability, tunneling/crossing the TCC and crossing the northern portion of Funks Reservoir.
- The TRR-West pipelines. Geotechnical considerations include pipe trench stability, tunneling/crossing the TCC, and crossing the northern portion of Funks Reservoir.
- The Funks pipelines. Geotechnical consideration include pipe trench stability and dewatering the trench along Funks Creek.

- The Dunnigan pipeline Alternative 1. Geotechnical considerations include pipe trench stability, tunneling under Interstate 5, Hwy 99, and the railroad; and dewatering the pipe trench as it heads east of the Hwy 99.
- The Dunnigan pipeline Alternative 2. Geotechnical considerations include the same as Dunnigan pipeline Alternative 1 and tunneling under the CBD and associated east levee (State Levee), crossing State Hwy 45, and going over the Sacramento River Levee.

The TCCA Red Bluff Pumping Plant improvements do not require any geotechnical considerations because the improvements are to an existing facility that involves no earthwork.

All of these features may be in close proximity of existing features near each location. Schedules should be planned and coordinated accordingly to protect existing features, and allow for operating windows, permitting, and associated approvals to avoid schedule delays.

4.6 Existing Utilities

4.6.1 Red Bluff Pumping Plant and TCC

The Red Bluff Pumping Plant and the TCC, which is a concrete-lined canal, needs to remain in service year round except for a 6- to 8-week period in December through early February. The dual TRR-West or the TRR-East pipelines will cross the canal at one location close to the entrance of the TCC to Funks Reservoir. Depending on time of year and further design, the dual 12-foot-diameter pipelines could be installed either by tunneling underneath the TCC or open-cutting the TCC.

Since the TCC and the Red Bluff Pumping Plan are Bureau of Reclamation owned facilities, work associated with the Red Bluff Pumping Plant, the TCC and Funks Reservoir will need to be coordinated with the Bureau of Reclamation and the Tehama-Colusa Canal Authority (TCCA).

4.6.2 GCID Main Canal

The GCID Main Canal is an earthen canal without any liner. It needs to remain in service year round, except for a 6- to 8-week period in December through early February. The dual TRR-East pipelines will cross the canal just west of TRR-East. It is expected that the dual 12-foot-diameter pipelines could be installed by open-cutting the canal. The connection of the GCID Main Canal to either TRR-East or TRR-West would be one of the last construction items for either reservoir project.

Since the GCID Main canal is a GCID owned facility, work associated with the GCID Main Canal will need to be coordinated with GCID.

4.6.3 PG&E

PG&E has two 230 kV transmission lines, running north to south, through the project site between Funks Reservoir and the GCID Main Canal. In PG&E’s same right-of-way corridor, they also have two high-pressure gas lines. Coordination with PG&E will have to occur during design to be able to cross their facilities with the TRR-East pipelines, or the TRR-West reservoir.

In addition, coordination will need to occur with PG& E if the decision is made to connect to their 230 kV transmission lines for obtaining electricity for the PGPs and for transmitting power generated by the PGPs back to the electrical grid. This coordination would include: establishing the point of interconnection (POI); designing the modification of existing structures and conductors for crossing transmission lines; designing, constructing, and starting up and commissioning the substation prior to energization; and sequencing with the pumping station power energizing and startup schedule with the utility.

4.6.4 WAPA

WAPA has one 230 kV and one 500 kV transmission line running north to south through the project site, between Funks Reservoir and the GCID Main Canal. Coordination with WAPA will have to occur during design to be able to cross under their facilities with the TRR-East or TRR-West pipelines.

In addition, coordination will need to occur with WAPA if the decision is made to connect to their 230 kV transmission lines to obtain electricity for the PGPs and transmit power generated by the PGPs back to the electrical grid. This coordination would include: establishing the POI; designing the modification of existing structures and conductors for crossing transmission lines; designing, constructing, and starting up and commissioning of the substation prior to energization; and sequencing with the pumping station power energizing and startup schedule with the utility.

4.6.5 CBD

The CBD is an existing earth drainage feature that is unlined that has a state levee on its eastern bank. The CBD in general and at the location of project facilities (River Mile 10.0) is full of water all year. The levee is maintained by numerous entities. The CBD itself is not maintained by anyone. The CBD water surface elevation is controlled by the Department of Water Resources at the Knights Landing Outfall Gates structure near the town of Knights Landing.

Design and construction of the CBD outlet structure for Dunnigan pipeline Alternatives 1 and 2, and tunneling under the CBD and east levee for Alternative 2 will need to be coordinated with local landowners, Reclamation District No. 108, and the Department of Water Resources.

4.7 Site Staging and Use

Staging areas will be required near each of the conveyance facilities being constructed. The staging areas will be developed by the construction contractors for various activities, including: construction office facilities, material laydown areas, and equipment storage and maintenance. Each of the facilities has one or more proposed staging areas identified.

4.7.1 Red Bluff Pumping Plant Improvements

There are two staging areas that can be used at the existing pumping plant, as shown on the figures in Appendix A.

4.7.2 GCID Main Canal Improvements

Staging areas are located at the main headgate structure, the Willows siphon, the Walker Creek siphon, and the railroad siphon.

4.7.3 TRR

4.7.3.1 TRR-East

Equipment laydown and staging areas for TRR-East will be primarily situated inside the footprint of the reservoir and I/O works areas. One temporary (approximately 21-acre) stockpile area will be located west of TRR-East and the GCID Canal and can be used for staging during construction activities. Relatively limited staging areas and site access routes should be considered as construction progresses to facilitate availability of adequate storage and laydown capacity and to avoid potential schedule delays.

4.7.3.2 TRR-West

Staging for TRR-West construction of the main reservoir, extension reservoir, and I/O works will be within the footprint of these same features. Because staging will occur in the same areas as construction, site access routes and laydown areas should be considered as construction progresses to avoid potential schedule delays.

One temporary (approximately 20-acre) stockpile area will be located north of TRR-West extension reservoir and can be used for staging during construction activities. The staging area for the extension reservoir connecting tunnel will be within the footprint of the main and extension reservoirs because this tunnel will be constructed after the reservoirs are excavated.

4.7.4 Funks

Staging areas at Funks Reservoir will be needed for the dredging equipment, the materials needed to build the PGP, and the liner material for the cofferdams. The PGP footprint and areas identified nearby will be used for staging of heavy equipment and construction materials used for dredging and during the cofferdam construction. Once the PGP construction begins, the staging area will be moved slightly up the Funks Creek valley. Many of the stockpile areas identified for Funks Reservoir materials would have dual purposes as staging and laydown areas throughout the life of the Project.

4.7.5 Remaining Conveyance Facilities

For the TRR-East pipelines, TRR-West pipelines, Funks pipelines, Dunnigan pipelines Alternatives 1 and 2, staging areas will be developed along the length of pipelines within the designated construction easements, at the contractor’s discretion. The electrical transmission lines will be installed after the TRR pipeline.

4.8 Construction Water

Average construction water use is expected to be approximately 350,000 to 400,000 gallons per day, primarily related to the pipelines for trench compaction, work at TRR East or TRR West, dust control, and lost water due to dredging of Funks Reservoir. Total water use for the Project associated with the HC facilities is roughly calculated to be approximately 175 to 200 million gallons.

Water used for construction would be transferred to the facility footprints from either the TC Canal or the GCID Main Canal by trucks and/or pipes. The pipes are not expected to be buried, except at crossings of heavily trafficked areas, where they may be installed several feet below ground surface. We have assumed water will be conveyed mostly by 4,000 gallon water trucks.

The Dunnigan pipeline Alternative 1 and 2 would obtain water from wells or dewatering efforts required during pipeline construction or from the TC Canal.

4.9 Tunneling

Between the TRR pipeline, Funks pipeline, and Dunnigan pipeline, seven tunnels will be constructed across the Project. Four proposed, 12-foot-diameter, tunnels (two for TRR-East and two for Funks) will be used to cross the GCID Main Canal and the TCC Canal. The remaining three tunnels are for the Dunnigan pipeline: for Alternative 1, 10.5-foot casings will be required, first under Interstate 5 and then Hwy 99 and railroad; and for Alternative 2 the tunnel locations and size will be the same at Alternative 1, with an additional tunnel of the same size to cross under the CBD.

For TRR-West there are four proposed, 12-foot-diameter tunnels, to connect the two reservoirs (main and extension) that make up the TRR-West reservoir. The tunnels will go under the PG&E transmission towers and two PG&E high-pressure gas pipelines.

All tunneling features will follow standard guidelines.

5.0 Site Materials and Use

The primary objective for materials will be to use excavated materials for fill, as a direct or single haul-and-place activity. The potential for double handling exists because the timing and suitability of materials will vary, as well as the coordination of where and when materials are needed as fill. Most excavation and materials processing activities can be sequenced early in the overall Project to maintain flexibility for efficient reuse of earthen materials (for example, as random fill). A less preferred option would be permanent disposal on site.

The least preferred option would be off-haul of materials for disposal. Disposal quantities should be small if more beneficial project site areas are identified for reuse. The project team will further develop the ultimate dispositions of these materials to optimize the reuse of material for the overall Sites project, as discussed in the following subsections for each TRR option or Funks Reservoir modification.

Haul roads are needed to perform the construction activities in and around the reservoirs. Haul routes will be designated to accommodate construction traffic and avoid public use. Within the project limits, the routes may be separated between light traffic use and heavy equipment hauling for site safety.

5.1 TRR

5.1.1 TRR-East

Construction of the TRR-East reservoir embankments will require that fill be obtained from borrow sources located elsewhere within the Sites project (that is, not from within the TRR-East footprint). Construction of TRR-East also will produce excess material that is unsuitable as embankment fill and must be hauled away from the TRR-East site.

The CDSM ground improvement under the reservoir embankments will consist of a large, treated, volume of in-place material mixing, which also will generate a significant volume of fluid spoils (soil, cement, and water). These CDSM spoils are unlikely to be acceptable as reservoir embankment fill and, therefore, will be hauled away from the TRR-East site. CDSM spoils may be acceptable after dewatering for non-engineered fill uses, such as for pipeline trench backfill in certain zones above the pipelines (zones not exposed). CDSM spoils to be reused will be hauled to a stockpile location for dewatering prior to reuse. Some CDSM spoils may be unsuitable for reuse and have to be disposed of either on site (elsewhere within the Sites project) or hauled offsite for disposal.

Development of the TRR-East reservoir will require excavation of surficial soils and underlying soils to a depth of 2 feet across the TRR-East reservoir footprint. These soils are anticipated to be unsuitable for use as reservoir embankment fill and, therefore, will be hauled away from the TRR-East site. As for the CDSM spoils, some of the soils excavated across the TR- East reservoir footprint may be acceptable for non-engineered fill uses, and some may need to be disposed of on site or hauled offsite for disposal.

To construct the TRR-East reservoir embankments, fill will need to be obtained from borrow sources located elsewhere within the Sites project. The primary source of fill for the embankments will be the excavations for the TRR pipelines trenches. The pipeline trenches will produce significant quantities of materials that will be suitable as embankment fill; these materials will be hauled from the pipeline trench excavations to the TRR-East site.

5.1.2 TRR-West

The TRR-West option (if selected) will produce very large quantities of materials from the excavations that are needed to create the reservoir. As much as 8 to 9 million cubic yards of material may be produced from these excavations. Very little of this material will be needed as fill at the TRR-West location. Therefore, these large quantities of material will be hauled from the TRR-West site to other locations on the Sites project for use as fill. Other locations for depositing this excess material include HR reservoir dams, road construction, fill for the Sites Ladoga Road bridge abutments, quarry restoration, or disposed in the Sites Reservoir Deadpool.

The vast majority of the material that would be excavated for development of the TRR-West option will be suitable for beneficial reuse as general fill on the overall Project. This reuse will include placement as Zone 4 random fill at the dams, as fill for the large embankments of Sites-Lodoga Road, as fill for quarry restoration, or as other general fill. Topsoil stripped from the TRR-West footprint will not be suitable as general fill; a stockpile area is located adjacent to TRR-West to allow temporary storage of topsoil strippings.

5.2 Funks

Funks Reservoir modifications will involve predominantly excavations by dredging in over-water areas or conventional earthmoving when the reservoir pool is lowered. These activities will produce large quantities of materials that will not be used as fill at Funks and will be used elsewhere on the Sites project. Approximately 740,000 bank cubic yards of materials will be excavated by hydraulic dredging and conventional excavation from Funk Reservoir. These materials will be placed in stockpile areas for dewatering, to prepare these materials for later beneficial reuse on the Project. Likely, some quantity of dredged material will be unsuitable for reuse as engineered fill and may need to be disposed of onsite or offsite. At least 80 percent of materials are estimated to be suitable for reuse on the Project after dewatering. After dewatering, potential uses of these materials may include pipeline backfill, Zone 4 random fill (the stockpiles will be close to Golden Gate Dam), Sites-Lodoga Road embankment fill, quarry restoration, or other general fill.

5.3 General Concrete

It is anticipated that there will be a concrete batch plant onsite to supply concrete for the PGPs and other facilities. At this point, it is unknown if excavated site materials will be available or if aggregate will be hauled in from offsite. This will be verified through future geotechnical investigations. It is anticipated that concrete low strength material will be used as backfill for the large-diameter pipes. This material can potentially made from onsite materials mixed with hauled-in cement. This will be verified with future geotechnical investigations.

6.0 Equipment and Workforce

6.1 Labor Force, Project Labor Agreements

Providing for a sufficient labor force for a project of this magnitude poses challenges but is manageable. Much of the labor force is anticipated to come from the surrounding region, with contractors also bringing some skilled work force from other areas. While Colusa County is rural, with a population of about 20,000, the surrounding counties, including Placer, Sacramento and Yolo counties, have a regional population of over 2 million. It may be advantageous to consider project labor agreements with trade unions as a means of accommodating the project labor requirements, as well as avoiding labor disputes. A project labor agreement, well in advance of the need for craft labor, would provide for established labor rates, benefits, and work rules, as well as stability of the workforce. Unions and contractors will have advance notice in identifying required craft labor and training programs. Further, project labor agreements will minimize the risk of labor disputes during the course of the work. This strategy has been used successfully on other major civil works projects in California.

6.2 Equipment Needs

The required equipment consists of standard heavy earthmoving and excavation equipment, typical for large civil projects. Although the quantity of equipment may be large, especially for TRR West construction, this type of equipment is commonly found in the region and elsewhere. Large contractors would use their own equipment, lease or purchase new equipment.

The approach to estimating the equipment use and limitations for the construction cost estimates, includes the following:

- The equipment use tables are intended to inform the project team of expected equipment type, hours and horsepower, as well as expected labor needed.
- At this point in the Project, the design is at feasibility level. Further design development will determine final quantities, with other factors influencing final equipment use.
- Various contractors will approach the work differently from each other, and likely differently from the design engineer’s interpretation of equipment use and staffing.

- The equipment used for construction cost estimating are an approximation of the equipment, crews, and production needed to complete the Project. This is somewhat dictated by a lack of design details, although some details and quantities have been extrapolated based on best industry practices and expectations.
- Site geologic study and interpretation is incomplete. Future geotechnical work will affect final design and quantities.
- Procurement strategies and outcomes, including contract packages, will have some impact on the use and timing of equipment and crews.
- Travel speeds for vehicles within the Project site: The average speed for pickup trucks and supervisory vehicles will be about 20 miles per hour (mph), but will vary with individual duties and activities.
- Travel speeds for offsite hauling vehicles: For offsite hauling vehicles (such as those making deliveries to the job), an average of 40 mph was used from points of origination to delivery sites and returns to points of origin.
- Travel speeds for onsite hauling vehicles: The team used average speeds for hauling calculations. For onsite hauling vehicles, such as those used to haul excavated or processed material, speeds averaged 15 mph.
- Travel speeds for support equipment: Equipment such as water trucks and graders have travel speeds of about 15 mph. Operational speeds while performing work will be about 3 to 5 mph.
- No off-road, mobile, electric-powered equipment is anticipated at this time.
- Workforce and staff will vary during the course of the Project, as work activities ramp-up, peak, and taper off toward completion.
- Regarding staff and workforce commute, it is anticipated that much of the workforce will come from the surrounding area, including the greater Sacramento area. The average daily commute is expected to be approximately 70 miles, or about 1.5 hours, each way.
- Start and end dates reflect the preliminary construction schedule as provided in Appendix B.

The actual daily equipment and workforce use will vary based on what activities are being performed across the Project at any given time.

6.3 Equipment on Roads

Daily construction traffic will consist of trucks hauling equipment and materials to and from the worksites and the daily arrival and departure of construction workers. Construction traffic on local roadways will include dump trucks, bottom-dump trucks, concrete trucks, flatbed trucks for delivering construction equipment and permanent project equipment, pickups, water trucks, equipment maintenance vehicles, and other delivery trucks. Dump trucks would be used for earth moving and clearing, removal of excavated material, and import of other structural and paving materials. Other delivery trucks would deliver construction equipment, job trailer items, concrete-forming materials, reinforcing steel and structural steel, piping materials, foundation piles and sheet piling, sand and gravel from offsite sources, new facility equipment, and other construction-related deliveries. Construction equipment/materials would not be permitted to pass through the community of Maxwell on the Maxwell Sites Road.

7.0 Construction Sequencing Plan and Construction Schedule

7.1 General Plan and Approach

The first activities for project construction will include permitting and obtaining access on roads and real estate. Initial access will also allow for setup of staging, stockpile, office, and shop facilities, as well as mobilization of workforce and resources.

The general sequence of nonroad construction will begin with the Dunnigan Pipeline Alt 1 or Alt 2 and follow with the rest of the conveyance facilities. These facilities will be constructed in parallel over two to three years. Construction of the electrical transmission lines (after the TRR pipeline) and electrical substations will be initiated last in the sequence.

Note that construction within 1,000 feet of occupied residences will be restricted between 10:00 p.m. and 7:00 a.m. to eliminate potential noise concerns. Construction in areas beyond 1,000 feet of occupied residents may occur 24 hours a day, 7 days a week.

7.2 Construction Schedule

See Table 1 for the estimated construction schedule on conveyance facilities, including dates for permitting, engineering, and geotechnical investigations. The construction schedule is provided in Appendix C.

Table 1. Estimate Construction Schedule for Conveyance Facilities

Task Name	Duration (days)	Start Date	Finish Date
California Water Commission Award of Funds	0	12/1/23	12/1/23
Determine Engineering Procurement & Delivery Method	120	1/1/22	6/16/22
Sites Board Approval/Notice to Proceed for Phase 3	23	6/1/22	7/1/22
Real Estate Access & Permitting (Geotech & Surveying)	260	7/5/21	7/1/22
Initial Geotech & Surveying	130	7/4/22	12/30/22
Final Geotech Investigation	130	1/2/23	6/30/23
Engineering	867	9/1/22	1/15/25
Conveyance to Sacramento River Construction			
Dunnigan Pipeline – Alternative 1	355	9/26/24	2/4/26
Dunnigan Pipeline – Alternative 2	505	2/13/25	1/20/27
Regulating Reservoirs and Conveyance Construction			
Funks/TRR Pipelines	505	2/13/25	1/20/27
Transmission Powerlines	765	5/22/25	4/26/28
Funks Reservoir	680	5/22/25	12/29/27
Funks Pumping Generating Plant	880	5/22/25	10/4/28
TRR-East or TRR-West Reservoir	780	5/22/25	5/17/28
TRR Pumping Generating Plant	880	5/22/25	10/4/28
Substations	645	3/12/26	8/30/28
Sacramento River Diversion and Conveyance Construction			
Red Bluff Pumping Plan Improvements	560	2/3/25	3/26/27
GCID Improvements	680	5/22/25	12/29/27

7.3 Schedule and Work Hours

A more detailed schedule can be found in Appendix B. Note the following assumptions:

- The construction schedule is calculated on 20 working days per month to account for holidays and weather delays.
- Durations of construction are based on production rates associated with the anticipated equipment types needed for construction.

- Productions and durations are calculated on 10-hour work shifts, accounting for breaks.
- Crews would likely work 6 days per week on critical functions.

7.4 Procurement and Contract Packaging

The construction schedule includes assumptions on procurement and contract packaging on the conveyance facilities listed in Section 3.1.

7.5 Commissioning and Interface with HR Facilities

Most of the HC facilities can be commissioned without the HR facilities. However there are some HC facilities that will require HR facilities prior to final commission. These facilities include the tie-in of the TRR and Funks pipelines to the Golden Gate Dam Inlet/outlet tunnels (HR) so that full testing of the PGP's pumps and hydropower generators can occur. Also power from PGE & WAPA from their point of connection to the PGP switch yards will be required for full testing of the PGP equipment.

The most recent schedule including HC and HR facilities is provided in Appendix B.

8.0 Conclusions

The objective of this TM is to show that the Project can be constructed with existing technology and availability of construction materials, work force, and equipment. This study shows that the HC facilities can be constructed by the end of 2028, for a construction duration of about 4 years, with full commissioning in 2029 and 2030 (together with the HR facilities).

The construction schedule to have the HC facilities complete by end of 2028 is reasonable, but will require careful planning to ensure long-lead time equipment is specified and ordered early. This equipment includes the pumps, generator turbines, and switchgear for substations. The timing of completing work at existing facilities such as installing new pumps at the Red Bluff Pumping Plant, dredging of the Funks Reservoir and tying into the GCID Main Canal will be performed over several seasons given the short duration when these facilities may be taken out of service.

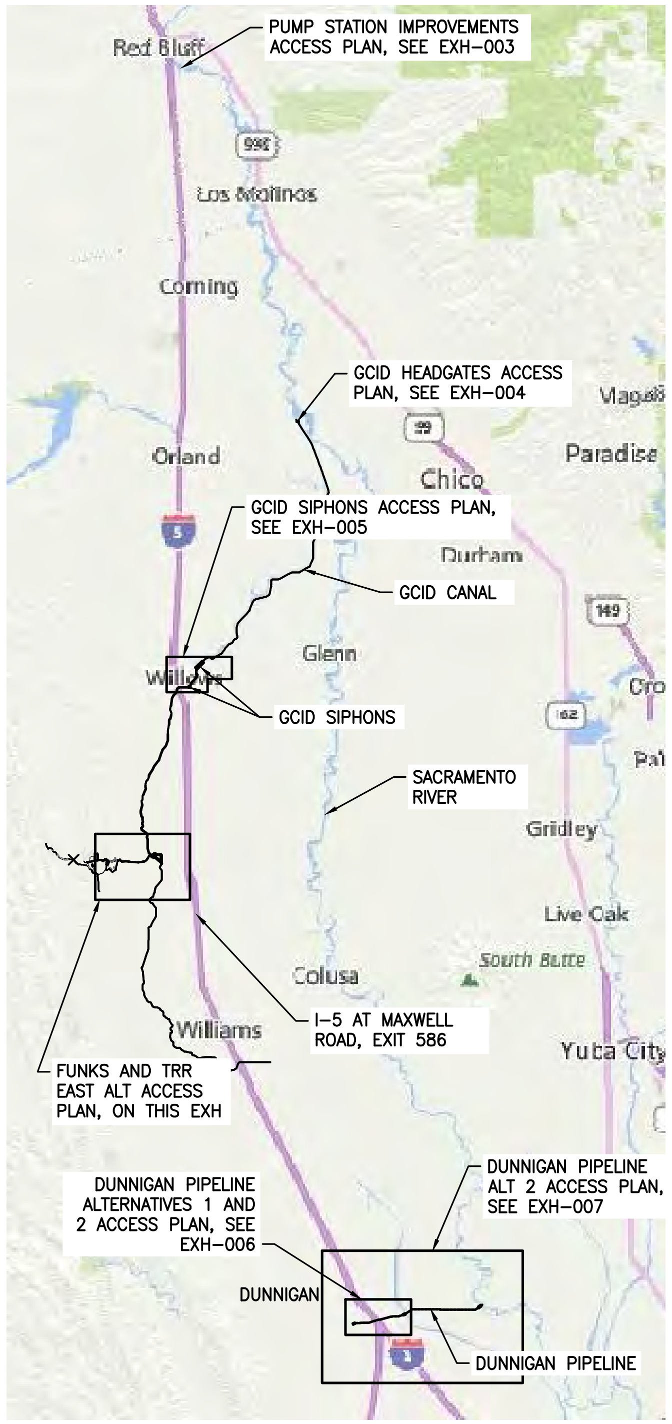
Construction materials are primarily composed of earthwork and concrete, both of which are readily available in the timeframe allowed for the quantity required. Earthwork may require moving excavated spoils for reuse on other project features such as the large reservoirs and for construction of the TRR East. However, there should be sufficient spoils material available given the large volume generated from the pipelines construction.

Providing for a sufficient labor force for this project poses a challenge, but is manageable. It is anticipated that much of the labor force would come from the surrounding region, with contractors also bringing some skilled work force from other areas. The surrounding counties, including Placer, Sacramento and Yolo Counties, have a regional population of over two million. It may be advantageous to consider project labor agreements with trade unions as a means of accommodating the project labor requirements, as well as avoiding labor disputes. This strategy has been used successfully on other large civil works projects in California.

The required equipment consists of standard heavy earthmoving and excavation equipment. Although the quantity of equipment may be large, especially for reservoir construction, this type of equipment is commonly found in the region and elsewhere. Large contractors would use their own equipment, lease or purchase new equipment.

In summary, although there are risks to the scheduled four-year completion of construction, the HC facilities of the Sites Reservoir Project can be constructed with existing technology and available construction materials, work force and equipment.

Appendix A
Site Access Plans

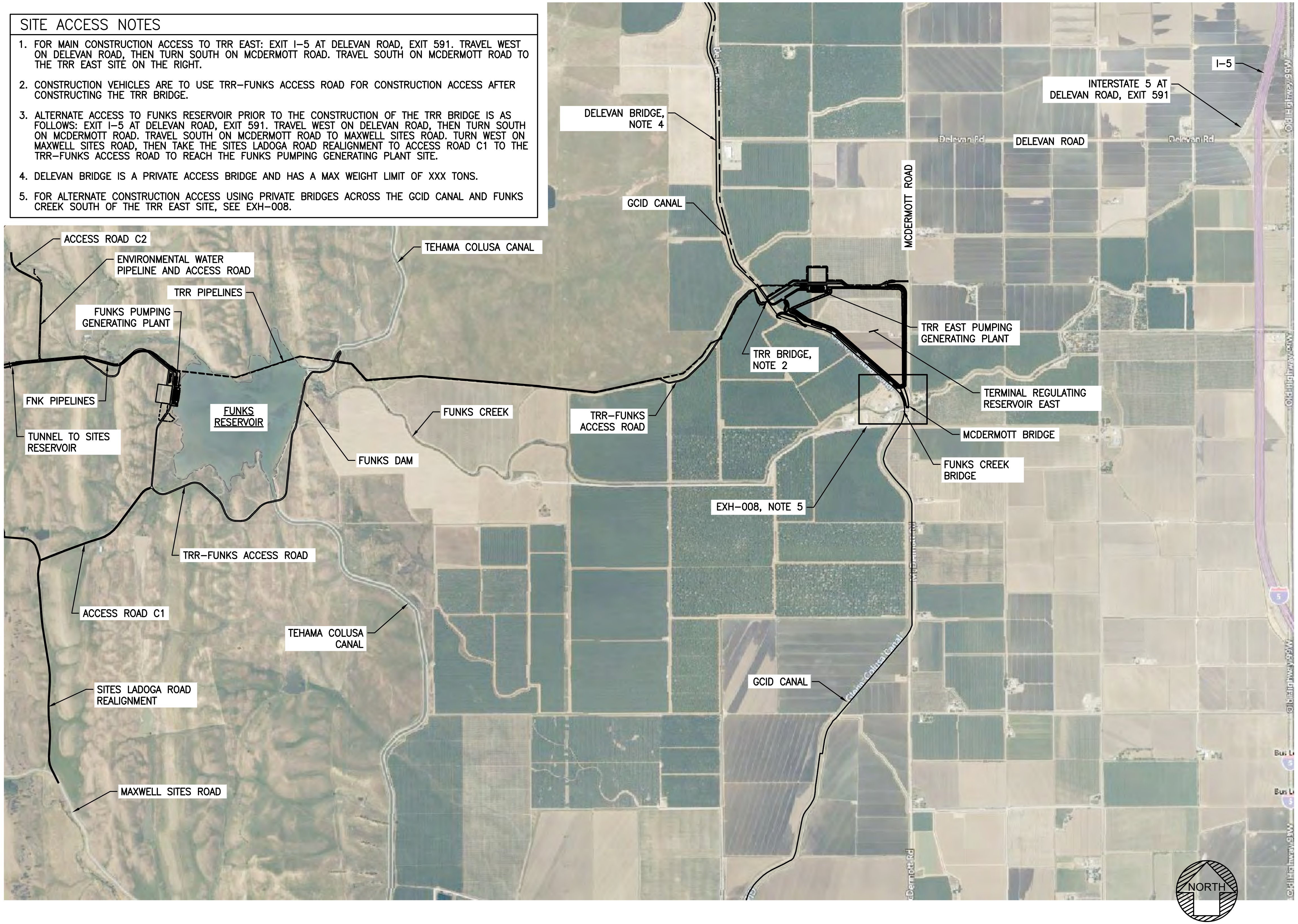


NORTH

OVERALL LOCATION PLAN
NTS

SITE ACCESS NOTES

1. FOR MAIN CONSTRUCTION ACCESS TO TRR EAST: EXIT I-5 AT DELEVAN ROAD, EXIT 591. TRAVEL WEST ON DELEVAN ROAD, THEN TURN SOUTH ON MCDERMOTT ROAD. TRAVEL SOUTH ON MCDERMOTT ROAD TO THE TRR EAST SITE ON THE RIGHT.
2. CONSTRUCTION VEHICLES ARE TO USE TRR-FUNKS ACCESS ROAD FOR CONSTRUCTION ACCESS AFTER CONSTRUCTING THE TRR BRIDGE.
3. ALTERNATE ACCESS TO FUNKS RESERVOIR PRIOR TO THE CONSTRUCTION OF THE TRR BRIDGE IS AS FOLLOWS: EXIT I-5 AT DELEVAN ROAD, EXIT 591. TRAVEL WEST ON DELEVAN ROAD, THEN TURN SOUTH ON MCDERMOTT ROAD. TRAVEL SOUTH ON MCDERMOTT ROAD TO MAXWELL SITES ROAD. TURN WEST ON MAXWELL SITES ROAD, THEN TAKE THE SITES LADOGA ROAD REALIGNMENT TO ACCESS ROAD C1 TO THE TRR-FUNKS ACCESS ROAD TO REACH THE FUNKS PUMPING GENERATING PLANT SITE.
4. DELEVAN BRIDGE IS A PRIVATE ACCESS BRIDGE AND HAS A MAX WEIGHT LIMIT OF XXX TONS.
5. FOR ALTERNATE CONSTRUCTION ACCESS USING PRIVATE BRIDGES ACROSS THE GCID CANAL AND FUNKS CREEK SOUTH OF THE TRR EAST SITE, SEE EXH-008.



FUNKS AND TRR EAST ALT ACCESS PLAN
SCALE: 1" = 1500'

0 1500' 3000'

DRAFT – PREDECISIONAL WORKING DOCUMENT
– FOR DISCUSSION PURPOSES ONLY

I/R	DATE	BY	CHK	APPR	DESCRIPTION

DESIGNED BY: B CHELONIS
DRAWN BY: B CHELONIS
CHECKED BY: J SMITH
IN CHARGE: P RUDE
DATE: APRIL 2021

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STATE OF CALIFORNIA

Sites

SITES RESERVOIR TO 2
OVERALL LOCATION
AND ACCESS PLAN
TERMINAL REGULATING RESERVOIR EAST ALT

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

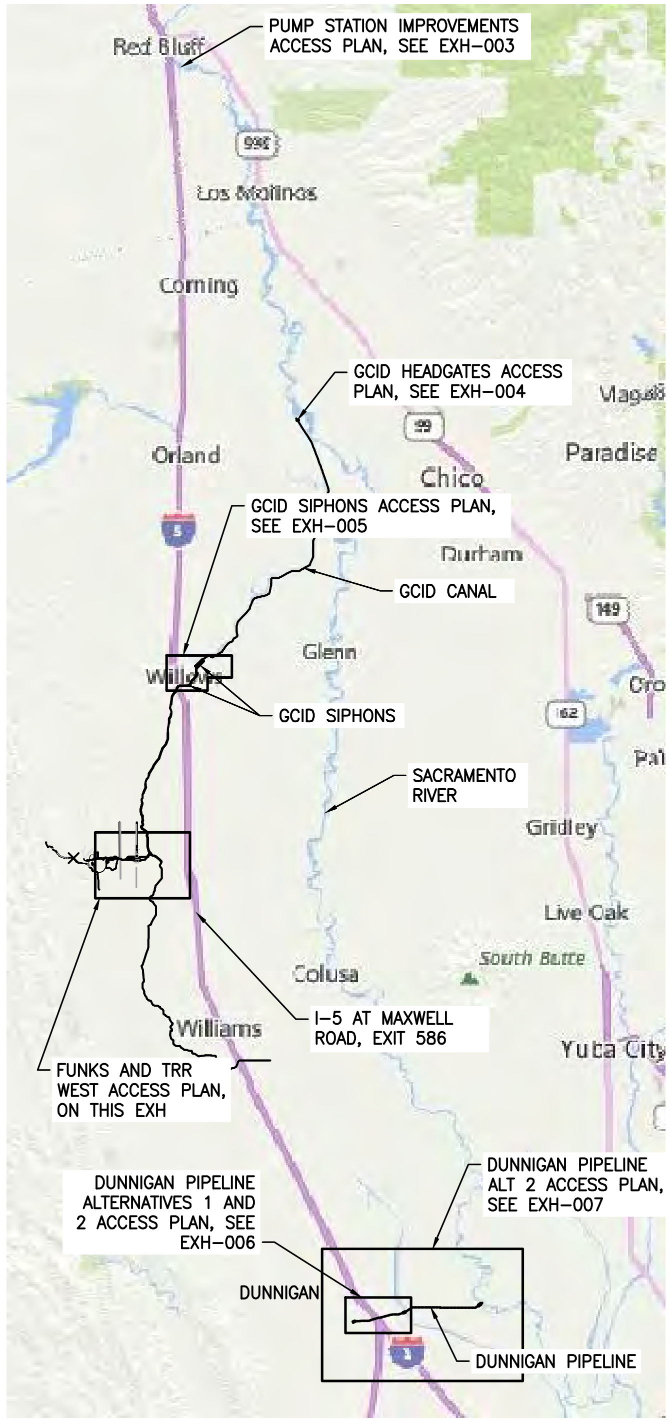
DRAWING NO.
EXH-001

PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION

PLOTTED BY:CHELONIS, BECKY/RDD –April 15, 2021–3:44:42 PM
DRAWING: GEN-EXH-001_D3380600.dwg
JACOBS PROJECT # D3880600

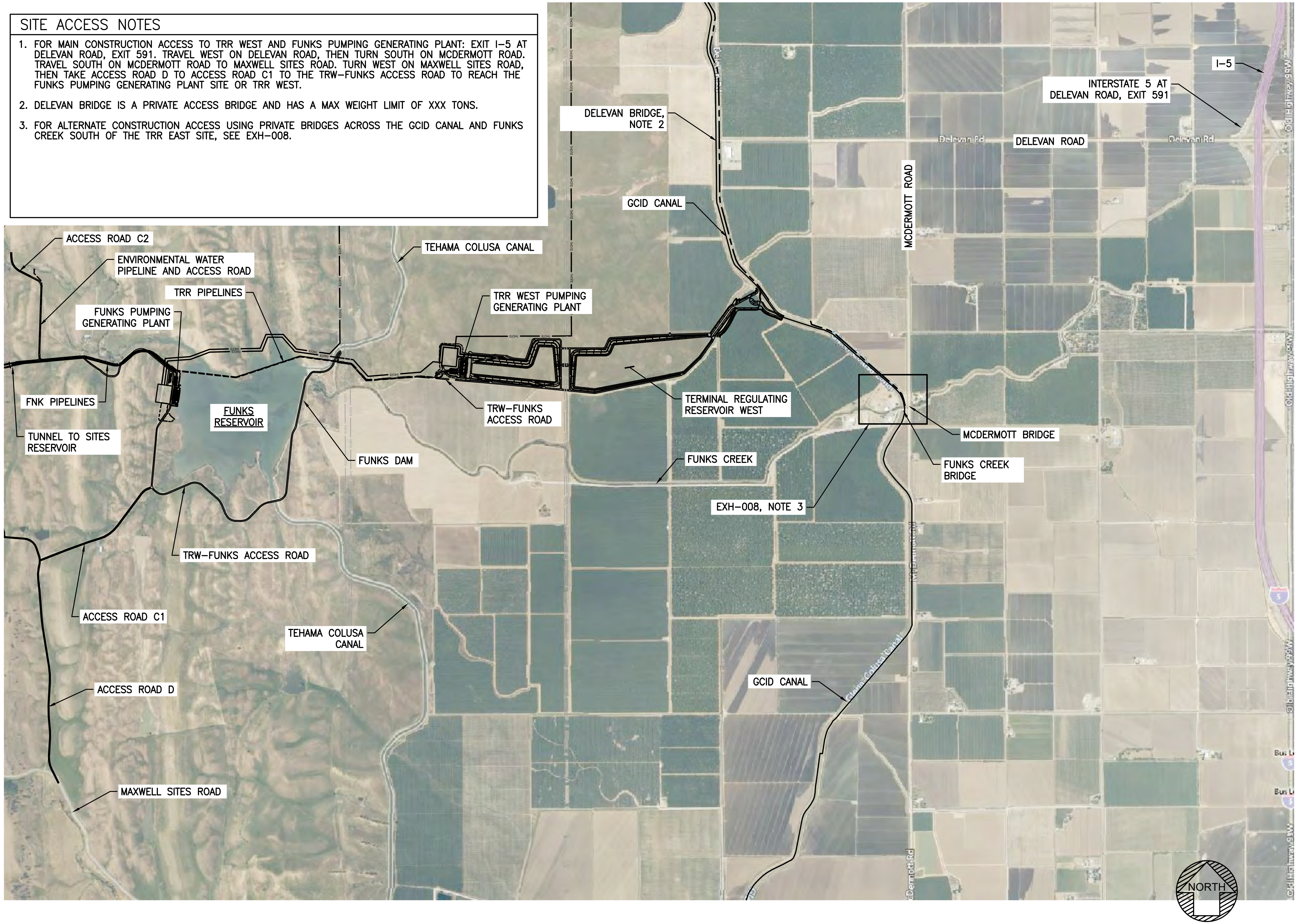
SITE ACCESS NOTES

1. FOR MAIN CONSTRUCTION ACCESS TO TRR WEST AND FUNKS PUMPING GENERATING PLANT: EXIT I-5 AT DELEVAN ROAD, EXIT 591. TRAVEL WEST ON DELEVAN ROAD, THEN TURN SOUTH ON MCDERMOTT ROAD. TRAVEL SOUTH ON MCDERMOTT ROAD TO MAXWELL SITES ROAD. TURN WEST ON MAXWELL SITES ROAD, THEN TAKE ACCESS ROAD D TO ACCESS ROAD C1 TO THE TRW-FUNKS ACCESS ROAD TO REACH THE FUNKS PUMPING GENERATING PLANT SITE OR TRR WEST.
2. DELEVAN BRIDGE IS A PRIVATE ACCESS BRIDGE AND HAS A MAX WEIGHT LIMIT OF XXX TONS.
3. FOR ALTERNATE CONSTRUCTION ACCESS USING PRIVATE BRIDGES ACROSS THE GCID CANAL AND FUNKS CREEK SOUTH OF THE TRR EAST SITE, SEE EXH-008.



NORTH

OVERALL LOCATION PLAN
NTS



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FUNKS AND TRR WEST ALT ACCESS PLAN
SCALE: 1" = 1500'

0 1500' 3000'

I/R	DATE	BY	CHK	APPR	DESCRIPTION

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SITES RESERVOIR TO 2
OVERALL LOCATION AND ACCESS PLAN
TERMINAL REGULATING RESERVOIR WEST ALT

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

DRAWING NO.
EXH-002

PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION

PLOTTED BY:CHELONIS, BECKY/RDD -April 15, 2021-3:44:42 PM
DRAWING: GEN-EXH-002_D3380600.dwg
JACOBS PROJECT # D3880600

SITE ACCESS NOTES

1. FOR CONSTRUCTION ACCESS TO THE RED BLUFF PUMPING PLANT, EXIT I–5 AT SOUTH MAIN STREET (EXIT 647). TRAVEL SOUTH ON SOUTH MAIN STREET, THEN TURN EAST ON ALTUBE AVENUE. PROCEED TO PUMPING PLANT ON ALTUBE AVENUE AS SHOWN ON THIS DRAWING.

0 150' 300'

1" = 150'

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ACCESS PLAN

SCALE: 1" = 150'

I/R	DATE	BY	CHK	APPR	DESCRIPTION

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IN CHARGE: P PRUDE
DATE: MARCH 2021

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Sites

SITES RESERVOIR TO 2
RED BLUFF PUMPING PLANT
ACCESS PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

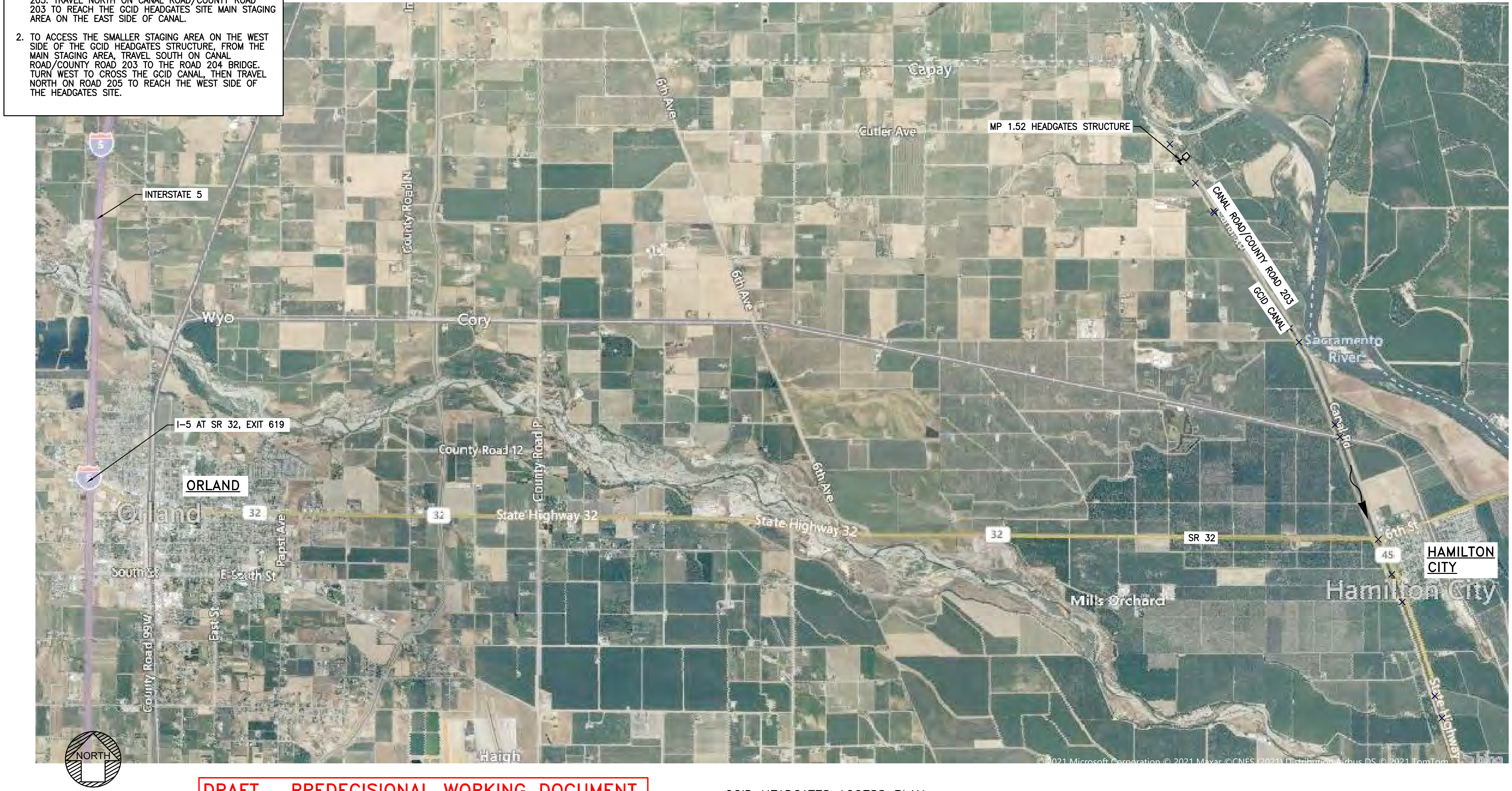
DRAWING NO.
EXH–003

PLOTTED BY:CHELONIS, BECKY/RDD –March 19, 2021–3:44:42 PM
DRAWING: GEN–EXH–003_D3380600.dwg
JACOBS PROJECT # D3380600

PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION

SITE ACCESS NOTES

1. GCID HEADGATES SITE ACCESS ROUTE: EXIT INTERSTATE 5 AT ORLAND, CALIFORNIA STATE HIGHWAY 32 (SR 32), EXIT 619. CONTINUE EAST ON SR 32 TO HAMILTON CITY, THEN TURN NORTH ON CANAL ROAD/COUNTY ROAD 203. TRAVEL NORTH ON CANAL ROAD/COUNTY ROAD 203 TO REACH THE GCID HEADGATES SITE MAIN STAGING AREA ON THE EAST SIDE OF CANAL.
2. TO ACCESS THE SMALLER STAGING AREA ON THE WEST SIDE OF THE GCID HEADGATES STRUCTURE, FROM THE MAIN STAGING AREA, TRAVEL SOUTH ON CANAL ROAD/COUNTY ROAD 203 TO THE ROAD 204 BRIDGE. TURN WEST TO CROSS THE GCID CANAL, THEN TRAVEL NORTH ON ROAD 205 TO REACH THE WEST SIDE OF THE HEADGATES SITE.



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0 30' 60'
1" = 30'

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GCID HEADGATES ACCESS PLAN

SCALE: 1" = 30'

I/R	DATE	BY	CHK	APPR	DESCRIPTION

DESIGNED BY: B CHELONIS
DRAWN BY: B CHELONIS
CHECKED BY: J SMITH
IN CHARGE: P PRUDE
DATE: MARCH 2021

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STATE OF CALIFORNIA

Sites

SITES RESERVOIR TO 2
GCID MAIN CANAL
HEADGATES ACCESS PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

DRAWING NO.
EXH-004

PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION

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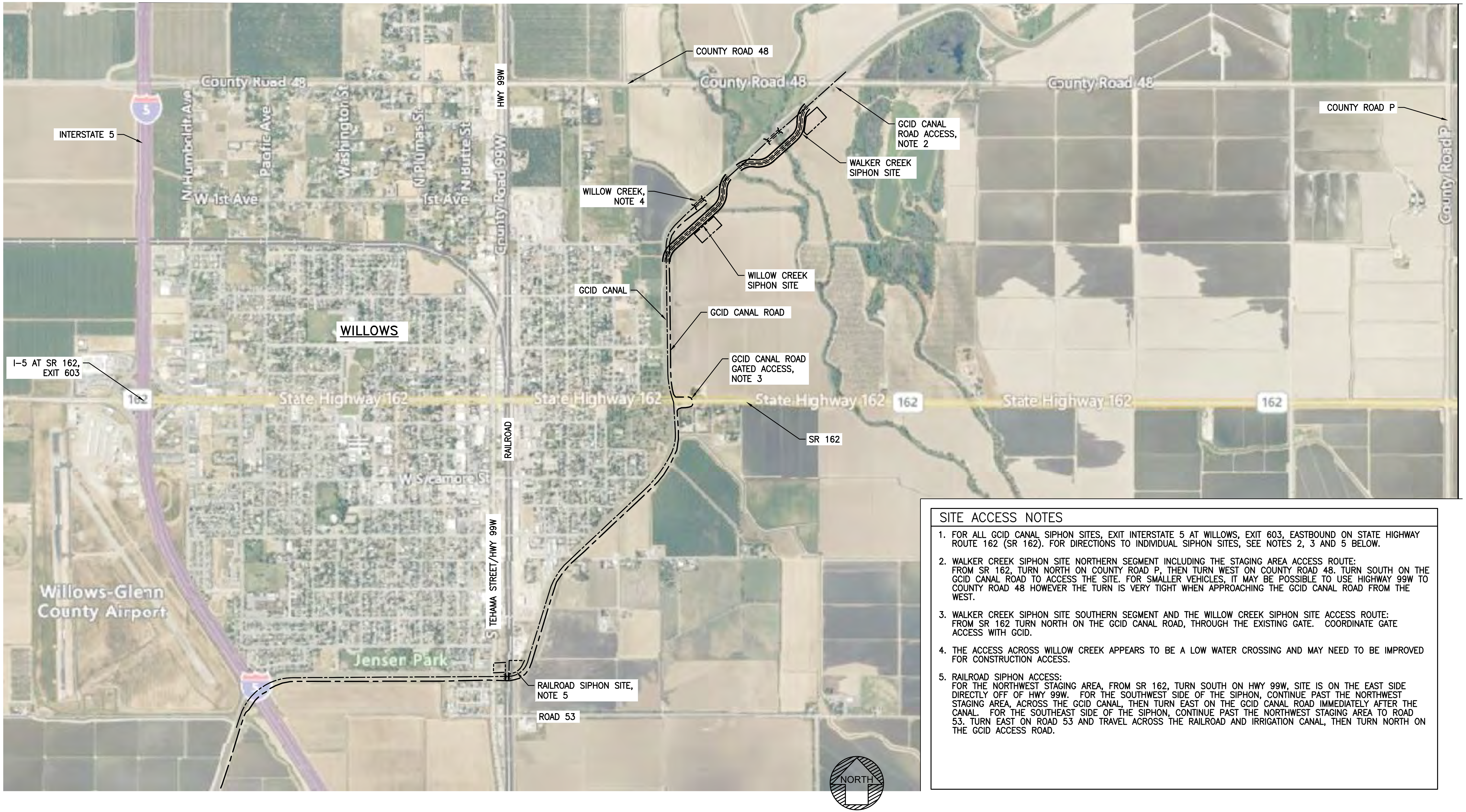
DRAWING: GEN-EXH-004_D3380600.dwg
JACOBS PROJECT # D3880600



SITE ACCESS NOTES

1. FOR ALL GCID CANAL SIPHON SITES, EXIT INTERSTATE 5 AT WILLOWS, EXIT 603, EASTBOUND ON STATE HIGHWAY ROUTE 162 (SR 162). FOR DIRECTIONS TO INDIVIDUAL SIPHON SITES, SEE NOTES 2, 3 AND 5 BELOW.
2. WALKER CREEK SIPHON SITE NORTHERN SEGMENT INCLUDING THE STAGING AREA ACCESS ROUTE:
   FROM SR 162, TURN NORTH ON COUNTY ROAD P, THEN TURN WEST ON COUNTY ROAD 48. TURN SOUTH ON THE GCID CANAL ROAD TO ACCESS THE SITE. FOR SMALLER VEHICLES, IT MAY BE POSSIBLE TO USE HIGHWAY 99W TO COUNTY ROAD 48 HOWEVER THE TURN IS VERY TIGHT WHEN APPROACHING THE GCID CANAL ROAD FROM THE WEST.
3. WALKER CREEK SIPHON SITE SOUTHERN SEGMENT AND THE WILLOW CREEK SIPHON SITE ACCESS ROUTE:
   FROM SR 162 TURN NORTH ON THE GCID CANAL ROAD, THROUGH THE EXISTING GATE. COORDINATE GATE ACCESS WITH GCID.
4. THE ACCESS ACROSS WILLOW CREEK APPEARS TO BE A LOW WATER CROSSING AND MAY NEED TO BE IMPROVED FOR CONSTRUCTION ACCESS.
5. RAILROAD SIPHON ACCESS:
   FOR THE NORTHWEST STAGING AREA, FROM SR 162, TURN SOUTH ON HWY 99W, SITE IS ON THE EAST SIDE DIRECTLY OFF OF HWY 99W. FOR THE SOUTHWEST SIDE OF THE SIPHON, CONTINUE PAST THE NORTHWEST STAGING AREA, ACROSS THE GCID CANAL, THEN TURN EAST ON THE GCID CANAL ROAD IMMEDIATELY AFTER THE CANAL. FOR THE SOUTHEAST SIDE OF THE SIPHON, CONTINUE PAST THE NORTHWEST STAGING AREA TO ROAD 53. TURN EAST ON ROAD 53 AND TRAVEL ACROSS THE RAILROAD AND IRRIGATION CANAL, THEN TURN NORTH ON THE GCID ACCESS ROAD.

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– FOR DISCUSSION PURPOSES ONLY

GCID SIPHONS ACCESS PLAN
SCALE: 1" = 800'

0 800' 1600'
1" = 800'

I/R	DATE	BY	CHK	APPR	DESCRIPTION

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DRAWN BY: B CHELONIS
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STATE OF CALIFORNIA

Sites

SITES RESERVOIR TO 2

GCID SIPHONS ACCESS PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

DRAWING NO.
EXH-005

PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION

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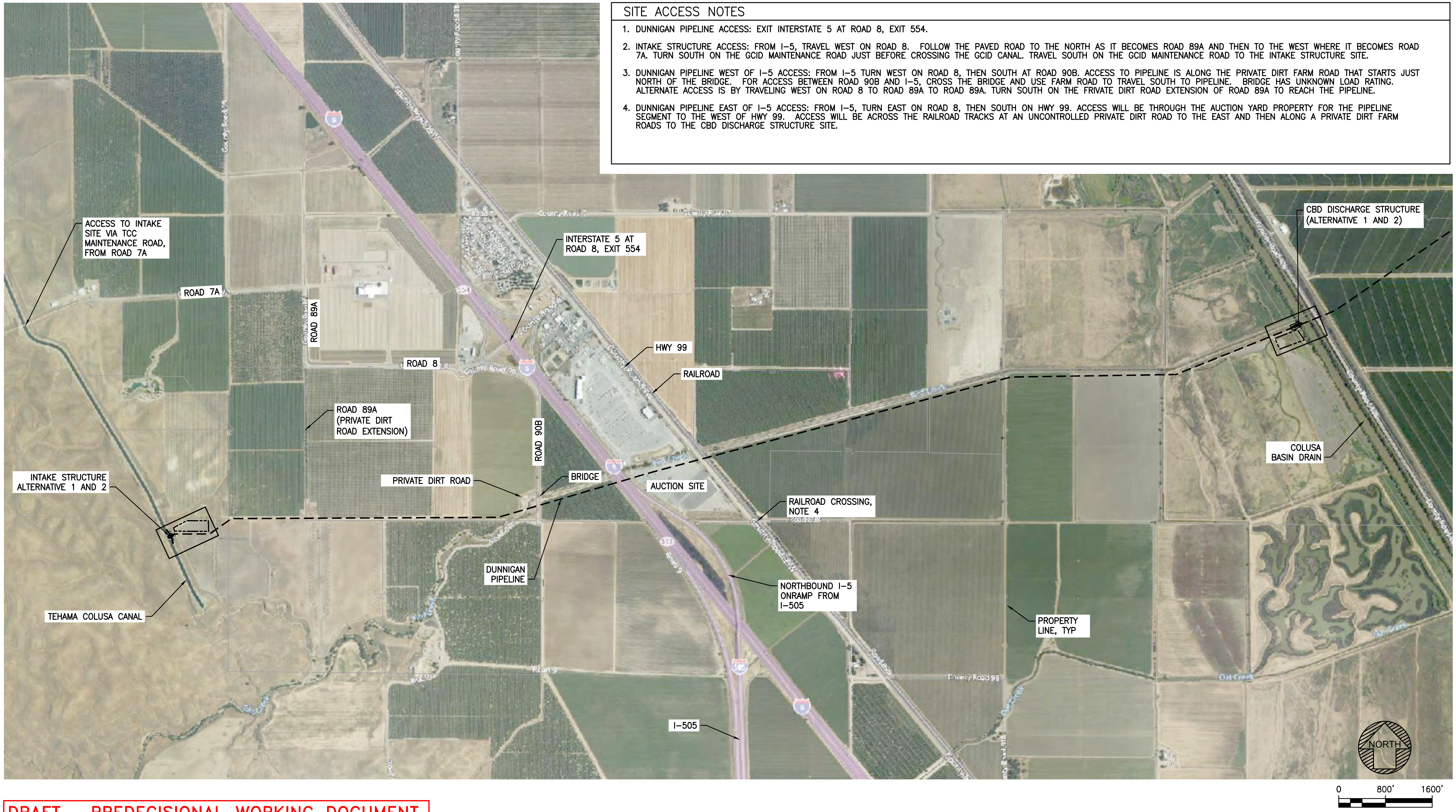
DRAWING: GEN-EXH-005_D3380600.dwg
JACOBS PROJECT # D3880600

SITE ACCESS NOTES

1. DUNNIGAN PIPELINE ACCESS: EXIT INTERSTATE 5 AT ROAD 8, EXIT 554.
2. INTAKE STRUCTURE ACCESS: FROM I–5, TRAVEL WEST ON ROAD 8. FOLLOW THE PAVED ROAD TO THE NORTH AS IT BECOMES ROAD 89A AND THEN TO THE WEST WHERE IT BECOMES ROAD 7A. TURN SOUTH ON THE GCID MAINTENANCE ROAD JUST BEFORE CROSSING THE GCID CANAL. TRAVEL SOUTH ON THE GCID MAINTENANCE ROAD TO THE INTAKE STRUCTURE SITE.
3. DUNNIGAN PIPELINE WEST OF I–5 ACCESS: FROM I–5 TURN WEST ON ROAD 8, THEN SOUTH AT ROAD 90B. ACCESS TO PIPELINE IS ALONG THE PRIVATE DIRT FARM ROAD THAT STARTS JUST NORTH OF THE BRIDGE. FOR ACCESS BETWEEN ROAD 90B AND I–5, CROSS THE BRIDGE AND USE FARM ROAD TO TRAVEL SOUTH TO PIPELINE. BRIDGE HAS UNKNOWN LOAD RATING. ALTERNATE ACCESS IS BY TRAVELING WEST ON ROAD 8 TO ROAD 89A TO ROAD 89A. TURN SOUTH ON THE FRIVATE DIRT ROAD EXTENSION OF ROAD 89A TO REACH THE PIPELINE.
4. DUNNIGAN PIPELINE EAST OF I–5 ACCESS: FROM I–5, TURN EAST ON ROAD 8, THEN SOUTH ON HWY 99. ACCESS WILL BE THROUGH THE AUCTION YARD PROPERTY FOR THE PIPELINE SEGMENT TO THE WEST OF HWY 99. ACCESS WILL BE ACROSS THE RAILROAD TRACKS AT AN UNCONTROLLED PRIVATE DIRT ROAD TO THE EAST AND THEN ALONG A PRIVATE DIRT FARM ROADS TO THE CBD DISCHARGE STRUCTURE SITE.



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DUNNIGAN PIPELINE ACCESS PLAN

SCALE: 1" = 800'

I/R	DATE	BY	CHK	APPR	DESCRIPTION

DESIGNED BY: B CHELONIS
DRAWN BY: B CHELONIS
CHECKED BY: J SMITH
IN CHARGE: P RUDE
DATE: MARCH 2021

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REGISTERED PROFESSIONAL ENGINEER
STATE OF CALIFORNIA

Sites

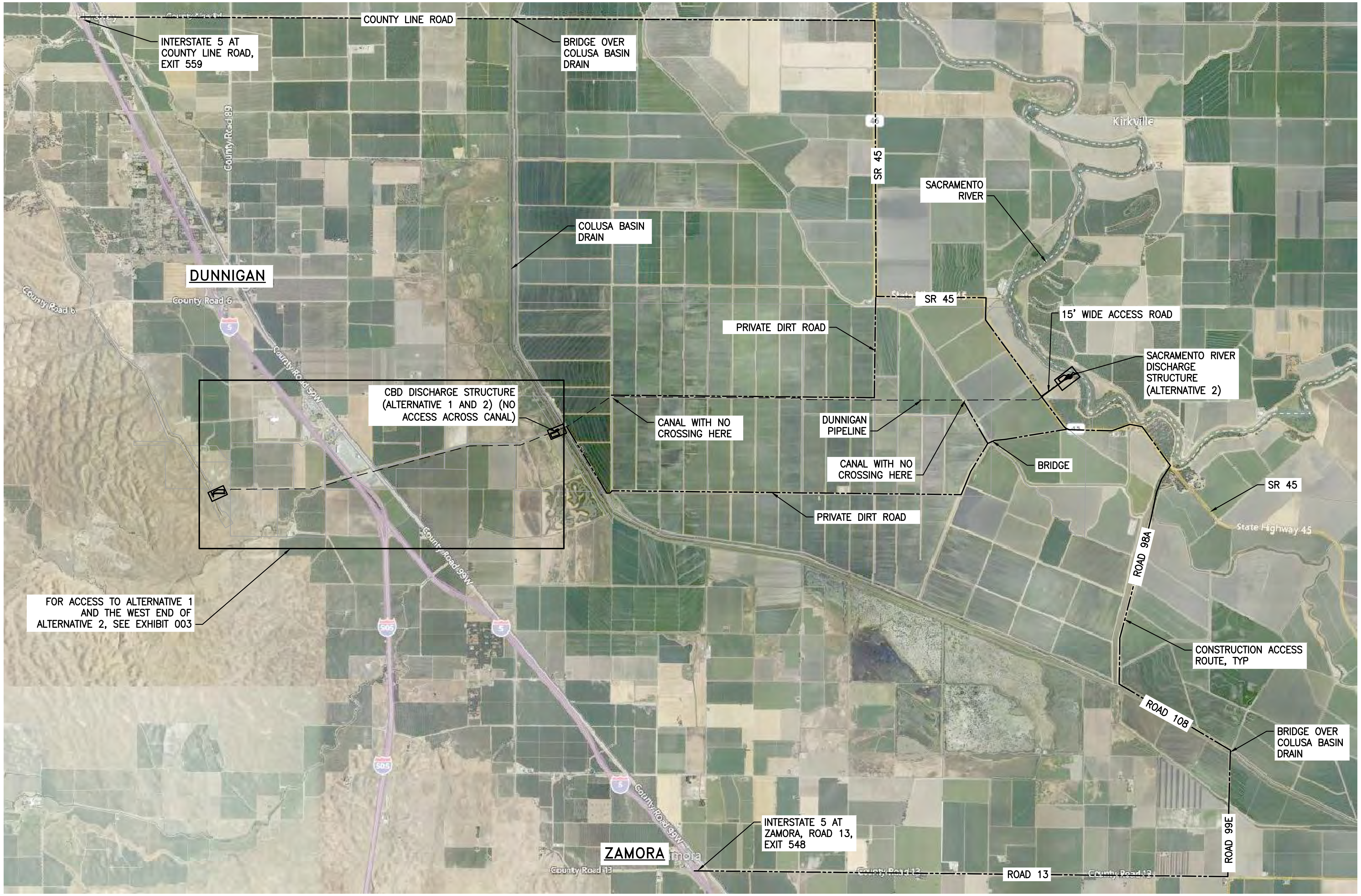
SITES RESERVOIR TO 2
DUNNIGAN PIPELINE
ALTS 1 AND 2 ACCESS PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

DRAWING NO.
EXH–006

PLOTTED BY:CHELONIS, BECKY/RDD –March 19, 2021–3:44:42 PM
DRAWING: GEN–EXH–006_D3380600.dwg
JACOBS PROJECT # D3880600

PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION



NORTH

SITE ACCESS NOTES

1. DUNNIGAN PIPELINE ACCESS FROM NORTH:
   EXIT INTERSTATE 5 AT COUNTY LINE ROAD, EXIT 559. CONTINUE EAST ON COUNTY ROAD, THEN TURN SOUTH ON SR 45. TRAVEL SOUTH ON SR 45 AND THEN PROCEED SOUTH ON PRIVATE DIRT ROAD TO ACCESS THE CENTRAL PORTION OF DUNNIGAN PIPELINE.

2. DUNNIGAN PIPELINE ACCESS FROM THE SOUTH:
   EXIT INTERSTATE 5 AT ZAMORA, ROAD 13, EXIT 548. CONTINUE EAST ON ROAD 13, THEN TURN NORTH ON ROAD 99E. CROSS THE GCID CANAL BRIDGE, THEN TURN NORTHWEST ON ROAD 108. TURN NORTH ON ROAD 98A AND CONTINUE ON THAT ROAD UNTIL IT INTERSECTS WITH SR 45. TURN NORTH ON SR 45 AND CONTINUE TO ACCESS ROUTES ALONG PRIVATE DIRT ROADS AS SHOWN IN PLAN.

DRAFT – PREDECISIONAL WORKING DOCUMENT
– FOR DISCUSSION PURPOSES ONLY

DUNNIGAN PIPELINE ACCESS PLAN
SCALE: 1" = 3000'

0 3000' 6000'

PLOTTED BY:CHELONIS, BECKY/RDD –March 19, 2021–3:44:42 PM
DRAWING: GEN–EXH–007_D3380600.dwg
JACOBS PROJECT # D3880600

I/R	DATE	BY	CHK	APPR	DESCRIPTION

DESIGNED BY: B CHELONIS
DRAWN BY: B CHELONIS
CHECKED BY: J SMITH
IN CHARGE: P RUDE
DATE: MARCH 2021

JACOBS
2525 AIRPARK DR
REDDING CA, 96001
PHONE: (530) 243–5831

Sites

SITES RESERVOIR TO 2
DUNNIGAN PIPELINE
ALT 2 ACCESS PLAN

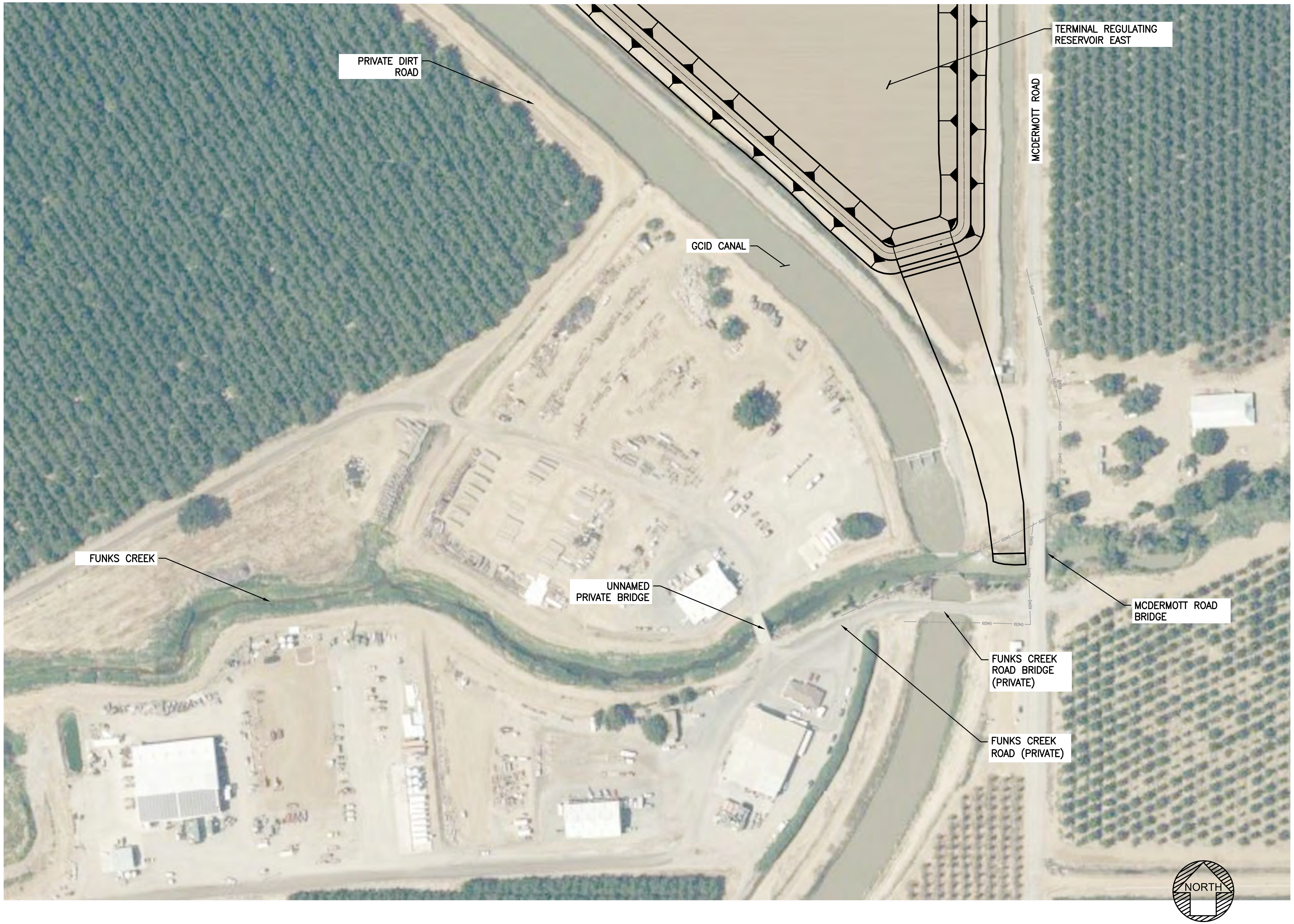
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

DRAWING NO.
EXH–007

PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION

SITE ACCESS NOTES

1. MCDERMOTT ROAD BRIDGE HAS A MAX WEIGHT LIMIT OF XXX TONS.
2. FUNKS CREEK ROAD BRIDGE IS A PRIVATE ACCESS BRIDGE AND HAS A MAX WEIGHT LIMIT OF XXX TONS.
3. UNNAMED PRIVATE BRIDGE IS A PRIVATE ACCESS BRIDGE AND HAS A MAX WEIGHT LIMIT OF XXX TONS.
4. ALTERNATE CONSTRUCTION ACCESS PRIOR TO TRR BRIDGE CONSTRUCTION USING THE PRIVATE ACCESS BRIDGES IS BY AGREEMENT WITH THE OWNER ONLY. COORDINATE DETAILS WITH OWNER, INCLUDING ACCEPTABLE WEIGHT LIMITS FOR BRIDGES.



DRAFT – PREDECISIONAL WORKING DOCUMENT – FOR DISCUSSION PURPOSES ONLY

PRIVATE BRIDGE ACCESS PLAN

SCALE: 1" =100'

0 100' 200'

I/R	DATE	BY	CHK	APPR	DESCRIPTION

DESIGNED BY: B CHELONIS
DRAWN BY: B CHELONIS
CHECKED BY:
IN CHARGE: P RUDE
DATE: MARCH 2021

JACOBS
2525 AIRPARK DR
REDDING CA, 96001
PHONE: (530) 243-5831

Sites

SITES RESERVOIR TO 2

PRIVATE BRIDGE ACCESS PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALE FOR REDUCED PLOTS
0 1"

DRAWING NO.
EXH-008

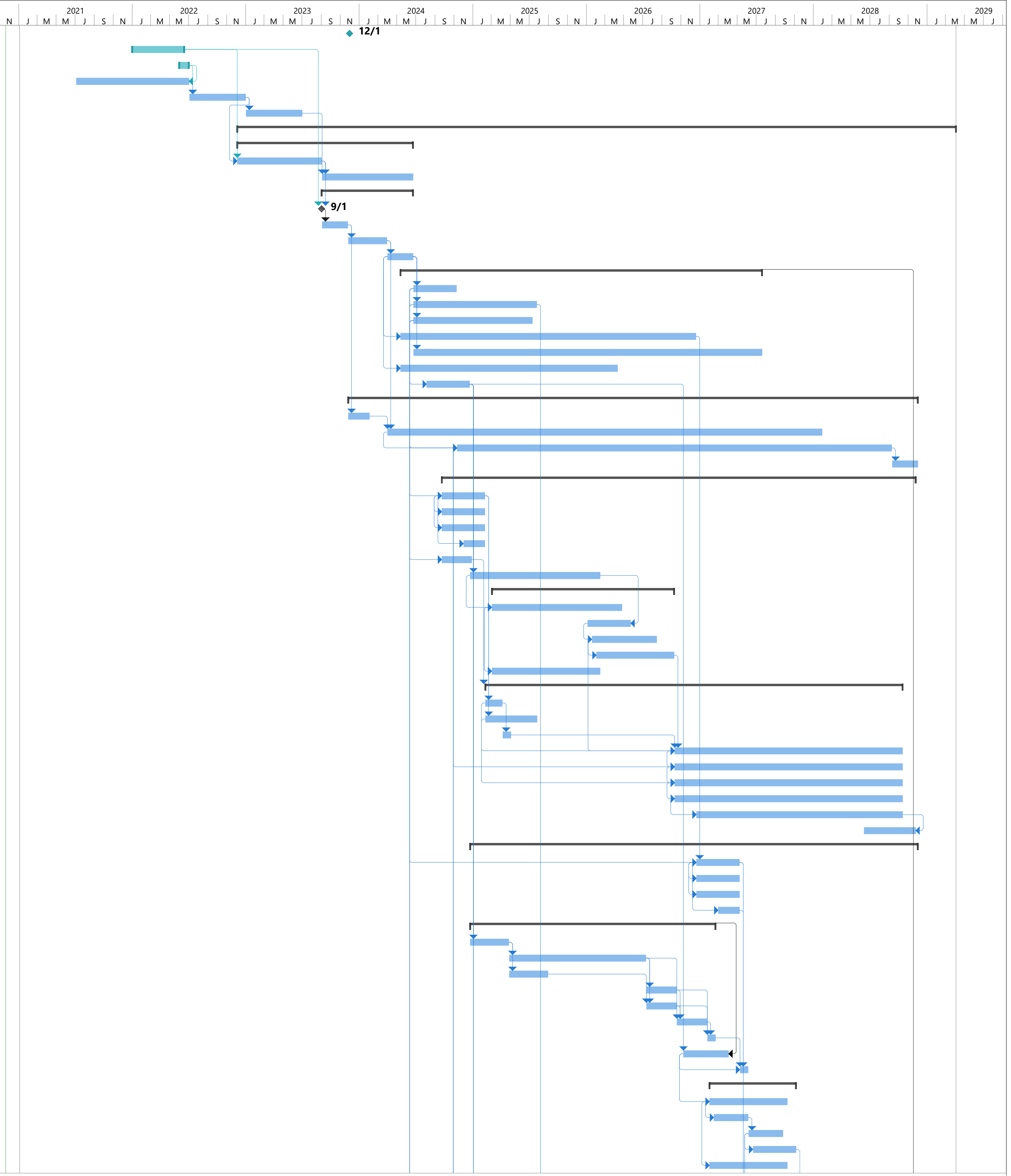
PROJECT FEASIBILITY STUDY – NOT FOR CONSTRUCTION

PLOTTED BY:CHELONIS, BECKY/RDD –March 19, 2021–3:44:42 PM
DRAWING: GEN–EXH–008_D3380600.dwg
JACOBS PROJECT # D3880600

Appendix B
Construction Schedule

Sites Reservoir
Preliminary Construction Schedule
Roads, Dams, and I/O Facilities
November 2020

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Successors
1		CWC Award of Funds	0 days	Fri 12/1/23	Fri 12/1/23		
2		Determine Engineering Procurement & Delivery Method	120 days	Sat 1/1/22	Thu 6/16/22		9,12
3		Sites Board Approval/NTP for Phase 3	23 days	Wed 6/1/22	Fri 7/1/22		4FF,5
4		Real Estate Access & Permitting (Geotech & Surveying)	260 days	Mon 7/5/21	Fri 7/1/22	3FF	5
5		Initial Geotech & Surveying	130 days	Mon 7/4/22	Fri 12/30/22	3,4	6,9FS-20 days
6		Final Geotech Investigation	130 days	Mon 1/2/23	Fri 6/30/23	5	10
7		**Reservoir Facilities**	**1652 days**	**Mon 12/5/22**	**Tue 4/3/29**		
8		**Engineering**	**405 days**	**Mon 12/5/22**	**Fri 6/21/24**		
9		Preliminary Engineering	195 days	Mon 12/5/22	Fri 9/1/23	2,5FS-20 days	10,12
10		Final Engineering	210 days	Mon 9/4/23	Fri 6/21/24	6,9	
11		**Administrative and General**	**210 days**	**Fri 9/1/23**	**Fri 6/21/24**		
12		Contract Award	0 days	Fri 9/1/23	Fri 9/1/23	2,9	13
13		Notice To Proceed	60 days	Mon 9/4/23	Fri 11/24/23	12	14,25
14		Early Submittals And Approvals	90 days	Mon 11/27/23	Fri 3/29/24	13	15,26
15		Mobilization	60 days	Mon 4/1/24	Fri 6/21/24	14	17,18,20SS+30 days,22SS+30 days,19,21
16		**Roads, Bridges, Access, and Site Development**	**831 days**	**Mon 5/13/24**	**Mon 7/19/27**		**198**
17		Site Access and Staging Development	100 days	Mon 6/24/24	Fri 11/8/24	15	23SS+30 days,180SS+50 days,184SS+50 days,34SS+65 days
18		Northern Construction Access Roads	284 days	Mon 6/24/24	Thu 7/24/25	15	53SS+100 days,84,27SS+100 days
19		Southern Construction Access Roads	274 days	Mon 6/24/24	Thu 7/10/25	15	30SS+65 days,180SS+50 days,184SS+50 days
20		Sites Lodoga Road Realignment and Bridge	680 days	Mon 5/13/24	Fri 12/18/26	15SS+30 days	53
21		Huffmaster Road Realignment	801 days	Mon 6/24/24	Mon 7/19/27	15	
22		Reservoir Footprint Mitigation Actions	500 days	Mon 5/13/24	Fri 4/10/26	15SS+30 days	
23		Demolition and Clearing	100 days	Mon 8/5/24	Fri 12/20/24	17SS+30 days	35,182,65,58,88
24		**Process and Haul Filter Materials to Project**	**1310 days**	**Mon 11/27/23**	**Fri 12/1/28**		
25		Offsite Quarry Development	50 days	Mon 11/27/23	Fri 2/2/24	13	26
26		Process Filter Materials	1000 days	Mon 4/1/24	Fri 1/28/28	14,25	27SS+30 days
27		Filter Material Haul to Stockpile	1000 days	Mon 11/11/24	Fri 9/8/28	26SS+30 days,18SS+100 days	28,47SS+30 days,77SS+30 days,98SS+30 days,118SS+30 days,138SS+30 days
28		Quarry Reclamation and Restoration	60 days	Mon 9/11/28	Fri 12/1/28	27	
29		**Golden Gate Dam Construction**	**1090 days**	**Mon 9/23/24**	**Fri 11/24/28**		
30		Golden Gate Access and Staging	100 days	Mon 9/23/24	Fri 2/7/25	19SS+65 days	31SS,33SS+50 days,32SS,43,44
31		Erosion and Sediment Control	100 days	Mon 9/23/24	Fri 2/7/25	30SS	
32		Clearing / Grubbing Topsoil Salvage from Work Areas	100 days	Mon 9/23/24	Fri 2/7/25	30SS	
33		Demolition	50 days	Mon 12/2/24	Fri 2/7/25	30SS+50 days	
34		GG Dam - Bypass Pipeline and U/S Cofferdam	70 days	Mon 9/23/24	Fri 12/27/24	17SS+65 days	42
35		GG Dam - Foundation Excavation	300 days	Mon 12/23/24	Fri 2/13/26	23	37SS+50 days,38FF+70 days
36		**GG Dam - Foundation Preparation and Grouting**	**420 days**	**Mon 3/3/25**	**Fri 10/9/26**		
37		Foundation Cleaning	300 days	Mon 3/3/25	Fri 4/24/26	35SS+50 days	41SS
38		Grout Cap	100 days	Mon 1/5/26	Fri 5/22/26	35FF+70 days	39SS+10 days
39		Consolidation Grouting	150 days	Mon 1/19/26	Fri 8/14/26	38SS+10 days	40SS+10 days,46SS+100 days
40		Curtain Grouting	180 days	Mon 2/2/26	Fri 10/9/26	39SS+10 days	46
41		Dental Excavation and Concrete	250 days	Mon 3/3/25	Fri 2/13/26	37SS	
42		**GG Dam - Embankment**	**960 days**	**Mon 2/10/25**	**Fri 10/13/28**	**34**	
43		Initial Borrow Development (Core Material)	40 days	Mon 2/10/25	Fri 4/4/25	30	46SS+20 days,45
44		Initial Quarry Development for Zones 3 and 4	120 days	Mon 2/10/25	Fri 7/25/25	30	48SS+40 days
45		Borrow Overburden and Waste to Disposal Site	20 days	Mon 4/7/25	Fri 5/2/25	43	46
46		Place Zone 1 - Core	525 days	Mon 10/12/26	Fri 10/13/28	43SS+20 days,45,39SS+100 days,4	47SS
47		Place Zone 2A & 2B - Filters, Drains and Transitions	525 days	Mon 10/12/26	Fri 10/13/28	46SS,27SS+30 days	48SS
48		Place Zone 3 - Rockfill	525 days	Mon 10/12/26	Fri 10/13/28	47SS,44SS+40 days	49SS
49		Place Zone 4 - Random	525 days	Mon 10/12/26	Fri 10/13/28	48SS	50SS+50 days
50		Place Rip Rap	475 days	Mon 12/21/26	Fri 10/13/28	49SS+50 days	51FF+30 days
51		Site Reclamation and Topsoil Replacement	120 days	Mon 6/12/28	Fri 11/24/28	50FF+30 days	
52		**Sites Dam Construction**	**1030 days**	**Mon 12/23/24**	**Fri 12/1/28**		
53		Sites Dam Access and Staging	100 days	Mon 12/21/26	Fri 5/7/27	18SS+100 days,20	54SS,56SS+50 days,55SS,74,75
54		Erosion and Sediment Control	100 days	Mon 12/21/26	Fri 5/7/27	53SS	
55		Clearing / Grubbing Topsoil Salvage from Work Areas	100 days	Mon 12/21/26	Fri 5/7/27	53SS	
56		Demolition	50 days	Mon 3/1/27	Fri 5/7/27	53SS+50 days	66
57		**Sites Diversion Outlet Facility**	**565 days**	**Mon 12/23/24**	**Fri 2/19/27**		**65FF+30 days**
58		Develop Downstream Portal	90 days	Mon 12/23/24	Fri 4/25/25	23	59,60
59		Tunnel Excavation and Lining	315 days	Mon 4/28/25	Fri 7/10/26	58	62,61,63
60		Develop Upstream Portal	90 days	Mon 4/28/25	Fri 8/29/25	58	62
61		Outlet Structure Concrete	70 days	Mon 7/13/26	Fri 10/16/26	59	64,63
62		Inlet Structure Concrete	70 days	Mon 7/13/26	Fri 10/16/26	59,60	64,63
63		Mechanical	70 days	Mon 10/19/26	Fri 1/22/27	59,61,62	64
64		Sites Diversion Completion and Restoration	20 days	Mon 1/25/27	Fri 2/19/27	61,62,63	66
65		Sites Dam - Foundation Excavation	105 days	Mon 11/9/26	Fri 4/2/27	23,57FF+30 days	68SS+60 days,66SS+50 days
66		Construct Cofferdam to El. 310	20 days	Mon 5/10/27	Fri 6/4/27	56,65SS+50 days,64	
67		**Sites Dam - Foundation Preparation and Grouting**	**200 days**	**Mon 2/1/27**	**Fri 11/5/27**		
68		Foundation Cleaning	180 days	Mon 2/1/27	Fri 10/8/27	65SS+60 days	72SS,69SS+10 days
69		Grout Cap	80 days	Mon 2/15/27	Fri 6/4/27	68SS+10 days	70
70		Consolidation Grouting	80 days	Mon 6/7/27	Fri 9/24/27	69	71SS+10 days,76SS+100 days
71		Curtain Grouting	100 days	Mon 6/21/27	Fri 11/5/27	70SS+10 days	76
72		Dental Excavation and Concrete	180 days	Mon 2/1/27	Fri 10/8/27	68SS	

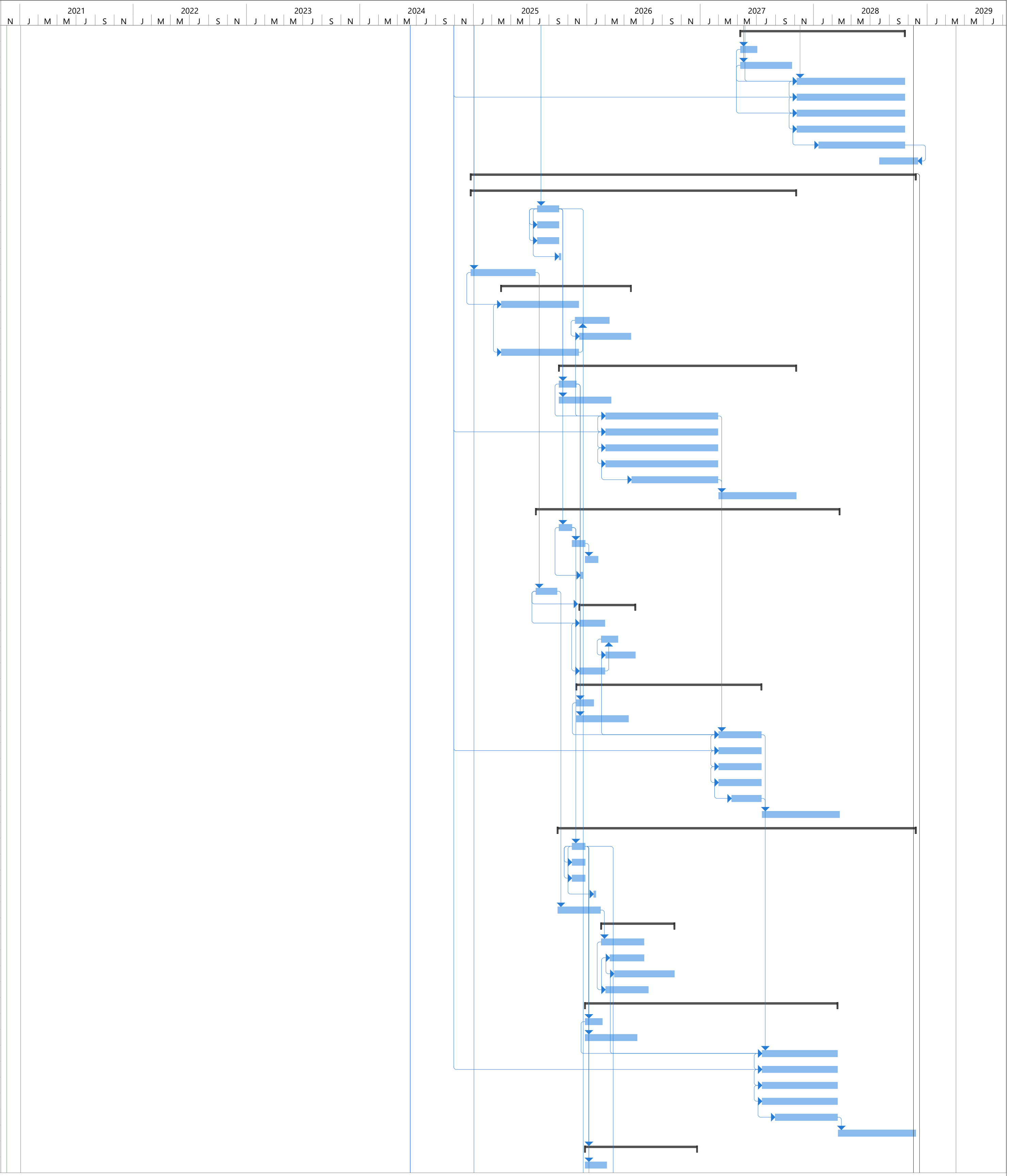


Project: Sites Reservoir
Date: Fri 11/20/20

Task	▬	Milestone	◆	Project Summary	⎴	Inactive Milestone	◇	Manual Task	▬
Split	┈	Summary	⎴	Inactive Task	▭	Inactive Summary	⎴	Duration-only	▬
Manual Summary Rollup	▬	Start-only	[	External Tasks	▬	Deadline	⇩	Manual Progress	▬
Manual Summary	⎴	Finish-only	]	External Milestone	◆	Progress	▬		

Sites Reservoir
Preliminary Construction Schedule
Roads, Dams, and I/O Facilities
November 2020

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Successors
73		**Sites Dam - Embankment**	**380 days**	**Mon 5/10/27**	**Fri 10/20/28**		
74		Initial Borrow Development (Core Material)	40 days	Mon 5/10/27	Fri 7/2/27	53	76SS+20 days
75		Initial Quarry Development for Zones 3 and 4	120 days	Mon 5/10/27	Fri 10/22/27	53	78SS+40 days
76		Place Zone 1 - Core	250 days	Mon 11/8/27	Fri 10/20/28	70SS+100 days,74SS+20 days,71	77SS
77		Place Zone 2A & 2B - Filters, Drains and Transitions	250 days	Mon 11/8/27	Fri 10/20/28	76SS,27SS+30 days	78SS
78		Place Zone 3 - Rockfill	250 days	Mon 11/8/27	Fri 10/20/28	77SS,75SS+40 days	79SS
79		Place Zone 4 - Random	250 days	Mon 11/8/27	Fri 10/20/28	78SS	80SS+50 days
80		Place Rip Rap	200 days	Mon 1/17/28	Fri 10/20/28	79SS+50 days	81FF+30 days
81		Site Reclamation and Topsoil Replacement	90 days	Mon 7/31/28	Fri 12/1/28	80FF+30 days	
82		**Saddle Dams**	**1025 days**	**Mon 12/23/24**	**Fri 11/24/28**		**198**
83		**Saddle Dam 3**	**750 days**	**Mon 12/23/24**	**Fri 11/5/27**		
84		Saddle Dam 3 - Access and Staging	50 days	Fri 7/25/25	Thu 10/2/25	18	85SS,87SS+50 days,86SS,95,96,155,104
85		Erosion and Sediment Control	50 days	Fri 7/25/25	Thu 10/2/25	84SS	
86		Clearing / Grubbing Topsoil Salvage from Work Areas	50 days	Fri 7/25/25	Thu 10/2/25	84SS	
87		Demolition	5 days	Fri 10/3/25	Thu 10/9/25	84SS+50 days	
88		Saddle Dam 3 - Foundation Excavation	150 days	Mon 12/23/24	Fri 7/18/25	23	90SS+70 days,108
89		**Saddle Dam 3 - Foundation Preparation and Grouting**	**300 days**	**Mon 3/31/25**	**Fri 5/22/26**		
90		Foundation Cleaning	180 days	Mon 3/31/25	Fri 12/5/25	88SS+70 days	93SS
91		Grout Cap	80 days	Mon 11/24/25	Fri 3/13/26	93FS-10 days	92SS+10 days
92		Curtain Grouting	120 days	Mon 12/8/25	Fri 5/22/26	91SS+10 days	97SS+60 days
93		Dental Excavation and Concrete	180 days	Mon 3/31/25	Fri 12/5/25	90SS	91FS-10 days
94		**Saddle Dam 3 - Embankment**	**546 days**	**Fri 10/3/25**	**Fri 11/5/27**		
95		Initial Borrow Development (Core Material)	40 days	Fri 10/3/25	Thu 11/27/25	84	97SS+20 days,115,116
96		Initial Quarry Development for Zones 3 and 4	120 days	Fri 10/3/25	Thu 3/19/26	84	
97		Place Zone 1 - Core	260 days	Mon 3/2/26	Fri 2/26/27	95SS+20 days,92SS+60 days	98SS,117
98		Place Zone 2A & 2B - Filters, Drains and Transitions	260 days	Mon 3/2/26	Fri 2/26/27	97SS,27SS+30 days	99SS
99		Place Zone 3 - Rockfill	260 days	Mon 3/2/26	Fri 2/26/27	98SS	100SS
100		Place Zone 4 - Random	260 days	Mon 3/2/26	Fri 2/26/27	99SS	101SS+60 days
101		Place Rip Rap	200 days	Mon 5/25/26	Fri 2/26/27	100SS+60 days	102
102		Site Reclamation and Topsoil Replacement	180 days	Mon 3/1/27	Fri 11/5/27	101	
103		**Saddle Dam 5**	**700 days**	**Mon 7/21/25**	**Fri 3/24/28**		
104		Saddle Dam 5 - Access and Staging	30 days	Fri 10/3/25	Thu 11/13/25	84	107SS+50 days,105,124
105		Erosion and Sediment Control	30 days	Fri 11/14/25	Thu 12/25/25	104	106
106		Clearing / Grubbing Topsoil Salvage from Work Areas	30 days	Fri 12/26/25	Thu 2/5/26	105	
107		Demolition	5 days	Fri 12/12/25	Thu 12/18/25	104SS+50 days	
108		Saddle Dam 5 - Foundation Excavation	50 days	Mon 7/21/25	Fri 9/26/25	88	109SS+100 days,110SS+20 days,128
109		**Saddle Dam 5 - Foundation Preparation and Grouting**	**130 days**	**Mon 12/8/25**	**Fri 6/5/26**	**108SS+100 days**	
110		Foundation Cleaning	60 days	Mon 12/8/25	Fri 2/27/26	108SS+20 days	113SS
111		Grout Cap	40 days	Mon 2/16/26	Fri 4/10/26	113FS-10 days	112SS+10 days
112		Curtain Grouting	70 days	Mon 3/2/26	Fri 6/5/26	111SS+10 days	117SS+60 days
113		Dental Excavation and Concrete	60 days	Mon 12/8/25	Fri 2/27/26	110SS	111FS-10 days
114		**Saddle Dam 5 - Embankment**	**426 days**	**Fri 11/28/25**	**Fri 7/16/27**		
115		Initial Borrow Development (Core Material)	40 days	Fri 11/28/25	Thu 1/22/26	95	117SS+20 days
116		Initial Quarry Development for Zones 3 and 4	120 days	Fri 11/28/25	Thu 5/14/26	95	
117		Place Zone 1 - Core	100 days	Mon 3/1/27	Fri 7/16/27	112SS+60 days,115SS+20 days,97	118SS,137
118		Place Zone 2A & 2B - Filters, Drains and Transitions	100 days	Mon 3/1/27	Fri 7/16/27	117SS,27SS+30 days	119SS
119		Place Zone 3 - Rockfill	100 days	Mon 3/1/27	Fri 7/16/27	118SS	120SS
120		Place Zone 4 - Random	100 days	Mon 3/1/27	Fri 7/16/27	119SS	121SS+30 days
121		Place Rip Rap	70 days	Mon 4/12/27	Fri 7/16/27	120SS+30 days	122
122		Site Reclamation and Topsoil Replacement	180 days	Mon 7/19/27	Fri 3/24/28	121	
123		**Minor Saddle Dams (1,2,6,8A)**	**825 days**	**Mon 9/29/25**	**Fri 11/24/28**		
124		Minor Saddle Dams - Access and Staging	30 days	Fri 11/14/25	Thu 12/25/25	104	125SS,127SS+50 days,126SS,135,136,143,144,145,156,168
125		Erosion and Sediment Control	30 days	Fri 11/14/25	Thu 12/25/25	124SS	
126		Clearing / Grubbing Topsoil Salvage from Work Areas	30 days	Fri 11/14/25	Thu 12/25/25	124SS	
127		Demolition	5 days	Fri 1/23/26	Thu 1/29/26	124SS+50 days	
128		Minor Saddle Dams - Foundation Excavation	100 days	Mon 9/29/25	Fri 2/13/26	108	130
129		**Minor Saddle Dams - Foundation Preparation and Grout**	**170 days**	**Mon 2/16/26**	**Fri 10/9/26**		
130		Foundation Cleaning	100 days	Mon 2/16/26	Fri 7/3/26	128	133SS+10 days
131		Grout Cap	80 days	Mon 3/16/26	Fri 7/3/26	133SS+10 days	132SS+10 days
132		Curtain Grouting	140 days	Mon 3/30/26	Fri 10/9/26	131SS+10 days	137SS+60 days
133		Dental Excavation and Concrete	100 days	Mon 3/2/26	Fri 7/17/26	130SS+10 days	131SS+10 days
134		**Minor Saddle Dams - Embankment**	**581 days**	**Fri 12/26/25**	**Fri 3/17/28**		
135		Initial Borrow Development (Core Material)	40 days	Fri 12/26/25	Thu 2/19/26	124	137SS+20 days
136		Initial Quarry Development for Zones 3 and 4	120 days	Fri 12/26/25	Thu 6/11/26	124	
137		Place Zone 1 - Core	175 days	Mon 7/19/27	Fri 3/17/28	132SS+60 days,135SS+20 days,117	138SS
138		Place Zone 2A & 2B - Filters, Drains and Transitions	175 days	Mon 7/19/27	Fri 3/17/28	137SS,27SS+30 days	139SS
139		Place Zone 3 - Rockfill	175 days	Mon 7/19/27	Fri 3/17/28	138SS	140SS
140		Place Zone 4 - Random	175 days	Mon 7/19/27	Fri 3/17/28	139SS	141SS+30 days
141		Place Rip Rap	145 days	Mon 8/30/27	Fri 3/17/28	140SS+30 days	142
142		Site Reclamation and Topsoil Replacement	180 days	Mon 3/20/28	Fri 11/24/28	141	
143		**Saddle Dam 8B - Spillway**	**257 days**	**Fri 12/26/25**	**Mon 12/21/26**	**124**	
144		Batch Plant Setup and Operational	50 days	Fri 12/26/25	Thu 3/5/26	124	

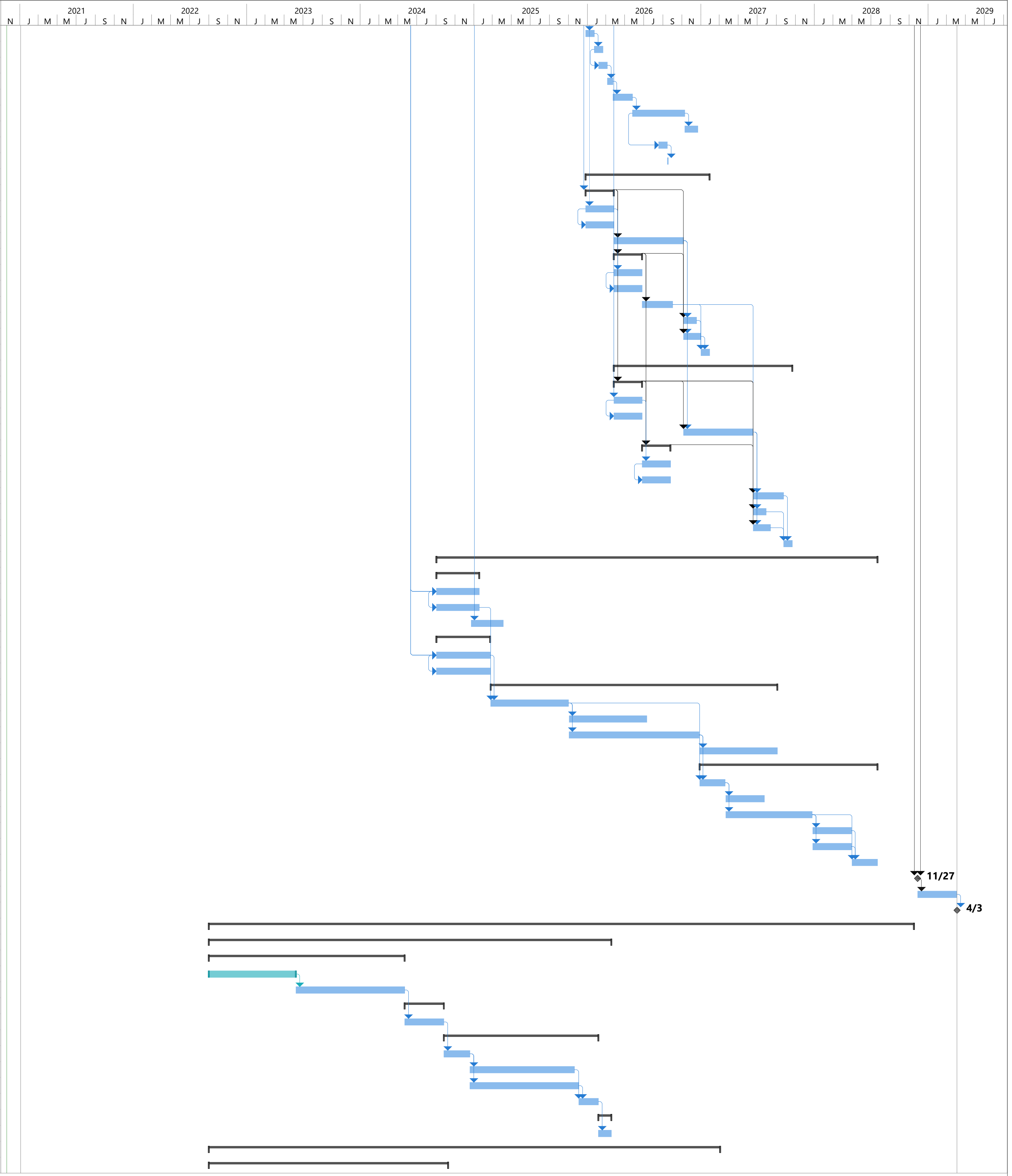


Project: Sites Reservoir
Date: Fri 11/20/20

Task	▬	Milestone	◆	Project Summary	┏━┓	Inactive Milestone	◇	Manual Task	▬	Manual Summary Rollup	▬	Start-only	[	External Tasks	▬	Deadline	↓
Split	┈	Summary	┏━┓	Inactive Task	▭	Inactive Summary	┏━┓	Duration-only	▬	Manual Summary	┏━┓	Finish-only	]	External Milestone	◆	Progress	━
																Manual Progress	━

Sites Reservoir
Preliminary Construction Schedule
Roads, Dams, and I/O Facilities
November 2020

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Successors
145	▬	SD8 - Foundation Excavation	20 days	Fri 12/26/25	Thu 1/22/26	124	146
146	▬	SD8 - Foundation Cleaning	20 days	Fri 1/23/26	Thu 2/19/26	145	147SS+10 days
147	▬	SD8 - Dental Excavation and Concrete	20 days	Fri 2/6/26	Thu 3/5/26	146SS+10 days	148
148	▬	SD8 - Grout Cap	12 days	Fri 3/6/26	Mon 3/23/26	147	149
149	▬	SD 8 - Foundation Grouting	45 days	Tue 3/24/26	Mon 5/25/26	148	150
150	▬	SD 8 - Mass Concrete	120 days	Tue 5/26/26	Mon 11/9/26	149	151,152SS+60 days
151	▬	SD 8 - Bridge	30 days	Tue 11/10/26	Mon 12/21/26	150	
152	▬	SD 8 - Clay Backfill	20 days	Tue 8/18/26	Mon 9/14/26	150SS+60 days	153
153	▬	SD 8 - Riprap and Drain Gravel	3 days	Tue 9/15/26	Thu 9/17/26	152	
154	▬	**Emergency Release Structure No. 1**	**285 days**	**Fri 12/26/25**	**Thu 1/28/27**		
155	▬	**Develop Downstream Portal**	**65 days**	**Fri 12/26/25**	**Thu 3/26/26**	**84**	**158,159,163,167**
156	▬	Portal Excavation	65 days	Fri 12/26/25	Thu 3/26/26	124	157SS,160
157	▬	Rock Bolting	65 days	Fri 12/26/25	Thu 3/26/26	156SS	
158	▬	Tunnel Excavation and Lining (12 ft)	160 days	Fri 3/27/26	Thu 11/5/26	155	164,163,170
159	▬	**Develop Upstream Portal**	**65 days**	**Fri 3/27/26**	**Thu 6/25/26**	**155**	**171,164,162**
160	▬	Portal Excavation	65 days	Fri 3/27/26	Thu 6/25/26	156	161SS
161	▬	Rock Bolting	65 days	Fri 3/27/26	Thu 6/25/26	160SS	
162	▬	Outlet Structure Concrete	70 days	Fri 6/26/26	Thu 10/1/26	159	165,174
163	▬	Install 10-Ft Cut and Cover Pipe	30 days	Fri 11/6/26	Thu 12/17/26	155,158	165
164	▬	Inlet Structure Concrete	40 days	Fri 11/6/26	Thu 12/31/26	158,159	165
165	▬	ERS - 1 Completion and Restoration	20 days	Fri 1/1/27	Thu 1/28/27	162,163,164	
166	▬	**Emergency Release Structure No. 2**	**410 days**	**Fri 3/27/26**	**Thu 10/21/27**		
167	▬	**Develop Downstream Portal**	**65 days**	**Fri 3/27/26**	**Thu 6/25/26**	**155**	**170,171,175,174**
168	▬	Portal Excavation	65 days	Fri 3/27/26	Thu 6/25/26	124	169SS,172
169	▬	Rock Bolting	65 days	Fri 3/27/26	Thu 6/25/26	168SS	
170	▬	Tunnel Excavation and Lining	160 days	Fri 11/6/26	Thu 6/17/27	167,158	176,175,174
171	▬	**Develop Upstream Portal**	**65 days**	**Fri 6/26/26**	**Thu 9/24/26**	**167,159**	**176**
172	▬	Portal Excavation	65 days	Fri 6/26/26	Thu 9/24/26	168	173SS
173	▬	Rock Bolting	65 days	Fri 6/26/26	Thu 9/24/26	172SS	
174	▬	Outlet Structure Concrete	70 days	Fri 6/18/27	Thu 9/23/27	162,167,170	177
175	▬	Install 10-Ft Cut and Cover Pipe	30 days	Fri 6/18/27	Thu 7/29/27	167,170	177
176	▬	Inlet Structure Concrete	40 days	Fri 6/18/27	Thu 8/12/27	170,171	177
177	▬	ERS - 2 Completion and Restoration	20 days	Fri 9/24/27	Thu 10/21/27	174,175,176	
178	▬	**Inlet Outlet Facilities**	**1015 days**	**Mon 9/2/24**	**Fri 7/21/28**		
179	▬	**Develop Downstream Portal**	**100 days**	**Mon 9/2/24**	**Fri 1/17/25**		
180	▬	Portal Excavation	100 days	Mon 9/2/24	Fri 1/17/25	17SS+50 days,19SS+50 days	181SS
181	▬	Rock Bolting	100 days	Mon 9/2/24	Fri 1/17/25	180SS	187
182	▬	Intake Channel Excavation	75 days	Mon 12/23/24	Fri 4/4/25	23	
183	▬	**Develop Upstream Portal**	**125 days**	**Mon 9/2/24**	**Fri 2/21/25**		
184	▬	Portal Excavation	125 days	Mon 9/2/24	Fri 2/21/25	17SS+50 days,19SS+50 days	185SS,187
185	▬	Rock Bolting	125 days	Mon 9/2/24	Fri 2/21/25	184SS	
186	▬	**Tunnels Excavation and Lining (Double Shift)**	**660 days**	**Mon 2/24/25**	**Fri 9/3/27**		
187	▬	North Tunnel Excavation - Two Headings, Double Shift	180 days	Mon 2/24/25	Fri 10/31/25	181,184	188,189,192
188	▬	North Tunnel Lining	180 days	Mon 11/3/25	Fri 7/10/26	187	
189	▬	South Tunnel Excvation - Double Shift	300 days	Mon 11/3/25	Fri 12/25/26	187	190,192
190	▬	South Tunnel Lining	180 days	Mon 12/28/26	Fri 9/3/27	189	
191	▬	**Intake and Outlet Structures**	**410 days**	**Mon 12/28/26**	**Fri 7/21/28**		
192	▬	Intake Structure Foundation	60 days	Mon 12/28/26	Fri 3/19/27	187,189	193,194
193	▬	Tunnel Bifurcation	90 days	Mon 3/22/27	Fri 7/23/27	192	
194	▬	Intake Structure Concrete	200 days	Mon 3/22/27	Fri 12/24/27	192	197,195,196
195	▬	Intake Structure Gates and Mechanical	90 days	Mon 12/27/27	Fri 4/28/28	194	197
196	▬	Tower Access Bridge	90 days	Mon 12/27/27	Fri 4/28/28	194	197
197	▬	I/O Completion and Restoration	60 days	Mon 5/1/28	Fri 7/21/28	194,195,196	
198	▬	Dams and I/O Ready for Commissioning	1 day	Mon 11/27/28	Mon 11/27/28	16,82	199
199	▬	Dams and I/O Startup and Commissioning	90 days	Tue 11/28/28	Mon 4/2/29	198	200
200	▬	Dams and I/O Substantial Completion	1 day	Tue 4/3/29	Tue 4/3/29	199	
201	▬	**Conveyance Facilities**	**1620 days**	**Thu 9/1/22**	**Wed 11/15/28**		
202	▬	**Dunnigan Pipeline - Alt 1**	**925 days**	**Thu 9/1/22**	**Wed 3/18/26**		
203	▬	**Engineering**	**450 days**	**Thu 9/1/22**	**Wed 5/22/24**		
204	📌	Preliminary	200 days	Thu 9/1/22	Wed 6/7/23		205
205	▬	Final	250 days	Thu 6/8/23	Wed 5/22/24	204	207
206	▬	**Bid and Award**	**90 days**	**Thu 5/23/24**	**Wed 9/25/24**		
207	▬	Bid and Award	90 days	Thu 5/23/24	Wed 9/25/24	205	209
208	▬	**Construction**	**355 days**	**Thu 9/26/24**	**Wed 2/4/26**		
209	▬	Submittals	60 days	Thu 9/26/24	Wed 12/18/24	207	210,211
210	▬	Structures	240 days	Thu 12/19/24	Wed 11/19/25	209	212
211	▬	Pipeline	250 days	Thu 12/19/24	Wed 12/3/25	209	212
212	▬	Testing	45 days	Thu 12/4/25	Wed 2/4/26	210,211	214
213	▬	**Commissioning**	**30 days**	**Thu 2/5/26**	**Wed 3/18/26**		
214	▬	Commission	30 days	Thu 2/5/26	Wed 3/18/26	212	
215	▬	**Dunnigan Pipeline - Alt 2**	**1175 days**	**Thu 9/1/22**	**Wed 3/3/27**		
216	▬	**Engineering**	**550 days**	**Thu 9/1/22**	**Wed 10/9/24**		

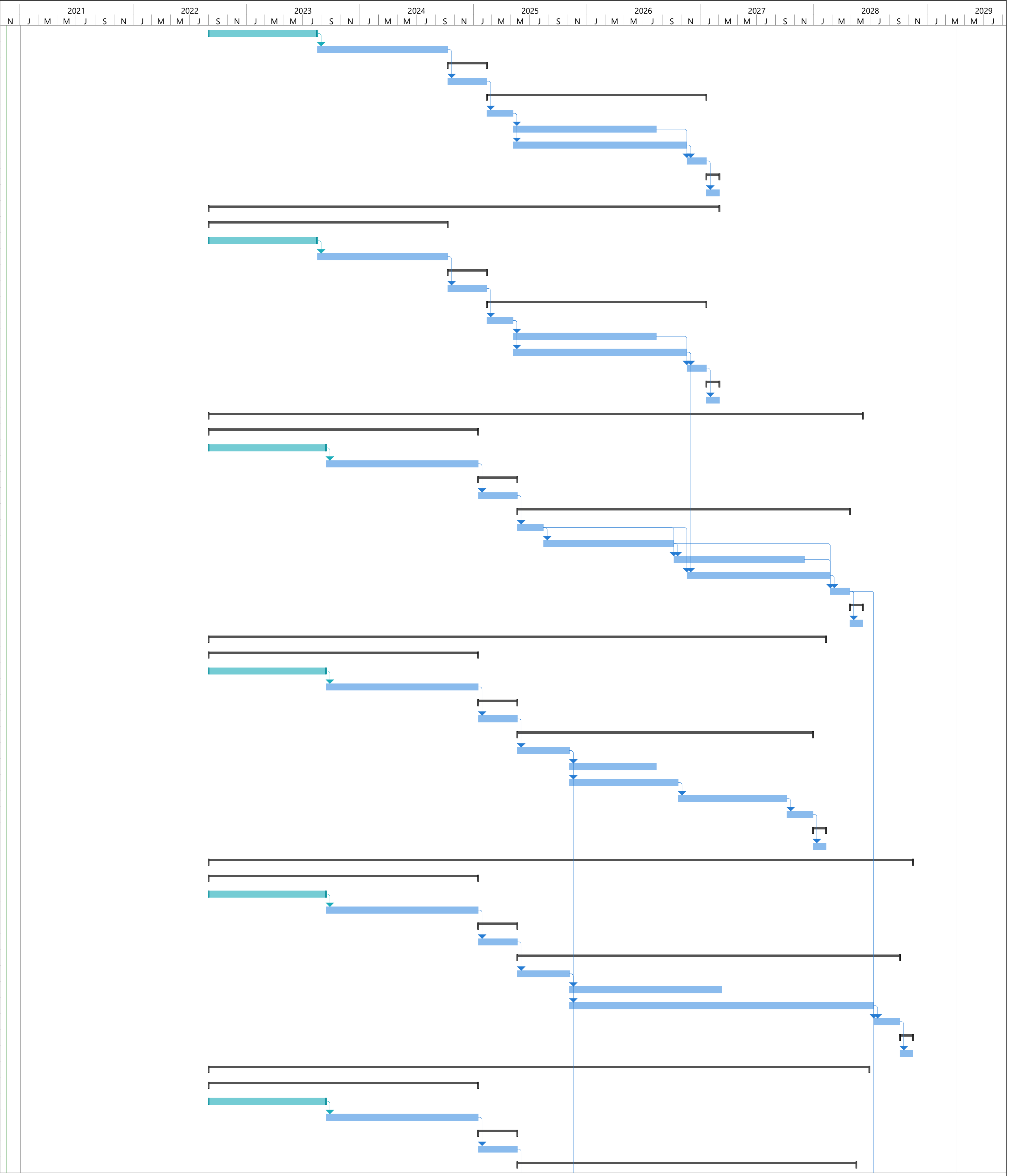


Project: Sites Reservoir
Date: Fri 11/20/20

Task	▬	Milestone	◆	Project Summary	⌐¬	Inactive Milestone	◇	Manual Task	▬	Manual Summary Rollup	▬	Start-only	[	External Tasks	▬	Deadline	⬇	Manual Progress	—
Split	┈	Summary	⌐¬	Inactive Task	▭	Inactive Summary	⌐¬	Duration-only	▬	Manual Summary	⌐¬	Finish-only	]	External Milestone	◆	Progress	—		

Sites Reservoir
Preliminary Construction Schedule
Roads, Dams, and I/O Facilities
November 2020

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Successors
217	📌	Preliminary	250 days	Thu 9/1/22	Wed 8/16/23		218
218	➜	Final	300 days	Thu 8/17/23	Wed 10/9/24	217	220
219	➜	**Bid and Award**	**90 days**	**Thu 10/10/24**	**Wed 2/12/25**		
220	➜	Bid and Award	90 days	Thu 10/10/24	Wed 2/12/25	218	222
221	➜	**Construction**	**505 days**	**Thu 2/13/25**	**Wed 1/20/27**		
222	➜	Submittals	60 days	Thu 2/13/25	Wed 5/7/25	220	223,224
223	➜	Structures	330 days	Thu 5/8/25	Wed 8/12/26	222	225
224	➜	Pipeline	400 days	Thu 5/8/25	Wed 11/18/26	222	225
225	➜	Testing	45 days	Thu 11/19/26	Wed 1/20/27	223,224	227
226	➜	**Commissioning**	**30 days**	**Thu 1/21/27**	**Wed 3/3/27**		
227	➜	Commission	30 days	Thu 1/21/27	Wed 3/3/27	225	
228	➜	**Funks/TRR Pipelines**	**1175 days**	**Thu 9/1/22**	**Wed 3/3/27**		
229	➜	**Engineering**	**550 days**	**Thu 9/1/22**	**Wed 10/9/24**		
230	📌	Preliminary	250 days	Thu 9/1/22	Wed 8/16/23		231
231	➜	Final	300 days	Thu 8/17/23	Wed 10/9/24	230	233
232	➜	**Bid and Award**	**90 days**	**Thu 10/10/24**	**Wed 2/12/25**		
233	➜	Bid and Award	90 days	Thu 10/10/24	Wed 2/12/25	231	235
234	➜	**Construction**	**505 days**	**Thu 2/13/25**	**Wed 1/20/27**		
235	➜	Submittals	60 days	Thu 2/13/25	Wed 5/7/25	233	236,237
236	➜	Structures	330 days	Thu 5/8/25	Wed 8/12/26	235	238
237	➜	Pipeline	400 days	Thu 5/8/25	Wed 11/18/26	235	238,251
238	➜	Testing	45 days	Thu 11/19/26	Wed 1/20/27	236,237	240
239	➜	**Commissioning**	**30 days**	**Thu 1/21/27**	**Wed 3/3/27**		
240	➜	Commission	30 days	Thu 1/21/27	Wed 3/3/27	238	
241	➜	**Transmission Powerlines**	**1505 days**	**Thu 9/1/22**	**Wed 6/7/28**		
242	➜	**Engineering**	**620 days**	**Thu 9/1/22**	**Wed 1/15/25**		
243	📌	Preliminary	270 days	Thu 9/1/22	Wed 9/13/23		244
244	➜	Final	350 days	Thu 9/14/23	Wed 1/15/25	243	246
245	➜	**Bid and Award**	**90 days**	**Thu 1/16/25**	**Wed 5/21/25**		
246	➜	Bid and Award	90 days	Thu 1/16/25	Wed 5/21/25	244	248
247	➜	**Construction**	**765 days**	**Thu 5/22/25**	**Wed 4/26/28**		
248	➜	Submittals	60 days	Thu 5/22/25	Wed 8/13/25	246	249,250,251
249	➜	Procurement	300 days	Thu 8/14/25	Wed 10/7/26	248	250,252
250	➜	Towers/Powerlines to POI	300 days	Thu 10/8/26	Wed 12/1/27	248,249	252
251	➜	Towers/Powerlines Funks/TRR	330 days	Thu 11/19/26	Wed 2/23/28	237,248	252
252	➜	Testing	45 days	Thu 2/24/28	Wed 4/26/28	249,250,251	254,279,307,320
253	➜	**Commissioning**	**30 days**	**Thu 4/27/28**	**Wed 6/7/28**		
254	➜	Commission	30 days	Thu 4/27/28	Wed 6/7/28	252	
255	➜	**Funks Reservoir**	**1420 days**	**Thu 9/1/22**	**Wed 2/9/28**		
256	➜	**Engineering**	**620 days**	**Thu 9/1/22**	**Wed 1/15/25**		
257	📌	Preliminary	270 days	Thu 9/1/22	Wed 9/13/23		258
258	➜	Final	350 days	Thu 9/14/23	Wed 1/15/25	257	260
259	➜	**Bid and Award**	**90 days**	**Thu 1/16/25**	**Wed 5/21/25**		
260	➜	Bid and Award	90 days	Thu 1/16/25	Wed 5/21/25	258	262
261	➜	**Construction**	**680 days**	**Thu 5/22/25**	**Wed 12/29/27**		
262	➜	Submittals	120 days	Thu 5/22/25	Wed 11/5/25	260	263,264,315
263	➜	Haulroads	200 days	Thu 11/6/25	Wed 8/12/26	262	
264	➜	Sediment Removal	250 days	Thu 11/6/25	Wed 10/21/26	262	265
265	➜	Cofferdams (build/remove)	250 days	Thu 10/22/26	Wed 10/6/27	264	266
266	➜	Testing	60 days	Thu 10/7/27	Wed 12/29/27	265	268
267	➜	**Commissioning**	**30 days**	**Thu 12/30/27**	**Wed 2/9/28**		
268	➜	Commission	30 days	Thu 12/30/27	Wed 2/9/28	266	
269	➜	**Funks Pumping Generating Plant**	**1620 days**	**Thu 9/1/22**	**Wed 11/15/28**		
270	➜	**Engineering**	**620 days**	**Thu 9/1/22**	**Wed 1/15/25**		
271	📌	Preliminary	270 days	Thu 9/1/22	Wed 9/13/23		272
272	➜	Final	350 days	Thu 9/14/23	Wed 1/15/25	271	274
273	➜	**Bid and Award**	**90 days**	**Thu 1/16/25**	**Wed 5/21/25**		
274	➜	Bid and Award	90 days	Thu 1/16/25	Wed 5/21/25	272	276
275	➜	**Construction**	**880 days**	**Thu 5/22/25**	**Wed 10/4/28**		
276	➜	Submittals	120 days	Thu 5/22/25	Wed 11/5/25	274	277,278
277	➜	Large Equipment Procurement	350 days	Thu 11/6/25	Wed 3/10/27	276	
278	➜	Structures	700 days	Thu 11/6/25	Wed 7/12/28	276	279
279	➜	Testing	60 days	Thu 7/13/28	Wed 10/4/28	252,278	281
280	➜	**Commissioning**	**30 days**	**Thu 10/5/28**	**Wed 11/15/28**		
281	➜	Commission	30 days	Thu 10/5/28	Wed 11/15/28	279	
282	➜	**TRR East Reservoir**	**1520 days**	**Thu 9/1/22**	**Wed 6/28/28**		
283	➜	**Engineering**	**620 days**	**Thu 9/1/22**	**Wed 1/15/25**		
284	📌	Preliminary	270 days	Thu 9/1/22	Wed 9/13/23		285
285	➜	Final	350 days	Thu 9/14/23	Wed 1/15/25	284	287
286	➜	**Bid and Award**	**90 days**	**Thu 1/16/25**	**Wed 5/21/25**		
287	➜	Bid and Award	90 days	Thu 1/16/25	Wed 5/21/25	285	289
288	➜	**Construction**	**780 days**	**Thu 5/22/25**	**Wed 5/17/28**		

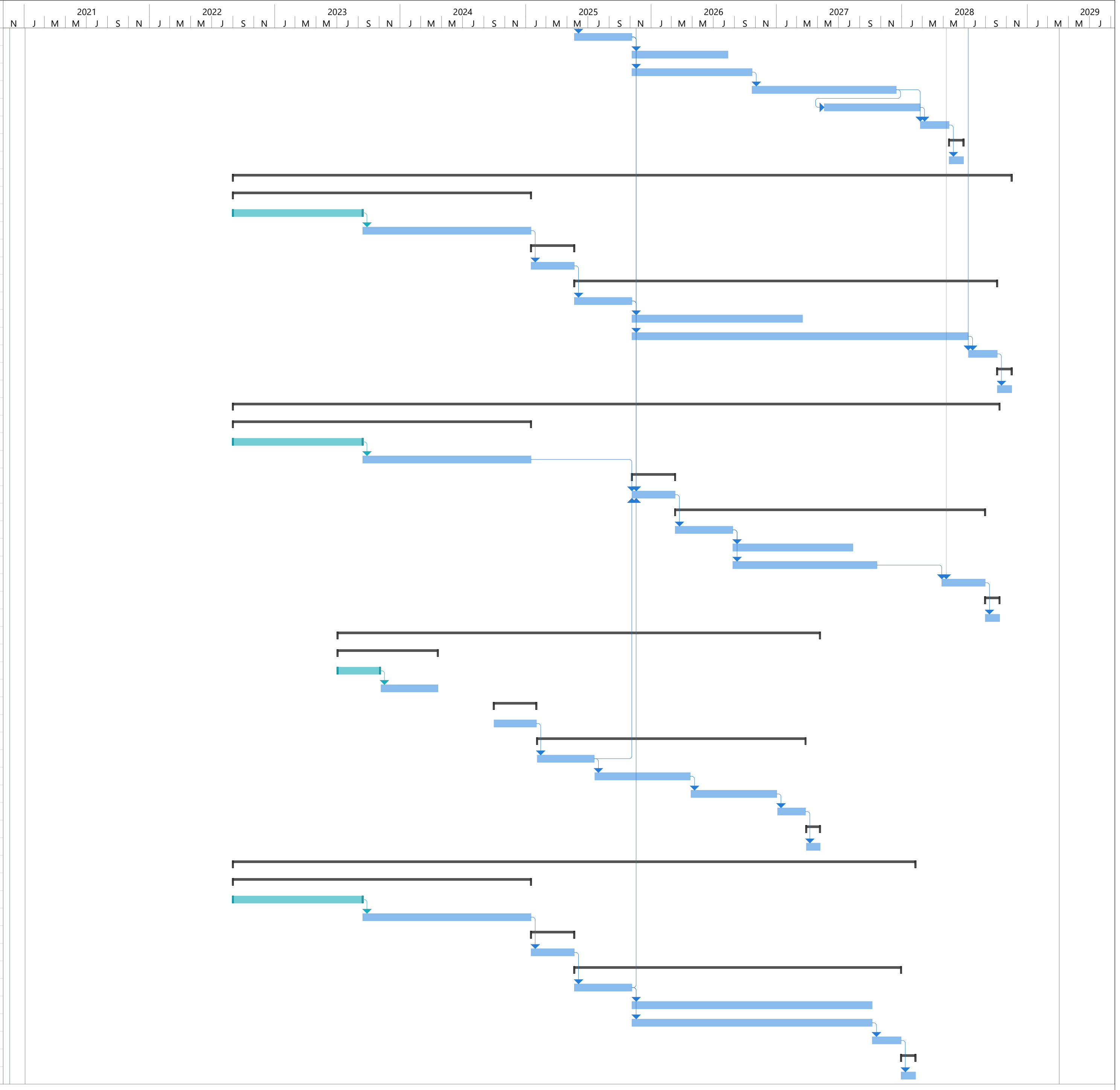


Project: Sites Reservoir
Date: Fri 11/20/20

Task	▬	Milestone	◆	Project Summary	⊓	Inactive Milestone	◇	Manual Task	▬	Manual Summary Rollup	▬	Start-only	[	External Tasks	▬	Deadline	⇩	Manual Progress	▬
Split	┈	Summary	⊓	Inactive Task	▭	Inactive Summary	⊓	Duration-only	▬	Manual Summary	⊓	Finish-only	]	External Milestone	◇	Progress	▬		

Sites Reservoir
Preliminary Construction Schedule
Roads, Dams, and I/O Facilities
November 2020

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Successors
289	⇨	Submittals	120 days	Thu 5/22/25	Wed 11/5/25	287	290,291,315
290	⇨	Haulroads	200 days	Thu 11/6/25	Wed 8/12/26	289	
291	⇨	Ground Improvement	250 days	Thu 11/6/25	Wed 10/21/26	289	292
292	⇨	Earthwork/Structures	300 days	Thu 10/22/26	Wed 12/15/27	291	293FS-1200 hrs,294
293	⇨	Subgrade and Liner	200 days	Thu 5/20/27	Wed 2/23/28	292FS-1200 hrs	294
294	⇨	Testing	60 days	Thu 2/24/28	Wed 5/17/28	292,293	296
295	⇨	**Commissioning**	**30 days**	**Thu 5/18/28**	**Wed 6/28/28**		
296	⇨	Commission	30 days	Thu 5/18/28	Wed 6/28/28	294	
297	⇨	**TRR Pumping Generating Plant**	**1620 days**	**Thu 9/1/22**	**Wed 11/15/28**		
298	⇨	**Engineering**	**620 days**	**Thu 9/1/22**	**Wed 1/15/25**		
299	📌	Preliminary	270 days	Thu 9/1/22	Wed 9/13/23		300
300	⇨	Final	350 days	Thu 9/14/23	Wed 1/15/25	299	302
301	⇨	**Bid and Award**	**90 days**	**Thu 1/16/25**	**Wed 5/21/25**		
302	⇨	Bid and Award	90 days	Thu 1/16/25	Wed 5/21/25	300	304
303	⇨	**Construction**	**880 days**	**Thu 5/22/25**	**Wed 10/4/28**		
304	⇨	Submittals	120 days	Thu 5/22/25	Wed 11/5/25	302	305,306
305	⇨	Large Equipment Procurement	355 days	Thu 11/6/25	Wed 3/17/27	304	
306	⇨	Structures	700 days	Thu 11/6/25	Wed 7/12/28	304	307
307	⇨	Testing	60 days	Thu 7/13/28	Wed 10/4/28	252,306	309
308	⇨	**Commissioning**	**30 days**	**Thu 10/5/28**	**Wed 11/15/28**		
309	⇨	Commission	30 days	Thu 10/5/28	Wed 11/15/28	307	
310	⇨	**Substations**	**1595 days**	**Thu 9/1/22**	**Wed 10/11/28**		
311	⇨	**Engineering**	**620 days**	**Thu 9/1/22**	**Wed 1/15/25**		
312	📌	Preliminary	270 days	Thu 9/1/22	Wed 9/13/23		313
313	⇨	Final	350 days	Thu 9/14/23	Wed 1/15/25	312	315
314	⇨	**Bid and Award**	**90 days**	**Thu 11/6/25**	**Wed 3/11/26**		
315	⇨	Bid and Award	90 days	Thu 11/6/25	Wed 3/11/26	262,289,313,330,343	317
316	⇨	**Construction**	**645 days**	**Thu 3/12/26**	**Wed 8/30/28**		
317	⇨	Submittals	120 days	Thu 3/12/26	Wed 8/26/26	315	318,319
318	⇨	Large Equipment Procurement	250 days	Thu 8/27/26	Wed 8/11/27	317	
319	⇨	Structures	300 days	Thu 8/27/26	Wed 10/20/27	317	320
320	⇨	Testing	90 days	Thu 4/27/28	Wed 8/30/28	252,319	322
321	⇨	**Commissioning**	**30 days**	**Thu 8/31/28**	**Wed 10/11/28**		
322	⇨	Commission	30 days	Thu 8/31/28	Wed 10/11/28	320	
323	⇨	**Red Bluff Pumping Plant Improvements**	**1005 days**	**Mon 7/3/23**	**Fri 5/7/27**		
324	⇨	**Engineering**	**210 days**	**Mon 7/3/23**	**Fri 4/19/24**		
325	📌	Preliminary	90 days	Mon 7/3/23	Fri 11/3/23		326
326	⇨	Final	120 days	Mon 11/6/23	Fri 4/19/24	325	
327	⇨	**Bid and Award**	**90 days**	**Mon 9/30/24**	**Fri 1/31/25**		
328	⇨	Bid and Award	90 days	Mon 9/30/24	Fri 1/31/25		330
329	⇨	**Construction**	**560 days**	**Mon 2/3/25**	**Fri 3/26/27**		
330	⇨	Submittals	120 days	Mon 2/3/25	Fri 7/18/25	328	315,331
331	⇨	Procurement	200 days	Mon 7/21/25	Fri 4/24/26	330	332
332	⇨	Mechanical/Electrical	180 days	Mon 4/27/26	Fri 1/1/27	331	333
333	⇨	Testing	60 days	Mon 1/4/27	Fri 3/26/27	332	335
334	⇨	**Commissioning**	**30 days**	**Mon 3/29/27**	**Fri 5/7/27**		
335	⇨	Commission	30 days	Mon 3/29/27	Fri 5/7/27	333	
336	⇨	**GCID Improvements**	**1420 days**	**Thu 9/1/22**	**Wed 2/9/28**		
337	⇨	**Engineering**	**620 days**	**Thu 9/1/22**	**Wed 1/15/25**		
338	📌	Preliminary	270 days	Thu 9/1/22	Wed 9/13/23		339
339	⇨	Final	350 days	Thu 9/14/23	Wed 1/15/25	338	341
340	⇨	**Bid and Award**	**90 days**	**Thu 1/16/25**	**Wed 5/21/25**		
341	⇨	Bid and Award	90 days	Thu 1/16/25	Wed 5/21/25	339	343
342	⇨	**Construction**	**680 days**	**Thu 5/22/25**	**Wed 12/29/27**		
343	⇨	Submittals	120 days	Thu 5/22/25	Wed 11/5/25	341	315,344,345
344	⇨	Structures	500 days	Thu 11/6/25	Wed 10/6/27	343	
345	⇨	Earthwork	500 days	Thu 11/6/25	Wed 10/6/27	343	346
346	⇨	Testing	60 days	Thu 10/7/27	Wed 12/29/27	345	348
347	⇨	**Commissioning**	**30 days**	**Thu 12/30/27**	**Wed 2/9/28**		
348	⇨	Commission	30 days	Thu 12/30/27	Wed 2/9/28	346	



Project: Sites Reservoir
Date: Fri 11/20/20

Task	▬	Milestone	◆	Project Summary	⊓	Inactive Milestone	◇	Manual Task	▬	Manual Summary Rollup	▬	Start-only	[	External Tasks	▬	Deadline	⇩	Manual Progress
Split	⋯	Summary	⊓	Inactive Task	▭	Inactive Summary	⊓	Duration-only	▬	Manual Summary	⊓	Finish-only	]	External Milestone	◆	Progress	▬	

Appendix L

Draft Sites Reservoir Pumping Load Profile

Draft Sites Reservoir Pumping Load Profile
Technical Memorandum

To:	Henry Luu (HDR)
CC:	Other recipient(s)
Date:	May 4, 2021
From:	Christine Vangelatos (ZGlobal) Chad Whittington (Jacobs) Wayne Dyok (H2O EcoPower)
Quality Review by:	Peter Rude, P.E. (Jacobs), Steve Micko (Jacobs)
Authority Agent Review by:	Reviewer
Subject:	Sites Reservoir Pumping Load Profile

1.0 Summary

Jacobs undertook CalSim II modeling to determine the average monthly reservoir inflows and releases, and Sites Reservoir levels for an 82-year hydrologic period. Jacobs then downscaled the monthly data to develop a daily time series of flows and water levels. Jacobs provided this data to H2O EcoPower to determine daily, monthly, and annual pumping needs, as well as a frequency distribution of pumping to enable Sites Reservoir Authority (Sites) to potentially negotiate a power sales agreement with solar projects to provide pumping energy. ZGlobal then examined how the pumping load profile might be used in a power sales agreement, considering the timing and magnitude of energy and power requirements, as well as potential capacity value.

Average annual pumping requirements at Sites Reservoir are estimated to be 81,100 megawatt hours (MWh), comprised of 57,100 MWh at Funks and 24,000 MWh at the Terminal Regulating Reservoir (TRR). Most of the pumping will take place during the months of January through March, although significant pumping can occur in April and December. In select high-flow years, a minimal amount of reservoir filling (that is, pumping) can occur during the months of May through November.

To minimize pumping costs, an initial determination was made that it would be cost effective to pump during the lowest-cost energy hours at full capacity. For the year 2030, these hours will typically be during the middle of the day when a significant amount of solar energy is available and between midnight and 5:00 a.m. Although there is greater system energy loss when pumping at full capacity, the price spread between low and high electrical demand hours is sufficient to justify this type of operation. Energy losses from the pumps and friction losses are on the order of 20 percent, but energy prices can vary by a factor of 8. That is, energy prices in months like March can vary from near $0 per MWh to over $80 per MWh during a 24-hour period. Hence it makes the most sense to pump as much as possible when energy prices are near $0 or, in some cases, are projected to be negative.

If pumping is on a continuous 24-hour basis due to high fill rates, not much can be done about adjusting pumping rates to take advantage of low pumping cost hours because the priority is to fill Sites Reservoir. When about 12 hours or fewer of full capacity pumping are called for, Sites can capitalize on the lower cost energy to minimize pumping costs. Therefore, the pumping load profile analysis assumed that pumping from Funks or TRR will be undertaken at full pumping capacity during the lowest electrical demand cost hours until the daily Sites Reservoir fill volume is satisfied.[1]

To accomplish the operational strategy of pumping during the low-cost hours, a minimum storage is needed in both Funks and TRR reservoirs. If 12 hours pumping at full capacity are needed (that is, 2,100 cubic feet per second [cfs] for a fill rate of 1,050 cfs), and assuming the low-cost hours are continuous,[2] then a storage volume of 1,040 acre-feet would be needed. Given that the estimated available storage in Funks is 1,170 acre-feet, sufficient volume exists to store an inflow of 1,050 cfs for 12 hours and then pump at 2,100 cfs for 12 hours. That is, Funks would be near empty and then fill for 12 hours, at which time the pumps would be turned on. After 12 hours, Funks reservoir would be back to the elevation of the previous day. If the Funks inflow rate is more than 1,050 cfs, the pumps would need to operate more than 12 hours, and less storage would be needed.

TRR may be more limited because the maximum pumping rate is 1,800 cfs. Although the storage volume at TRR is estimated to be 446 acre-feet and might be able to accommodate this pumping strategy, Sites is considering reducing the TRR storage volume.[3] Because pumping is not likely to be continuous for 12 hours, and the TRR storage volume is uncertain, this analysis assumes that TRR can accommodate the necessary storage volumes. If TRR becomes storage limited, then the pumps would need to operate over more hours at a potentially higher energy cost.

During the primary pumping months (January, February, and March), for approximately 40 percent of the days during this period, pumping is more than 12 hours per day. This reduces pumping operational flexibility. However, for 25 percent of the days when pumping is less than 12 hours per day, Sites can take advantage of low power rates to minimize pumping costs. During the remaining 35 percent of the time, pumping would last for less than an hour. This offers Sites a significant opportunity to cycle water by taking advantage of low power rates and pumping water to Sites Reservoir during these hours and then releasing the water back into Funks during periods of higher power rates in the morning and later afternoon/early evening. In this way, Sites would capitalize on energy arbitrage and could be eligible for capacity payments. At TRR, about 70 percent of the days in January, February, and March have less than one hour of pumping. This too offers a great opportunity for energy arbitrage.

At Funks for the months of April through December, depending on the month, 80 to more than 95 percent of the days have fewer than one hour of pumping, thereby offering an opportunity for energy arbitrage. Of course, the months of June through October provide release flows, so flow release days would need to be considered before any energy arbitrage or capacity allocations could be considered.

One of the purposes of developing the pumping profile is to examine the opportunities to purchase solar energy for Sites pumping. Inexpensive solar energy is typically available from about 10:00 a.m. though 3:00 p.m. Assuming that pumping can take place during these hours, purchasing solar energy from a solar farm may be a prudent course of action for Sites. Further, if Sites elects to enter the energy arbitrage market, after pumping and release obligations are satisfied, that opportunity also exists. At this time, the analysis excludes the pumped storage component, but that can easily be accommodated should Sites wish to quantify those benefits.

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[1] Because of the pumping and pipe energy losses, for those hours when there is not significant price variation, an optimization can be undertaken to minimize daily pumping costs. That is beyond the scope of this analysis. That exercise should be undertaken as part of an operational optimization later in the planning process. For example, if there are 4 hours of pumping at full capacity, it may be cost effective to reduce pumping rates and extend the pumping time to approximately 6 hours.

[2] This is actually not the case because the high-value hours are typically in the early morning before significant solar generation can take place and for five or six hours as the sun begins to set through the early evening hours. The lowest-cost hours are around noon when the solar generation is at a maximum. Power rates can also be low during the period after midnight to about 5:00 a.m. The assumption of continuous pumping leads to a conservative volume requirement in both Funks and TRR.

[3] To qualify for a capacity resource allocation, projects may require up to 5 hours of storage. The equivalent volume in TRR would be about 410 acre-feet. It is recommended that before reducing the live storage in Sites to less than 410 acre-feet, Sites should confer with ZGlobal to ascertain the current RA requirements. The TRR capacity value could be $500,000 to $1,000,000 or more per year based on current market levels and depending upon the MW credits that TRR can qualify for.

2.0 Introduction

The Sites Project Authority requested that Jacobs provide information related to the pumping load profile to enable Sites to have meaningful discussions with owners of solar projects who have expressed interest in selling solar energy to Sites. To develop meaningful information, Jacobs modeled 82 years of historical flow data to determine the timing and magnitude of pumping on a daily, monthly, and annual basis. Because of the variability of hydrology, it is necessary to assess pumping needs on a probabilistic basis. This technical memorandum describes the assumptions and details how the pumping load profile was developed. The technical memorandum summarizes the results to facilitate an understanding of the magnitude, timing, and variability of pumping. Recommendations for engaging with solar project owners are provided.

3.0 Methodology

Jacobs ran the CALSIM II model for the 1.5 million-acre-foot Sites Reservoir alternative to determine monthly fill flows into Sites Reservoir from both Funks Reservoir and the TRR, along with Sites Reservoir elevations. This information was then scaled down to a daily time step and resulting daily fill flows and water levels were transmitted to H2O EcoPower for further analysis. In addition, Jacobs provided storage volumes, reservoir elevations, and associated energy losses when pipe flows are at a maximum for both the Funks and TRR systems. For flows of 2,000 cfs at Funks, Jacobs estimated the energy losses to be 18 feet and at TRR, at a flow of 1,000 cfs, Jacobs estimated energy losses to be 14 feet. Since the maximum pumping flow from Funks is 2,100 cfs, the head loss associated with pumping at full capacity was estimated to be 19 feet and the head loss at TRR under a maximum pumping rate of 1,800 cfs was estimated to be 20 feet. Jacobs also preliminarily determined the pumping efficiency was 88 percent at Funks and 89 percent at TRR.[4]

The Excel spreadsheet provided by Jacobs was expanded to estimate the pumping power and energy for each day of the 82-year historic period. Because water level variations in both Funks and TRR are small, and the reservoirs essentially cycle daily, average water levels of 202 feet (Funks) and 121.5 feet (TRR) were used in the pumping power calculations.

Future hydrology (and variability) is assumed to be similar to historical hydrological patterns. Therefore, the distribution of flows and pumping needs represent future conditions, although variations will occur from year to year. Potential effects of climate change are ignored in this analysis.

Inspection of the daily Sites Reservoir fill data revealed that there were a number of days in which the pumping rates exceeded the capacity of the pumps. This is an artifact of the downscaling from monthly to daily values. Typically, these excess flows would be spread out within the month. Because the total energy requirements for the excess pumping would be the same if the pumping was done over one day or several adjacent days, the analysis was conducted without shifting flows. The total annual monthly and annual energy did not change and exceedance curves for water levels, hours of pumping, fill flows, and energy generation were only minimally affected during the days with high pumping rates and did not affect decision-making.

Pumping flows can vary from a maximum of 3,900 cfs for combined Funks and TRR pumping to a minimum of several cfs. For low flows, it does not make sense to pump at the inflow rates. Rather, pumping would be undertaken considering the pump efficiencies and pipeline energy losses and the cost of power. ZGlobal estimated the cost of power for each hour of each month and provided a cost-per-MWh for each hour of the day for each month. To keep the analysis manageable, weekend days and weekdays were combined to provide an average hourly rate for each hour of a day. The spread of power costs over a day was substantial, ranging from near zero during low electrical cost hours (for example, during the noon-hour period) in the months of January through March, to well over $60 per MWh during the high peak hours.

If there is pumping flexibility, then with fewer than 24 hours of pumping at full pumping capacity, pumping should be done at the lowest-cost hours to the extent possible. For this analysis, the strategy was to use existing storage at both Funks and TRR to pump at full capacity during the low-cost energy hours. If fill flows

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[4] The actual pumping efficiencies vary with head and discharge. Specific pump characteristics may be modeled in the future. The 88 and 89 percent efficiencies represent a reasonable approximation of expected efficiencies.

are high, then more hours would be added to the pumping, until pumping is done on a 24-hour basis at full capacity. Obviously during these very high pumping flows, nothing can be done to confine pumping to the low-cost hours. (In the future, Sites should consider optimizing pumping to minimize total pumping costs. Although pumping costs were not determined in this analysis, this could be easily accommodated. Given the wide range in hourly energy costs over a day, using the full capacity of the pumps would yield pumping costs close to the optimized costs.)

The next step was to determine the number of hours of pumping for each day by taking the ratio of flow to total pumping capacity and multiplying by 24 hours (for example, a flow of 1,050 at Funks would be half the pumping flow, so the pumps would operate for 12 hours that day). The MWh for pumping at full capacity was next calculated using the power equation “power = flow x pumping head/pump efficiency/constant.” The MWh needed for daily pumping is then a simple multiplication of hours of pumping times the power.

The calculations for each month were then extracted to provide monthly summary information. Total pumping energy at both Funks and TRR were then summed for each month and averaged over the 82 years of analysis. Both a monthly average energy and annual energy were calculated for Funks and TRR. To make sense of the up to 2,542 row entries for each month, the results were sorted by column and then exceedance curves were developed. The maximum, minimum, and 5, 10, 20, 30, 40, 50, 60, 70, 80, and 90 percent exceedances were extracted for each key parameter (flow, hours of pumping, pumping head, and pumping energy) to enable a better understanding of how pumping would vary over time. Note that except for pumping rates and hours of pumping, these exceedances are not coincident. The data columns were sorted from largest to smallest for each parameter and exceedance values extracted from the spreadsheet. The Funks daily energy values are close to coincident with Funks flows but they are not exact. Funks power and head levels were independently sorted. Summary tables for each month are presented in Appendix B and described under results.

From here, an hourly profile for pumping energy needs was derived as depicted in Appendix B. An average, high, and low hourly profile is created for each month. These monthly curves can be used to assist Sites in determining an appropriate match for a power purchase contract; for example, solar projects.

To assist in the development of the pumping load profile, Jacobs provided an assessment of pumping flexibility for each month of the CalSim II simulation period, where pumping flexibility is defined as the ability to shift pumping rates based on controlling diversion criteria and physical capacities. At this level of analysis, no modifications were made to the pumping schedule provided by Jacobs. Later in the design process, Jacobs will model the water conveyance system to optimize pumping and release flows.

Jacobs examined potential operational flexibility using a post-processing tool that identifies criteria that may be controlling monthly diversions simulated by CalSim II. Two conditions were evaluated: 1. Flexibility is provided in months when diversions are controlled only by Freemont weir spill protection criteria and/or near excess Delta outflow conditions, and 2. Flexibility is provided in months when diversions are controlled only by Freemont weir spill protection criteria, near excess Delta outflow conditions, pulse flow protection at Bend Bridge, and/or other constraints that are not included in the Sites Diversion Control tool. Out of the 984 months for which flows were assessed, under condition 1, 43 months have pumping flexibility; under condition 2, 177 months have pumping flexibility. These numbers suggest that there may be additional opportunities for pumping flexibility as the design process unfolds.

Table 1, Appendix A presents a summary of the required pumping energy and exceedance values that best illustrate the magnitude and time variation of pumping for each month of the year. The columns on the right side of the table present the total monthly pumping energy (in MWh) for the 82-year simulation, the average monthly energy, and the average daily energy for Funks, TRR, and the combined total. The total average annual pumping energy is presented at the bottom of the table. The totals are 57,100 MWh for Funks, 24,000 MWh for TRR, and a combined total of 81,100 MWh.

Exceedance levels for flow, daily hours of operation, pumping head, and pumping energy for each month for Funks and TRR are presented on the left side of Table 1. The first entry is the maximum daily value for the 82-year simulation and the last entry is the minimum daily value. The second entry is the 5 percent exceedance and the remaining entries are presented in 10 percent exceedance increments.

Slightly over 70 percent of the annual pumping occurs during the months of January, February, and March. About 16.5 percent of the pumping occurs in the shoulder months of April and December: the remaining 13 percent of the annual pumping energy is spread through the other 7 months, with most of that occurring in May, June, and November. Pumping during the months of July, August, and September is rare and these months have been excluded from Table 1.

During the months of January, February, and March, for 18, 26, and 33 percent of the days, respectively, pumping would take place for more than 20 hours per day.[5] Pumping more than 12 hours per day would occur in 30, 40, and 44 percent of the days in January, February, and March, respectively. Importantly, pumping fewer than 5 hours per day would occur 49, 43, and 35 percent of the time in January, February, and March, respectively. This suggests that even in the highest pumping months, pumping would not be fully capitalizing on the least-cost solar energy. This further suggests that during a large percentage of time, even during the highest pumping months, Sites could take advantage of the hourly energy price differentials and add pumping hours and then release that excess water back into Funks and TRR during the high-value hours.

During April and December, more than 85 and 82 percent of the days would require fewer than 5 hours of pumping. During the remaining months, more than 95 percent of the days would require fewer than 5 hours of pumping. Again, this strongly suggests that in these months when releases are low or zero, Sites could take advantage of low-cost solar energy and pump water into Sites Reservoir and then release that water during higher-value hours.

Because of the large fluctuations in Sites Reservoir, pumping is needed during both low and high reservoir levels. In analyzing each month of the year, the minimum pumping requirement varies from 30 to 63 MWh at Funks and 39 to 69 MWh at TRR, with each month having essentially the same MWh pumping range. Thus, depending upon the Sites Reservoir level, the total power requirement will vary from a low of 69 MWh to a high of 132 MWh, assuming that pumping is always undertaken at full capacity when power rates are lowest.

4.0 Recommendations

On an average annual basis, about 81,100 MWh of pumping energy will be required. This level of pumping energy could be provided by solar projects, even during periods of the year when the hours of sunlight in California are at a minimum. During discussions with solar project owners, Sites should consider entering into an agreement to provide pumping energy during low-cost energy periods when the projects are not otherwise pumping to fill Sites Reservoir. Sites could then release this water back into the Funks and TRR reservoirs to capitalize on the energy arbitrage. By undertaking this pump and release scheme, Sites may also be able to receive capacity payments.

If not capital cost-prohibitive, the TRR should be sized for a minimum of about 410 acre-feet to enable the pump and release scheme to take place. Without a pump and release scheme, there would be too many days with no generation to qualify for capacity payments. Given that several pumped storage projects are being considered in California, the incremental cost for Sites to undertake this pump and release approach compared to those other projects is likely to be small. However, one operational disadvantage that Sites has is the large reservoir level changes and that is likely to affect potential capacity payments.

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[5] Note, there are sometimes more than 24 hours of pumping during days when there is maximum pumping. This is an anomaly of the downscaling of the monthly flow data to daily flow data. This flow would actually be spread out over other days in the month once the pumping capacity is reached. However, because the pumping energy requirement is unaffected, no adjustments were made in this analysis.

Appendix A

Funks and TRR Duration Curves

TABLE 1 - FUNKS AND TRR DURATION CURVES

JANUARY			Pump				Pump			Funks	TRR	Total Pump
Exceeden	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000393	2442.02	27.9087946	314.6727	1600.178	1458.22998	19.443066	396.1727	1229.3038	Total 82 yr	1071420.81	262854.9998	1334275.8
0.050354	2264.41	25.8789718	314.3945	1383.012	1180.25	15.736667	395.8945	841.83349	Jan Avg	13066.10743	3205.548779	16271.656
0.100315	2111.831	24.1352065	312.7059	1223.073	631.590027	8.4212004	394.2059	429.30529	Daily Avg	421.4873366	103.4047993	524.89214
0.200236	1625.87	18.5813721	304.8954	903.5284	0	0	386.3954	0				
0.300157	1061.28	12.1289174	296.5848	592.0362	0	0	378.0848	0				
0.400079	673.8501	7.70114397	278.8468	376.6917	0	0	360.3468	0				
0.5	470.0298	5.37176897	256.7478	246.8329	0	0	338.2478	0				
0.600315	273.6802	3.12777344	247.072	142.5391	0	0	328.572	0				
0.700236	1.279785	0.01462612	206.1065	0.920234	0	0	287.6065	0				
0.800157	0	0	188.4531	0	0	0	269.9531	0				
0.900079	0	0	169.394	0	0	0	250.894	0				
1	0	0	147.4102	0	0	0	228.9102	0				

FEBRUARY			Pump				Pump			Energy (MWh)	Energy (MWh)	Energy (MWh)
Exceeden	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000432	2423.231	27.6940667	314.7329	1695.23	1498.82996	19.984399	396.2329	1274.4352	Total 82 yr	1184861.274	335101.0167	1519962.3
0.050086	2251.74	25.7341748	314.6312	1486.011	1265.40002	16.872	396.1312	951.10472	Feb Avg	14449.52773	4086.597764	18536.125
0.100173	2168.12	24.7785191	314.4554	1311.036	783.48999	10.446533	395.9554	592.04112	Daily Avg	511.4877072	144.6583279	656.14604
0.200345	2098.3	23.9805664	312.2298	1058.044	334.290009	4.4572001	393.7298	249.41636				
0.300086	1504.86	17.1983993	302.4157	834.2005	32.3499985	0.4313333	383.9157	26.662569				
0.400259	1039.19	11.8764565	281.6131	515.2459	0	0	363.1131	0				
0.5	577.71	6.60239955	263.3732	358.2607	0	0	344.8732	0				
0.600173	306.7202	3.50537388	252.8242	191.4906	0	0	334.3242	0				
0.700345	33.49023	0.38274554	217.6298	22.62993	0	0	299.1298	0				
0.800086	0	0	202.6639	0	0	0	284.1639	0				
0.900259	0	0	178.4717	0	0	0	259.9717	0				
1	0	0	157.2571	0	0	0	238.7571	0				

MARCH			Pump				Pump			Funks	TRR	Total Pump
Exceeden	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000393	2463.831	28.1580629	314.7828	1681.753	1964.53003	26.193734	396.2828	1693.2249	Total 82 yr	1344951.872	472118.6915	1817070.6
0.050354	2297.05	26.2519978	314.6563	1477.164	1424.20996	18.989466	396.1563	1151.2716	Mar Avg	16401.8521	5757.545019	22159.397
0.100315	2252.47	25.742512	314.5898	1335.833	960.640015	12.808534	396.0898	723.30586	Daily Avg	82.12903226	82.12903226	82.129032
0.200236	2116.85	24.1925715	314.3954	1134.959	321.640015	4.2885335	395.8954	231.5976				
0.300157	1822.951	20.8337249	309.1726	1007.249	183.380005	2.4450667	390.6726	138.80343				
0.400079	1382.741	15.8027543	291.5694	771.6567	21.4200001	0.2856	373.0694	19.606217				
0.5	328.04	3.74902902	268.9129	207.6408	0	0	350.4129	0				
0.600315	21.875	0.25	256.9563	12.19735	0	0	338.4563	0				
0.700236	0.299805	0.00342634	235.4708	0.215627	0	0	316.9708	0				
0.800157	0	0	217.2509	0	0	0	298.7509	0				
0.900079	0	0	189.0097	0	0	0	270.5097	0				
1	0	0	165.3058	0	0	0	246.8058	0				

APRIL			Pump				Pump			Funks	TRR	Total Pump
Exceedenc	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000407	2194.73	25.0826283	314.8211	1407.168	1999.77002	26.6636	396.3211	1693.5254	Total 82 yr	323938.9681	392075.5781	716014.55
0.05	1862	21.2799944	314.6467	1054.375	1727.17004	23.028934	396.1467	1371.8572	Apr Avg	3950.475221	4781.40949	8731.8847
0.1	967.7203	11.059661	314.5347	585.4472	1320.43994	17.605866	396.0347	1035.7505	Daily Avg	131.6825074	159.3803163	291.06282
0.2	85.47986	0.97691272	314.3584	58.95825	13.75	0.1833333	395.8584	12.043134				
0.3	14.54004	0.16617188	312.3038	10.20635	0	0	393.8038	0				
0.4	0	0	297.3032	0	0	0	378.8032	0				
0.5	0	0	270.6088	0	0	0	352.1088	0				
0.6	0	0	257.6522	0	0	0	339.1522	0				
0.7	0	0	247.0315	0	0	0	328.5315	0				
0.8	0	0	227.9011	0	0	0	309.4011	0				
0.9	0	0	201.7233	0	0	0	283.2233	0				
1	0	0	160.2539	0	0	0	241.7539	0				

MAY			Pump				Pump			Funks	TRR	Total Pump
Exceeden	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000393	1898.201	21.6937235	314.7995	1305.582	1320.43994	17.605866	396.2995	1044.2751	Total 82 yr	114307.6614	120513.2257	234820.89
0.050354	235.13	2.68719979	314.5524	141.3813	526.599976	7.021333	396.0524	433.41586	May Avg	1393.99587	1469.673484	2863.6694
0.100315	37.29004	0.42617188	314.3613	22.59739	99.6600037	1.3288	395.8613	91.204781	Daily Avg	44.96760871	47.40882207	92.376431
0.200236	14.70996	0.16811384	313.871	10.03409	0	0	395.371	0				
0.300157	3.089958	0.03531381	310.1866	1.856408	0	0	391.6866	0				
0.400079	0	0	296.7587	0	0	0	378.2587	0				
0.5	0	0	271.0571	0	0	0	352.5571	0				
0.600315	0	0	260.1208	0	0	0	341.6208	0				
0.700236	0	0	249.5553	0	0	0	331.0553	0				
0.800157	0	0	227.8497	0	0	0	309.3497	0				
0.900079	0	0	198.3286	0	0	0	279.8286	0				
1	0	0	149.2204	0	0	0	230.7204	0				

JUNE			Pump				Pump			Funks	TRR	Total Pump
Exceedenc	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000407	1501.699	17.1622754	314.7533	884.5977	926.880005	12.3584	396.2533	839.83362	Total 82 yr	63250.58194	123584.9836	186835.57
0.05	53.7998	0.61485491	314.4291	30.30292	534.719971	7.1295996	395.9291	436.23517	Jun Avg	771.3485602	1507.133946	2278.4825
0.1	11.72044	0.13394793	314.2202	8.421363	165.559998	2.2074666	395.7202	151.52841	Daily Avg	25.71161867	50.2377982	75.949417
0.2	0	0	313.0035	0	0	0	394.5035	0				
0.3	0	0	305.7403	0	0	0	387.2403	0				
0.4	0	0	294.1669	0	0	0	375.6669	0				
0.5	0	0	277.9456	0	0	0	359.4456	0				
0.6	0	0	257.6565	0	0	0	339.1565	0				
0.7	0	0	244.2583	0	0	0	325.7583	0				
0.8	0	0	222.2448	0	0	0	303.7448	0				
0.9	0	0	194.6394	0	0	0	276.1394	0				
1	0	0	147.3271	0	0	0	228.8271	0				

OCTOBER			Pump				Pump			Funks	TRR	Total Pump
Exceeden	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000393	806.3101	9.2149721	314.5096	568.3572	1440.14001	19.201867	396.0096	1299.9076	Total 82 yr	13441.28293	111265.4889	124706.77
0.050354	56.84003	0.64960031	309.257	33.68083	437.910004	5.8388	390.757	397.28751	Oct Avg	163.9180845	1356.896206	1520.8143
0.100315	5.42041	0.06194754	307.5948	3.50295	0	0	389.0948	0	Daily Avg	5.287680144	43.77084534	49.058525
0.200236	0	0	305.5208	0	0	0	387.0208	0				
0.300157	0	0	293.7048	0	0	0	375.2048	0				
0.400079	0	0	274.4802	0	0	0	355.9802	0				
0.5	0	0	254.9283	0	0	0	336.4283	0				
0.600315	0	0	246.3111	0	0	0	327.8111	0				
0.700236	0	0	199.63	0	0	0	281.13	0				
0.800157	0	0	180.3245	0	0	0	261.8245	0				
0.900079	0	0	165.0804	0	0	0	246.5804	0				
1	0	0	143.199	0	0	0	224.699	0				

NOVEMBER			Pump				Pump			Funks	TRR	Total Pump
Exceedenc	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000407	2335.91	26.6961133	314.7508	1628.731	558.219971	7.4429329	396.2508	497.51761	Total 82 yr	213290.4892	18490.44276	231780.93
0.05	891.3999	10.1874275	312.459	626.238	0	0	393.959	0	Nov Avg	2601.103527	225.4932044	2826.5967
0.1	417.6602	4.77325893	308.1205	236.037	0	0	389.6205	0	Daily Avg	86.70345089	7.516440146	94.219891
0.2	38.63988	0.4415986	304.4736	26.00529	0	0	385.9736	0				
0.3	0	0	291.4662	0	0	0	372.9662	0				
0.4	0	0	272.4477	0	0	0	353.9477	0				
0.5	0	0	252.874	0	0	0	334.374	0				
0.6	0	0	244.5296	0	0	0	326.0296	0				
0.7	0	0	198.9844	0	0	0	280.4844	0				
0.8	0	0	175.3592	0	0	0	256.8592	0				
0.9	0	0	164.877	0	0	0	246.377	0				
1	0	0	143.0681	0	0	0	224.5681	0				

DECEMBER			Pump				Pump			Funks	TRR	Total Pump
Exceedenc	Flow (cfs)	Funks (hours	Head (ft)	Energy (MWh)	TRR Flow (cfs	TRR Hours	TRR Head	TRR Energy (MWh)		Energy (MWh)	Energy (MWh)	Energy (MWh)
0.000393	2385.97	27.2682263	314.6636	1466.05	1558.43005	20.779067	396.1636	1285.5561	Total 82 yr	309833.7804	70051.89303	379885.67
0.050354	1731.04	19.7833147	313.2445	772.6618	52.9900017	0.7065334	394.7445	31.040517	Dec Avg	3778.460736	854.2913784	4632.7521
0.100315	1017.36	11.6269699	311.1546	470.6251	0	0	392.6546	0	Daily Avg	121.8858302	27.5577864	149.44362
0.200236	399.2998	4.56342634	304.1865	189.1786	0	0	385.6865	0				
0.300157	10.77002	0.12308594	291.3232	7.665546	0	0	372.8232	0				
0.400079	0	0	274.8018	0	0	0	356.3018	0				
0.5	0	0	252.6582	0	0	0	334.1582	0				
0.600315	0	0	244.4511	0	0	0	325.9511	0				
0.700236	0	0	199.2672	0	0	0	280.7672	0				
0.800157	0	0	178.888	0	0	0	260.388	0				
0.900079	0	0	167.3775	0	0	0	248.8775	0				
1	0	0	143.8353	0	0	0	225.3353	0				

Funks MWh	TRR MWh	Total MWh
57117.21758	24003.91773	81121.135

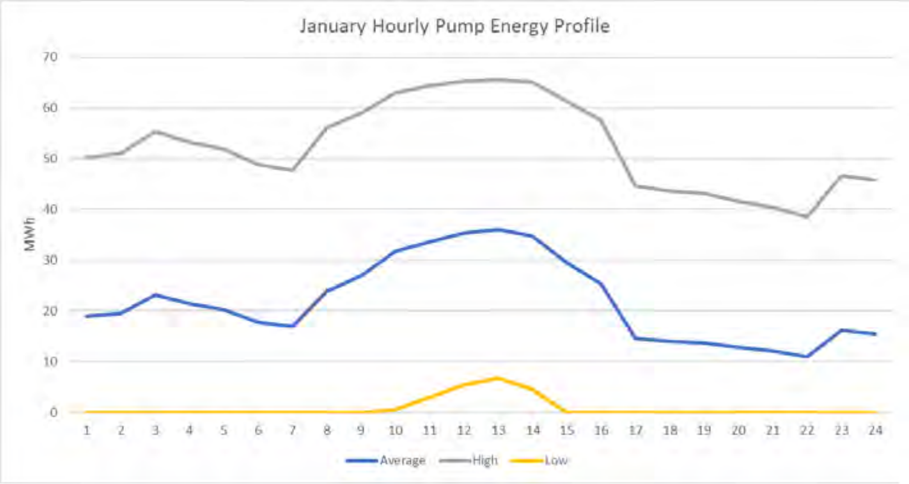
Appendix B

Hourly Pumping Profiles by Month

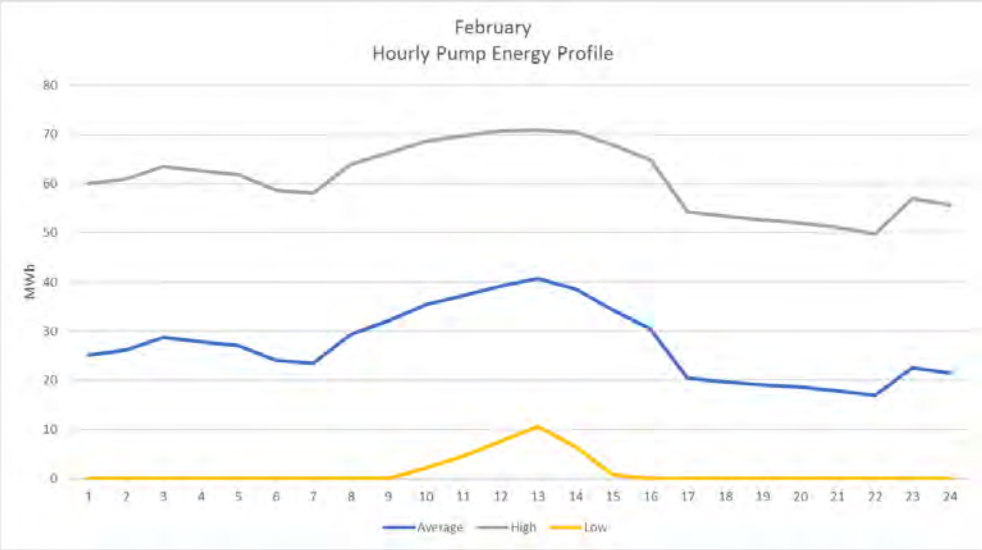
Appendix B – Hourly Pumping Profiles by Month

January					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	19	31	50	0	29%
2	20	31	51	0	30%
3	23	32	55	0	38%
4	21	32	53	0	34%
5	20	32	52	0	32%
6	18	31	49	0	27%
7	17	31	48	0	25%
8	24	32	56	0	39%
9	27	32	59	0	46%
10	32	31	63	0	56%
11	34	31	64	3	61%
12	35	30	65	5	65%
13	36	29	66	7	72%
14	35	30	65	5	63%
15	29	32	61	0	51%
16	25	32	58	0	42%
17	15	30	45	0	21%
18	14	30	44	0	20%
19	14	30	43	0	19%
20	13	29	42	0	17%
21	12	28	40	0	16%
22	11	28	39	0	14%
23	16	31	47	0	24%
24	15	30	46	0	22%
Daily MWh	525	667	1,192	0	72%

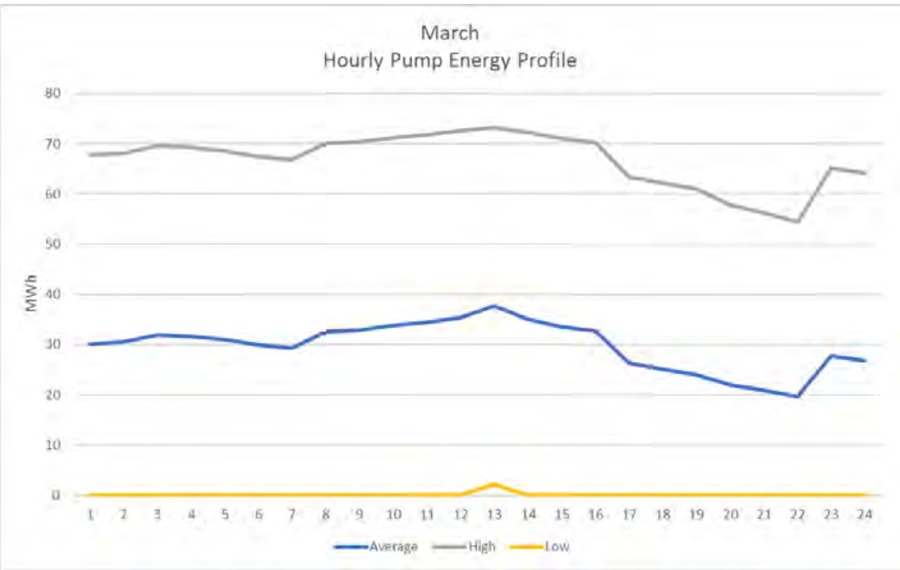
Std. Dev. = standard deviation



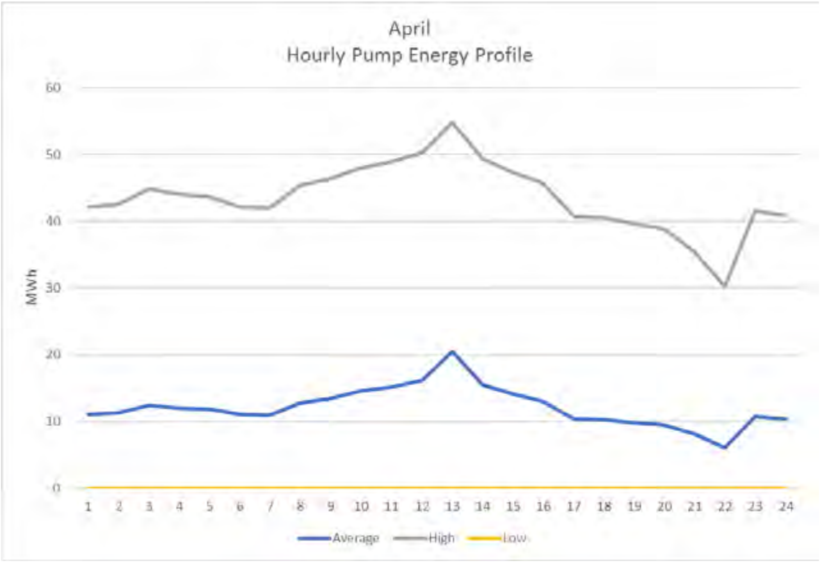
February					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	25	35	60	0	38%
2	26	35	61	0	40%
3	29	35	63	0	45%
4	28	35	63	0	43%
5	27	35	62	0	42%
6	24	35	59	0	36%
7	23	35	58	0	35%
8	29	35	64	0	47%
9	32	34	66	0	52%
10	35	33	69	2	59%
11	37	33	70	5	63%
12	39	32	71	8	67%
13	41	30	71	11	80%
14	39	32	70	7	66%
15	34	34	68	1	57%
16	30	34	65	0	49%
17	20	34	54	0	29%
18	20	34	53	0	27%
19	19	34	53	0	26%
20	19	33	52	0	26%
21	18	33	51	0	24%
22	17	33	50	0	23%
23	23	34	57	0	33%
24	21	34	56	0	31%
Daily MWh	656	749	1,405	0	80%



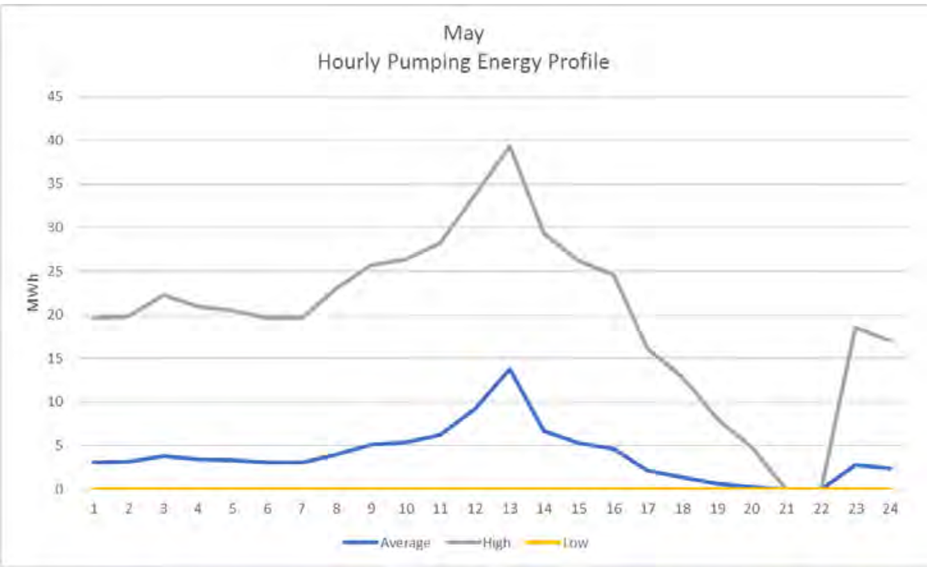
March					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	30	38	68	0	43%
2	31	38	68	0	44%
3	32	38	70	0	46%
4	32	38	69	0	46%
5	31	38	69	0	45%
6	30	38	67	0	43%
7	29	38	67	0	42%
8	32	38	70	0	47%
9	33	38	70	0	48%
10	34	37	71	0	50%
11	34	37	72	0	51%
12	35	37	73	0	53%
13	38	36	73	2	70%
14	35	37	72	0	52%
15	33	37	71	0	49%
16	33	38	70	0	48%
17	26	37	63	0	37%
18	25	37	62	0	35%
19	24	37	61	0	33%
20	22	36	58	0	30%
21	21	35	56	0	29%
22	20	35	54	0	27%
23	28	37	65	0	40%
24	27	37	64	0	38%
Daily MWh	715	842	1,557	0	70%



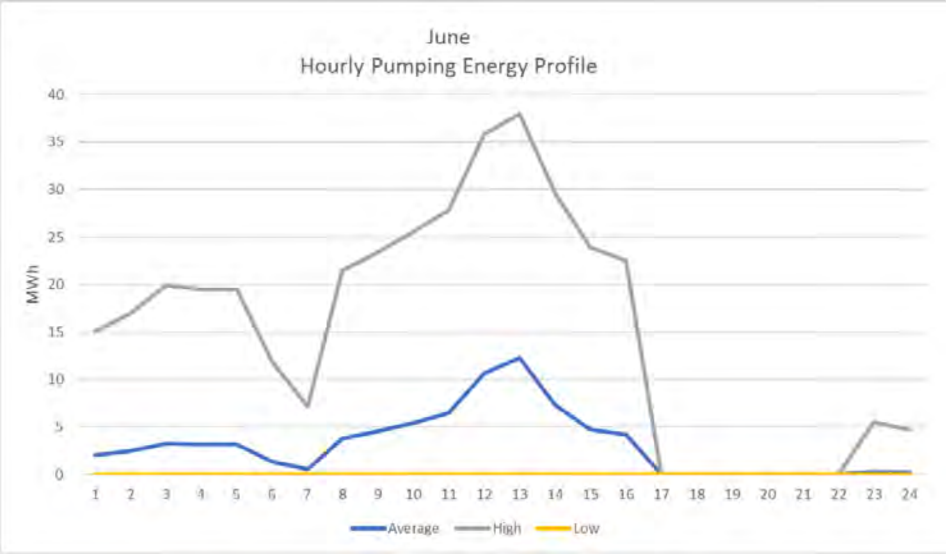
April					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	11	31	42	0	11%
2	11	31	43	0	12%
3	12	32	45	0	13%
4	12	32	44	0	13%
5	12	32	44	0	12%
6	11	31	42	0	11%
7	11	31	42	0	11%
8	13	33	45	0	14%
9	13	33	46	0	15%
10	15	33	48	0	17%
11	15	34	49	0	18%
12	16	34	50	0	20%
13	21	34	55	0	41%
14	15	34	49	0	18%
15	14	33	47	0	16%
16	13	33	46	0	14%
17	10	30	41	0	11%
18	10	30	41	0	10%
19	10	30	40	0	10%
20	10	29	39	0	10%
21	8	27	35	0	8%
22	6	24	30	0	6%
23	11	31	42	0	11%
24	10	30	41	0	11%
Daily MWh	291	716	1,007	0	41%



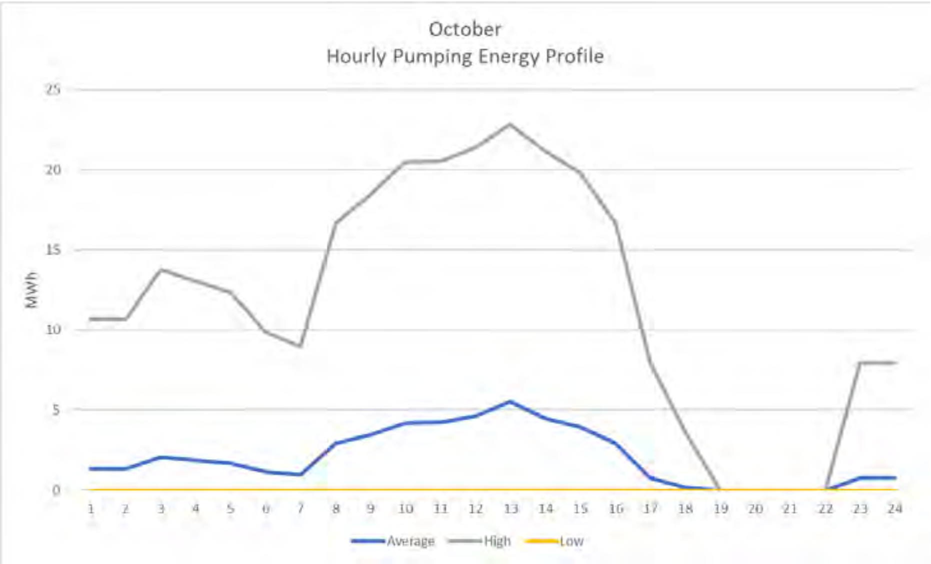
May					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	3	17	20	0	3%
2	3	17	20	0	3%
3	4	19	22	0	4%
4	3	18	21	0	4%
5	3	17	20	0	4%
6	3	17	20	0	3%
7	3	17	20	0	3%
8	4	19	23	0	4%
9	5	21	26	0	6%
10	5	21	26	0	6%
11	6	22	28	0	8%
12	9	25	34	0	14%
13	14	26	39	0	39%
14	7	23	29	0	8%
15	5	21	26	0	6%
16	5	20	25	0	5%
17	2	14	16	0	2%
18	1	11	13	0	1%
19	1	8	8	0	1%
20	0	5	5	0	0%
21	0	0	0	0	0%
22	0	0	0	0	0%
23	3	16	19	0	3%
24	2	15	17	0	3%
Daily MWh	92	336	429	0	39%



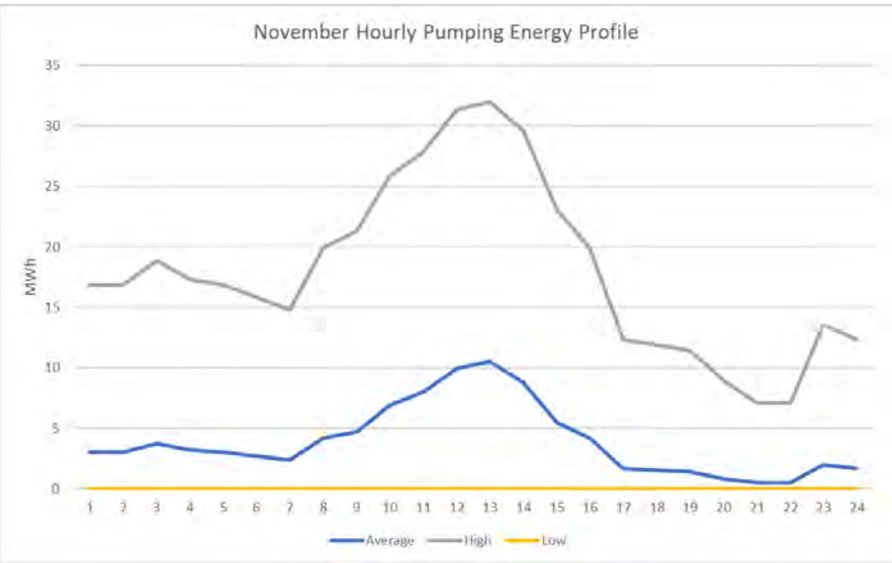
June					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	2	13	15	0	2%
2	2	14	17	0	3%
3	3	17	20	0	4%
4	3	16	19	0	4%
5	3	16	19	0	4%
6	1	11	12	0	2%
7	1	7	7	0	1%
8	4	18	21	0	5%
9	5	19	23	0	6%
10	5	20	26	0	7%
11	6	21	28	0	9%
12	11	25	36	0	16%
13	12	26	38	0	23%
14	7	22	30	0	10%
15	5	19	24	0	6%
16	4	18	23	0	5%
17	0	0	0	0	0%
18	0	0	0	0	0%
19	0	0	0	0	0%
20	0	0	0	0	0%
21	0	0	0	0	0%
22	0	0	0	0	0%
23	0	5	6	0	0%
24	0	4	5	0	0%
Daily MWh	76	248	324	0	23%



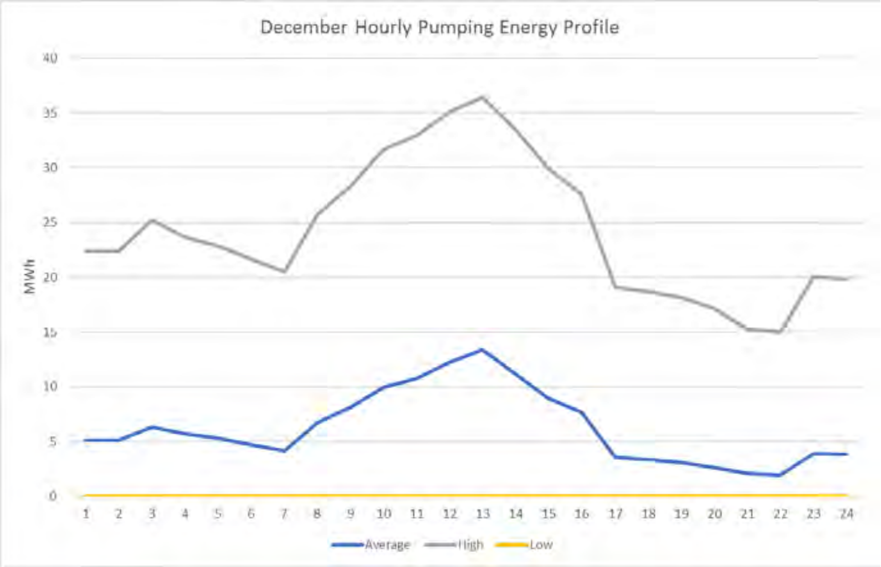
October					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	1	9	11	0	2%
2	1	9	11	0	2%
3	2	12	14	0	3%
4	2	11	13	0	3%
5	2	11	12	0	2%
6	1	9	10	0	2%
7	1	8	9	0	1%
8	3	14	17	0	4%
9	3	15	18	0	5%
10	4	16	20	0	6%
11	4	16	21	0	6%
12	5	17	21	0	7%
13	6	17	23	0	13%
14	4	17	21	0	7%
15	4	16	20	0	6%
16	3	14	17	0	4%
17	1	7	8	0	1%
18	0	3	4	0	0%
19	0	0	0	0	0%
20	0	0	0	0	0%
21	0	0	0	0	0%
22	0	0	0	0	0%
23	1	7	8	0	1%
24	1	7	8	0	1%
Daily MWH	49	200	249	0	13%



November					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	3	14	17	0	5%
2	3	14	17	0	5%
3	4	15	19	0	6%
4	3	14	17	0	5%
5	3	14	17	0	5%
6	3	13	16	0	4%
7	2	12	15	0	4%
8	4	16	20	0	7%
9	5	17	21	0	8%
10	7	19	26	0	12%
11	8	20	28	0	15%
12	10	21	31	0	19%
13	10	21	32	0	27%
14	9	21	30	0	16%
15	6	18	23	0	9%
16	4	16	20	0	7%
17	2	11	12	0	3%
18	2	10	12	0	2%
19	1	10	11	0	2%
20	1	8	9	0	1%
21	0	7	7	0	1%
22	0	7	7	0	1%
23	2	12	14	0	3%
24	2	11	12	0	3%
Daily MWh	94	285	379	0	27%



December					
Hour End	**Average**	**Std. Dev.**	**High**	**Low**	**%Time**
1	5	17	22	0	10%
2	5	17	22	0	10%
3	6	19	25	0	12%
4	6	18	24	0	11%
5	5	18	23	0	10%
6	5	17	22	0	9%
7	4	16	21	0	7%
8	7	19	26	0	13%
9	8	20	28	0	17%
10	10	22	32	0	20%
11	11	22	33	0	23%
12	12	23	35	0	26%
13	13	23	36	0	34%
14	11	22	33	0	23%
15	9	21	30	0	18%
16	8	20	28	0	16%
17	4	16	19	0	6%
18	3	15	19	0	5%
19	3	15	18	0	5%
20	3	14	17	0	4%
21	2	13	15	0	3%
22	2	13	15	0	2%
23	4	16	20	0	7%
24	4	16	20	0	7%
Daily MWh	149	386	535	0	34%



Appendix M
Resource Adequacy Valuation

Resource Adequacy Valuation
Technical Memorandum

To:	Sites Project Authority
cc:	Henry Lou, P.E., HDR
Date:	June 22, 2021
From:	Christine Vangelatos, ZGlobal and Brian Rahman, ZGlobal
Reviewed by:	Peter Rude, P.E., Jacobs, Wayne Dyok, H20 EcoPower
Subject:	Resource Adequacy Valuation for Sites

1.0 Summary

This memorandum provides an initial valuation assessment of the resource adequacy (RA) benefits for Sites. Based on analysis provided by H20 EcoPower, Sites has capability to generate energy during its water releases in the critical availability hours[1] when California's demand needs RA capacity. RA capacity is procured by load serving entities in California from various suppliers, on a bilateral contract basis. As described in Attachment 1, Sites can be studied before its eligibility to sell RA capacity to California's load-serving entities. Under the assumption that Sites' expected available release energy can be made available for dispatch by California Independent Service Operators (CAISO) during the defined RA availability hours, the qualifying capacity for RA contracts was derived using the data provided by H20 EcoPower for the expected 2021-2025 monthly exceedances and average power output for Sites. Based on these energy forecasts, ZGlobal determined the annual value for RA contracts to be between $1.98 million and $2.28 million annually (see Table 1).

TABLE 1. ANNUAL RESOURCE ADEQUACY VALUE FOR SITES

Methodology	Annual Value (2019 Dollars)
PMax Qualifying Capacity (QC)	$2,281,342
Historical Exceedance	$1,981,239

RA contracts can provide a consistent revenue stream to help offset capital or operational costs. Since RA contracts are for available capacity, they provide additional revenue streams to any expected energy revenues for the power deliveries.

1.1 Detailed Valuation Calculation for Sites

For compliance year 2021, there are two adopted methodologies (methods 1 and 2) for calculating the QC for hydropower resources. The RA valuation calculation in Table 1 derives the annual contract value based on both adopted methods. RA resources have the option to choose which method to use in deriving their net

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[1] Resource adequacy availability hours are currently between 4:00 p.m. and 9:00 p.m.

qualifying capacity (NQC) for the compliance year. The main difference is that Method 1 does not account for variations of QC resulting from water availability, while Method 2 does. Also, if a RA resource elects Method 2, its availability is not subject to potential penalties if actual availability does not align with monthly NQC megawatts (MW), as monitored and determined by CAISO.

1.1.1 Method 1 – Qualifying Capacity based on PMax

QC is the term used in the RA program that identifies the resource's capability as a result of validation and other processes needed to acquire a generator interconnection agreement with CAISO. QC is usually equal to the generator's PMax. NQC refers to the portion of QC that counts toward RA capacity. The NQC for solar, wind, biomass, geothermal, cogeneration, and some hydropower resources can be reduced from its QC by technology factors, which account for the effective load-carrying capability for the relevant technology type. Table 2 shows the technology factors for hydropower resources for compliance year 2021.

TABLE 2. TECHNOLOGY FACTOR FOR HYDROPOWER – COMPLIANCE YEAR 2021

Month	Technology Factor
January	0.60
February	0.65
March	0.78
April	0.75
May	0.70
June	0.72
July	0.79
August	0.72
September	0.73
October	0.68
November	0.59
December	0.67

Table 3 shows the detailed derivation of the RA value for Sites, using the PMax QC method and assuming a maximum capacity of 69.9 MW for the combined Funks and TPP Sites generation. Based on California Public Utility's (CPUC's) 2019 RA report[2], the weighted average price for all RA contracts for NP26 area resources was $3.51 per kilowatt-month (kW-month). For system RA contracts in NP26, the weighted average price was higher, at $4.29/kW-month. Jacobs used both prices to calculate a low and high range for Method 1, and use the average annual value to determine the RA value of $2.28 million, using Method 1.

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[2] California Public Utility (CPUC). 2021. *2019 Resource Adequacy Report*. https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442468127. March.

TABLE 3. ANNUAL RA VALUE FOR SITES – METHOD 1

Month	Technology Factor	Funks Pmax (MW)	TRR Pmax (MW)	Sites QC Total (MW)	NQC	NP26 Wt. Avg (All RA) ($/kW-month)	System RA NP26 Wt. Avg ($/kW-month)	RA Value (Low)	RA Value (High)
Jan	0.60	42.3	27.6	69.9	42.04	3.51	4.29	$147,565	$180,357
Feb	0.65	42.3	27.6	69.9	45.49	3.51	4.29	$159,669	$195,151
Mar	0.78	42.3	27.6	69.9	54.25	3.51	4.29	$190,409	$232,722
Apr	0.75	42.3	27.6	69.9	52.67	3.51	4.29	$184,884	$225,969
May	0.70	42.3	27.6	69.9	48.79	3.51	4.29	$171,243	$209,297
Jun	0.72	42.3	27.6	69.9	50.47	3.51	4.29	$177,159	$216,528
Jul	0.79	42.3	27.6	69.9	54.91	3.51	4.29	$192,721	$235,548
Aug	0.72	42.3	27.6	69.9	50.17	3.51	4.29	$176,114	$215,250
Sep	0.73	42.3	27.6	69.9	50.77	3.51	4.29	$178,197	$217,796
Oct	0.68	42.3	27.6	69.9	47.33	3.51	4.29	$166,130	$203,047
Nov	0.59	42.3	27.6	69.9	41.39	3.51	4.29	$145,286	$177,572
Dec	0.67	42.3	27.6	69.9	46.68	3.51	4.29	$163,831	$200,238
							Total	$2,053,208	$2,509,477
								Average	$2,281,342

1.2 Method 2 – Qualifying Capacity Based on 50% and 10% Exceedance Value

Table 4 shows the detailed derivation of the RA value for Sites, using the 50 and 10 percent exceedance QC method (Method 2), which CPUC adopted for the 2021 compliance year[3]. In this methodology, the QC is calculated monthly, based on the 10-year historical availability (based on self-scheduled or bid-in generation). For each month, the historical capacity available during the availability assessment hours is used to determine the 50 percent and 10 percent exceedance values. The 50 percent value is weighted by 80 percent, and the 10 percent value is weighted by 20 percent. Table 2 uses the analysis provided by H20 EcoPower regarding the expected 2021-2025 monthly exceedances. This results in the QC values for Sites that ranges between 58.3 and 63.2 MW. After applying the technology factors, the NQC ranges between 34.5 and 49.2 MW for the combined Funks and TRR capacity. Using the weighted average NP26 RA contract prices from 2019, the average annual RA contract value is $1.98 million using Method 2.

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[3] California Public Utility Commission (CPUC). 2020. *Adopting Local and Flexible Obligations and Refining RA Program.* http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=342083913. June 30.

TABLE 4. ANNUAL RA VALUE FOR SITES – METHOD 2

Month	Sites Total 50% Exceedance (MW)	Sites Total 10% Exceedance (MW)	.8 * 50% MW	.20 * 10% MW	QC	NQC	RA NP26 Wt. Avg (All RA) ($/kW-month)	System RA NP26 Wt. Avg ($/kW-month)	RA Value (Low)	RA Value (High)
Jan	56.7	69.5	45.36	13.90	59.26	35.64	3.51	4.29	$125,112	$152,914
Feb	58.2	69.9	46.58	13.98	60.56	39.41	3.51	4.29	$138,327	$169,066
Mar	59.5	69.9	47.59	13.99	61.58	47.79	3.51	4.29	$167,738	$205,013
Apr	59.9	69.9	47.90	13.99	61.89	46.63	3.51	4.29	$163,685	$200,059
May	60.0	69.9	47.98	13.98	61.96	43.24	3.51	4.29	$151,789	$185,520
Jun	61.6	69.9	49.24	13.97	63.21	45.64	3.51	4.29	$160,213	$195,816
Jul	60.8	69.8	48.63	13.95	62.58	49.16	3.51	4.29	$172,540	$210,882
Aug	59.0	69.3	47.20	13.87	61.07	43.84	3.51	4.29	$153,865	$188,057
Sep	57.4	68.8	45.91	13.75	59.66	43.33	3.51	4.29	$152,091	$185,889
Oct	56.3	68.3	45.03	13.67	58.70	39.74	3.51	4.29	$139,504	$170,505
Nov	55.8	68.5	44.65	13.69	58.35	34.55	3.51	4.29	$121,270	$148,218
Dec	55.8	69.2	44.61	13.83	58.44	39.03	3.51	4.29	$136,982	$167,422
								Total	$1,783,115	$2,179,363
									Average	$1,981,239

Attachment 1

Resource Adequacy Background

Attachment 1

Resource Adequacy Background

The acquisition of capacity to meet CAISO's balancing authority 15% reserve margin requirement is governed by the state's RA structure. The California legislature enacted Assembly Bill (AB) 380 in 2005 to ensure availability of adequate capacity for CAISO dispatch. Specifically, Section 380 of the CPUC requires that:

> *Each load-serving entity shall be subject to the same requirements for resource adequacy…that are applicable to electrical corporations pursuant to this section, or otherwise required by law, or by order or decision of the commission.*

The RA program rules, procurement, and reporting requirements apply to all load-serving entities (investor-owned utilities, community choice aggregators, and energy service providers) in the CAISO balancing area. The RA program sets the framework and enables bilateral contracts between suppliers and load-serving entities. It is not a competitive capacity market.

The CPUC has ultimate jurisdiction over California's RA program. The CPUC approves the RA plans and procurement costs for each of the load-serving entities. CAISO ensures RA plans are consistent with CPUC rules, and capacity is made available to its markets and dispatched as required by the CPUC. As the responsible balancing authority, CAISO has its own reporting requirements for its participants; these are consistent with CPUC requirements. Further, CAISO procures additional MW capacity if it detects shortages to the planning reserve margin (115% of peak load forecast). There are two mechanisms for CAISO's capacity procurement:

- Capacity Procurement Mechanism (CPM). If individual load-serving entities do not meet their capacity requirements, and if all load-serving entities collectively do not meet a requirement, CAISO may designate CPM capacity through an auction process.
- Reliability Must-Run (RMR). CAISO has also signed agreements with local resources to designate them as RMR capacity to meet reliability needs. This is a last resort option. It typically will be approved by the Federal Energy Regulatory Commission, if there is little or no competition for other resources to meet the reliability need.

There are three categories of RA capacity:

1. System. Capacity is procured to meet 15 percent expected peak loads in the entire CAISO balancing area. System capacity obligation is based on LSE's monthly peak forecast for its load served, within each transmission access charge (TAC) area. There are 3 TAC areas in CAISO: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E). System requirements are divided into North of Path 26 (PG&E TAC) and South of Path 26 (SCE and SDG&E TACs), with a maximum flow allocation in each direction. The forecast used by the CPUC to calculate the 15 percent planning margin is based on a 1-in-2 weather year approved by the California Energy Commission. Each load-serving entity is allocated a portion of the 15 percent planning margin and required to procure capacity contracts that cover their obligation for the compliance year.
2. Local. Capacity is procured to ensure there is adequate local capacity in transmission constrained areas. Local RA need is determined by CAISO engineering studies and provided to CPUC, which sets the target procurement amount for each load-serving entity. Local requirements are set 3 years ahead and updated each year.

   CAISO studies 10 local reliability areas annually and determines requirements based on minimum generation capacity needed in the local area to meet a 1-in-10 weather year load peak and an N-1-1 contingency. Therefore, local capacity requirements are largely driven by reliability issues in the 10 local areas shown in Figure 1. CPUC allocates local area requirements pro rata to CPUC-jurisdictional load serving entities based on peak-month load ratio shares in each TAC. Unlike system requirements, local requirements are not contingent on whether the entity serves load in the local area. Load-serving entities have local requirements for all areas within a TAC in which they serve load.

Figure 1. Local Capacity Areas for Resource Adequacy

3. Flexible. These fast-ramping resources can follow load and supply changes that occur during the CAISO's largest continuous 3-hour ramp in each month. The large 3-hour ramp changes are driven by the change in delivery from solar resources, combined with demand changes during the same ramping period. CAISO determines flexible capacity needs each year. CPUC distributes requirements pro rata to jurisdictional load serving entities based on monthly load ratio shares. Flexible RA requirements are divided among three categories, and are defined as maximum or minimum percentages that may be met using resources in one or more categories (refer to Figure 2).

	Category 1	Category 2	Category 3
Must-offer obligation	17 Hours	5 Hours	5 Hours
	5 AM- 10 PM Daily For the whole year	3 PM to 8 PM for May – September	3 PM to 8 PM for May – September
	5 AM- 10 PM Daily For the whole year	2 PM- 7 PM for January- April and October-December	2 PM- 7 PM for January- April and October-December
	Daily	Daily	Non-holiday weekdays
Energy limitation	At least 6 Hours	At least 3 Hours	At least 3 Hours
Starts	The minimum of two starts per day or the number of starts feasible with minimum up and down time	At least one start per day	Minimum 5 starts a month
Percentage of LSE portfolio of flexible resources	At least 62 % for May – September	Up to 38% for categories 2 and 3 combined	Up to 5%
	At least 46 % for January- April and October-December	Up to 54% for categories 2 and 3 combined	Up to 5%

Figure 2. Flexible Ramp Categories

The CPUC may issue penalties for non-compliance, including failure to meet requirements (deficiencies) and failure to make filings when and as directed. There is a waiver option for local deficiencies in the year- or month-ahead processes for all three years of local requirements. Load-serving entities requesting waivers must demonstrate that they were unable to procure sufficient capacity. For example, the load-serving entity will show evidence that it reasonably solicited bids for capacity, but was unable to procure capacity because of a lack of responses or unreasonable bid terms. There is no waiver process for system or flexibility deficiencies.

RA is a compliance program for load-serving entities. The compliance horizon is currently 3 years. Capacity can be procured from generators within the CAISO or from imports outside the CAISO. Generators become eligible to provide RA capacity based on interconnection studies performed by the CAISO. A generator gets designated as being able to provide certain levels of QC and NQC, as follows:

- Full Capacity Deliverability Status (FCDS) – The resource can fully deliver its NQC given the transmission capacity and CAISO's participating transmission owners have upgraded their systems to meet reliability criteria.
- Interim Deliverability (ID) – The resource has reduced NQC at time of COD because all transmission upgrades needed to meet reliability criteria are pending completion. FCDS status will be achieved once transmission upgrades are complete.
- Partial Deliverability Status (PD) – The resource cannot fully deliver its QC (such as, maximum capacity or PMax) because of transmission limitations; therefore, the resource is granted PD status for level of MW that can count as RA capacity.
- Energy Only (EO) – Generators with EO status are not qualified to provide RA capacity.

Generators receive FCDS when they go through the CAISO's Interconnection Application Process and request that the CAISO study the generator as a fully deliverable resource. CAISO determines what network upgrades are needed to allow the generator to produce energy during peak-load hours. A generator agrees to pay for network upgrades that are reimbursed over 5 years. Once network upgrades are complete, a generator gets designated as FCDS and can be counted toward satisfying a load serving entity's RA obligation. While awaiting network upgrades, a generator can receive PD or ID status.

Note that there are differences between QC and NQC. QC is a result of CAISO validation and other processes needed to acquire a generator interconnection agreement with CAISO. QC is usually equal to the generator's

PMax. NQC refers to the portion of QC that will count toward RA capacity. The NQC for solar, wind, biomass, geothermal, cogeneration, and some hydropower resources can be reduced from its QC by technology factors, which account for the effective load-carrying capability for the relevant technology type. Figure 3 shows the technology factors for solar, wind, biomass, and hydropower resources for compliance year 2021.

Solar PV and Solar Thermal	
Month	**CY 2021 Solar ELCC**
1	4.0%
2	3.0%
3	18.0%
4	15.0%
5	16.0%
6	31.0%
7	39.0%
8	27.0%
9	14.0%
10	2.0%
11	2.0%
12	0.0%

Wind	
Month	**CY 2021 Wind ELCC**
1	14.0%
2	12.0%
3	28.0%
4	25.0%
5	25.0%
6	33.0%
7	23.0%
8	21.0%
9	15.0%
10	8.0%
11	12.0%
12	13.0%

Biomass				
Month	**2017**	**2018**	**2019**	**Average**
1	81%	91%	93%	88%
2	92%	89%	92%	91%
3	88%	86%	93%	89%
4	80%	85%	90%	85%
5	91%	88%	91%	90%
6	94%	91%	95%	93%
7	89%	92%	94%	92%
8	97%	93%	93%	94%
9	93%	95%	94%	94%
10	86%	88%	89%	87%
11	90%	88%	92%	90%
12	91%	92%	93%	92%

Hydro				
Month	**2017**	**2018**	**2019**	**Average**
1	57%	62%	61%	60%
2	67%	65%	63%	65%
3	83%	67%	83%	78%
4	77%	72%	78%	75%
5	63%	73%	73%	70%
6	77%	72%	68%	72%
7	80%	74%	81%	79%
8	72%	70%	73%	72%
9	72%	77%	70%	73%
10	64%	70%	69%	68%
11	60%	56%	62%	59%
12	75%	59%	67%	67%

Figure 3. 2021 Compliance Year Technology Factors

Load-serving entities can also procure system RA from imported energy. Load-serving entities must request allocation of import capability through CAISO's annual maximum import capability process. Each year, CAISO determines how many MW are available for RA on each intertie. The load-serving entity will need to nominate MW on the relevant intertie and CAISO will allocate the available MW to the nominating entities based on its load share ratio and requested MW. Once they receive their maximum import capability allocation, the load-serving entity can then use that intertie capacity to import energy into CAISO to satisfy its system RA obligation.

Appendix N

Final HC Operations, Maintenance, and Replacement

Final HC Operations, Maintenance, and Replacement Technical Memorandum

To:	Sites Project Authority
CC:	Henry Luu, P.E. (HDR)
Date:	May 25, 2021
From:	Jeff Smith, P.E./Jacobs
Quality Review by:	Peter Rude, P.E./Jacobs
Authority Agent Review by:	Henry Luu, P.E. (HDR)
Subject:	Operations, Maintenance, and Replacement for HC Facilities

1.0 Introduction

The project consists of a large reservoir, ancillary roads, and conveyance facilities. The Sites Joint Power Authority (Authority) decided to segregate the design of these facilities into two segments. The first segment, “HR” (Segment H Reservoir), is responsible for design of the reservoir features, including several dams, inlet/outlet tunnels at Golden Gate Dam, and relocation of roads displaced by the reservoir. The other segment is known as the “HC” segment (Segment H Conveyance) and includes improvements to the two existing diversion canals from the Sacramento River to the project area (Tehama-Colusa Canal [TCC] and Glenn-Colusa Irrigation District [GCID] Main Canal), regulating reservoirs (existing Funks Reservoir and a new Terminal Regulating Reservoir [TRR]), two pumping generating plants (PGPs) and their respective substations, electrical interconnection transmission lines, large-diameter pipelines from each PGP to Sites Reservoir, and a large-diameter pipeline to convey water from the TCC to the Colusa Basin Drain or Sacramento River near Dunnigan, California.

This technical memorandum will cover the HC facilities. Detailed descriptions of each facility are in the next section. An overall site plan of the project area is provided in Figure 1.

1.1 General Description of Facilities

Following is a list of the individual new facilities and existing facilities that require improvements.

- Improvements to the Tehama-Colusa Canal Authority (TCCA) Red Bluff Pumping Plant on the Sacramento River
- GCID Main Canal improvements upstream of the TRR
- TRR – East Alternative
- TRR – West Alternative
- TRR PGP with respective substation
- TRR pipelines

- Funks Reservoir – sediment removal
- Funks PGP with respective substation
- Funks pipelines
- Western Area Power Administration (WAPA) or Pacific Gas and Electric (PG&E) Substation/Switchyard
- Power transmission lines
- Dunnigan Pipeline (Alternative 1 and Alternative 2)
- Administration and operations building
- Maintenance and storage building
- Access roads

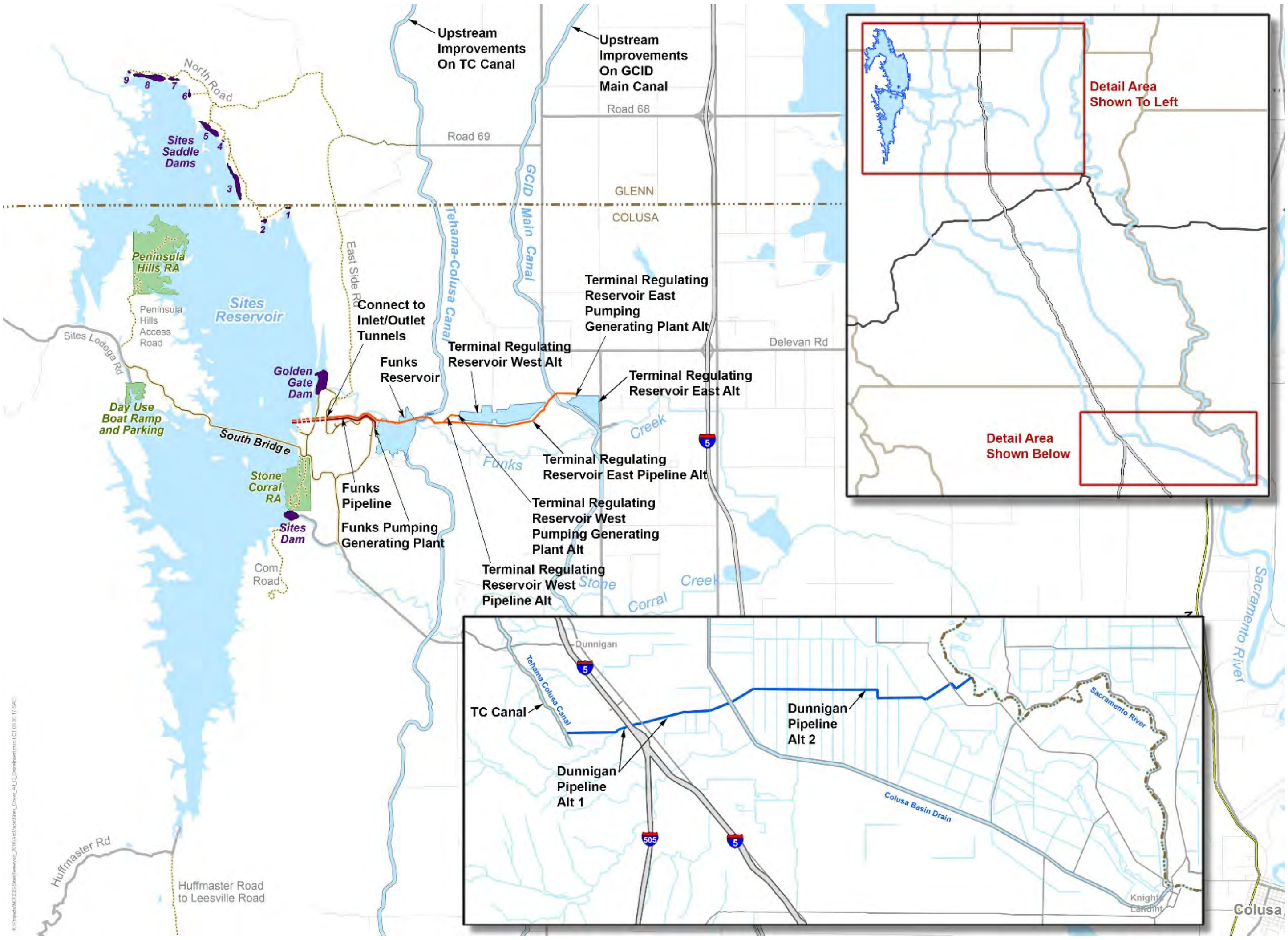

Figure 1: Project Area Site Plan

1.1.1 Improvements to the TCCA Red Bluff Pumping Plant

The Red Bluff Diversion is located on the Sacramento River in Red Bluff, California. The facility includes a 2,500 cubic feet per second (cfs) capacity, 1,180-foot-long fish screen structure, forebay, pumping plant (current capacity 2,000 cfs), an electrical switchyard, and a 660-foot-long access bridge, canal, and siphon under Red Bank Creek, to deliver water from the Sacramento River into the TCC and Corning Canal. This facility was constructed and put into operation in October 2012. The pumping plant was designed to accommodate the Sites Project and includes space to add 2 additional, 250 cfs, 600-horsepower (hp) pumping units, bringing the total pumping capacity to 2,500 cfs.

1.1.2 GCID Main Canal Improvements

The GCID Main Canal delivers water from the Sacramento River to users along its route, from its diversion point approximately 5 miles northwest of Hamilton City to southeast of the City of Williams. The canal is a 65-mile-long, unlined, earthen channel, with capacity varying from 3,000 cfs at the upstream end to 300 cfs at the southern terminus. Water conveyed by the canal is pumped by the Hamilton City Main Pump Station into the GCID Main Canal.

Improvements to the GCID Main Canal will include a new 3,000 cfs headworks structure just downstream of the Hamilton City Diversion, two siphon structures (Willow Creek and Walker Creek), a railroad siphon at Willows, canal earthwork, and some canal bank gravel road improvements. The need for replacement of the siphons and railroad crossing will be determined after a canal hydraulic model and a condition assessment are completed, which is anticipated to be in Spring 2021.

1.1.3 TRR

This is a new reservoir that will be hydraulically connected to the GCID Main Canal about 3 miles east of Funks Reservoir and just upstream of the Funks Creek Siphon, at milepost 41.3 on the GCID Main Canal. The footprint of the TRR will be approximately 130 acres, with a storage volume of approximately 600 acre-feet. The TRR will also include gates to control water flow in and out of the GCID Main Canal. There are two alternative locations for the TRR: one on the eastern side of the GCID Main Canal (TRR East) and one on the western side of the GCID Main Canal (TRR West).

1.1.4 TRR PGP

This will be a pumping and generating plant that will be used to pump water from the TRR to the Sites Reservoir. This facility will also include hydroelectric turbines to generate electricity when flow is released from Sites Reservoir to the TRR and GCID Main Canal. As part of this PGP facility, there will also be an energy-dissipation facility that will allow releases back to the TRR as backup to the hydroelectric turbine facilities. The pumping plant will have a capacity of 1,800 cfs; the generating plant will have a capacity of 1,000 cfs.

1.1.5 TRR Pipelines

These are two, parallel, 12-foot-diameter pipelines that will be used to convey water between the TRR PGP and the Sites Reservoir. These pipelines will connect from the piping manifold at TRR PGP to the downstream side of the two proposed 23-foot-diameter tunnels connected to the Site Reservoir inlet/outlet structure. The approximate length of these pipelines will be 4.4 miles each. Just downstream of the piping manifold connecting the TRR pipelines with the two inlet/outlet tunnels, there is a 24-inch-diameter environmental water pipeline that is approximately 2,550 feet long and discharges into Funks Creek.

1.1.6 Funks Reservoir

The U.S. Bureau of Reclamation (Reclamation) constructed the Funks Reservoir in the mid-1970s with the intent of providing operational flexibility for the TCC. There are check structures on the TCC just upstream and downstream of the reservoir. The TCC is located about 1 mile east of the proposed Sites Reservoir. At the time of construction, the reservoir had a useable capacity of 1,170 acre-feet between operating levels of 199.5 and 205.2 feet elevation, and 1,080 acre-feet of inactive storage below elevation 199.5 feet, for a total capacity of 2,250 acre-feet; however, the addition of sediment from Funks Creek and the TCC have likely reduced the total storage volume. Additionally, a cofferdam will be constructed within Funks Reservoir to facilitate construction of the TRR pipelines. The resulting storage volume reductions will be offset by sediment removal and excavation where storage capacity can be regained. The spillway has a capacity of 2,500 cfs. The project will remove accumulated sediment to recapture the design storage volume.

1.1.7 Funks PGP

This is a pumping and generating plant that will be used to pump water from Funks Reservoir to the Sites Reservoir. This facility will also include hydroelectric turbines to generate electricity when flow is released from Sites Reservoir to Funks Reservoir and, ultimately, the TCC. There will also be an energy-dissipation facility as part of this PGP facility that will allow releases back to Funks Reservoir as backup to the hydroelectric turbine facilities. The pumping plant will have a capacity of 2,100 cfs and the generating plant will have a capacity of 2,000 cfs.

1.1.8 Funks Pipelines

These are 2 parallel, 12-foot-diameter pipelines used to convey water between the Funks PGP and the Sites Reservoir. These pipelines will connect from the piping manifold at Funks PGP to the downstream side of the two proposed 23-foot-diameter tunnels connected to the Site Reservoir inlet/outlet structure. The approximate length of these pipelines is 1 mile each.

1.1.9 Dunnigan Pipeline

The Dunnigan pipeline consists of either a 9- or 10.5-diameter pipeline that will be used to release water from the TCC to the Sacramento River. The concept is to release flow from Sites Reservoir to Funks Reservoir, where the flow will then go south about 40 miles to near the end of the TCC. At this point, flow will be diverted into the Dunnigan pipeline, where flow will head either to the Colusa Basin Drain (CBD), which flows to Sacramento River, or directly to the Sacramento River. If the pipeline discharges directly into the Sacramento River, a portion of the water will also be diverted and discharged in the CBD. Alternative 1 consists of a 9-foot-diameter pipeline that is about 4 miles long and discharges into the CBD. Alternative 2 consists of a 10.5-foot-diameter pipeline that is about 10 miles long and discharges directly into the Sacramento River.

1.1.10 WAPA or PG&E Substation/Switchyard

There are 230 kilovolt (kV) electrical transmission lines running near the proposed project area. Specifically, the WAPA transmission lines run very close to Funks Reservoir in a north-south direction, with a parallel 230 kV line owned by PG&E approximately 1 mile east of the WAPA transmission lines. It is anticipated that one of these transmission lines will be connected to provide power for the project, as well as receive generated electrical power from the hydroelectric turbines. Switchyards and substations will be needed to provide power to both the TRR PGP and Funks PGP sites.

1.1.11 Electrical Transmission Lines

Electrical transmission lines will be required to interconnect to the WAPA or PG&E 230 kV transmission lines and to the TRR PGP and the Funks PGP.

Administration and Operations Building

At this time, staffing requirements for operating and maintaining the Sites facilities have not been defined, but an administration and operations building is anticipated to be needed. This building is anticipated to be located next to the Funks PGP.

1.1.12 Maintenance and Storage Building

A building is also expected to be required to provide maintenance and storage associated with the project. This building is anticipated to be located next to the Funks PGP.

1.1.13 Access Roads

Access to the proposed TRR site would likely be from McDermott Road, which lies adjacent to the proposed reservoir. Access to the Funks complex (PGP and Reservoir) is currently accomplished using the operations and maintenance (O&M) road along the TCC. A new access road will be required that allows larger equipment and year-round access. It is also anticipated that roads will be constructed within the TRR and Funks Pipeline easements, not only to provide access to the pipelines and electrical power transmission lines, but also as a secondary access road to the project facilities.

1.2 Purpose and Scope

The purpose of this task is to describe the inspection and OM&R activities associated with each of the HC project facilities. This task supports the Sites Project Feasibility Report, but is not intended to serve as a detailed inspection and O&M manual that would be used for the constructed facilities. It is also not intended to serve as the document used for replacement costs of the facility, but does provide rough numbers to use to determine long-term costs for replacement of facilities as they become non-operational.

1.3 Limitations

The scope of work for this TM was restricted to the development of the inspection and O&M activities for the Sites Reservoir under the Conveyance (HC) contract. O&M for the Sites Reservoir facilities are separately considered in a companion TM for the HR contract.

This TM is intended for the sole use of the Sites Project Authority. The scope of services performed may not be appropriate to satisfy the needs of other users, and any use or re-use of this document or of the findings, conclusions, or recommendations presented herein is at the sole risk of said user.

2.0 Facility Operation and Maintenance

This section describes typical O&M activities associated with each of the individual facilities.

2.1 TCCA Red Bluff Pumping Plant

The TCCA Red Bluff Pumping Plant is an existing facility that has a detailed O&M plan, which was developed when the facility was constructed. The addition of the two pumps and associated equipment is not anticipated to change the current O&M activities since this project is only replicating existing equipment Although performing the O&M activities for these two additional pumps may take a little more time, the types of activities will remain the same.

2.2 GCID Main Canal Improvements

Improvements to the GCID Main Canal entail replacement of existing structures to provide greater conveyance reliability and additional earthwork along the GCID Main Canal banks to provide freeboard and all-weather access. The GCID Main Canal is owned and operated by GCID, which is responsible for operating and maintaining the canal. O&M activities for these improvements are not anticipated to increase GCID's workload.

2.3 Terminal Regulating Reservoir

For the TRR, regular inspections are included as part of the everyday operations where a worker periodically drives around to visually inspect the facilities for major obvious issues. Special inspection and additional items for TRR East and TRR West Alternates include details in the following subsections.

2.3.1 TRR East Alternate

- Annual dam safety inspection
- Five-year dam safety inspection, using a dam safety inspection team of experienced consultants from various firms appointed by the California Division of Safety of Dams
- Quarterly vegetation/weed abatement (such as, hydrophilic plant control) and rodent control activities along perimeter length of embankment
- Annual preventative leak location survey of the reservoir liner

- Bi-monthly instrumentation monitoring and maintenance
- Annual debris removal at spillway outfall to Funks Creek

2.3.2 TRR West Alternate

- We are assuming that this is a non-California Division of Safety of Dams jurisdictional facility that, therefore, will not require any dam safety inspections
- Quarterly vegetation/weed abatement (such as, hydrophilic plant control) and rodent control activities along perimeter length of inlet/outlet embankment
- Annual preventative leak location survey of the reservoir liner
- Bi-monthly instrumentation monitoring and maintenance

2.4 TRR and Funks PGPs

The TRR and Funks PGPs include several features that require individual attention. These individual facilities include: 1) pumping plant, 2) hydroelectric turbines, 3) energy-dissipating units, and 4) electrical switchgear.

2.4.1 Pumping Plant

Each of the pumping plants consist of 13 large, vertical, turbine pump units that include the motors and pumps. Operation of these units assumes control is dictated by starting up and shutting down pump motors, as well as fluctuating speed by a predisposed program within a programmable logic controller.

Maintenance of pumps requires a variety of activities at specific intervals as follows:

- Annually examine impeller thoroughly for cavitation or other damage. Use a nondestructive test to check for cracks in impeller vanes.
- Annually check condition of interior coating of pump casing and suction inlet.
- Annually check top and bottom wearing ring clearances at four points, 90 degrees apart. Compare to the design clearance and previous readings. If clearance is approaching 200 percent of design clearance, schedule wearing ring replacement.
- Weekly check flow and pressure of packing cooling water. Check for excessive heat and for leakage past the packing. Tighten the packing gland as leakage becomes excessive and grease the packing box when required.
- Weekly check the packing gland for excessive leakage.
- Daily check the bearing temperature and lubricant level.
- Annually take oil sample from all bearings, preferably while unit is running some time before a scheduled outage.
- Annually thoroughly inspect stress-carrying parts of rotor for cracks. Check bolted connections for tightness and any evidence of movement. Check stator frame for loose connections, cracks, or other damage. Check stator air gap at a minimum of four positions, top and bottom.
- Annually clean exterior surfaces of coils and check for leaks.

2.4.2 Hydroelectric Turbines

Each of the PGP’s has two hydroelectric turbines. Operation of these units assumes control is dictated by a predisposed program within a programmable logic controller that helps to control the turbine for a given flowrate.

Maintenance of these generators requires a variety of activities at specific intervals, as follows:

- Annually examine runner thoroughly for cavitation or other damage. Use a nondestructive test to check for cracks in runner buckets.
- Annually check condition of interior coating of spiral case and draft tube.
- Annually check top and bottom wearing ring clearances at four points, 90 degrees apart. Compare to the design clearance and previous readings. If clearance is approaching 200 percent of design clearance, schedule wearing ring replacement.
- Weekly check flow and pressure of packing cooling water. Check for excessive heat and for leakage past the packing. Tighten the packing gland as leakage becomes excessive and grease the packing box when required.
- Annually measure clearance between gates at the top, middle, and bottom with feeler gauges with gates closed and the servomotor pressure released. Check clearance between wicket gates and upper and lower facing plates. Check gates and facing plates for cavitation damage, corrosion, or other damage.
- Annually observe servomotor, shift ring, and wicket gate linkage as it is moved through its full range of motion in both directions.
- Weekly check the packing gland for excessive leakage.
- Daily check the bearing temperature and lubricant level.
- Annually check shaft runout with dial indicator or with proximity probes and a strip chart recorder. At a minimum, check runout at full load, and, if possible, record the runout as the unit is loaded from speed-no-load to full load.
- Annually take oil sample from all bearings, preferably while unit is running some time before a scheduled outage.
- Annually thoroughly inspect stress-carrying parts of rotor for cracks. Check bolted connections for tightness and any evidence of movement. Check stator frame for loose connections, cracks, or other damage. Check stator air gap at a minimum of four positions, top and bottom.
- Annually clean exterior surfaces of coils and check for leaks.
- Monthly check condition of brake airline filters and lubricators. If lubricator is not installed, operate unit jacks to lubricate brake cylinders.
- Annually measure brake shoe thickness and check condition of brake ring.

2.4.3 Energy-dissipating Units

There are two energy-dissipating units at each PGP. The energy-dissipating units are anticipated to be fixed cone valve type. These units require little maintenance due to their simple moving parts, combined with high-strength materials that make them resilient. Maintenance of these valves primarily involves visual inspection and lubrication of bearings as needed.

2.4.4 Electrical Switchgear

Each of the PGP’s has electrical switchgear that require the following tests to be performed annually.

- Visual/mechanical inspections
  - General visual and mechanical inspections
  - Moisture and corona inspections
  - Wiring and bolted connection checks
  - General wiring checks
  - Moving parts and interlocks

  - Insulators and barrier checks

- Electrical tests
  - Bolted connection electrical tests
  - Insulation electrical tests
  - Dielectric withstand tests
  - Control wiring electrical tests
  - Instrument transformers
  - Circuit breakers and switches
  - Control power transfer scheme
  - Metering electrical tests
  - Current injection tests
  - System function test
  - Cubicle heaters
  - Surge arresters
  - Dual-source phasing check

2.5 TRR, Funks, Funks Environmental and Dunnigan Pipelines

The pipelines will require very minimal maintenance, but require the following tasks to provide a longer life:

- Annually check cathodic-protection-test-stations, voltage-drop readings as an indicator of the useful status of the Cathodic Protection system.
- Every 5 years, drain the pipelines and visually inspect the lining of the pipe, making repairs as needed.
- Annually check all valves (including appurtenances) by opening and closing to make sure they are operational.
- Annually check the surge protection system, including the compressors and instrumentation, to confirm the surge system is functioning as intended.

For the energy-dissipating valves on the Funks Environmental and Dunnigan Pipeline at the CBD discharge facility, periodic visual inspection and lubrication of bearings is all that is required.

2.6 TRR and Funks Substations

- Annually perform visual inspection of electrical equipment.
- Annually perform Thermo-scan of electrical equipment.

2.7 Electrical Transmission Lines

- Twice a year, use helicopter or drones to fly over lines and identify hardware, insulators, conductors, and structure issues.
- Twice a year, use infrared inspection to identify hot spots on splices and at conductor attachment hardware.
- Every 5 years, use foot patrol inspection to identify issues not captured by aerial patrols.
- Every 20 years, perform tower inspection/tower footer repair including pole painting for galvanized poles.
- Every 3 years, perform tree trimming and conduct grass mowing as required.

3.0 Facility OM&R Costs

This section provides typical O&M costs associated with each of the individual facilities, as well as replacement costs for facilities based on durations of various components of each facility. For example, mechanical equipment is given a 20-year life before replacement is required, concrete and masonry should last 100 years before replacement is required and electrical equipment is typically about 40 years. Pipelines are expected to last 100 years before replacement is required, but replacement will require the entire cost of a new pipeline.

Table 1 provides a summary of the operations, maintenance, and replacement costs for each major facility including both TRR Alternatives (East and West). The breakdown of costs for each facility and activity are included in Appendix A. It should be noted that tables in Appendix A contain activities at various durations, such as every 6 months or every 20 years. Appendix A also includes the duration of various facility components by discipline (mechanical, structural, electrical, etc.) before replacement costs will be needed. The cost for each has been adjusted to reflect the annual cost in 2021 dollars, on an annual basis.

As shown in Table 1, pumping costs for the associated PGP's and replacement costs are the largest components of the total OM&R costs.

Pumping costs for the two PGPs are based on an average electrical rate of $0.03153/kilowatt-hour and Sites Reservoir at an average water surface elevation of 450 feet. This results in costs of $10/acre-foot for the Funks pumping and $14/acre-foot for pumping from the TRR East Alternative. There is very little energy saved for the TRR West Alternative, so this $14/acre-foot cost can be used for both alternatives. A pumping cost TM is provided in Appendix B.

Table 1 also includes only operational pumping costs for the TCCA pumping station at Red Bluff and the GCID Pumping Station at Hamilton City. Since these pumping stations are used to deliver irrigation water for their respective agencies, it was assumed the maintenance and replacement costs are covered elsewhere. The average annual volume of water pumped by the TCCA pumping station for the Sites Project is 197,000 acre-feet, while the pumping at GCID for the Sites Project is about 61,000 acre-feet. Based on data provided by TCCA and GCID, the amount of energy (kWh) required to pump one acre-foot of water is 19.45 for TCCA and 12.45 for GCID. The energy charge for TCCA is $0.03074/kilowatt-hour while GCID pays about $0.1273 per kWh. Using this data, the annual pumping cost for Sites Project water delivered in the TC Canal is about $117,600 while the water delivered in the GCID Main is about $97,000.

Table 1. Annual Operations, Maintenance, and Replacement Costs.

Summary OM&R Costs				
	Cost			
Facility	Operations	Maintenance	Replacement	Total
Funks PGP	$2,283,200	$46,200	$2,750,000	$5,079,400
TRR PGP	$1,167,200	$46,200	$2,750,000	$3,963,400
TCCA Pumping Station	$117,600	N/A	N/A	$117,600
GCID Main Pumping Station	$96,700	N/A	N/A	$96,700
Funks Reservoir	$0	$0	$0	$0
TRR - East Reservoir	$0	$133,000	$129,500	$262,500
TRR - West Reservoir	$0	$83,000	$129,500	$212,500
All Pipelines including Dunnigan #1	$39,000	$16,000	$4,662,000	$4,717,000
All Pipelines including Dunnigan #2	$39,000	$16,000	$6,309,000	$6,364,000
Substations (two)	$0	$72,000	$4,450,000	$4,522,000

Transmission Lines	0	$25,600	$833,333	$858,933
Total (with TRR-East&Dunn #1)	**$3,703,700**	**$339,000**	**$15,574,833**	**$19,617,533**
Total (with TRR-West&Dunn #1)	**$3,703,700**	**$289,000**	**$15,574,833**	**$19,567,533**
Total (with TRR-East&Dunn #2)	**$3,703,700**	**$339,000**	**$17,221,833**	**$21,264,533**
Total (with TRR-West&Dunn #2)	**$3,703,700**	**$289,000**	**$17,221,833**	**$21,214,533**

Appendix A

Funks PGP							**$5,079,400**
Operations							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
	Entire PGP						
		Daily	Operator (1)	2088	hr	$75	$156,600
			Operator (2)	2088	hr	$75	$156,600
		Pumping	Average annual pumping - some years no pumping and others maximum pumping - take average	197,000	ac-ft	$10.00	$1,970,000
			Subtotal				**$2,283,200**
Maintenance							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
	Pumping Plant						
		Daily					
			Check bearing temperature and lubricant level.	180	hr	$50	$9,000
		Weekly		50	hr	$50	$2,500
			Check packing cooling water.				
			Check the packing gland for excessive leakage.				
		Annually		60	hr	$100	$6,000
			Examine impeller				
			Check condition of interior coating of pump casing and suction inlet				
			Check top and bottom wearing ring clearances				
			Obtain oil sample from all bearings				
			Inspect stress carrying parts of rotor for cracks				
			Check bolted connections for tightness and any evidence of movement.				
			Check stator frame for loose connections, cracks, or other damage.				
			Check stator air gap at a minimum of four positions, top, and bottom.				
			Clean exterior surfaces of coils and check for leaks.				

	Turbines						
		Daily					
			Check bearing temperature and lubricant level.	180	hr	$50	$9,000
		Weekly		50	hr	$50	$2,500
			Check packing cooling water.				
			Check the packing gland for excessive leakage.				
		Monthly		24	hr	$50	$1,200
			Check condition of brake air line filters and lubricators				
		Annually		80	hr	$100	$8,000
			Examine runner				
			Check condition of interior coating of spiral case and draft tube				
			Check top and bottom wearing ring clearances				
			Obtain oil sample from all bearings				
			Inspect stress carrying parts of rotor for cracks				
			Check bolted connections for tightness and any evidence of movement.				
			Check stator frame for loose connections, cracks, or other damage.				
			Check stator air gap at a minimum of four positions, top, and bottom.				
			Clean exterior surfaces of coils and check for leaks.				
			Measure clearance between gates at the top, middle, and bottom with feeler gauges with gates closed and the servomotor pressure released				
			Check clearance between wicket gates and upper and lower facing plates				
			Check gates and facing plates for cavitation damage, corrosion, or other damage				
			Observe servomotor, shift ring, and wicket gate linkage as it is moved through its full range of motion in both directions.				
			Check shaft runout with dial indicator or with proximity probes and a strip chart recorder				

			Measure brake shoe thickness and check condition of brake ring.				
	Switchgear						
		Annually		80	hr	$100	$8,000
			Visual Inspections				
			Tests				
			Subtotal				**$46,200**
Replacement				Cost ($M)			
	Unit		*Frequency (yrs)*	*Capital*	*Annual*		
	PGP	Mechanical	*20*	*35*	*1.75*		
		Structural	100	30	*0.3*		
		Electrical	40	28	*0.7*		
			Subtotal				**$2,750,000**

TRR PGP						**$3,963,400**
Operations						*Annual*
Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
Entire PGP						
	Daily	Operator (1)	2088	hr	$75	$156,600
		Operator (2)	2088	hr	$75	$156,600
	Pumping	Average annual pumping - some years no pumping and others maximum pumping - take average	61,000	ac-ft	$14.00	$854,000
		Subtotal				**$1,167,200**
Maintenance						*Annual*
Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
Pumping Plant						
	Daily					
		Check bearing temperature and lubricant level.	180	hr	$50	$9,000
	Weekly		50	hr	$50	$2,500
		Check packing cooling water.				
		Check the packing gland for excessive leakage.				
	Annually		60	hr	$100	$6,000
		Examine impeller				
		Check condition of interior coating of pump casing and suction inlet				
		Check top and bottom wearing ring clearances				
		Obtain oil sample from all bearings				
		Inspect stress carrying parts of rotor for cracks				
		Check bolted connections for tightness and any evidence of movement.				
		Check stator frame for loose connections, cracks, or other damage.				
		Check stator air gap at a minimum of four positions, top, and bottom.				

			Clean exterior surfaces of coils and check for leaks.				
	Turbines						
		Daily					
			Check bearing temperature and lubricant level.	180	hr	$50	$9,000
		Weekly		50	hr	$50	$2,500
			Check packing cooling water.				
			Check the packing gland for excessive leakage.				
		Monthly		24	hr	$50	$1,200
			Check condition of brake air line filters and lubricators				
		Annually		80	hr	$100	$8,000
			Examine runner				
			Check condition of interior coating of spiral case and draft tube				
			Check top and bottom wearing ring clearances				
			Obtain oil sample from all bearings				
			Inspect stress carrying parts of rotor for cracks				
			Check bolted connections for tightness and any evidence of movement.				
			Check stator frame for loose connections, cracks, or other damage.				
			Check stator air gap at a minimum of four positions, top, and bottom.				
			Clean exterior surfaces of coils and check for leaks.				
			Measure clearance between gates at the top, middle, and bottom with feeler gauges with gates closed and the servomotor pressure released				
			Check clearance between wicket gates and upper and lower facing plates				
			Check gates and facing plates for cavitation damage, corrosion, or other damage				

			Observe servomotor, shift ring, and wicket gate linkage as it is moved through its full range of motion in both directions.				
			Check shaft runout with dial indicator or with proximity probes and a strip chart recorder				
			Measure brake shoe thickness and check condition of brake ring.				
	Switchgear						
		Annually		80	hr	$100	$8,000
			Visual Inspections				
			Tests				
			Subtotal				**$46,200**
Replacement				Cost ($M)			
	Unit		*Frequency (yrs)*	*Capital*	*Annual*		
	PGP	Mechanical	*20*	*35*	*1.75*		
		Structural	100	30	*0.3*		
		Electrical	40	28	*0.7*		
			Subtotal				**$2,750,000**

All Pipelines						***Dunnigan Alt #1***	**$4,717,000**
						Dunnigan Alt #2	**$6,364,000**
Operations							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		Weekly	Operator (drive alignment)	200	hr	$75	$15,000
		5 years	New 4x4 Pickup	2	ea	$60,000	$24,000
			Subtotal				**$39,000**
Maintenance							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		Annually		100	hr	$100	$10,000
			Perform Cathodic Protection system test				
			Check condition of gates, valves, and appurtenances				
			Check surge control system				
			4x4 Pickup (fuel, oil,…)				$2,000
		5 Years		40	hr	$100	$4,000
			Visual Inspections of Inside (200 hours every 5 years)				
			Subtotal				**$16,000**
Replacement				Cost ($M)			
	Unit		*Frequency (yrs)*	*Capital*	*Annual*		
	Funks/TRR	Full	100	$ 369.60	*$3.70*		
	Dunn #1	Full	100	$96.6	*$0.97*		
	Dunn #2	Full	100	$261.3	*$2.61*		
			Subtotal with Dunnigan #1				**$4,662,000**
			Subtotal with Dunnigan #2				**$6,309,000**

TRR-East Reservoir							**$262,500**
Operations							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		None					
Maintenance							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		Daily					
			Regular site inspection (cost covered by PGP Operator)				
		Bi-monthly					
			Instrumentation monitoring and maintenance	6	ea	$10,000	$60,000
		Quarterly					
			Vegetation/weed abatement and rodent control	4	ea	$ 2,000	$8,000
		Annually					
			Annual Dam Safety inspection	1	ea	$15,000	$15,000
			Preventative leak location survey of reservoir liner	1	ea	$15,000	$15,000
			Debris removal at spillway outfall to Funks Creek	1	ea	$15,000	$15,000
		5-years					
			5-Year Dam Safety inspection	0.2	ea	$100,000	$20,000
			Subtotal				**$133,000**
Replacement				Cost ($M)			
	Unit		*Frequency (yrs)*	*Capital*	*Annual*		
	Structures	Mechanical	*20*	*$1.4*	*$0.07*		
		Structural	100	$5.2	*$0.05*		
		Electrical	40	$0.3	*$0.01*		
			Subtotal				**$129,500**

TRR-West Reservoir							**$212,500**
Operations							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		None					
Maintenance							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		Daily					
			Regular site inspection (cost covered by PGP Operator)				
		Bi-monthly					
			Instrumentation monitoring and maintenance	6	ea	$10,000	$ 60,000
		Quarterly					
			Vegetation/weed abatement and rodent control	4	ea	$2,000	$8,000
		Annually					
			Preventative leak location survey of reservoir liner	1	ea	$15,000	$15,000
			Subtotal				**$83,000**
Replacement				Cost ($M)			
	Unit		*Frequency (yrs)*	*Capital*	*Annual*		
	Structures	Mechanical	*20*	*$1.4*	*$0.07*		
		Structural	100	$5.2	*$0.05*		
		Electrical	40	$0.3	*$0.01*		
			Subtotal				**$129,500**

Substations (each)							**$2,286,000**
Operations							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		None					
Maintenance							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		Annually		240	hr	$150	$36,000
			Annually perform visual inspection of electrical equipment				
			Annually perform Thermo-scan of electrical equipment				
			Subtotal				**$36,000**
Replacement				Cost ($M)			
	Unit		*Frequency (yrs)*	*Capital*	*Annual*		
	Full	Electrical	*40*	*90*	*2.25*		
			Subtotal				**$2,250,000**

Transmission Lines							**$858,933**
Operations							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		None					
Maintenance							*Annual*
	Unit	*Frequency*	*Item*	*Quantity*	*Unit*	*Unit Cost*	*Cost*
		Every 6 months	Use helicopter or drones to fly over lines and identify hardware, insulator, conductor, and structure issues	16	hr	$600	$9,600
		Every 6 months	Conduct infrared inspection to identify hot spots on splices and at conductor attachment hardware	100	hr	$100	$10,000
		Every 5 Years	Conduct foot patrol inspection to identify issues not captured by aerial patrols (50 hours total)	20	hr	$150	$3,000
		Every 20 Years	Perform tower inspection/tower footer repair including pole painting for galvanized poles (200 hours total)	20	hr	$150	$3,000
			Subtotal				**$25,600**
Replacement				Cost ($M)			
	Unit		*Frequency (yrs)*	*Capital*	*Annual*		
	Full	Electrical	*60*	*$50*	*$0.83*		
			Subtotal				**$833,333**

Appendix B

Draft Pumping Costs Technical Memorandum

To:	Henry Luu/HDR
CC:	Other recipient(s)
Date:	March 19, 2021
From:	Jeff Smith/Jacobs
Quality Review:	Peter Rude/Jacobs
Authority Agent Review:	Reviewer
Subject:	Pump Costs Calculations

1.0 Purpose

The proposed Site Project consists of two pumping generating plants (PGPs) used to convey water up to the Sites Reservoir and generate electricity through releases from the reservoir. The two PGPs consist of Funks, located on the Tehama Colusa Canal, and the Terminal Regulating Reservoir (TRR), located on the Glenn-Colusa Irrigation District Main Canal. The purpose of this technical memorandum is to determine the estimated cost to pump water from each of these two PGPs to the Sites Reservoir.

2.0 Assumptions and Calculations

To perform the calculations requested, assumptions and calculations were made, as described in the following sections.

2.1 Assumptions

- Months for pumping are November through May.
- Pumping costs vary by month as follows:

Month	Cost ($/kilowatt-hour)
November	0.03833
December	0.03982
January	0.03805
February	0.03795
March	0.03605
April	0.03646
May	0.03708
Average	**0.03768**

- Average pumping flows are 2,100 cubic feet per second (cfs) for Funks and 1,000 cfs for TRR. These flows are used to determine pipe friction losses

- Sites reservoir elevation levels:
  - Full = 498 feet
  - Low = 340 feet

2.2 Calculation

The cost of pumping water is determined using following formula:

$/acre-foot = 1.0241 * $/KWh * Head / efficiency

where

$/KWh = $0.03768

Head (feet) = static lift + friction loss

Static lift (range 135-298) + 14 = range 149 - 312 [Funks PGP]

Static lift (range 216-379) + 37 = range 253 – 416 [TRR PGP]

Efficiency = 0.84 [based on manufacturer pump curves for selected pump]

3.0 Results

The purpose of this technical memorandum is to share the cost of pumping water from both PGPs; but the cost will vary depending on the Sites reservoir level. Other variable head losses for the PGPs include: 1) fluctuating Funks and TRR reservoir levels; and 2) variable friction losses resulting from changing flow rates. Although these two variables change the potential pumping head and resulting pumping costs, the variables are very small in comparison to the static lift required; therefore, these small fluctuations are not included in the estimate.

Table 1 shows the costs of pumping an acre-foot for the minimum and maximum Sites Reservoir levels provided in Section 2.1.

Table 1. Minimum and Maximum Reservoir Level Pumping Costs

	Cost ($/acre-foot)	
PGP	Min. Reservoir Elevation = 340 feet	Max. Reservoir Elevation = 498 feet
Funks	$6.84	$14.33
TRR	$11.62	$19.11

When the reservoir level is between the minimum and maximum amounts, the cost to pump water is a linear interpolation between the values shown in table 1. For example, if the reservoir level is at 400 feet, interpolation of the values in Table 1 show a cost of $9.60 per acre-foot for Funks PGP and $14.38 per acre-foot for TRR. Table 2 contains the costs for both PGPs at various incremental reservoir levels.

Table 2. Reservoir Level Pumping Costs

Reservoir Level (feet)	340 (min.)	360	380	400	420	440	460	480	498 (max.)
Funks	$6.84	$7.76	$8.68	$9.60	$10.52	$11.44	$12.36	$13.28	$14.33
TRR	$11.62	$12.54	$13.46	$14.38	$15.30	$16.22	$17.13	$18.05	$19.11