Coastal Treatment Plant
Export Sludge Force Main Pre-Design Report

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1 INTRODUCTION

The South Orange County Wastewater Authority (SOCWA) treats approximately 26 million gallons of wastewater each day at four treatment facilities. The Coastal Treatment Plant (CTP), located within the County of Orange Aliso and Wood Canyon Wilderness Park, has a capacity of 6.7 million gallons per day (MGD). Primary and thickened waste activated sludge (TWAS) are combined in the Export Sludge wet well and pumped to the Regional Treatment Plant (RTP) for digestion and dewatering. Sludge conveyance is accomplished via progressing cavity pumps and a dual force main system. Export Sludge is pumped through one of two parallel 4-inch ductile iron force mains approximately 4.5 miles along the eastern side of Aliso Creek to Alicia Parkway, continuing through Laguna Niguel Regional Park to the RTP, located along La Paz Road west of King Road.

The Export Sludge force mains, constructed in approximately 1980, are becoming prone to failure as a result of their age and pipe condition, including but not limited to corrosion impacts. The pipelines' proximity to Aliso Creek has the potential to result in discharge of sludge to areas that may be tributary to the Creek in the event of pipeline failure. Two recent failures of the Export Sludge force mains occurred in December 2010 and January 2011, during which discharge to the Creek was avoided.

Ten Export Sludge force main replacement alternatives were identified during development of an Environmental Impact Report (EIR) for the Export Sludge System Replacement Project. This Pre-Design Report (PDR), developed as a supporting document to the EIR, focuses on three alternatives that are believed to provide the most rapid implementation schedule for replacement of the Export Sludge System. These three alternatives include two options for the replacement of the dual 4-inch Export Sludge force mains with a new 6-inch force main (Alternatives FM-1 and FM-2) and an option for hauling of export sludge from the CTP to the RTP (Alternative TR-1).

2 PURPOSE AND SCOPE

This PDR, while defining the three alternatives for replacement of the dual 4-inch Export Sludge force mains, also confirms other critical design parameters including, but not limited to, pipe size, pipe material, hydraulics of sludge pumping, maintenance and cleaning, budgetary cost of alternatives, life-cycle analysis of various on-site thickening alternatives, and various operational procedures. An important objective of the PDR is to support preparation of the EIR, as well as refine the preliminary design based on environmental documentation comments.

Three project alternatives are evaluated within the PDR, including:

- Alternative FM-1: New 6-inch force main alignment located east of Aliso Creek, generally following the existing Effluent Transmission Main (ETM) easement.
- Alternative FM-2: New 6-inch force main alignment located west of Aliso Creek within the existing paved area of Aliso Water Management Agency (AWMA) Road.
- Alternative TR-1: Truck hauling of sludge between the two treatment plants along existing streets, assuming alternative thickening concepts at the CTP to minimize truck trips.

It is noted that each of the defined alternatives will require incorporation of Export Sludge storage at the CTP. The sludge storage is needed for Alternatives FM-1 and FM-2 to provide the ability to maintain the single 6-inch pipeline, and required for Alternative TR-1 to eliminate the need for night and weekend truck trips. These concepts are further explored later in the PDR.

3 PROJECT BACKGROUND

Placed into operation in the early 1980s, the Export Sludge force main system experiences operational and maintenance challenges related to high pressure, solids deposition, and corrosion (both interior and exterior). Replacement has been planned since the early 1990s. The South Coast Water District, the operating agency for the Export Sludge system at that time, planned a three phase project to construct a new 6-inch Export Sludge force main. The Phase I project, completed in 1999, installed a new force main within the limits of the County of Orange Laguna Niguel Regional Park, including a crossing beneath Alicia Parkway. The Phase II portion of the project was completed in early 2000, consisting of a new 6-inch pipeline beneath Aliso Viejo Community Association (AVCA) Road.

Neither the Phase I nor Phase II pipelines were placed into service at that time. Construction of the final and longest segment of the force main system (Phase III) was terminated with the proposed construction of the Aliso Creek Emergency Sewer by the Moulton Niguel Water District. There are also two short sections of pipeline that had not been installed at the time of the project stoppage:

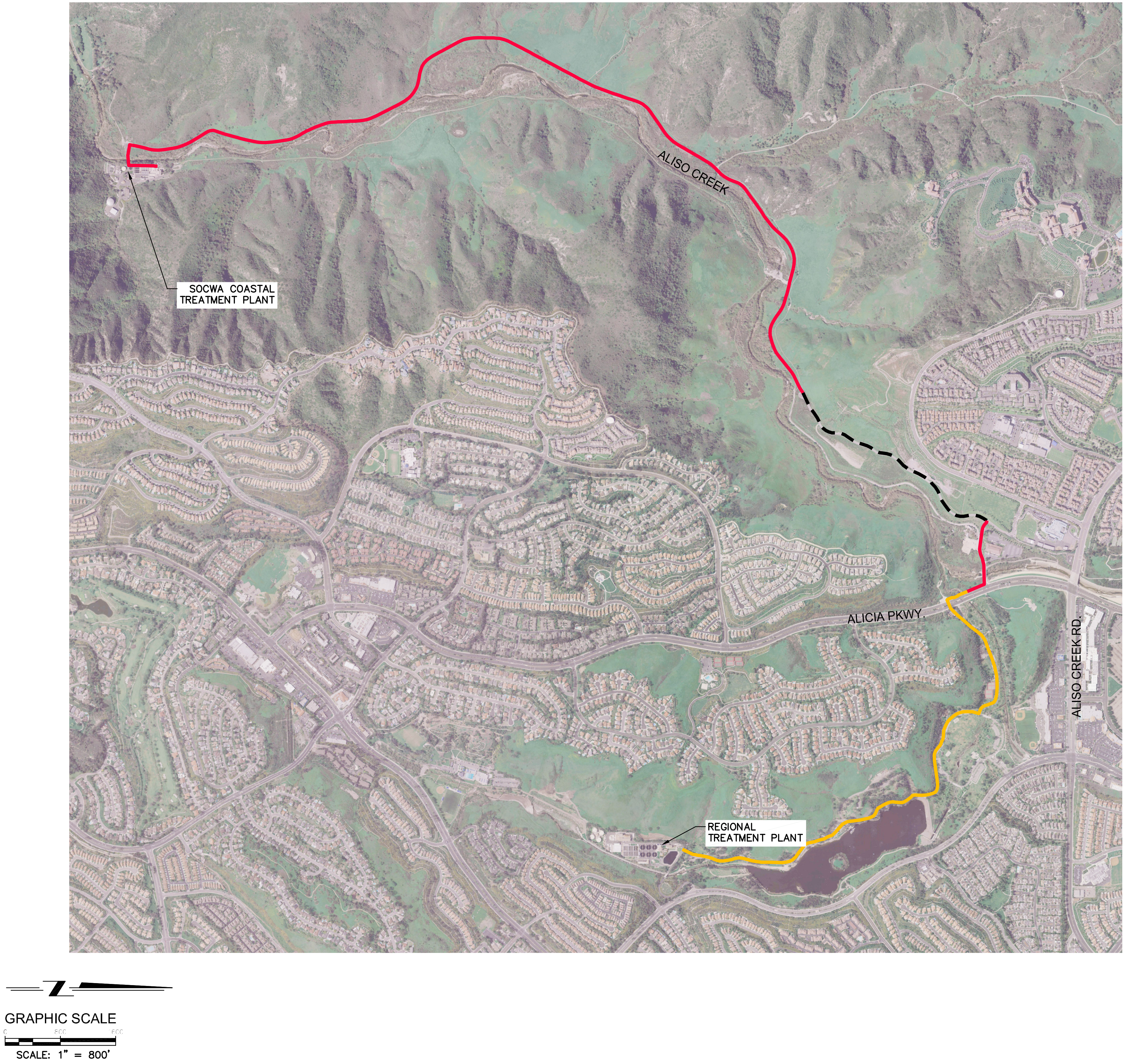
- Connection of the 6-inch pipeline in the Laguna Niguel Regional Park with the existing infrastructure inside the RTP.
- Connection of the 6-inch pipeline from Alicia Parkway to the new pipeline beneath the AVCA Road; this portion entailed a creek crossing to be supported from the AWMA Road access bridge.

Figure 3-1 provides an illustration of the approximate location of the Phase I, II and III Export Sludge facilities.

3.1 Existing Sludge Export Facilities

3.1.1 Existing CTP Export Pump Station

The existing CTP Export Sludge Pump Station consists of a sludge wet well and two positive displacement sludge pumps. Only one pump is needed for current sludge volumes, with the second pump acting as a redundant emergency unit. The pumps are progressing cavity, positive displacement pumps equipped with variable frequency drives. The pump speed varies with wet well level and discharge pressure. Discharge pressure is limited at 240 pounds per square inch (psi). The Export Sludge pumps are automatically shut down when that pressure is exceeded. Additional information is provided in Section 4 of this report.



LEGEND

— PHASE III
- - - PHASE II EXISTING 6" SLUDGE LINE
— PHASE I EXISTING 6" SLUDGE LINE

FIGURE 3–1
Export Sludge Force Main Replacement Project
As Envisioned in 1999

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3.1.2 Dual 4-Inch Force Mains

The Export Sludge force mains were placed into service approximately 30 years ago. The pipelines are approximately 23,000 linear feet in length (4.36 miles). Force main length, variability in sludge concentration, pumping pressure, alignment through two County of Orange parks, intermittent operational scenarios, concern over interior and exterior corrosion, and cleaning and flushing of the force mains are challenges that must be overcome in replacing the existing force mains and to provide long-term reliability for SOCWA sludge handling operations.

The Export Sludge system experiences operational challenges consistent with pumped sludge pipelines of extended lengths. Pumping rates are balanced with force main pressure, based on variability in sludge concentration, composition and environmental conditions. Low pumping rates minimize pressure and energy consumption, but encourage solids deposition and scaling. Sludge pumping at the CTP is also not a 24-hour operation, resulting in maximum pressures when reinitiating the sludge pumping cycle. Stagnant sludge, grease and scale can build-up on pipeline walls, increasing cleaning frequency, energy consumption, and overall cost.

3.2 Previous Studies of the Export Sludge Force Main System

In 2001, Dudek was retained by SOCWA, in conjunction with the Moulton Niguel Water District (MNWD), to conduct vegetation mapping, wetlands delineation, and sensitive plant and wildlife surveys for an approximately 19,270-foot alignment along the west side of Aliso Creek. The anticipated project (Aliso Creek Emergency Sewer or ACES) consisted of a sewer pipeline for MNWD and the new 6-inch Export Sludge force main for SOCWA. Dudek prepared a Biological Resources Technical Report, and SOCWA staff prepared a Mitigated Negative Declaration in accordance with the California Environmental Quality Act (CEQA). Following adoption of the CEQA document, Dudek prepared and processed wetlands permit applications pursuant to Sections 401 and 404 of the Federal Clean Water Act and Section 1601 of the California Fish and Game Code. Final permits were obtained from the U.S. Army Corps of Engineers (ACOE), California Department of Fish and Game (CDFG), and the Regional Water Quality Control Board (RWQCB) in 2002. After reviewing the projected costs for the sewer construction, MNWD elected to cancel the ACES project.

In 2006, Dudek completed the SOCWA Coastal Treatment Plant Export Sludge Force Main Replacement Study which identified five alternative alignments, including two eastern alternatives, two western alternatives and one combination alternative crossing Aliso Creek from west to east. Plans for replacement of the Export Sludge System were postponed again in 2006, with proposed projects for the stabilization of the lower reach of Aliso Creek by the County of Orange and the United States Army Corp of Engineers (USACOE). The rational involved combining the two projects to minimize disruption to Aliso and Wood Canyons Wilderness Park. SOCWA staff was informed in 2010 that, as a result of a combination of institutional and financial concerns, construction of the stabilization project would be delayed a minimum of five years. At that point, SOCWA elected to move forward with develop of an EIR and PDR for Export Sludge System replacement.

4 EXPORT SLUDGE FORCE MAIN REPLACEMENT ALTERNATIVES

4.1 Sludge Force Main Alternative Descriptions

Based on the results of previous reports and ongoing evaluation of available options, SOCWA narrowed the pipeline replacement options to two preferred alignments. The two pipeline alignments, designated FM-1 and FM-2, incorporate component reaches of one or more of the previously studied alignments in 2006. Figure 4-1 provides a key map of the preliminary FM-1 and FM-2 alignments presented in Appendix A and B, respectively. Figures 4-2 and 4-3 illustrate the connection points of each pipeline alternative at the CTP and the Phase I Export Sludge pipeline. Appendices A and B provide preliminary plan and profile drawings for FM-1 and FM-2, respectively. Figures 4-4 and 4-5 provide illustrations of typical cross-sections for the FM-1 and FM-2 alignments, respectively, regarding horizontal alignment of the new Export Sludge force main. Horizontal alignment will vary depending on actual construction conditions, as well as to minimize impact to environmentally and/or archeologically sensitive areas.

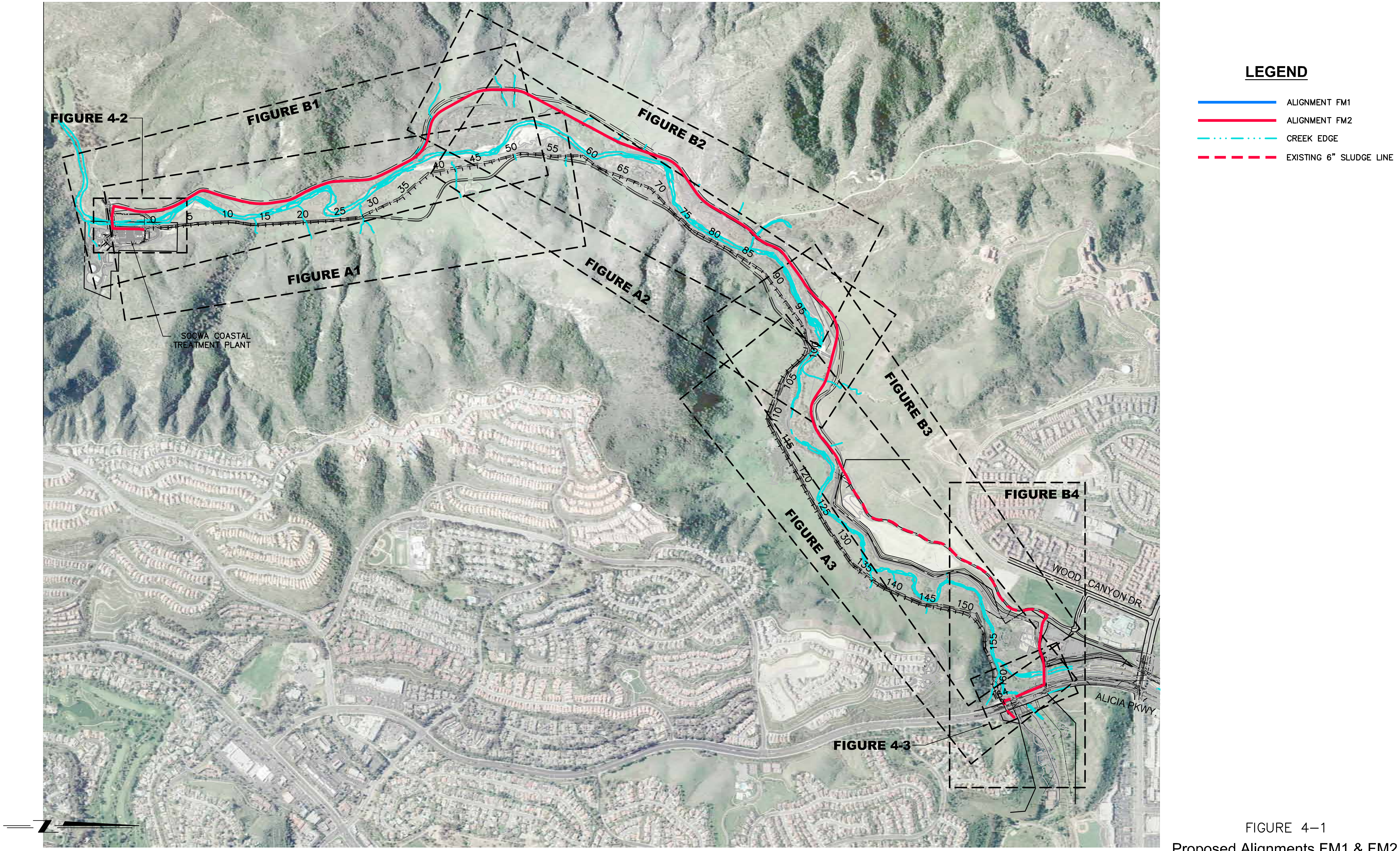
The two alternative alignments are defined as follows:

- Alternative FM-1: Alignment East of Aliso Creek. Referring to the plan and profile drawings in Appendix A, the FM-1 alignment follows the eastern side of Aliso Creek, generally along the alignment of the existing ETM easement. The proposed alignment also parallels the existing dirt roadway and existing 18-inch MNWD sewer pipeline easement along portions of the proposed alignment.

  The existing Export Sludge system is comprised of two parallel 4-inch ductile iron force mains. The force mains are aligned within the existing 60-foot ETM easement, east of the creek. The 36-inch ETM is constructed at a variety of depths between 5 and 15 feet, approximately 10 feet inside the eastern easement boundary. The existing Export Sludge force mains are constructed approximately four feet west of the ETM, at a depth of approximately five to nine feet. Construction conditions along the alignment result in minor variations in the relative location of the ETM and Export Sludge force main alignments.

  In addition to the ETM and Export Sludge force mains, MNWD constructed an 18-inch vitrified clay sewer within an easement that parallels the ETM easement. This sewer alignment varies considerably in relation to the ETM alignment, from approximately five feet inside the western ETM easement boundary to over 30 feet outside the western ETM easement boundary. The sewer is constructed at a depth of approximately 10 feet.

  The ETM and Export Sludge force mains are located further away from Aliso Creek compared to the existing MNWD pipeline. An existing dirt road is located over or in the vicinity of the MNWD sewer and ETM alignments. SOCWA staff uses the dirt access road to observe aboveground conditions relative to the Export Sludge alignment and to service the air-vacuum release valves for the ETM. The profile of the existing dual 4-inch force mains is on a consistently rising grade, thereby avoiding the need for combination sewage air-vacuum valves at high points or blow-offs at low points.



GRAPHIC SCALE

SCALE: 1" = 600'

KEYMAP

SCALE: 1"=600'

FIGURE 4–1

Proposed Alignments FM1 & FM2
Drawing Keymap

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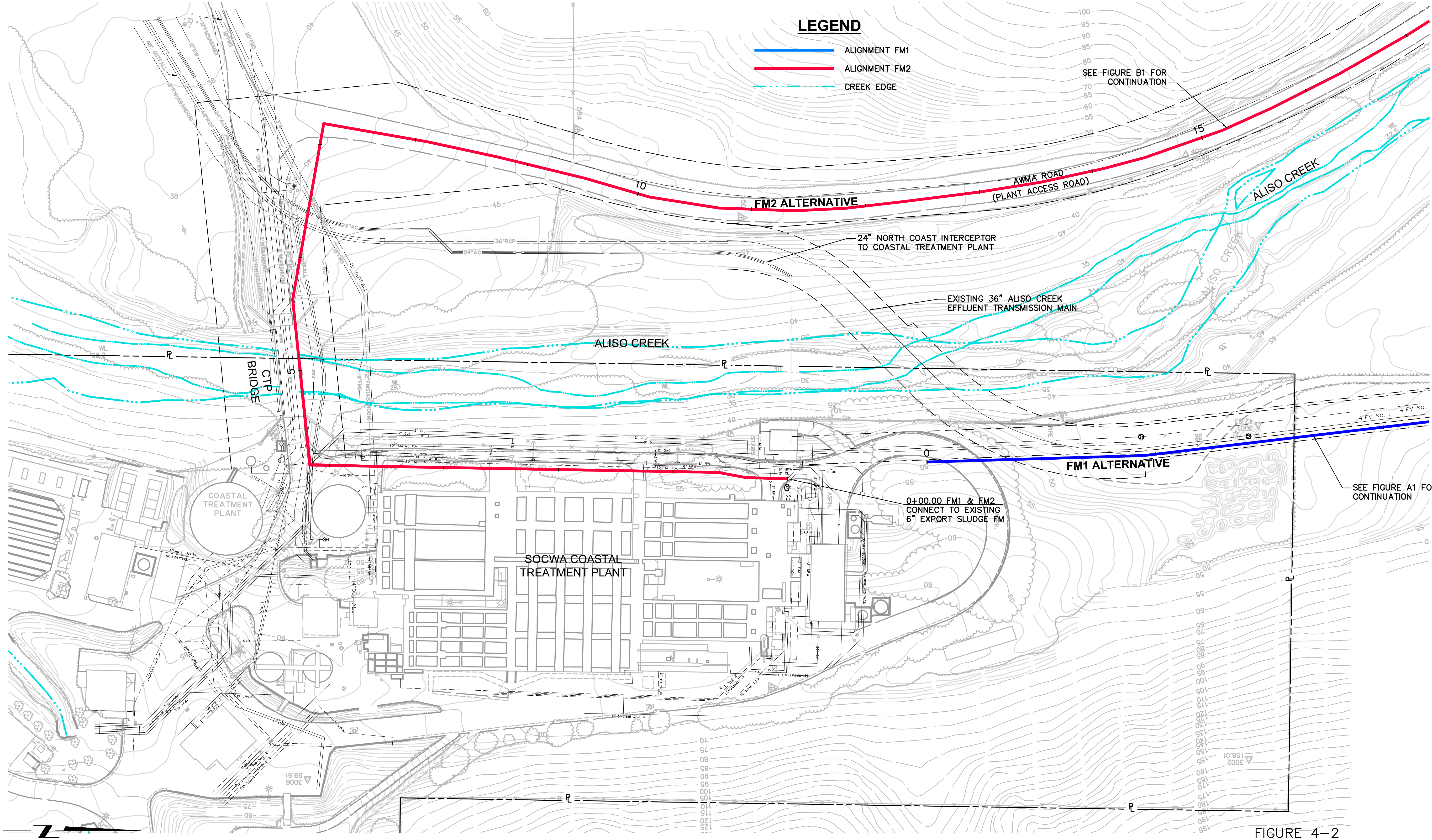

PLAN
SCALE: 1"=40'

GRAPHIC SCALE
0 40' 80'
SCALE: 1" = 40'

FIGURE 4–2
Proposed Alignments FM1 & FM2
Enlarged Plan

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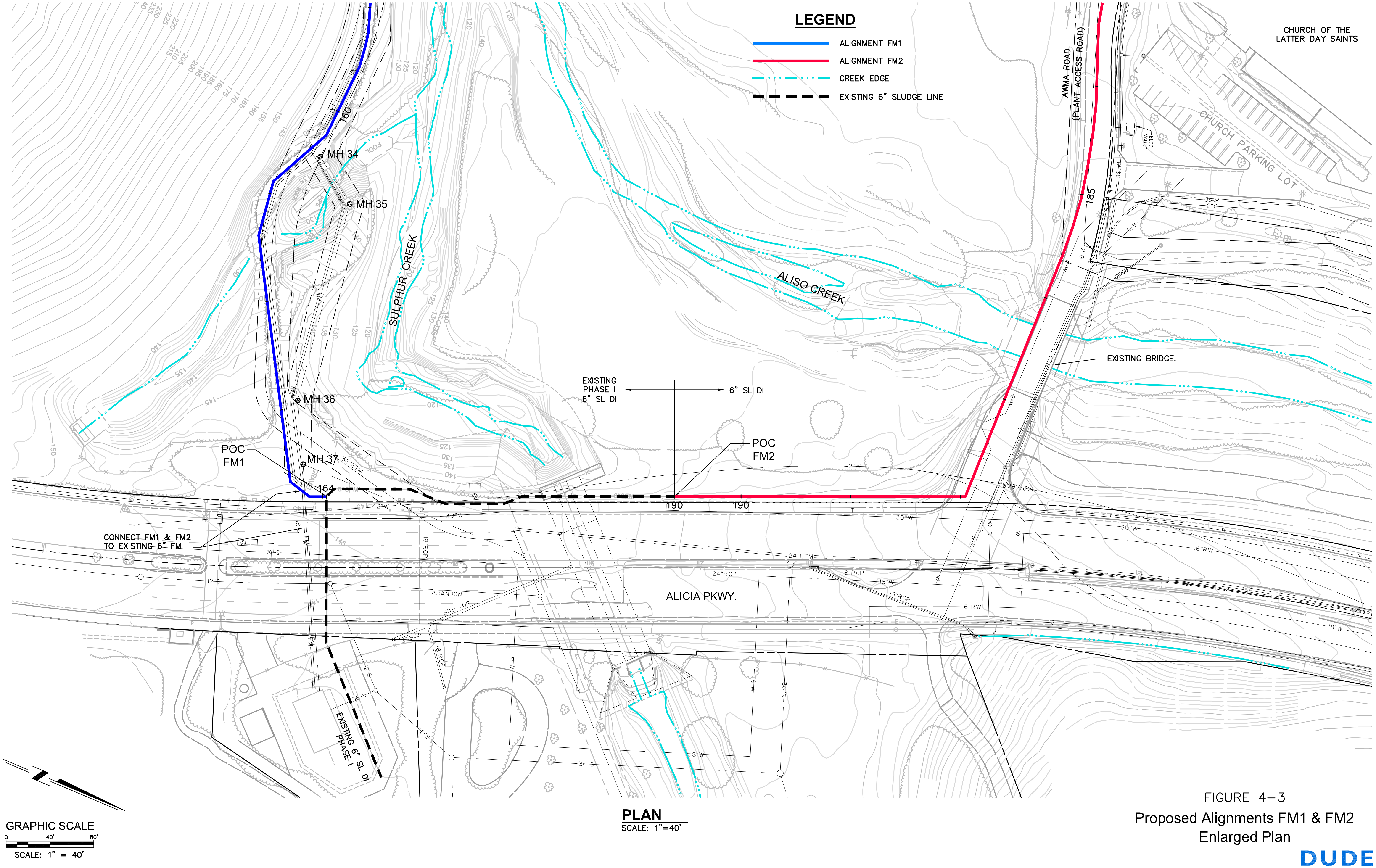

PLAN

SCALE: 1"=40'

FIGURE 4-3

Proposed Alignments FM1 & FM2
Enlarged Plan

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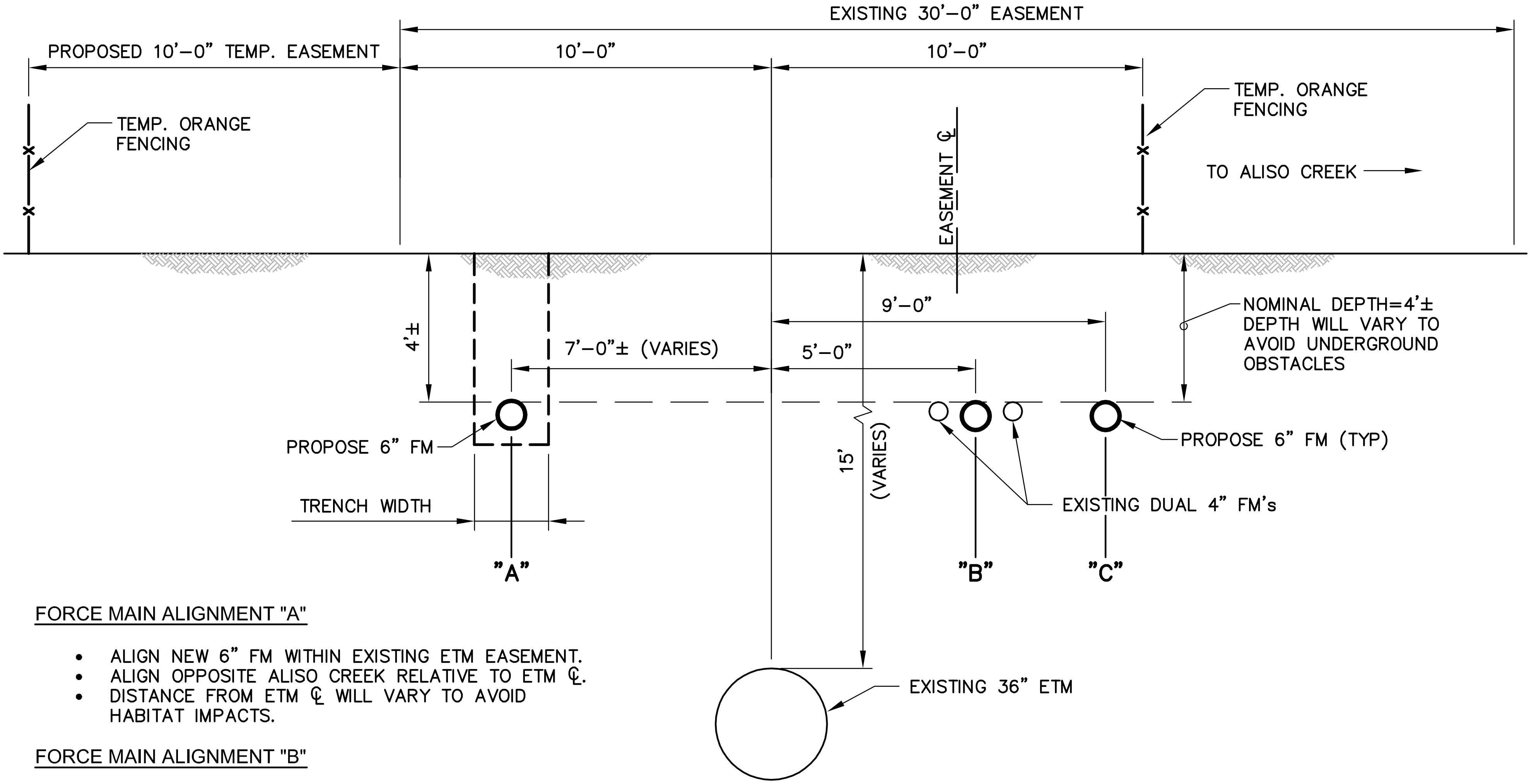
P:\101.Engineering\SOCWA\6731 Export Sludge Forcemain PreDesign\6-Design Data\CAD 6731\dwg\6731 Figure 4-4 X-Sections 9/13/2012 3:22 PM



FORCE MAIN ALIGNMENT "A"

- ALIGN NEW 6" FM WITHIN EXISTING ETM EASEMENT.
- ALIGN OPPOSITE ALISO CREEK RELATIVE TO ETM ℄.
- DISTANCE FROM ETM ℄ WILL VARY TO AVOID HABITAT IMPACTS.

FORCE MAIN ALIGNMENT "B"

- ALIGN NEW 6" FM WITHIN EXISTING ETM EASEMENT.
- ALIGN TO REPLACE EXISTING 4" FM's IN PLACE.

FORCE MAIN ALIGNMENT "C"

- ALIGN NEW 6" FM WITHIN EXISTING ETM OR 18" SEWER EASEMENT.
- ALIGN ON CREEK SIDE OF ETM ℄.
- DISTANCE FROM ETM ℄ WILL VARY TO AVOID HABITAT IMPACTS.
- WHEN IN SEWER EASEMENT, ALIGN 5' OF EASTERN RIGHT-OF-WAY LIMITS.

FM-1 CROSS SECTION
SCALE: 1"=4'

FIGURE 4–4

FM-1 CROSS SECTION

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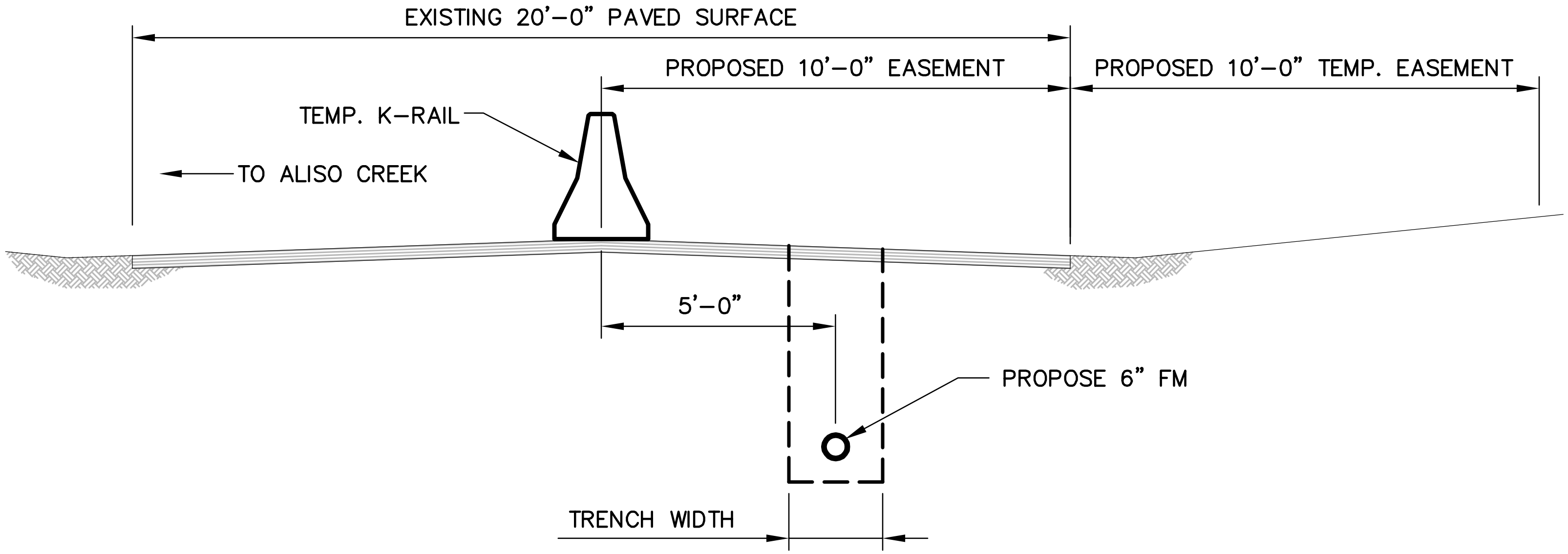

FM-2 CROSS SECTION

SCALE: 1"=4'

FIGURE 4-5

FM-2 CROSS SECTION

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The replacement pipeline is projected to parallel the existing ETM and MNWD sewer alignments, typically being constructed within the previously disturbed areas of the original ETM and/or sewer construction. The new 6-inch Export Sludge Force Main is generally planned to be constructed approximately seven feet to the east of the ETM alignment, at a depth of approximately four feet. Figure 4-4 identifies a series of horizontal alignments associated with the new force main construction. These alignments are required to minimize environmental impact and enhance project constructability. The new Export Sludge force main is planned to be constructed of high density polyethylene (HDPE) materials, thereby minimizing anticipated corrosion challenges.

Construction conditions located at approximately Station 80+00 of the new Export Sludge force main alignment result in the need for special construction. Topographic conditions result in a large rock outcropping on the east side of the pipeline alignment, while the meandering alignment of Aliso Creek encroaches from the west. The site conditions necessitate future bank stabilization to prevent impact to the various pipeline facilities in this area. Several construction options have been identified for this limited area prior to the future bank stabilization efforts, including aboveground construction over an approximate 200-foot length of the force main alignment, shallow trenching with concrete encasement over the same 200-foot length, or construction of the 6-inch force main within the existing 18-inch sewer within the area. The new Export Sludge force main would then be reconstructed to bypass the area as part of subsequent bank stabilization efforts at a later date. The exact construction techniques will be determined during final design to facilitate construction without significant disturbance of the existing terrain.

The FM-1 alignment offers the advantage of confining buried utilities to previously disturbed land areas. This alignment may lead to a future agreement with OC Parks to relocate the existing access road to the east side of Aliso Creek, centralizing SOCWA facilities on the eastern side of the Creek. This alignment may also allow SOCWA to cede the existing paved roadway to OC Parks as part of a future 'ocean-to-mountains bikeway.' The FM-1 alternative would also avoid two crossings of Aliso Creek utilizing existing bridges.

- <u>Alternative FM-2: Alignment West of Aliso Creek within AWMA Road.</u> Referring to the plan and profile drawings in Appendix B, this alignment follows the existing CTP access road (AWMA Road).

  AWMA Road is the primary access to the CTP for SOCWA staff. The roadway is also regularly used by park patrons as a walking and riding trail. The roadway extends from Alicia Parkway, across Aliso Creek by bridge, past the existing ranger station, and along the western side of Aliso Creek. SOCWA maintains a CTP access gate approximately one mile from Alicia Parkway along the road alignment.

  The new 6-inch Export Sludge force main would connect to the existing 6-inch ductile iron force main (approx. 3,460 lineal feet in length) installed during Phase II of the Export Sludge Force Main project. This connection is located within the existing cul-de-sac, adjacent to the SOCWA gate. A final segment of the force main is also required to connect the northern end of the existing 6-inch force main in AVCA Road to the southern extent of the Phase I force main in Alicia Parkway.

The AWMA Road profile presents construction challenges resulting from vertical rise and fall of the roadway. Following the road profile with the force main alignment requires the installation of at least two air-vacuum valves (ARV's). SOCWA staff has indicated that ARV's present maintenance and potential adverse environmental issues. As such, SOCWA prefers to avoid these facilities, if possible. Therefore, the PDR identifies use of trenchless construction methods, specifically horizontal directional drilling (HDD), to avoid deep trenching and installation of ARV's. HDD would also provide the ability to avoid the many cultural sites located along the western side of Aliso Creek.

SOCWA currently holds an easement for the existing roadway. However, there is no easement for underground utilities on the west side of Aliso Creek within Aliso and Wood Canyons Wilderness Park. An agreement would need to be negotiated with the County of Orange for such a utility easement.

The new Export Sludge force main for Alternative FM-2 would be required to cross Aliso Creek at two locations. The pipeline would be suspended from the AWMA Road Access Bridge, near Alicia Parkway, and from the CTP Access Bridge, adjacent to the treatment facility. The long-term viability of the AWMA Road Access Bridge needs to be determined as part of this alternative approach.

The 2006 Dudek report proposed a hybrid alternative using the existing 6-inch pipeline within AVCA Road. The alignment required a new pipe bridge across Aliso Creek, with the majority of the new Export Sludge force main following the existing easement (similar to Alternative FM-1). This alternative was initially considered as part of the EIR process (Alternative FM-3). However, the impacts of construction a new structure within Aliso Creek were considered to be too intrusive. This alternative was eliminated from further consideration.

4.1.1 Sludge Force Main Alternative Advantages/Disadvantages

Table 4-1 presents a qualitative and quantitative comparison of the two proposed Export Sludge force main alternative alignments (FM-1 and FM-2).

4.1.2 Aliso Creek Stabilization

SOCWA facilities along Aliso Creek from Alicia Parkway to the CTP are threatened by storm events within the watershed. The most recent threat occurred between December 2004 and through February 2005, when portions of the CTP access road, just south of the Aliso Creek Wildlife and Habitat Enhancement Project (ACWHEP) structure, were eroded by the creek. Portions of the MNWD sewer, located along the eastern side of Aliso Creek, were also impacted. The impacted section of the road was bypassed with a new road in June 2005, through an emergency relocation project.

The impacts of creek erosion were not originally intended to be included in the EIR process. At the inception of the EIR process, it was believed that the creek would be stabilized within the next five to ten years through a project developed by the County of Orange and USACOE. However, in mid-2011, the County of Orange informed SOCWA that the stabilization project had been indefinitely postponed. As a result, impacts of future Aliso Creek erosion need to be addressed relative to comparison of alternatives for replacement of the Export Sludge system.

SOCWA retained TetraTech in December 2010 to evaluate potential impacts of creek erosion on Alternatives FM-1, FM-2 and TR-1. The resulting report entitled ‘Lower Aliso Creek Erosion Assessment’ rated the vulnerability of each alternative along Aliso Creek to bank erosion considering the following: 1) fluvial erosion potential, 2) geotechnical erosion risk, and 3) erosion risk associated with bend migration. Risks were categorized as High, Moderate or Low. High-rated erosion risk indicates that the proposed alternative will likely be impacted by bank erosion over the 50-year planning period. Therefore, bank protection measures are recommended within the next ten years. The proposed FM-1 alignment along the east bank of the Creek is potentially subject to approximately 3,300 feet of high-rated erosion risk. The proposed FM-2 alignment along the west bank is potentially subject to approximately 1,200 feet of high-rated erosion risk.

Table 4-1 Alignment Comparison/Advantages & Disadvantages

Advantages/Disadvantages	FM-1	FM-2
Maintenance Access	Alignment deviates at times from existing dirt access road/maintenance access	Alignment follows paved roads throughout
Bank Stabilization	Bank Stabilization required at “pinch” points between creek and alignment, existing topography is challenging	Bank Stabilization still required but less intrusive than eastern alignment
Environmental Mitigation	Mitigation required as a result of potential impacts to sensitive habitats and species	Less mitigation required due to the alignment’s location mostly within existing paved roadway
Creek Crossings	No major creek crossings	Force main crosses Aliso Creek at CTP Bridge and Park Access Bridge off Aliso Parkway
Length of New installed Pipeline	Total installed length approximately 16,600 linear feet	Pipeline connects to existing 3,460 lineal feet at Phase II, total installed length approximately 15,800 linear feet
Construction Method	Traditional open cut excavation	Profile of both AWMA and AVCA roads are not advantageous, deep cuts, or alternate trenchless construction methods are required
Easement Acquisition	Minimal new easements required	New easements for below grade utilities potentially required
Pipeline Material	Force main can use a single pipe material, preferred material is high density polyethylene (HDPE)	Pipeline will require HDPE in trenchless areas, change in material to connect to existing pipelines
Profile Topography	Uses grade advantageously, constantly rising without deep excavation	Profile of AWMA and AVCA roads are not advantageous, variable grade and profile
Historical Artifacts	Seven archaeological sites are recorded within 250 feet of the existing dirt road, thus there is a high potential for impacts to archaeological resources. Aligned to minimize impacts	Greater number of potentially significant archaeological sites when compared to FM-1; higher potential for impacts to archaeological resources
Air-Vacuum Release Valves	Not needed	Needed at existing AVCA Road high point
Traffic/Community Impacts	Impacts during construction to hikers	Impacts during construction to hikers, treatment plant deliveries, vehicle traffic and bicyclists

Erosion assessment was undertaken to evaluate impacts of potential channel erosion on proposed alternatives for the replacement of the Export Sludge system. However, this assessment also has implications for existing SOCWA infrastructure. The proposed alignment of the FM-1 pipeline is roughly the same alignment as the existing Export Sludge force mains and ETM. The ETM is constructed below the existing force mains, and the proposed FM-1 pipeline, making it less vulnerable to channel erosion. However, the erosion risk to the ETM is comparative to the erosion risk posed to the proposed FM-1 pipeline. AWMA Road (upon which the TR-1 alternative is dependent) is roughly the same alignment as the proposed FM-2 pipeline, but the road is at greater elevation than the proposed pipeline. Therefore, the erosion risk to AWMA Road is likely greater than that of the proposed FM-2 pipeline.

4.2 Sludge Trucking Alternative Description

Trucking of Export Sludge involves loading of sludge trucks at the CTP, transport along existing surface streets, and unloading of sludge at the RTP. Section 5 of this PDR provides a detailed discussion of the anticipated sludge volumes and associated trucking parameters necessary for proper sludge handling. Of particular concern is the interaction between park patrons and sludge transport vehicles on AWMA Road, within the limits of the Park.

Figure 4-6 provides an illustration of the required trucking route for transport of Export Sludge from the CTP to the RTP. The sludge trucking alignment is projected to normally travel a route from the CTP following the AWMA Road north through the Wilderness Park until the road exits the Park, becoming AVCA Road. Trucks continue east onto the original AWMA Road, passing the Park ranger station and parking lot. Trucks would be required to continue across the AWMA Road Access Bridge, prior to reaching Alicia Parkway, then travel on public streets to the RTP site.

Structural analysis of the AWMA Road Bridge, completed in November 2012, found that the bridge does not meet current structural standards. That analysis recommended posting a gross vehicle weight limit restriction of 16,000 pounds on the bridge. The anticipated weight of a fully loaded truck would approach 80,000 pounds. As a result, SOCWA would be required to route truck traffic, as shown on Figure 4-6, or rebuild the bridge. The alternate route passes by Wood Canyon Elementary School. SOCWA currently restricts truck traffic along this alignment to non-school hours. SOCWA staff has indicated that using this route for sludge hauling during school hours is not acceptable.

4.3 Biological & Cultural Considerations

The project alternatives (Alternatives FM-1, FM-2 and TR-1) each result in varying impact to Park biological and cultural resources. The EIR developed for this project fully identifies, discusses and vets these impacts. However, such impacts are also significant with regard to evaluation of the various alternatives within this PDR.

4.3.1 FM-1 Alternative

Construction of the FM-1 alternative parallels the alignment of the previously constructed ETM, MNWD sewer, and existing Export Sludge force mains. Review of the ETM construction drawings identifies a previous construction corridor of approximately 110 feet, centered on the ETM alignment. As such, both biological and cultural resources along this alignment would have encountered significant previous disturbance. Figure 4-7 illustrates how construction of the new6-inch Export Sludge force main will be generally confined to previously disturbed construction areas.

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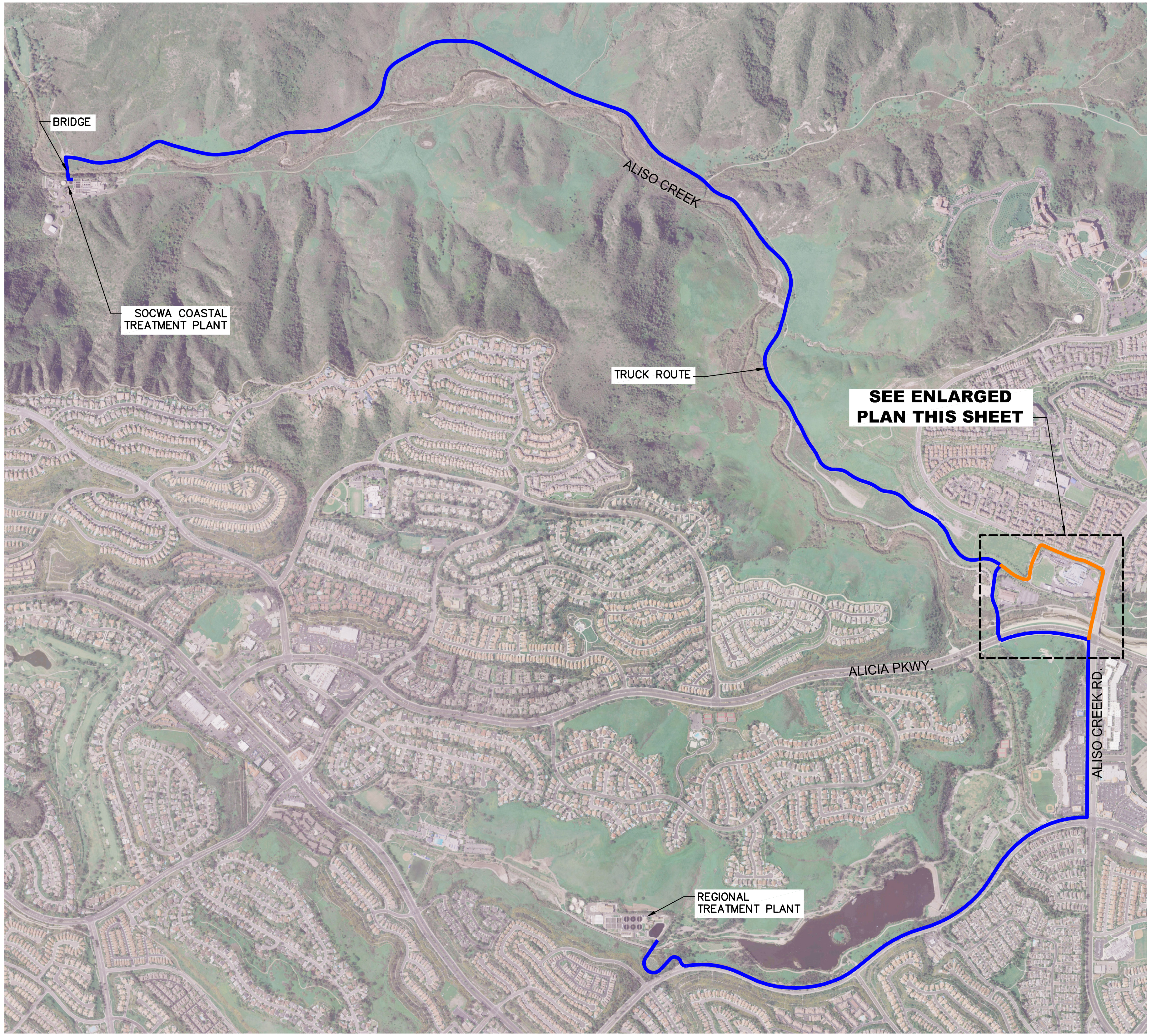

TRUCK ROUTE PLAN
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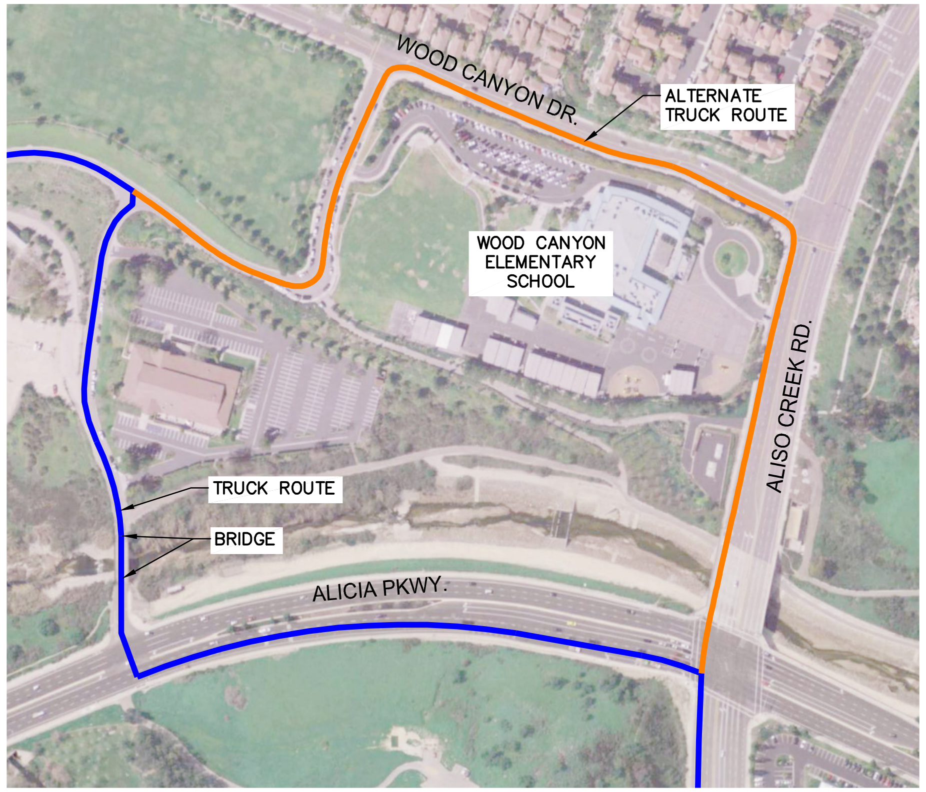

TRUCK ROUTE ENLARGED PLAN
SCALE: 1"=800'

FIGURE 4–6
ALTERNATE TR-1 ROUTE MAP

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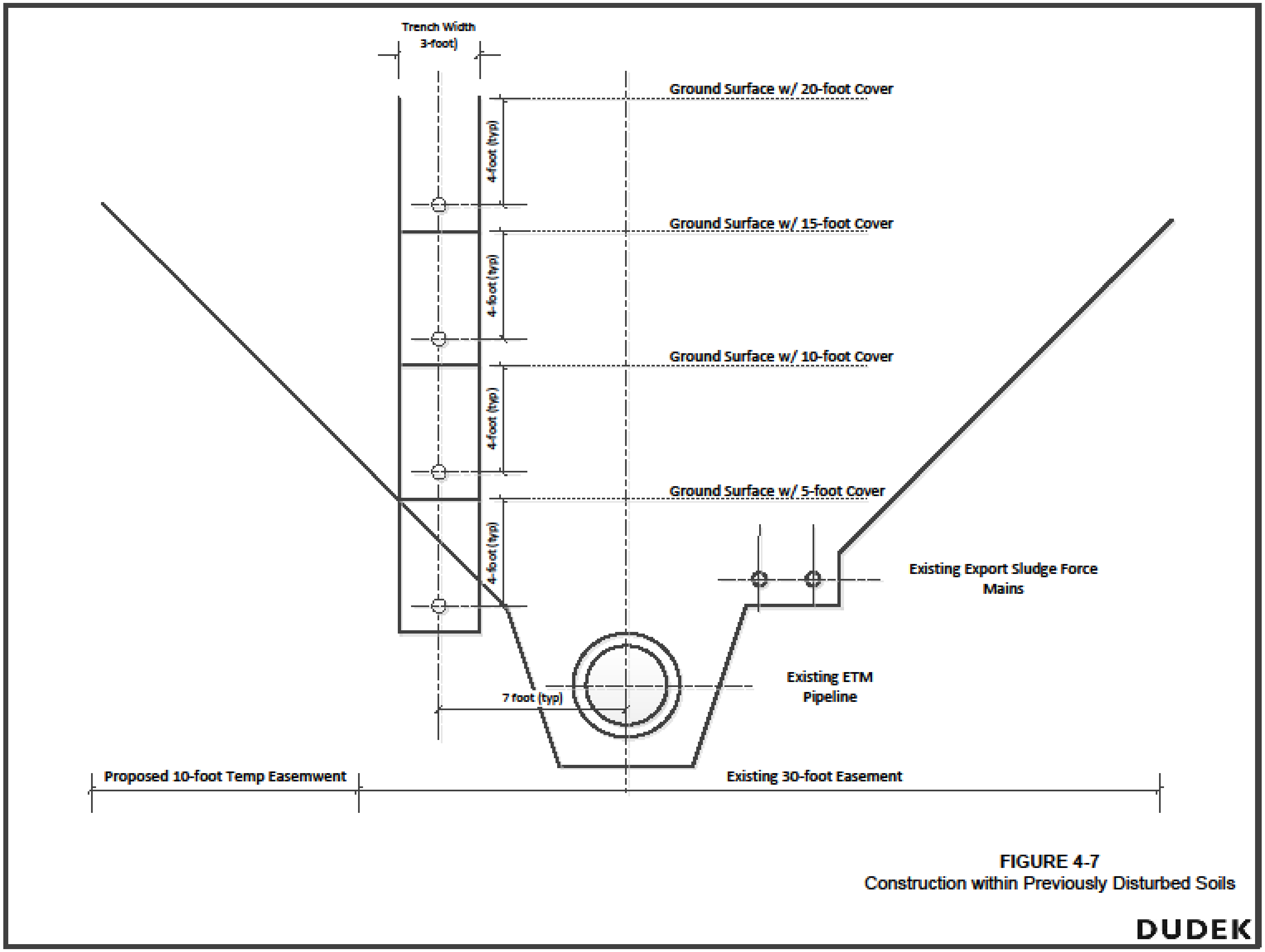
Figure 4-7 Construction within Previously Disturbed Soils



Cultural resources within the proposed alignment were identified for the EIR development. Approximately seven archeological sites were found in the vicinity of the proposed alignment. The identified sites encompassed area from the base of the steep slopes to well within the Aliso Creek channel in all cases. Based on the information available, meandering of the Aliso Creek channel over the years appears to have displaced existing ground, leaving only the approximate width of the ETM construction easement. This being the case, the Creek and the previous construction are anticipated to lessen the potential impact that the FM-1 alternative may have on potentially remaining cultural or archeological sites.

Biological conditions along the alignment also have been impacted by the previous construction, but have recovered with time. The existing alignment has an existing dirt roadway for access along the entire length of the project. However, based on the anticipated construction area needed as shown on Figure 4-4, temporary impacts to biological resources are anticipated. The new Export Sludge force main would be constructed within the previously disturbed portion of the existing ETM easement.

4.3.2 FM-2 Alternative

Construction of the FM-2 alternative will be primarily located within the existing AWMA Road alignment. Existing cultural and biological resources are more prevalent along the proposed FM-2 alignment. Furthermore, as the roadway is used by Park patrons on a regular basis, construction within the roadway would represent more significant impacts.

Archeological sites reviewed for EIR development indicate significant cultural resource sites throughout the FM-2 alignment. Furthermore, unlike the FM-1 alignment, significant previous disturbance of these sites has not been documented. Also, Aliso Creek does not appear to have had the same impact on these sites as on the eastern side of the Creek. Construction along the proposed FM-2 alignment is, therefore, considered to have a significantly higher impact on existing archeological and cultural resources.

The presence of the existing roadway has the effect of confining park patrons traveling through the Park to the paved surface. As such, the biological resources along the western side of Aliso Creek are less impacted at this time. Construction of the FM-2 alternative, as shown on Figure 4-5, will be primarily confined to the roadway surface. However, temporary construction easements will be needed to facilitate construction activities. These easements will constitute temporary impacts to the biological resources. The new Export Sludge force main easement would remain within the confines of the roadway boundary.

Unlike the FM-1 alignment, the FM-2 alignment will also result in more impacts to the various Park patrons who use the roadway for recreational purposes. As shown on Figure 4-4, the construction would be confined to one half of the existing roadway surface, thereby allowing continued use of the roadway during construction for Park patrons and SOCWA operations personnel. These impacts are also considered to be temporary.

4.3.3 TR-1 Alternative

The TR-1 alternative is not anticipated to have any significant impact on cultural resources, as ground disturbance is not required. However, traffic and noise are anticipated to have significant impact on the biological and recreational resources of the Park.

Trucking of sludge from the CTP to the RTP will be a year-round requirement for proper operation of the wastewater facilities. As such, several trucks will be required to traverse AWMA Road each day. The noise impact may be significant during the breeding seasons of the year for protected animals and birds. These impacts would be difficult to mitigate. Other biological resource impacts would be minimal as the trucks would be confined to the roadway surface.

Park patrons would be impacted regularly by the truck traffic. As with the biological resources, mitigation of these impacts would be difficult to accomplish. As presented in Section 6 of this PDR, the truck traffic will be dictated by the quantity of sludge to be conveyed, and this traffic will be required to continue on a daily basis.

4.4 Trenchless Construction Considerations

The FM-1 and FM-2 alternatives may incorporate trenchless construction techniques. These techniques, including horizontal directional drilling, pipe jacking and microtunneling, have the ability to facilitate construction with minimal disturbance of the ground surface. Such techniques are also useful in avoiding existing natural resources, such as fluvial channels. However, trenchless construction is considerably more expensive than traditional construction techniques, and is typically only used when necessary.

Along the FM-1 alignment, trenchless construction may be useful in avoiding locations where Aliso Creek has eroded the eastern bank causing minimal construction area for open trench construction. In these cases, trenchless construction may be useful in constructing through the hillside for short distances to avoid the narrow construction corridor. However, this construction technique places the new Export Sludge pipeline out of reach for maintenance purposes, and is therefore less desirable than conventional construction. As present, no trenchless construction is proposed for the FM-1 alignment. However, during final design, minimal trenchless construction may be incorporated if warranted.

The FM-2 alternative has significant ground elevation changes along its length. In several of these areas, the depth needed for conventional construction is unreasonable. In these cases, trenchless construction may be used to install the pipelines along the required line and grade for proper operation. These techniques can also be used to avoid biologically sensitive and other natural areas where open trench construction would result in highly significant resource impacts. Additionally, the extensive cultural resource sites located along the FM-2 alignment may continue to be impacted despite the use of trenchless construction, depending on the depth of construction and the depth of the cultural site.

Finally, trenchless construction can be used to avoid the risk of erosive impacts to the new pipeline alignment by Aliso Creek. It has been noted that Aliso Creek has had higher impact to previously disturbed ground than undisturbed areas. In particular, the erosive forces of the creek have been identified to have particular impact to pipeline trenches along the channel length. Trenchless construction may be used to construct the new Export Sludge force main below the erosive zone of the Creek, thereby minimizing the impact of erosion on the new pipeline alignment. This construction has the impact of lowering the overall grade of the pipeline alignment, and thus increasing the construction cost. Comparison with other erosion control methods will be required during design to determine the most effective method of protection.

5 EXISTING SLUDGE CONDITIONS AT COASTAL TREATMENT PLANT

5.1 Sludge Characteristics

Sludge characteristics are compiled with respect to flow, solids content, and total pounds of sludge. These characteristics determine the pumping hydraulics (Alternatives FM-1 and FM-2), as well as the number of truck trips for Alternative TR-1. Primary sludge is thickened within the primary clarifiers and pumped to the Export Sludge Pump Station wet well. Waste activated sludge (WAS) is thickened in a dissolved air flotation thickener (DAF). The resulting TWAS is normally diluted before being pumped to the wet well and combined with the primary sludge. This dilution is required to maintain an overall sludge solids concentration that can be pumped by the existing Export Sludge facilities. Pumping controls limit pump discharge pressure to 240 psi.

Existing sludge flows and characteristics are reported in Table 5-1. Maximum month conditions are used for sizing the system's hydraulic components. Average day conditions are used to estimate annual cost, as well as average environmental impact. Individual sludge flows and export flow are metered separately. Sludge production is calculated using these flows and the total suspended solids (TSS) or total solids (TS) concentrations, as determined in the laboratory.

Primary sludge, in pounds per day (ppd), is calculated using influent TSS concentrations, measured influent flow, and the primary clarifier removal rate of 67.4 percent. The removal efficiency was reported in the Coastal Treatment Plant Export Sludge Equalization Basin Draft, 2006. Primary sludge may also be calculated based on the primary sludge flow and thickened primary sludge TS concentration. However, reported TS data over-estimates the solids production. Using TS, the average calculated primary sludge production is 10,342 ppd. The average TSS entering the plant is calculated to be 10,492 ppd. This comparison reveals an apparent discrepancy in sludge production, as the primary sludge essentially equals the total influent TSS. Approximately one-third of the TSS would typically be expected to be transported from primary clarifiers to the aeration basins. Considering this apparent discrepancy, the primary sludge volume is based on influent TSS and primary clarifier removal efficiency.

TWAS solids production is calculated based on the waste activated sludge flow, waste activated sludge TSS concentration, and a thickener solids capture efficiency of 95 percent.

The sum of metered sludge flows is approximately equal to the metered Export Sludge flow. The sum of the primary sludge and TWAS meters averages 86,860 gallons per day. This value compares favorably to a metered export flow of 88,744 gallons per day.

It is projected that, as the tributary service area is built-out, sludge production in terms of pounds per day will not increase substantially.

Table 5-1 Existing Sludge Flows and Characteristics

Parameter	Unit	Average Day	Maximum Month
Primary Sludge[(1)]			
Flow	gpd	61,016	66,000
Sludge Production	lb/d	7,072	10,205
Percent Total Solids	%	1.40	2.01
Percent Volatile Solids	%	1.24	1.79
Waste Activated Sludge			
Flow	gpd	228,000	252,000
Total Suspended Solids	mg/L	1,985	2,479
Total Volatile Solids	mg/L	1,663	2,076
Thickened Waste Activated Sludge[(2)]			
Flow	gpd	25,844	41,000
Sludge Production	lb/d	3,491	4,245
Percent Total Solids	%	1.80	2.76
Percent Volatile Solids	%	1.5	2.36
Export Sludge - Reported			
Flow	gpd	88,744	100,547
Sludge Production	lb/d	8,615	13,417
Percent Total Solids	%	1.16	1.60
Percent Volatile Solids	%	0.92	1.30

Notes: (1) Calculated from the influent TSS and assuming a 67.4% removal in the primary clarifiers.
(2) Calculated from WAS flow and WAS concentrations assuming 95% capture rate in the DAF thickener.

5.2 Comparison to Past Reports

Total solids production reported in Table 5-1 was compared to projections made in previous reports, as reported Table 5-2. Reported values are very similar among the past reports. The most current values are used in this evaluation.

Table 5-2 Solids Production Comparison

Report	Total Sludge Production (pounds per day)
Table 4-1	10,564 - 14,450
Coastal Treatment Plant Export Sludge Equalization Basin Draft, November 2006, Malcolm Pirnie	9,332 - 14,758
Draft Coastal Sludge Pump Station Evaluation, June 2002, Tetra Tech	9,174 - 11,468
SOCWA Sludge Report January 2005 through April 2006	11,527 (average)

5.3 On-site Sludge Export Facilities

5.3.1 Existing Pump Station

The existing Export Sludge Pump Station consists of the sludge wet well and two progressing cavity sludge pumps. Only one pump is needed for current flows, with the second pump acting as an installed spare. The pumps are progressing cavity, positive displacement pumps equipped with variable frequency drives. As stated previously, pump speed varies with wet well level and discharge pressure. Discharge pressure is limited to 240 psi. Table 5-3 provides existing pump design criteria.

Table 5-3 Existing Sludge Export Pumps

Parameter	Rated Flow (gpm)	Rated Pressure (psi)	Motor Horsepower
Pump Rating, each	100	250	30

5.3.2 Planned Export Sludge Equalization Basin

The report Coastal Treatment Plant Export Sludge Equalization Basin Draft provides a preliminary design for new facilities to include a sludge equalization basin, new Export Sludge pumps, truck loading pumps, basin mixing pumps, and odor control. This PDR assumes that the facilities are common to the three alternatives. The basin would be required for emergency conditions related to FM-1 or FM-2, especially considering a single force main.

The referenced report determines an equalization basin volume of 240,000 gallons. It was apparently sized for the existing rated capacity of the CTP, not current flows. The volume requires additional review relative to current growth projections (no expected future increase in solids production). The volume also considered trucking solids at 3.5 percent TS. This value is considerably lower than El Toro Water District currently achieves in their trucking operation to the RTP. SOCWA operations staff reports solids content from 3.8 to 5.1 percent TS. Volumes should be reviewed with respect to achieving higher TS concentrations to limit the number of truck hauling trips.

6 SLUDGE TRUCKING ALTERNATIVE EVALUATION

6.1 Introduction

This section discusses Alternative TR-1, comprised of trucking a combination of primary sludge and TWAS from the CTP to the RTP. This alternative is similar to El Toro Water District's current operation. Sludge is discharged into the Sludge Equalization Tanks at the RTP, and subsequently pumped into the DAFs for co-thickening with the RTP waste activated sludge. Thickening is important to reduce the sludge volume pumped to the anaerobic digesters. Reduced volume increases digester detention time, increases digester solids destruction, and reduces digester heat requirements, which is especially important during winter months.

6.2 Trucking Criteria

Under emergency conditions, sludge has been trucked from the CTP to the RTP in the past. Trucks are loaded from the Export Pump Station wet well. It is reported that no more than five trucks per day have been needed in the past. However, the exact time of year or sludge production rate is unknown relative to the identified trucking operation.

Trucking criteria are important in determining the number of truck-trips per day. The criteria also establish cost and other impacts; with percent solids hauled being the most important criterion. The needed percent TS has been calculated based on limiting the number of average truck trips to five per day on a seven day per week hauling schedule. El Toro Water District hauls between 5,300 to 5,400 gallons per load. Using a value of 5,300 gallons, an average TS of 4.8 percent is required to meet this trip goal on the average. Section 6 uses this average value to establish the viability in meeting this thickening goal for the proposed trucking alternative.

Additional thickening of sludge has been considered as a means of reducing the number of required truck trips. However, El Toro Water District staff has indicated that thickening combined sludge to more than 5.5 percent can dramatically increase the amount of time required to load and unload the sludge truck.

6.3 Trucking Alternative (TR-1)

Alternative TR-1, as defined, would eliminate the use of the existing Export Sludge force main system. CTP sludge would be thickened and loaded into 5,500 gallon tanker trailers, then hauled to the RTP for discharge and treatment. Table 6-1 defines the projected sludge volumes to be hauled under this alternative.

Table 6-1 Projected Sludge Quantities

	Sludge Quantity	
	Average	Max Month
Primary Sludge (ppd)	7,072	10,205
TWAS (ppd)	3,491	4,245
Total Sludge Quantity (ppd)	10,563	14,450
Max Solids content (%)	4.6	5.0
Sludge Volume (gpd)	27,534	34,652

Assuming a 5,500 gallon tanker trailer, the required daily truck hauling trips between CTP and RTP would be computed as shown in Table 6-2.

Table 6-2 Required Truck Trip per Day

	Required Daily Trips	
Operating Scenario	Average	Max Month
7-Day Hauling	5.0	6.3
5-Day Hauling	7.0	8.8

On the average, a total of five truck trips per day will be required in a 7-day work week to haul sludge from CTP to RTP. It is, therefore, necessary to define the total available truck trips based on the projected operational constraints. Table 6-3 defines the total number of truck trips that are projected to be available on a daily basis.

Table 6-3 Available Hauling Trips per Day

Description	Value
Truck Loading/Unloading Rate (gpm)	300
Truck Loading/Unloading Time (min)	20
Per Trip Haul Distance (mi)	10
Average Haul Speed (mph)	25
Round Trip Hauling Time (min)	88
Available Hauling Trips per Day	6.1

An important part of this analysis is the impact on staffing and operating procedures at SOCWA's existing treatment plants. SOCWA facilities currently operate on a ten hour per day schedule (7:00 am to 5:00 pm), Monday through Friday. Two operators are on duty at the RTP between 7:00 am to 4:00 pm on Saturday and Sunday. Operations staff inspects the CTP over the weekend. Otherwise, the CTP is not staffed on weekends.

Adoption of a seven day per week trucking schedule requires shifting of staff, and the potential hiring of additional SOCWA staff. Based on experience at El Toro Water District, it is assumed that loading, travel time, and unloading of a sludge hauling truck takes approximately 1.5 to 2.0 hours. Therefore, it is projected that a normal operating weekday will deliver approximately six truckloads each day. To increase the available truck trips, SOCWA would require the following:

- Obtaining and operating a second sludge truck and trailer, and
- Increasing the duration of the operating day.

The above analysis is based on the assumption that two trucks are required to maintain a five-day hauling schedule. Labor cost, calculated in Section 5.4, is based only on the time required for the truck driver(s). No additional labor has been included for impacts to treatment plant operations.

It is noted that SOCWA currently has only one staff member licensed to operate the identified sludge transport equipment. This individual is largely committed on a daily basis to hauling dewatered biosolids to the Prima Deshecha Landfill. It is unlikely that existing SOCWA staff will be sufficient to accommodate the sludge transport roles contemplated in this analysis.

Handling of five additional truckloads of sludge each day at the RTP (beyond that currently handled for the El Toro Water District) will likely require facility modifications to avoid truck coordination and unloading conflicts. It is likely that one of the existing RTP dissolved air floatation (DAF) units could be modified to provide a second sludge receiving station. These modifications have not been addressed in this analysis.

Based on this analysis, two trucks and trailers are assumed for this alternative. During maximum month conditions, an extended hauling day may be instituted to accommodate additional sludge volumes, or third party hauling can be used to supplement normal operations for a short duration. Actual sludge volumes will dictate the potential need for these operational scenarios.

6.4 Trucking Alternative Cost Opinion

Based on the information developed above, the projected cost of the trucking operations can be determined. Unit costs for the evaluation are presented in Table 6-4.

Table 6-4 Trucking Alternative Unit Costs

Description	Unit Cost
Tanker Trailer (5,500 gal)	$ 150,000
Truck Cab	$ 110,000
Annual Truck/Trailer O&M	$ 10,000
Truck/Trailer Fuel Economy (mpg)	4.0
Average Fuel Cost ($/gal)	$4.50
Round Trip Hauling Distance (mi)	20
Miscellaneous Driving Distance (mi)	15

Using the unit cost information from Table 6-4, the projected cost of the hauling operations can be determined. Table 6-5 and 6-6 provide the projected total annual cost for projected hauling operations for 7-day and 5-day schedules, respectively. It is noted that this analysis does not account for sludge thickening costs, which are developed in Section 6 of this report. Section 12 provides complete cost comparisons of each project alternative.

Table 6-5 7-Day Hauling Cost Opinion

	Average	Max Month
Required No. of Trucks	1	1
Cost per Truck/Trailer	$ 260,000	$ 260,000
Truck Replacement Cost (PW)	$ 46,000	$ 46,000
Annual Fuel Cost	$ 47,000	$ 58,000
Annual Labor Cost	$ 73,000	$ 73,000
Annual O&M	$ 10,000	$ 20,000
Equivalent Annual Cost	$ 157,000	$ 167,000

Table 6-6 5-Day Hauling Cost Opinion

	Average	Max Month
Required No. of Trucks	2	2
Cost per Truck/Trailer	$ 260,000	$ 260,000
Truck Replacement Cost (PW)	$ 92,000	$ 92,000
Annual Fuel Cost	$ 45,000	$ 56,000
Annual Labor Cost	$ 73,000	$ 73,000
Annual O&M	$ 20,000	$ 20,000
Equivalent Annual Cost	$ 188,000	$ 198,000

From above, the number of trucks required is highly dependent on the total quantity of sludge that is required to be transported. In these analyses, we have assumed that only one additional employee would be hired, even if two trucks are purchased. It is projected that the additional hauling operations during maximum month periods will be accommodated with existing personnel, as the need is only for a small portion of the year. Based on a 7-day hauling schedule, operation with two trucks results in a 20 percent increase in cost on an annual basis. This annual cost will be combined with the sludge thickening facilities cost in Section 13 to fully define the trucking alternative cost.

6.5 Third Party Trucking Alternative

As an option to Alternative TR-1, SOCWA could elect to conduct its sludge hauling operations through a third party vendor. To define this alternative, available third-party sludge hauling companies were contacted. The cost of third party hauling is developed based on the same basic criteria as in-house hauling, particularly a 7-day hauling schedule and 7-hour working day. Table 6-7 defines the projected cost of third party hauling operations.

Table 6-7 Third Party Hauling Cost Opinion

Description	Value / Cost
Third Party Cost per Hour	$ 100
Working Hours per Day	7
Work Days per Week	7
Equivalent Annual Cost	$ 255,000

Based on the provided information, third-party hauling appears to be less cost effective than in-house hauling operations. This result is consistent with the analyses performed by El Toro Water District in evaluating their sludge hauling alternatives. It is noted that third party hauling may be cost effective in accommodating seasonal sludge volume increases. However, SOCWA may also be better served by extending the hauling day from nine to ten hours during these high sludge volume periods, thereby accommodating the increased volume using in-house equipment and personnel.

6.6 Truck Routing

The proposed sludge trucking alternative is projected to normally travel a route from the CTP following the AWMA Road north through the Wilderness Park until the road exits the Park, becoming AVCA Road. Trucks would continue east onto the original AWMA Road, passing the Park ranger station and parking lot. Trucks would continue across the AWMA Road Access Bridge, prior to reaching Alicia Parkway.

A structural analysis of the AWMA Road Bridge completed in November 2011 found that the bridge does not meet current structural standards. The analysis recommended posting a gross vehicle weight limit restriction of 16,000 pounds on the bridge. SOCWA subsequently rerouted truck traffic, as shown in Figure 4-6. Future sludge trucks would be required to follow this identified routing as well.

An alternative traffic route, shown in Figure 4-6, passes by Wood Canyon Elementary School. SOCWA currently restricts truck traffic to non-school hours. SOCWA staff has indicated that using this route for sludge hauling during school hours is not acceptable.

Potential replacement of the AWMA Road Access Bridge is being addressed in a separate analysis. The anticipated bridge replacement cost is approximately $3 million. Traffic analysis has shown that less than 10 percent of the vehicle traffic crossing the AWMA Road Access Bridge is currently related to SOCWA operations. The SOCWA Board is not interested in financing the entire bridge, but has expressed interest in a cost sharing arrangement for replacement of the bridge. Possible participants in a cost sharing agreement may include the County of Orange, the City of Aliso Viejo, and the City of Laguna Niguel. As of the preparation of this report, none of these potential participants have expressed interest in a cost-sharing arrangement. Therefore, capital costs for Alternative TR-1 includes the $3,000,000 cost for replacement of the bridge.

An agreement between OC Parks and SOCWA allows use of AWMA Road on weekends and holidays for public use by park patrons. Pedestrian and bicycle traffic on AWMA Road can be significant during these periods. Heavy use of the roadway by these patrons does not lend itself to safe and reliable weekend sludge hauling operations. As a result, sludge hauling operations would be required to be limited to five days per week, excluding weekends.

Section 5.3 of this report noted that SOCWA is not adequately staffed for evening and night sludge hauling operations. Night hauling of sludge would also require the trucks to traverse approximately 3 miles of unlit roadway. This situation poses a safety concern for both the truck driver and for Park wildlife. In addition, truck traffic within the park may increase noise levels for residences on the perimeter of the park.

7 SLUDGE THICKENING ALTERNATIVES

7.1 Introduction

As discussed previously, combined primary sludge and TWAS must have an average TS content of 4.8 percent to limit the number of daily truck trips to five. This section discusses the feasibility of meeting this goal on a long-term basis. Various alternatives, which assure that the goal is met, are evaluated.

7.2 Existing Thickening

Primary sludge is thickened in the primary clarifiers. This operation is common practice in wastewater treatment plants based on achievable solids content and cost. Concentrations ranging from 4 to 5 percent TS are commonly achievable in well-designed basins. Concentration depends upon several factors, including ability to pump higher solids, wastewater temperature, and primary clarifier configuration. In discussions with operations staff, solids concentrations ranging from 4 to 5 percent are achievable in the west primary clarifiers. The east primary clarifiers are shallower and have a smaller sludge hopper design. Expected solids concentrations are lower, between 3 to 4 percent TS, for these units.

WAS is thickened in one of two DAF thickeners (DAFs). Only one thickener is required for current solids production. No polymer is added to the process, as the TWAS is required to be diluted to maintain pressures in the sludge export system. With proper polymer selection, TWAS concentrations between 4 to 5 percent TS are achievable.

The existing DAFs operate within recognized design criteria as reported in Table 7-1. As reported, the loadings are within normal ranges for one unit in operation. This provides one spare thickener for reliability.

Table 7-1 Dissolved Air Flotation Thickener Loading

Parameter	Recommended Criterion	Average Operation	Maximum Month Operation
Liquid Loading (gpd/sf)[1]	600 – 800	600	663
Solids Loading (lb/sf/hr)[2]	0.8	0.40	0.46

Notes: (1) gpd/sf – gallons per day per square foot

(2) lb/sf/hr – pounds per square foot per hour

7.3 Thickening Process Alternatives

To meet the required average 4.8 percent TS goal reliably, various alternatives are identified. These alternatives are reported in Table 7-2. It lists available process alternatives, applicable use, and comments.

Table 7-2 Potential Thickening Alternatives

Alternative	Primary	WAS(1)	Notes
In-Basin	X		Typical design based on cost.
Gravity Thickener	X		Low solids concentration when used for WAS. Best used for primary sludge.
DAF(2) Thickener	X	X	For primary sludge, normally co-thickened with WAS. Higher power use.
Gravity Belt Thickener		X	Has been used on primary sludge, but plugging and odors are a concern.
Disk Thickener		X	Little experience with primary sludge.
Rotary Drum Thickener	X	X	Little experience with primary sludge.
Centrifuge	X	X	Normally used in large plants. Higher power use.

Notes: (1) WAS – Waste Activated Sludge
(2) DAF – Dissolved Air Flotation

7.3.1 In-basin Thickening

As discussed previously, this process is the current method of thickening SOCWA's primary sludge. It is typically selected based on cost and ease of operation. Factors affecting thickening performance include wastewater age, temperature, and configuration of the sludge piping. Holding sludge for long periods, especially during warm temperatures, can result in solubilization and sludge floating.

In-basin thickening is not recommended for secondary clarifiers, as required TS concentrations cannot be achieved. In-basin thickening also requires high sludge blanket levels that may lead to solids washout.

To maintain the highest TS concentrations possible, installation of sludge density meters is recommended. A set-point value is entered into the SCADA system. The sludge pumps operate based on an interval timer. After a time delay to allow the thickened sludge to reach the meter, the pumping continues until the TS concentration drops below the set point for prescribed duration. This operation helps the operators to achieve the highest TS concentration possible.

7.3.2 Gravity Thickening

Gravity thickeners are suitable for primary sludge. While capable of thickening WAS, they cannot achieve the required TS concentrations to meet the prescribed goal. This alternative would eliminate the thickening limitations of the east primary clarifiers.

Under this alternative, existing DAFs would be converted to gravity thickeners. One DAF would operate while the other would provide mechanical standby. This alternative requires a new process to thicken the WAS.

The recommended gravity thickening criteria and expected loading are reported in Table 7-3, based on one unit in operation.

Table 7-3 Gravity Thickener Loading

Parameter	Recommended Criterion	Average Operation	Maximum Month Operation
Liquid Loading (gpd/sf)[1]	600 – 800	160	174
Solids Loading (lb/sf/hr)[2]	0.8 – 1.2	0.8	1.1

Notes: (1) gpd/sf – gallons per day per square foot
(2) lb/sf/hr – pounds per square foot per hour

The existing DAFs are large enough for primary thickening. Liquid loading is low. However, flow is based on current operation. In reality, sludge pumping will be increased to keep low primary clarifier sludge blankets. Secondary effluent is sometimes added as elutriation water to limit potential septicity and sludge floating.

7.3.3 DAF Thickening

DAF thickeners can be used on combined primary and WAS sludge. Currently, the primary and WAS from the CTP is pumped into the DAF thickeners at the RTP. While not common, combined thickening is used in many wastewater treatment plants. The recommended criteria and loadings are shown on Table 7-4, based on two units in operation. For the maximum sludge loadings, both the liquid and solids criterion will be exceeded with one unit in operation. Another stand-by process will be required with this process alternative, which could consist of a third DAF or another process, such as a drum thickener.

Table 7-4 DAF Co-Thickening Loading

Parameter	Recommended Criterion	Average Operation	Maximum Month Operation
Liquid Loading (gpd/sf)[1]	600 – 800	380	418
Solids Loading (lb/sf/hr)[2]	0.8 – 1.2	0.6	0.7

Notes: (1) gpd/sf – gallons per day per square foot
(2) lb/sf/hr – pounds per square foot per hour

7.3.4 Gravity Belt Thickeners

Gravity belt thickeners have been used extensively for thickening WAS. These thickeners have been applied to primary sludge, but operational issues with blinding of the belt have been experienced. This alternative would work in combination with the gravity thickener alternative.

TWAS concentrations between 6 to 8 percent are achievable. However, two units would be required for reliability.

7.3.5 Disk Thickeners

Disk thickeners are a new technology offering several advantages, including smaller foot-print and lower energy consumption as compared to other process alternatives. Santa Margarita Water District has experienced good results with disk thickeners at the Chiquita Water Reclamation Plant. Disk thickeners are used for WAS thickening. Limited experience is available using disk thickeners on primary sludge.

At present, there is one manufacturer of disk thickeners. Disk thickeners can handle loadings up to 180 gallons per minute (gpm). The maximum month WAS flow at CTP is reported to be 175 gpm. Therefore, two units will be required, one duty and one standby. Disk thickeners are capable of achieving between 6 and 8 percent TS.

7.3.6 Drum Thickeners

Drum thickeners are similar to disk thickeners, with the exception that there is more than one manufacturer. More drum thickener installations exist, including some experience thickening primary sludge. Drum thickeners have capacities in the range of 25 to 400 gpm. Two drum thickeners will be required for reliability, and they can achieve TS concentrations between 6 and 8 percent.

7.3.7 Centrifuges

Centrifuges were originally developed for sludge dewatering, and are capable of achieving TS concentrations of 25 percent or higher. Centrifuges have also been applied to thickening. Centrifuges have a higher energy consumption, more complex operation, and higher capital costs as compared to disk or drum thickeners.

7.4 Thickening Alternatives

Based on existing conditions and available thickening processes, four thickening alternatives are identified as being most feasible for CTP. These processes are listed in Table 7-5, and consider primary and WAS requirements.

Table 7-5 Potential Thickening Alternatives

Alternative	Primary	WAS(1)	Notes
No. 1	In-Basin	DAF(2) Thickener	Polymer facilities would be added to increase thickened WAS concentration to 5 percent.
No. 2	Gravity Thickener	Disk Thickener	Existing DAFs would be re-converted to gravity thickeners.
No. 3	DAF Thickener	DAF Thickener	Primary and WAS would be co-thickened.
No. 4	Rotary Drum Thickener	DAF Thickener	Polymer facilities would be added to increase thickened WAS concentration to 5 percent.

Notes: (1) WAS – Waste Activated Sludge
(2) DAF – Dissolved Air Flotation

7.4.1 Expected Performance

Expected combined TS concentrations are reported in Table 7-6. Alternative 1 is expected to achieve the lowest solids concentrations, primarily resulting from the lower TS expected when operating the east primary clarifiers. If the west clarifiers can be operated exclusively, the average solids goal of 4.8 percent is achievable.

The other three alternatives are capable of meeting the average goal. The alternatives including either disk thickeners or drum thickeners will meet the goal most reliably.

Table 7-6 Probable Sludge Concentrations (Percent)

Alternative	West Primary	East Primary	WAS(1)	Combined
No. 1	4-5	3-4	4-5	3.3-5.0
No. 2	4-5	4-5	6-8	4.7-6.0
No. 3	N/A(2)	N/A	N/A	4-5
No. 4	6-8	6-8	4-5	5.3-7.0

Notes: (1) WAS – Waste Activated Sludge
(2) N/A – All combined

7.4.2 Site Layout

This section discusses the potential location of new facilities required for Alternatives 2 through 4. Alternative 1 does not require new construction other than minor space requirements for the DAF polymer facilities.

Alternatives 2 and 4 include construction of new disk or drum thickeners. The thickeners can be located outside of a building. The equipment is enclosed, and no special odor control equipment is required. The facilities include polymer storage and blenders, the thickeners, thickened sludge pumps, and electrical controls. The facility would be covered with a canopy structure to protect from the sun.

Thickened sludge would be pumped to the planned Sludge Equalization Basin or the existing Sludge Export wet well. The new facilities could be co-located with the new Equalization Basin, as shown on Figure 7-1. The facilities would be constructed just east of the equalization tank. Based on existing grades, a retaining wall would also be required, which is included in the identified capital cost.

Alternative 3 includes a new DAF thickener with an inside diameter of 22 feet to match the existing units. The new DAF would be located near the existing units to share polymer storage, thickened sludge pumping, and other ancillary facilities. The unit would require its own pressurization facilities, including pump and retention tank.

The third DAF is shown on Figure 7-2, located to the southwest of the existing units.

7.4.3 Cost Opinions

An equivalent annual cost approach is used to compare the life cycle cost of the thickening alternatives listed in Table 6-5. Average annual flows are used to estimate operations and maintenance (O&M) cost, while the maximum month flows are used to size the facilities to determine capital cost. Capital costs include a construction and estimating contingency of 30 percent, as well as 20 percent for project costs. Project costs include engineering, construction management, legal and administrative costs. The economic factors are included in Section 12 of this PDR.

Figure 7-1 Site Plan for Sludge Thickening Alternative 2 and 4

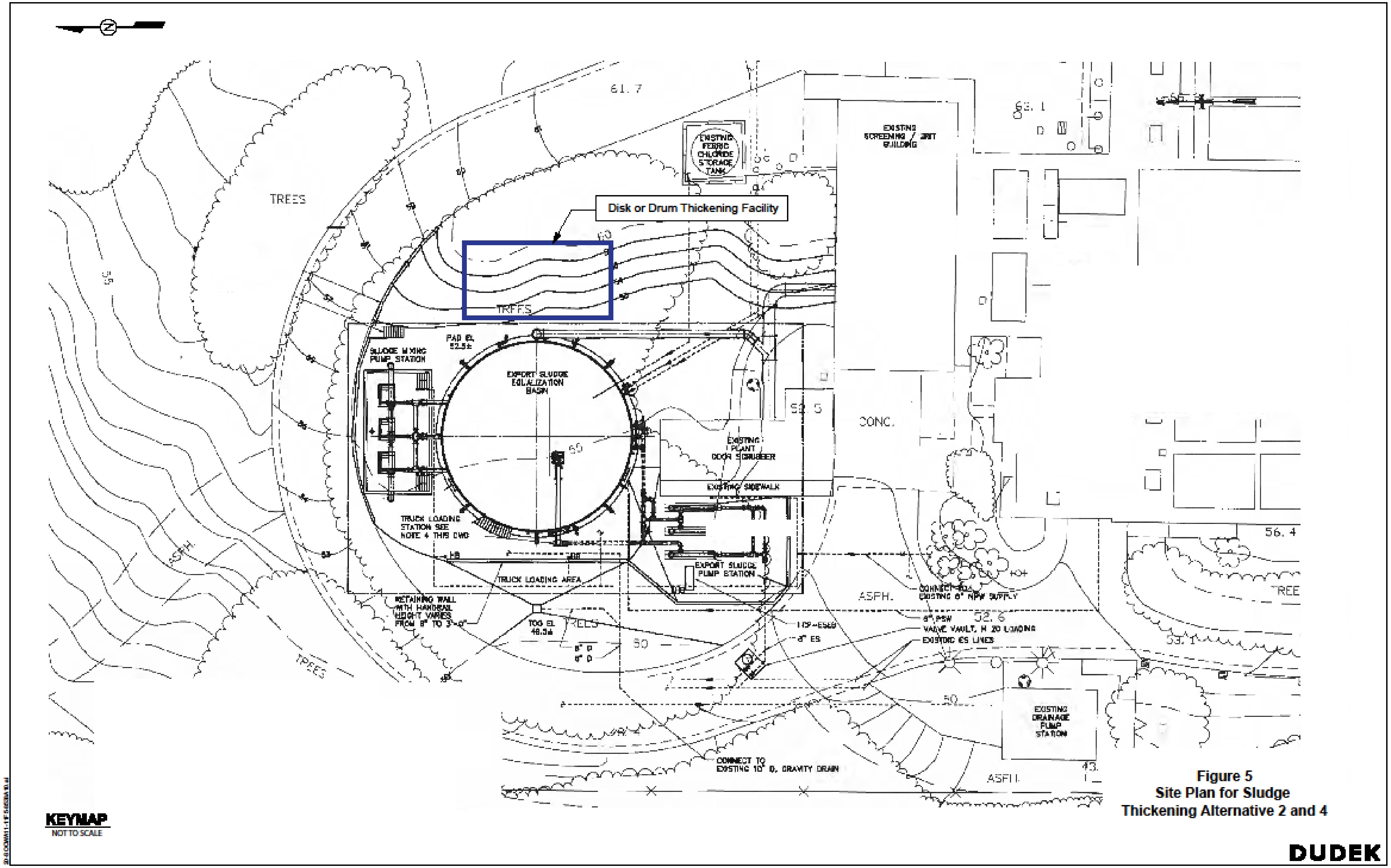


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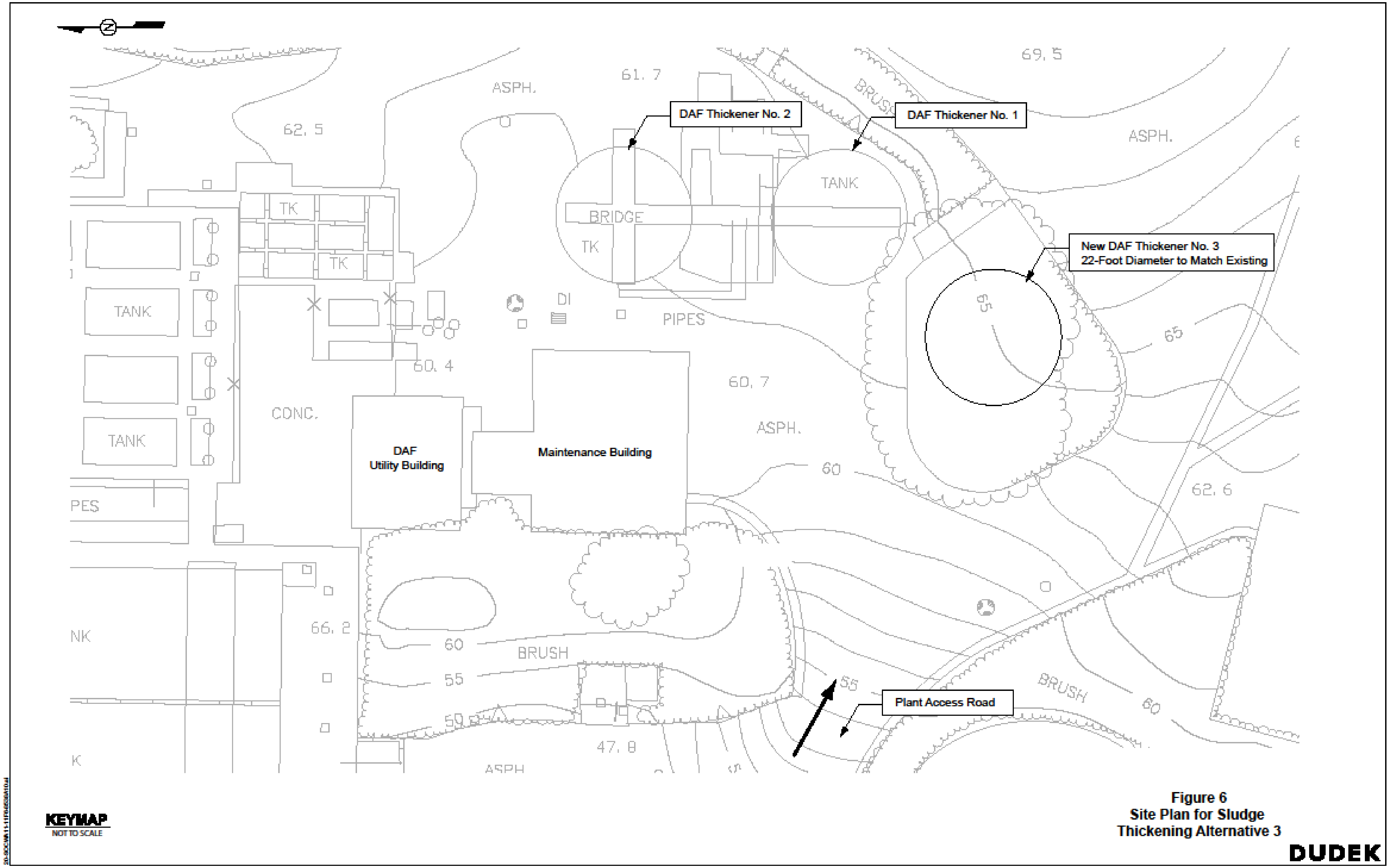
Figure 7-2 Site Plan for Sludge Thickening Alternative 3



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Annual cost considerations include electrical power, chemical usage, and operation and maintenance costs.

The estimated capital costs are presented in Table 7-7, while the O&M costs and equivalent annual cost is presented in Table 7-8.

Table 7-7 Estimated Capital Costs

Cost Element	Alternative			
	1	2	3	4
Primary Thickening Modifications	$0	$516,000	$923,000	$893,000
WAS Thickening Modifications	$46,000	$811,000	Included in Primary Cost	$46,000
Subtotal	$46,000	$1,327,000	$923,000	$939,000
Contingency @ 30 percent	$14,000	$398,000	$277,000	$282,000
Subtotal – Construction Cost	$60,000	$1,725,000	$1,200,000	$1,221,000
Project Costs @ 20 percent	$12,000	$345,000	$240,000	$244,000
Estimated Capital Cost	$72,000	$2,070,000	$1,440,000	$1,465,000

Table 7-8 Estimated Equivalent Annual Costs

Cost Element	Alternative			
	1	2	3	4
Total Capital Cost	$72,000	$2,070,000	$1,440,000	$1,465,000
PW of Salvage Value	$0	$55,000	$70,000	$55,000
Annual Costs				
Electrical	$10,000	$1,000	$12,000	$2,000
Polymer	$12,000	$15,000	$35,000	$49,000
Maintenance	$2,000	$4,000	$4,000	$6,000
Operations	$13,000	$26,000	$26,000	$26,000
Total Annual Cost	$43,000	$222,000	$196,000	$206,000

Notes: (1) Present worth value of annual costs over 20-years plus capital cost minus salvage value

7.5 Alternative Comparison

The four identified sludge thickening alternatives are compared with respect to key evaluation factors, including:

- Ability to meet the average TS goal of 4.8 percent
- Proven performance
- Cost
- Site Impacts

7.5.1 Ability to Meet Thickening Goal

To limit the number of daily truck trips to five, an average TS concentration of 4.8 percent is required. This concentration requires the ability to thicken to concentrations above 4.8 percent at times to compensate for periods of poorer thickening.

Alternatives 2 and 4 offer the highest probability of meeting the goal on a consistent basis. These alternatives include disk or drum thickeners with the capability of thickening to between 6 and 8 percent.

Alternative 3 consists of all DAF thickeners. With proper polymer selection, this alternative is capable of meeting the identified goal. DAF loadings would be well within conservative design criteria.

Alternative 1 may not be able to meet the identified goal at all times. This alternative depends on required operation of the east primary clarifiers. The shallow side water depth and relatively small sludge hopper of the east clarifiers limit these units to achievement of only 3 to 4 percent TS.

7.5.2 Proven Performance

Not considering TS, Alternative 1 has the highest level of proven performance. In-basin and DAF thickening is used successfully at all four SOCWA plants. The in-basin thickening has no mechanical components other than the sludge pumps, common to all alternatives.

Alternative 3 consists of all DAF thickeners to co-thicken the sludge. Co-thickening of the CTP sludge is currently being done at the RTP. This alternative has proven performance at other wastewater treatment plants.

Alternatives 2 and 4 include drum or disk thickeners. Though newer technology, disk thickeners have a proven performance for thickening WAS. Drum thickeners have limited experience thickening primary sludge. Some of the potential clogging challenges are reduced considering the fine influent screens recently installed at the CTP.

7.5.3 Cost

Alternative 1 has the lowest cost with respect to capital, O&M, and equivalent annual cost. The only needed upgrades are the polymer facilities. Alternative 2 has the highest capital cost. The annual O&M costs are the lowest as a result of reduced electrical and polymer use for the gravity thickeners. The disk thickeners also have low electrical demand.

Alternatives 3 and 4 have similar capital costs and O&M costs. Alternative 4 has a lower electrical demand resulting from the drum thickeners; however higher chemical costs are expected.

7.5.4 Site Impacts

Alternative 1 has no site impacts.

The new facilities for Alternatives 2 and 4 may be located east of the planned Sludge Equalization Basin. Alternative 2 will require re-routing the primary sludge piping to the gravity thickeners (current DAF thickeners) and re-routing the WAS piping to the disk thickener facility. Alternative 4 would require only re-routing primary sludge piping to the drum thickener facility. There are no significant site impacts, and access would be available to the new facilities.

The new DAF required for Alternative 3 can be constructed southwest of the existing units. There is space for a third DAF, and its location will not greatly impact access to the other DAFs or other facilities. Small diameter piping will need to be relocated. There does not appear to be major piping or electrical duct banks in the area. The primary sludge piping will require re-routing to the DAF facilities.

7.6 Thickening Recommendations

This section provides recommendations only concerning thickening prior to trucking to the RTP.

Alternative 2 is not recommended due to the high capital cost.

Alternative 3 is not recommended. It has a higher energy consumption compared to Alternative 4, and Alternative 4 is capable of producing higher TS concentrations. The site impacts are also less than Alternative 3.

Alternative 4 would provide a higher probability of meeting the average TS goal of 4.8 percent as compared to Alternative 1. However, this comes at a high price with changes to current operating practices.

Considering the above, a modified alternative is considered, consisting of:

1. Maintain the current in-basin and DAF thickening (Alternative 1).
2. CTP staff work to optimize treatment performance of both the primary treatment and dissolved air flotation thickening systems to meet the 4.8 percent TS target. Where necessary, extended hours of operation conducted to remove Export Sludge from the CTP.
3. If the existing process proves inadequate to consistently meet the 4.8 percent TS target install one drum thickener adjacent to the new Export Sludge Equalization Basin. The drum thickener would concentrate the combined sludge from the basin only in the event that TS is below 4.8 percent. This side treatment may not need to be operated all of the time.
4. Only one drum thickener could be installed. This would reduce the capital costs to $527,000, including new polymer equipment for the drum and the DAF thickeners.

Based on the analyses performed, this modified alternative provides the best overall benefit and is the recommended alternative (Table 7-9).

Table 7-9 Modified Alternative Equivalent Annual Costs

Cost Element	Cost
Total Capital Cost	$ 527,000
Present Worth of Salvage Value	$ 110,670
Annual Costs	
Electrical	$ 9,850
Polymer	$ 20,800
O&M	$ 19,200
Total Annual cost	$ 49,850
Equivalent Annual Cost[1]	$ 93,000

Note: [1] Calculated at 6 percent over 20 years

8 PUMPING DESIGN CRITERIA AND HYDRAULICS

This section discusses the recommended design criteria and hydraulics for Alternatives FM-1 and FM-2. Design criteria have bearing on system hydraulics.

8.1 Design Criteria

Design criteria are compiled based on previous design experience, results of phone surveys to operating pumping operations, and acceptable engineering practice.

8.1.1 Flushing Velocity

A minimum pipe velocity of 2 feet-per-second (fps) is recommended. Flushing velocity is important to prevent deposition of solids that may result in an increase in pumping pressure. Increased pumping pressure impacts energy consumption and potentially the system design pressure.

Flushing velocity is an important aspect of this project resulting from the relatively low flow rates. The average export flow is approximately 89,000 gallons per day or 62 gallons per minute. The resulting flushing velocities for nominal 4, 6, and 8- inch diameter pipe are reported in Table 8-1.

Table 8-1 Flushing Velocities

	Nominal Pipe Diameter (inches)		
	4	6	8
Pipe Velocity (fps)[1]	1.6	0.7	0.4

Notes: (1) Velocity at 62 gpm

Velocity would be increased by increasing the operational flow rate. However, the increased pumping rate would require pumping thinner primary sludge, continuing to dilute TWAS, and possibly dilute the combined sludge. Dilution would impact the DAF co-thickening process at the RTP. Higher liquid loading rates could reduce thickener performance. Increased flow would also increase export pumping energy costs.

Larger capacity pumps could be installed to increase the pumping rate to achieve flushing velocity. Using a variable speed drive, the pumping rate would increase periodically, for short durations to flush the force main. However, this option would also impact the DAF process at the RTP.

The most feasible method is to periodically flush the force main with secondary effluent. This operation would be done on a planned basis. Flow would be diverted to Export Sludge Equalization Basin during the flushing operation.

As Export Sludge pumping at the CTP is an intermittent operation, flushing could be used to both clean the force main and prevent sludge deposition and scaling during non-pumping periods. Operations staff would pump effluent from the CTP into the force main upon ceasing sludge pumping operations. The effluent would expel the sludge from the force main to the RTP. As a result, the force main would be filled with effluent during non-operational periods. Upon return to sludge pumping operations, the sludge would easily displace effluent from the force main, thereby avoiding potentially high pressures necessary to re-entrain settled sludge within the force main. Effluent water pumping could also be increased to achieve reliable scouring velocities after sludge is expelled to effectively clean the force main on an intermittent basis, providing for longer service life of the force main.

8.1.2 Pipe Diameter

An 8-inch diameter pipe is larger than required for the expected flows. It would also result in very low pipe velocities. Normally, minimum diameter considered should be 6-inches. However, the CTP export system has operated successfully with a 4-inch pipe. The pipe diameter needs to balance past experience, pipe material, and flushing velocity. The selection is discussed further below based on hydraulics, force main profile, and available materials.

8.1.3 Fittings

Long-radius elbows should be used. Side-flow tees should be avoided. Full-port plug valves are recommended. Air release valves should be avoided, as they can leak and can have serious consequences considering the proposed alignment. The City of San Diego has removed air release valves on their 8-inch sludge line connecting the North City Water Reclamation Plant to the Metropolitan Biosolids Center. The valves were at the end of the line, and the hydraulic grade was not high enough to seat the valves. This lack of seating resulted in leaks. Gas does accumulate, but the high points are at the end of the system, and the pipe periodically "burps".

8.1.4 Pipe Profile

To eliminate the need for air release valves, the pipe profile should ideally be rising from the CTP to the RTP. High points in the profile allow gas accumulation that may increase pumping pressure. As noted for the City of San Diego sludge pipeline, gas accumulation can be expected. Alignments FM-1 and FM-2 each have at least one location where a combination sewage air vacuum release valve may be recommended during design.

8.2 Pumping Hydraulics

The following discussions present expected pumping pressures for Alternatives FM-1 and FM-2. While the sludge volumes and characteristics are not expected to change greatly in the future, the hydraulic calculations are important because of new force main characteristics, including:

- Different pipe diameter
- Different pipe material
- Different alignment
- Comparison of resulting O&M costs to Alternative TR-1

Sludge pumping hydraulics is complicated by the nature of the material and higher solids content. Pressure losses are also impacted as to whether or not the flow is laminar or turbulent. These factors are accounted for in adjusting the calculated clean water losses.

8.2.1 Hydraulic Modeling

Sludge hydraulics is calculated for the existing and future conditions for Alternatives FM-1 and FM-2. Clean water hydraulics are estimated using the Hazen Williams formula for straight pipe and adjusted for minor losses using accepted K values for valves, fittings, and other such appurtenance. A spreadsheet hydraulic model was prepared for future SOCWA use.

Once losses are determined for the clean water conditions, they were adjusted for expected sludge characteristics. Three calculation approaches are used. The results are compared for existing and future operational conditions. A recommended design pressure is identified.

8.2.1.1 Modeling Approaches

Modeling of sludge-induced friction loss in pipes can be difficult when considering long transmission mains. Available literature (EPA, Sanks) agree that pumping solids at equal to, or less than, 1.0 percent solids under sufficient velocity (i.e. turbulent flow) will produce losses similar, or equal, to water losses. Under laminar flow, resulting from low velocity or increased solids content, sludge behaves as a non-Newtonian (plastic) fluid. Under these conditions, the physical characteristics of the sludge (yield stress, coefficient of rigidity, density, viscosity, among others) have a large impact on the ability to pump the sludge and the resultant head loss. Additionally, these characteristics vary between sludges, as well as between a single sludge of varying solids content.

The Manual of Practice No. 8, Design of Municipal Wastewater Treatment Plants (WEF-ASCE) provides multiple methods for estimating friction loss for sludge pumping. These methods include applying a factor to the calculated water head loss, graphical interpretation, and even equations derived from laboratory and field experiments based on solids content. To best develop and recommend a design pressure for the Sludge Export Force Main, each method was used to predict and compare expected pressures.

8.2.1.2 Sludge Factors

The method for applying sludge factors to the calculated water headloss has been presented by various authors. One of the more commonly accepted methods using friction loss due to water is calculated using Hazen Williams (Mulbarger, as cited by Sanks). A Hazen Williams C-factor of 140 must be used for calculating the water friction loss (Sanks). A factor is then applied to determine headloss for sludge. The friction factor is determined by graphical interpretation depending on velocity and percent solids under worst-case and routine operating scenarios. This method has the advantage of being independent of laminar or turbulent flow determinations. However, it does require interpretation on a log-scale, which can be difficult. Table 8-2 provides the results of the interpretation for the worst-case scenario, while Table 8-3 provides the factor under routine operating conditions.

Table 8-2 Sludge to Water Headloss Factor for Worst Case(1)

Velocity (ft/s)	Percent Solids (%)			
	1	2	3	4
0.30	5.00	80.00	200.00	300.00
0.40	3.00	50.00	130.00	200.00
0.50	2.00	35.00	93.00	145.00
0.75	1.50	17.00	45.00	71.00
1.00	1.50	10.00	27.00	42.00
1.50	1.50	5.00	13.00	20.00
2.00	1.50	3.00	8.00	12.00
2.50	1.50	2.00	5.25	8.00
3.00	1.50	1.50	3.75	5.50
4.00	1.50	1.50	2.25	3.20
5.00	1.50	1.50	1.50	2.00

Notes: (1) Sanks, et. al., 1981

Table 8-3 Sludge to Water Headloss Factor for Routine Operations(1)

Velocity (ft/s)	Percent Solids (%)			
	1	2	3	4
0.30	2.50	45.00	110.00	180.00
0.40	1.50	25.00	60.00	100.00
0.50	1.10	18.00	45.00	75.00
0.75	1.00	9.00	22.00	36.00
1.00	1.00	5.00	14.00	22.00
1.50	1.00	2.50	6.50	10.00
2.00	1.00	1.50	4.00	6.00
2.50	1.00	1.00	2.63	4.00
3.00	1.00	1.00	1.88	2.75
4.00	1.00	1.00	1.00	1.60
5.00	1.00	1.00	1.00	1.00

Notes: (1) Sanks, et. al., 1981

The tables show the effect of low velocity for sludge flow, with increasingly large factors as velocity decreases and percent solids increases.

A pumping hydraulic model was created to determine the static loss, minor losses, and friction loss for water with a Hazen Williams C of 140. The friction loss was then multiplied by the appropriate factor from the above tables. The total dynamic head (TDH) was then determined as the sum of the modified friction loss and other losses. The TDH was determined for both conditions.

8.2.1.3 Buckingham & Darcy-Weisbach Equations

As a non-Newtonian fluid under laminar flow, wastewater sludge can be considered to act as a Bingham plastic (WEF-ASCE). A Bingham plastic behaves as a semi-solid under low pressure, but flows as a viscous fluid under high pressure. The pressure needed to create flow is described as the yield stress. Determining the yield stress, as well as the coefficient of rigidity, allows for calculation of headloss using the Buckingham equation:

$$\frac{H}{L} = 32 \times \left(\frac{S_y}{6\rho g D} + \frac{R_c V}{\rho g D^2}\right)$$

Where,

$\frac{H}{L} = Friction\ headloss\ per\ unit\ length\ (m/m)$

$S_y = Yield\ Stress\ (N/m^2)$

$\rho = Fluid\ Density\ (kg/m^3)$

$g = acceleration\ due\ to\ gravity\ (m/s^2)$

$D = Pipe\ Diameter\ (m)$

$V = Velocity\ (m/s)$

$R_c = Coefficient\ of\ Rigidity\ (Ns/m^2)$

The coefficient of rigidity and yield stress are determined experimentally. These factors vary according to temperature and viscosity. Where these characteristics cannot be determined, a graphical determination is made from literature published by the American Society of Civil Engineers (ASCE, 2000). The graphs present non-linear increase of each characteristic under increases solids concentration, as shown in Table 8-4.

Table 8-4 Estimation of Sludge Characteristics

Percent Solids (%)	Coefficient of Rigidity (N-s/m2)(1)	Yield Stress (N/m2)(1)
2	0.007	0.9
3	0.015	3.5
4	0.022	7
5	0.035	8.5

Notes: (1) ASCE, 2000

Determination of laminar flow is based on a modified Reynold's number, Re:

$$Re = \rho VD/R_c$$

Laminar flow exists when Reynold's number is less than 2,000, and flow is turbulent for Reynold's number greater than 3,000.

The Buckingham equation only applies to laminar flow conditions. Turbulent flow can be determined using the Reynold's number and the Hedstrom's number to determine the friction factor, f, from a modified Moody's diagram published in the EPA's Sludge Manual (EPA). The Hedstrom number (He) is calculated as follows:

$$He = D^2 \rho S_y / R_c^2$$

The modified Moody's diagram can also be used to assign laminar or turbulent flow conditions. Utilizing the Darcy-Weisbach equation, friction loss is calculated as:

$$H = 2f\rho \frac{LD}{V^2}$$

The Hedstrom and Reynolds numbers change according to the percent solids, as determined from the ASCE curves, pipe diameter, and velocity.

A hydraulic model was created to calculate both He and Re, based on a given percent solids. Laminar or turbulent flow was determined according to the Reynolds number and the modified Moody's diagram. In cases were the Re was greater than 3,000, but the Moody's diagram suggested laminar flow, the Moody's diagram was considered to dominate. The friction factor, f, was determined by graphical interpretation for varying pipe velocities. For laminar flow conditions, the Buckingham equation was used to determine laminar-flow friction loss, while the Darcy-Weisbach equation was used for friction loss under turbulent flow. These friction losses were grouped to produce a system curve for various flows.

8.2.1.4 Solids Concentration-Derived Formulas

The final method analyzed for determining sludge headloss uses equations derived from pipeline and sludge testing data, determining headloss as a function of solids content and the Hazen Williams coefficient C (Murakami). Thickened sludge, WAS sludge and digested sludges were examined for characteristics related to pseudoplastic fluids, where the fluids viscosity decreases as the shear rate and shear stress increase. These characteristics include the pseudoplastic viscosity coefficient, k, and the pseudoplastic viscosity index, n.

Under laminar flow conditions, head loss is calculated as:

$$H(m) = 1.9 \times 10^{-3} k^{0.88} \frac{L}{D^{1.2}} V^{0.2}$$

Where,

$k = (0.067 - 0.0008T)C^{(2.80-0.006T)} for\ digester\ sludge$

$k = (0.053 - 0.0001T)C^{(3.07-0.016T)} for\ thickened\ sludge$

$k = (0.058 - 0.0008T)C^{(3.15-0.0009T)} for\ waste\ activated\ sludge$

$C = solids\ concentration$

$T = fluid\ temperature\ (°C)$

For turbulent flow,

$$H(m) = 9.06 \left(\frac{1}{C_H}\right)^{1.93\times(1-C/100)} \frac{L}{D^{1.18}} V^{1.82}$$

Where,

$C_H = Hazen\ Williams\ Coefficient = 110\ for\ mortar - lined, cast\ iron\ pipe$

$C_H = Hazen\ Williams\ Coefficient = 95\ for\ carbon\ steel\ pipe$

Murakami's approach includes calculation of a modified Reynolds number, determined from n and k, as well as a critical velocity for determining laminar or turbulent flow. Laminar flow is considered to occur at Reynolds number below 2,320. Critical velocity is calculated as:

$$V_c = 1.2 \frac{C_H}{100} k^{0.52}$$

A hydraulic model was produced using Murakami's equations. A Hazen Williams coefficient of 100 was used and the model uses the k equation for thickened sludge. Murakami's experiment included thickened sludges ranging between 0.9 and 4.5 percent solids.

Murakami's equations do not depend on graphical interpretation, and are independent of specific sludge characteristics (yield stress, shear stress, shear rate, among others). The equations can be used to examine head loss for any sludge concentration.

8.2.1.5 Existing Conditions

The hydraulic models were prepared for the existing 4-inch ductile iron export force main. The force main increases to 6-inches in diameter at the Regional Treatment Plant. Record drawings indicate that the sludge is pumped to the Sludge Equalization Tanks, where El Toro WTP sludge is trucked and off-loaded. However, recent modifications to the force main route CTP sludge to the RTP DAF thickener. Sludge is combined with RTP WAS downstream of the DAF backpressure valve, just prior to entering the DAF tank.

Data obtained from SCADA records for the CTP Export Sludge force main were analyzed and compared to predicted headlosses from the models described previously. The data included hourly pumping rates, hourly pressure and daily percent solids over the previous two years.

Variances in data made it difficult to correlate the predicted headloss in a manner that would allow for gauging the effects of differing percent solids. For example, the data consistently shows a single flow rate with wide ranging pressures. While this result may indicate a change in the percent solids, it is not known. Percent solids data is collected as a daily composite sample (daily average of 1.16 percent), while the pressure and flow rate vary constantly to maintain a set point pressure. Additionally, conversations with SOCWA staff indicate that the percent solids data may be misleading and may be higher than reported.

An attempt was made to back-calculate the friction factor, f, from the Darcy-Weisbach equation according to the EPA method. A relationship between f and the pumping velocity was observed. However, the relationship was independent of percent solids over the range of 1 to 2 percent. Assuming that the Export Sludge is pumped in this concentration range, the data was analyzed to determine a manageable pressure range for maximum and average flow rates, as provided in Table 8-5.

Table 8-5 Export Pumping Criteria

	Flow (gpm)	Pressure (psi)
Average	60	125 - 150
Maximum	100	200 - 220

Hydraulic system curves were developed according to the methods described above. The system curves are provided in Figures 8-1, 8-2, and 8-3 for 1.0 percent solids, 2.0 percent solids, and 3.0 percent solids, respectively.

Figure 8-1 Existing Pipeline System Curve at 1 Percent Solids

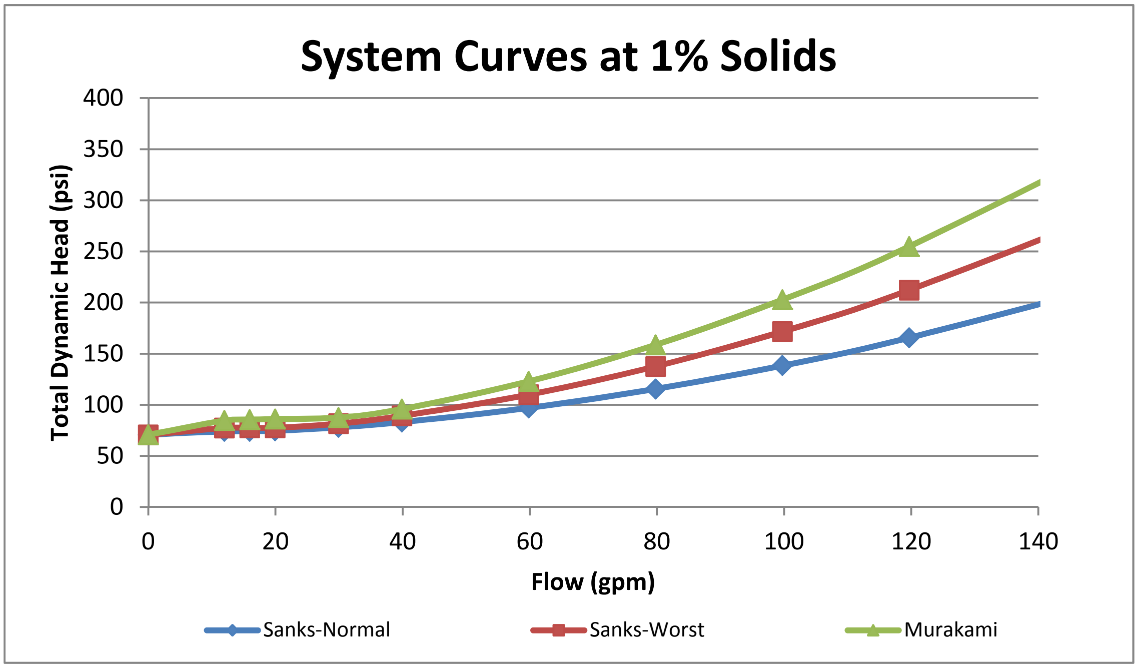


Figure 8-2 Existing Pipeline System Curve at 2 Percent Solids

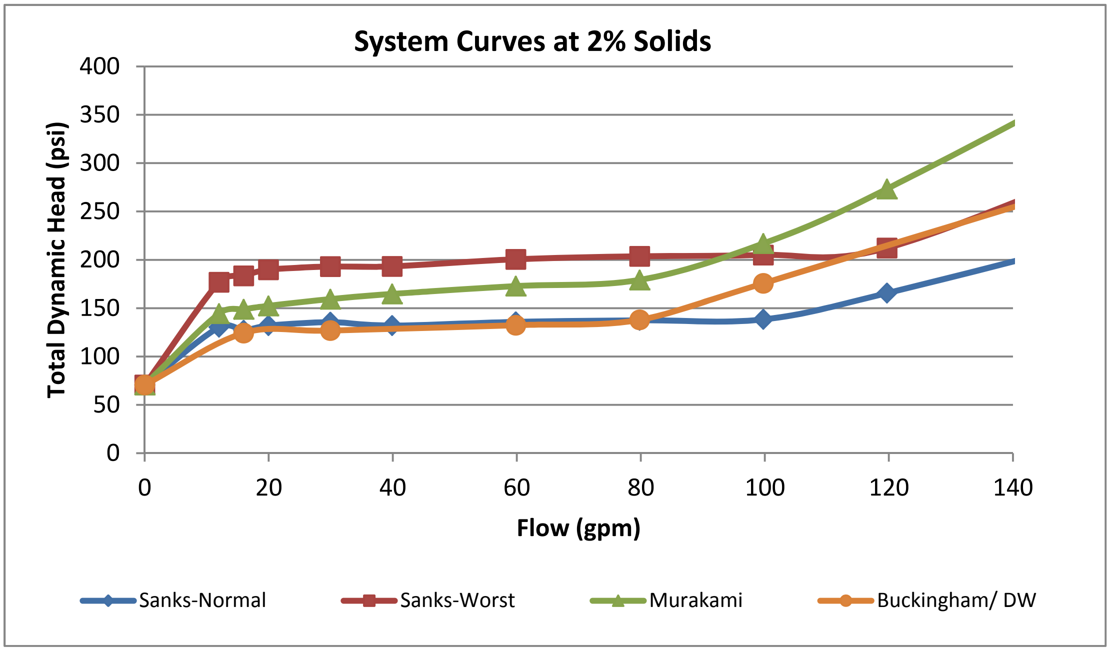
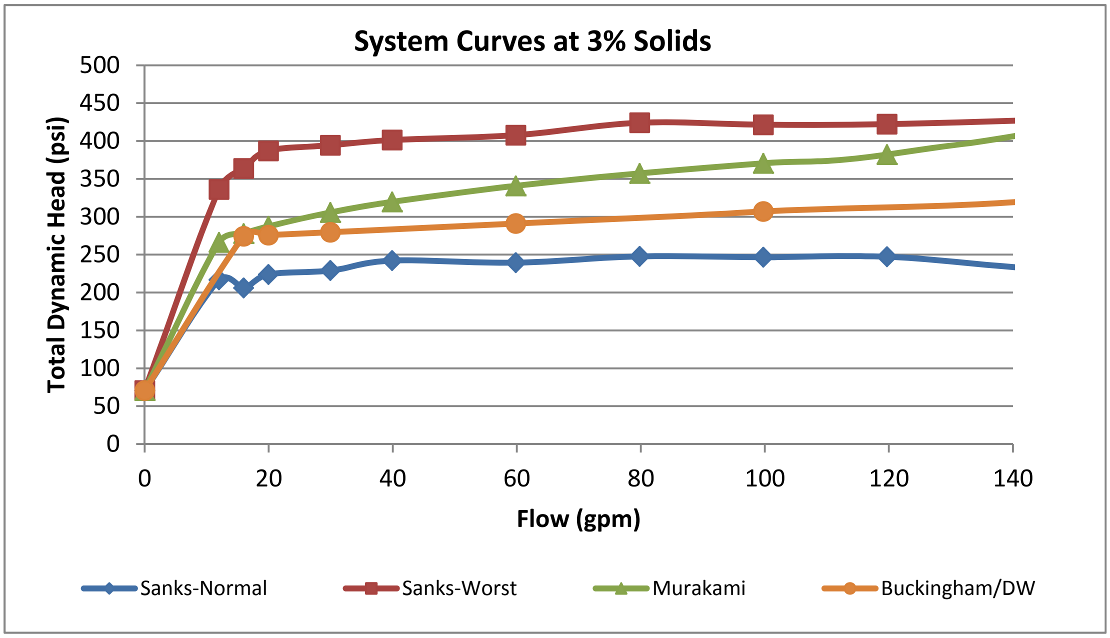


Figure 8-3 Existing Pipeline System Curve at 3 Percent Solids



It is noted that at 1.0 percent solids, the system curves takes the shape typical for pumping water. At 2.0- and 3.0 percent solids, the curves take a much different shape, suggesting a non-Newtonian fluid. A comparison of the method results to CTP data is provided in Table 8-6.

Table 8-6 Model Results for Existing Conditions

	1% Solids		2% Solids	
Flow Rate (gpm)	60	100	60	100
CTP	125 - 150	200 - 220	125 - 150	200 - 220
Sludge Factor-Routine	97	138	136	138
Sludge Factor-Worst Case	110	172	201	205
Murakami	123	203	173	217
Buckingham/Darcy-Weisbach	N/A	N/A	132	176
Average	110	171	160.5	184

The modeling results suggest that the routine sludge factor method under-estimates the pressure, especially under increasing percent solids concentrations. Comparing the results and the previous figures, both the Murakami and Buckingham equations appear to suggest the best approximation of headloss through the existing force main, particularly Murakami's equations.

8.2.1.6 Future Conditions

Hydraulic models, following the methods presented, were created for the proposed alignments through the Aliso and Wood Canyons Park, and using the Phase I and Phase II projects which installed 6-inch diameter ductile iron pipe through the Laguna Niguel Regional Park. Both alignments assume the continued practice of co-thickening at the RTP DAF thickeners. Additionally, both alignments assume an increase in the proposed pipe diameter due to previous difficulties in maintaining a 4-inch pipeline. As stated previously, the minimum diameter for sludge pipelines is recommended to be 6 inches (EPA, WEF-ASCE).

Various pipe materials were reviewed in relation to inner diameter, pressure rating, and the CTP flows. Ductile iron pipe provides an inner diameter greater than the nominal diameter. A 6-inch pipe will have an inner diameter of 6.275 with standard mortar lining. Under the current average flow of 60 gpm, this diameter results in a velocity of 0.62 feet per second (fps). This velocity is extremely low. Industry standards for wastewater flow, either pumped or gravity, recommend a minimum velocity of 2 fps. Sludge flows are recommended at 2 fps or more to prevent deposition. Under current flows, the Phase I and Phase II portions of the new pipeline experience this low velocity. It is recommended that the new alignment utilize a smaller diameter.

High-density polyethylene (HDPE) pipe with a 250 pounds per square inch (psi) pressure rating has an inner diameter of 5.3 inches. This diameter increases average velocity to 0.87 fps. Under maximum month flows (100 gpm), the velocity will increase to 1.45 fps. While these velocities are still below industry standards, a smaller pipe size is not available under the current pressures without returning to a 4-inch diameter ductile iron pipe. For these reasons, the proposed alignments were modeled assuming 6-inch HDPE pipe.

As a result of the limited velocities, periodic flushing of either alignment is recommended. Flushing with secondary effluent is recommended as the fluid is equivalent to pumping clean water. Recommended flushing velocities are 5 to 7 fps. Required flow and pressure impacts will be discussed under each alternative.

8.2.1.7 East Alignment (FM-1)

The east force main alignment (Alternative FM-1) follows the existing 4-inch pipeline through Aliso and Wood Canyons Park. This alignment has the advantage of minimal elevation changes and a flat profile. The results of the hydraulic model under changing percent solids are present in Figures 8-4 (1 percent solids), 8-5 (2 percent solids), and 8-6 (3 percent solids), respectively.

Figure 8-4 **Pipeline Alternative FM-1 System Curve at 1 Percent Solids**

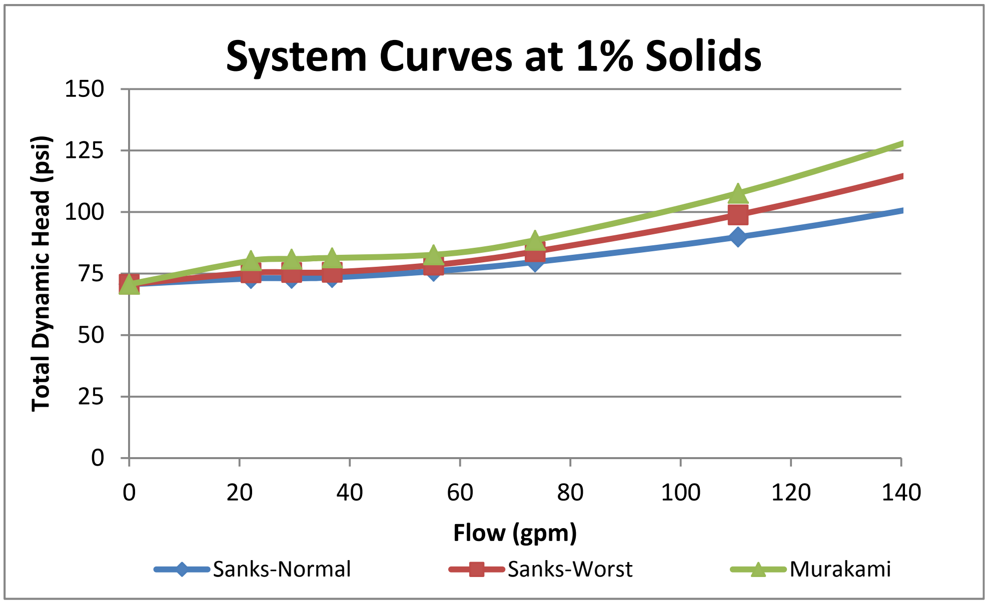


Figure 8-5 **Pipeline Alternative FM-1 System Curve at 2 Percent Solids**

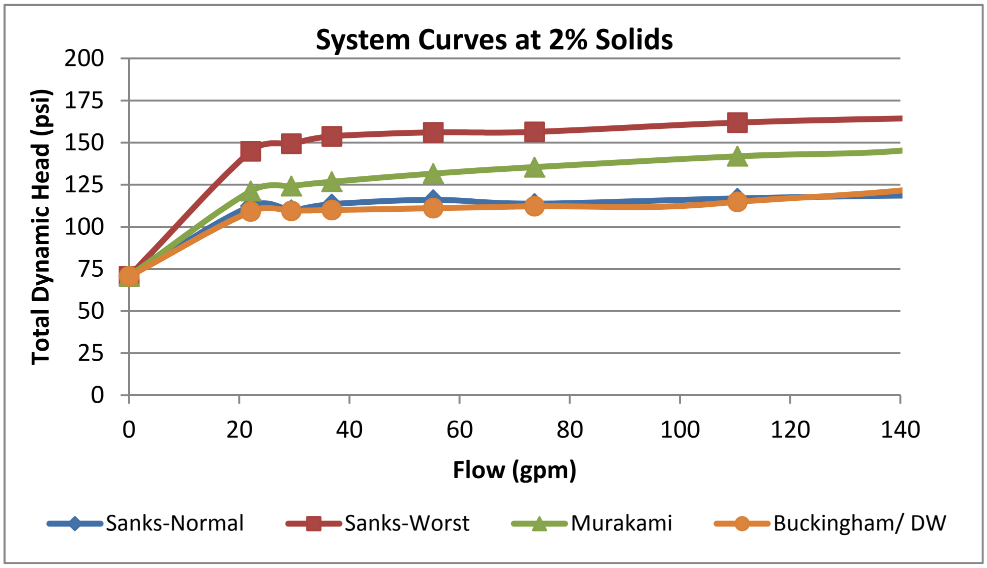
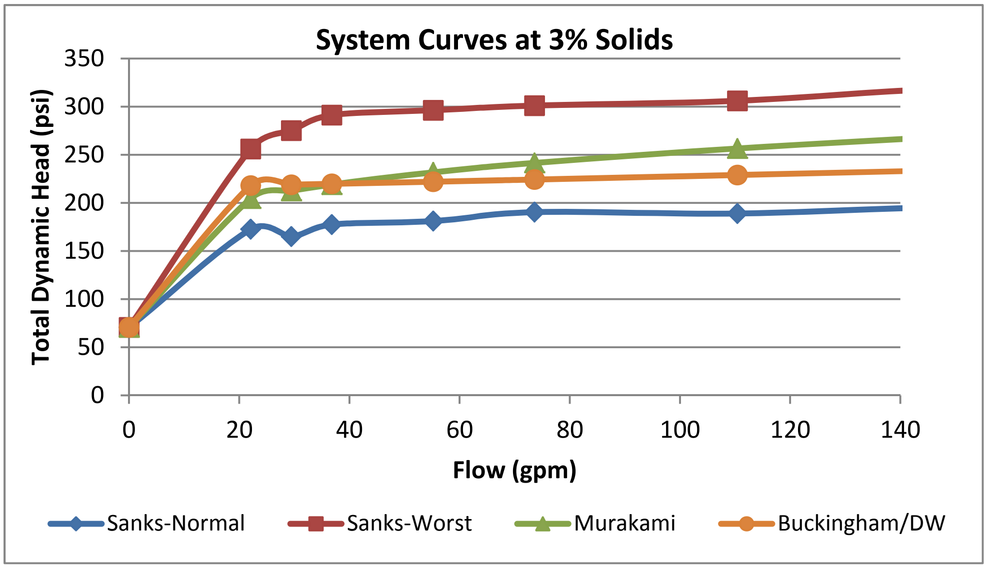


Figure 8-6 Pipeline Alternative FM-1 System Curve at 3 Percent Solids



The results, except for the routine-sludge factor method, indicate that pumping at more than 2 percent solids will approach or exceed the pressure rating of the HDPE pipe. Table 8-7 provides the model results for 1 and 2 percent solids. An average headloss is also provided.

Table 8-7 Alternative FM-1 Hydraulic Model Results

	1% Solids		2% Solids	
Flow Rate (gpm)	60	100	60	100
Sludge Factor-Routine	77	86	115	118
Sludge Factor-Worst Case	80	95	156	158
Murakami	84	102	133	140
Buckingham/DW	N/A	N/A	112	114
Average	80	94	129	133

Using a clean-water hydraulic model, a flow of 325 gpm will produce a pressure of 214 psi, and a flushing velocity of 4.7 fps through the 6-inch HDPE pipe. Velocity through the Phase I and II ductile iron pipe will reduce to 3.4 fps. At 214 psi, a safety factor of approximately 1.2 is provided for the HDPE pipe. The ductile iron pipe is rated for 350 psi.

8.2.1.8 West Alignment (FM 2)

The proposed west force main alignment (Alternative FM-2) follows the existing access road through the park to the RTP. The alignment traverses significant elevation changes. The use of HDPE pipe allows for horizontal direction drilling through the larger elevation changes, reducing the need for deep trenching or problematic air-release valves. The west alignment is significantly longer than the east alignment, by approximately 2,700 feet.

The results of the hydraulic model under changing percent solids are present in Figures 8-7 (1 percent solids), 8-8 (2 percent solids), and 8-9 (3 percent solids), respectively.

Figure 8-7 Pipeline Alternative FM-2 System Curve at 1 Percent Solids

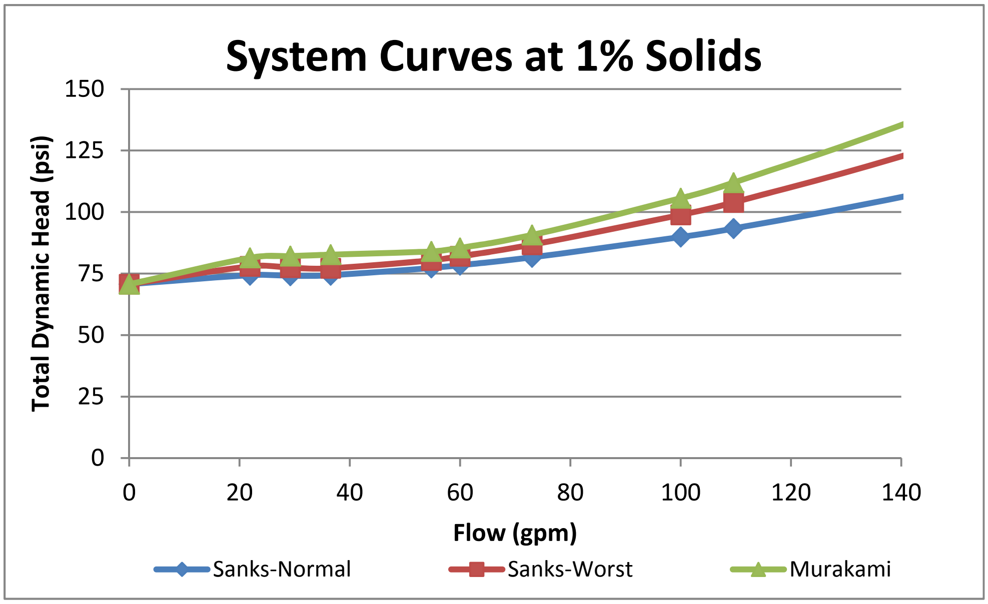


Figure 8-8 Pipeline Alternative FM-2 System Curve at 2 Percent Solids

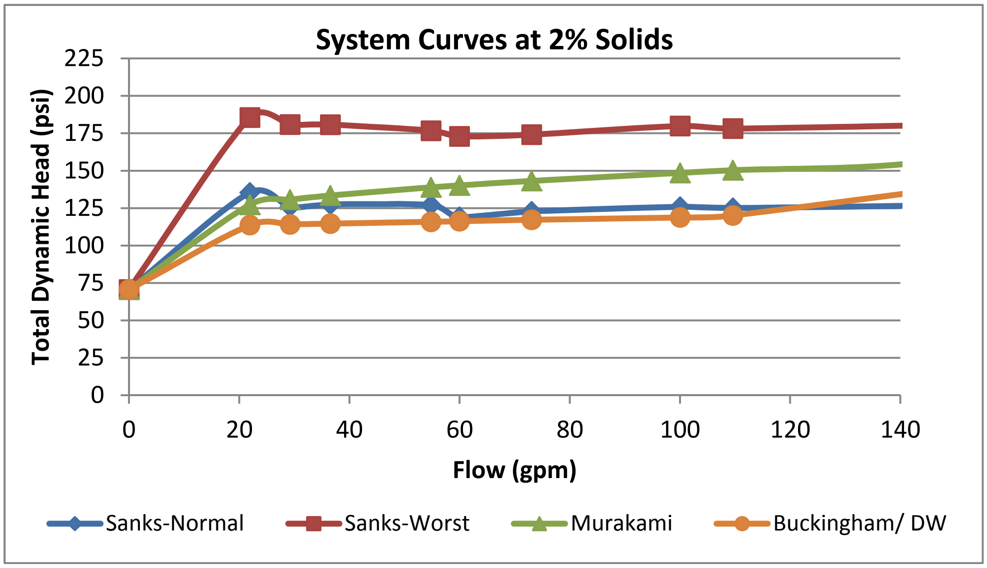
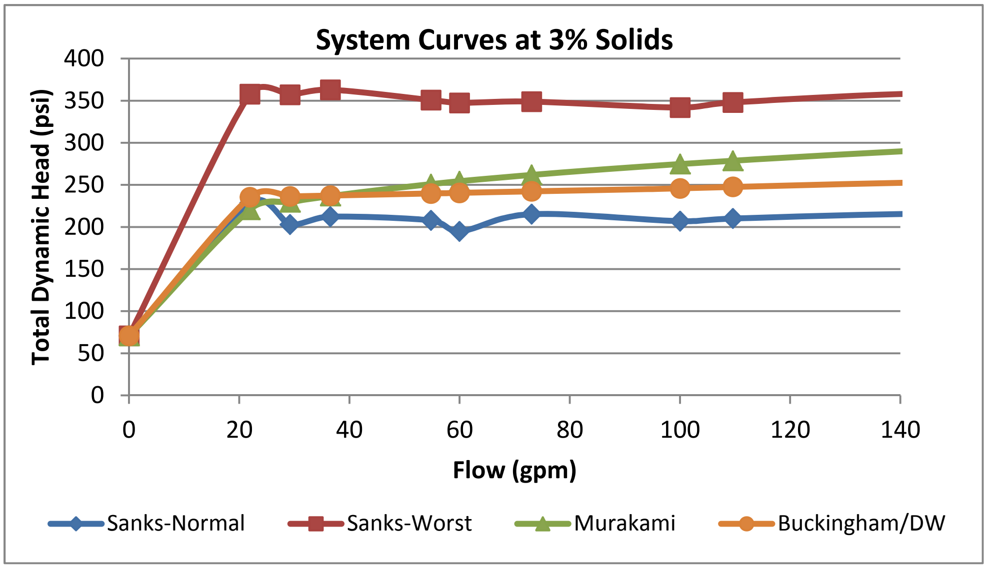


Figure 8-9 Pipeline Alternative FM-2 System Curve at 3 Percent Solids



Similar to Alternative FM-1, the results indicate that pumping at more than 2 percent solids will approach or exceed the pressure rating of the HDPE pipe. Table 8-8 provides the model results for 1 and 2 percent solids.

Table 8-8 Alternative FM-2 Hydraulic Model Results

	1% Solids		2% Solids	
Flow Rate (gpm)	60	100	60	100
Sludge Factor-Routine	78	90	119	126
Sludge Factor-Worst Case	82	99	173	180
Murakami	85	106	140	149
Buckingham/DW	N/A	N/A	116	120
Average	82	98	137	144

Similar to Alternative FM-1, a slightly lower flow of 300 gpm will produce a pressure of 214 psi, providing a 1.2 safety factor. The flushing velocity through the HDPE pipe is 4.4 fps and the velocity through the Phase I and II ductile iron pipe will reduce to 3.1 fps.

8.3 Recommended Design Pressure

The various hydraulic models provide a range of headloss predictions. The Murakami's equations more closely approximate the existing conditions. It is noted that the existing conditions most likely include internal scaling or build-up of debris along the pipe wall resulting from the age and low velocities of the existing export pumping system.

Considering the existing and proposed alignments, the sludge factor-routine condition consistently predicts the lowest headloss. It is not recommended for design consideration. Additionally, the Bingingham, Darcy-Weisbach method appears to under-estimate headloss in the

1 to 2 percent solids region. At 3 percent solids, the method does approach the Murakami estimates.

The Murakami and sludge factor-worst case scenario appear to provide the most conservative estimates for pumping solids in the 1 to 2 percent solids range. Due to the low velocities expected, pumping at a higher percent solids concentration is not recommended. This condition would further reduce the velocity. Solids deposition would occur, and the effect on pumping pressures cannot be estimated.

At 1 percent solids, the two methods are within 4 to 7 psi of each other. This result is expected as the system curves indicate Newtonian fluid behavior. However, at 2 percent solids, the Murakami method is as much as 33 psi less. To determine a recommended design pressure, additional information will need to be considered, as discussed below.

First, reviewing the figures presented in the previous sections, the Murakami curves and the Bingingham, Darcy-Weisbach curves approach each other as the percent solids increase (increasingly laminar flow conditions). The Bingingham approach to laminar flow calculations has long been an accepted method considering its introduction decades ago and continued inclusion and discussion in recent publication (ASCE, Murakami, Bechtel). Additionally, research into computational fluid dynamics (CFD) modeling for estimating sludge-induced friction losses has shown that the sludge factor method appears to under-estimate headloss in turbulent flow and over-estimate headloss in laminar flow (Bechtel).

Under the proposed scenarios, and for varying percent solids, the average of the hydraulic methods is considerably close to the headloss predicted by the Murakami equations. Additionally, the Murakami equations most closely predict the existing conditions, suggesting that the equations provide some safety factor for age and unknown conditions. Therefore, it is recommended that Murakami's equations be used in estimating pipeline pressure for pumping solids at any solids content.

Considering the low velocities encountered in the Alternative FM-1 and FM-2 alignments, it is recommended that the percent solids be limited to less than 2 percent. For Alternative FM-1 and FM-2, Murakami estimates a headloss of approximately 105 psi at 1 percent solids, and 150 psi at 2 percent solids. This result is considerably less than current pressures and is predominantly due to the increase in internal pipe diameter.

The overall design pressure is determined to be the 250 psi pressure rating of the 6-inch HDPE pipe. This design will allow for flushing velocity while limiting the inner diameter as much as is practical.

Flushing of the pipeline will be required as a frequent maintenance practice. Secondary effluent will be utilized for flushing. The RTP DAF thickeners will not be capable of receiving the flushing volume. A bypass pipeline should be installed at RTP to route flushing flows to the primary clarifiers.

9 PIPELINE MATERIAL EVALUATION

Ductile iron pipe (DIP) is typically specified for long-distance sludge pumping. DIP can be lined with cement, glass, or polyethylene. DIP has higher-pressure rating compared to other pipe materials. DIP also provides a larger inner-diameter. However, for the flows and pipe diameters present at the CTP, RTP and the Phase I and II pipeline upgrades, the increased diameter reduces velocities below 2 fps.

As discussed previously, HDPE pipe provides a reduced inner diameter, capable of meeting the design pressure. The HDPE pipe also provides a smooth surface to reduce friction. Most importantly, HDPE is applicable to trenchless construction methods that eliminate the need for ARV's. HDPE pipe material is, therefore, recommended.

10 PIPELINE MAINTENANCE CONSIDERATIONS

This section describes the recommended maintenance and design considerations for Alternatives FM-1 and FM-2. Agencies with similar sludge conveyance pipelines were interviewed to ascertain potential operational and maintenance challenges that may have been experienced. The results of those interviews are provided in Appendix C.

10.1 Flushing

As discussed above, periodic flushing will be required. The normal operating velocity will be lower than the recommended 2.0 fps. The flushing operation will be coordinated with RTP operations. Currently, a fire hydrant at the RTP is used to flush back to the CTP. The flushing flow is discharged to the plant drainage pump station. In the future, it is recommended that the flow be diverted to the Primary Clarifier Influent Channel to reduce the risk of overloading the drainage pump station wet well.

Frequency of flushing is recommended quarterly to reduce deposition and prevent increased pressures in the pipeline. If pressures increase significantly over the period, then more frequent flushing should occur. The phone surveys suggest that other municipalities clean export sludge lines in periods ranging from every 3 months to every 12 months. All agencies surveyed monitor pressure and clean when the pressure reaches a predetermined setpoint. The agencies also indicated an approximate time of 24 hours necessary to adequately clean the force main.

As Export Sludge pumping at the CTP is an intermittent operation, flushing can be used to both clean the force main and prevent sludge deposition and scaling during non-pumping periods. Operations staff would pump flow from the RTP into the force main upon ceasing sludge pumping operations. The flow would expel the sludge from the force main to the CTP. As a result, the force main would be filled with secondary effluent during non-operational periods. Upon return to sludge pumping operations, the sludge would easily displace the water from the force main, thereby avoiding potentially high pressures necessary to re-entrain settled sludge within the force main. Pumping from RTP could also be increased to achieve reliable scouring velocities after sludge is expelled to effectively clean the force main on an intermittent basis, providing for longer service life of the force main.

Another consideration in flushing operations is the installation of clean-outs along the force main alignment. Clean-outs would allow access along the length of the pipeline for additional cleaning. This cleaning access would be useful if a blockage occurs that cannot be cleared through flushing. However, considering the location of the pipeline, the clean-outs should be located strategically to avoid any release to the environment. Installing the clean-outs in concrete vaults will help protect against unwanted release.

10.2 Mechanical Cleaning

Mechanical cleaning would entail the use of compressible "pigs". Pipeline pigging has been implemented in the past. A pig receiving station is located at the RTP, prior to discharge to the Sludge Equalization Tanks.

Under past pigging operations, the pig was not always retrieved at the receiving station. The pig may have made its way into the crossovers between the parallel 4-inch force mains. These crossovers have subsequently been removed. Operations staff has also used a "smart" pig that allows sensing its location at the surface. This pig was also not recovered at the RTP.

The City of San Diego has operated two sludge pipelines for over ten years. One pipeline conveys raw sludge, the other digested sludge. Both pipelines have been pigged only once. No increase of system pressure has been observed. With good design, mechanical cleaning can be avoided for long intervals.

Other agencies, such as the Las Virgenes Municipal Water District, perform mechanical cleaning every three to four months, depending on system pressure. The cleaning involves first flushing the pipeline for an extended period prior to pigging. The pigs often miss the receiving station and are later retrieved from the raw sludge wet well at the receiving facility.

The project currently considers a single pipeline. With the history of losing pigs, coupled with the expected deep profile, mechanical cleaning is not recommended for normal maintenance. However, pig launching capability may be incorporated in any new pumping design. The pig catching facility already exists at the RTP.

10.3 Export Sludge Equalization Basin

The Phase I and Phase II portions of a new force main were installed in the late 1990's as a single pipeline, as compared to the existing dual pipeline system. A single pipeline increases operational complexity during shutdowns for flushing, maintenance or repair. The shutdown of a single pipeline requires storage of solids within the plant's treatment basins. Storage of solids results in rapidly deteriorating effluent quality. Also, production of recycled water must be terminated within 24 to 48 hours of an Export Sludge system shutdown. As effluent water quality deteriorates, SOCWA risks the potential of NPDES permit limit violations. Construction of an Export Sludge Equalization Basin is proposed to provide approximately three days of sludge storage during flushing operations. This tankage facilitates continued construction of a single pipeline option.

The Export Sludge Equalization Basin is also necessary for implementation of Alternative TR-1. As noted in Section 5, trucking of sludge on weekends and holidays may not be possible as a result of the high number of Park patrons using AWMA Road. The Export Sludge Equalization Basin allows storage of sludge over a three-day weekend.

The concept for the Export Sludge Equalization Basin was originally developed as part of a Preliminary Design Report (prepared in 2006). The project will be further refined in the summer of 2012, with construction expected to begin in late 2012. This project is moving ahead independent of a final recommendation for the Export Sludge system replacement, as it is a necessary component for both the FM and TR alternatives.

11 ENVIRONMENTAL IMPACTS & ONGOING COMPLIANCE

Presently, the intent of SOCWA is to complete a preliminary evaluation of the various alternatives based on implementation, constructability, access, potential environmental mitigation and project cost. Close coordination with ongoing environmental compliance will assure that studies, surveys and research focuses on the various project alternatives. For the environmental scope tasks, the environmental compliance work has thus far conducted the following:

- Prepared the Notice of Preparation (NOP) and reviewed public comments on the NOP
- Conducted the NOP scoping meeting
- Met with cultural and Native American stakeholders to discuss Dudek research methods
- Conducted field surveys for several topics
    - Cultural resources
    - Paleontological resources
    - Biological resources (including rare plants, least Bell's vireo and SW willow flycatcher, CA gnatcatcher, pond turtle, and wetland delineation)
    - Visual survey
- Prepared preliminary memos addressing the topics of biology and cultural resources. Memos to be posted to SOCWA website and to be subject of next public workshop
- Prepared much of the existing conditions sections of the EIR, for 10 environmental topics
- Conducted research on cumulative projects for use in EIR

The result of the PDR will provide clear and coherent project descriptions for the ongoing Environmental Impact Report to comply with the CEQA process.

12 GEOTECHNICAL REVIEW

Ninyo & Moore performed a preliminary geotechnical evaluation of the two Export Sludge force main alternative alignments, dated November 18, 2011. The results of that report are presented in Appendix D. Based on the geotechnical evaluations, the geotechnical conditions on both sides of the Aliso Creek are found to be similar.

The proposed alignments roughly parallel the existing creek and are generally underlain by older alluvial and slope wash deposits (undifferentiated). The pipeline alignments are located near the base of the canyon wall slopes, which are comprised of Tertiary age sedimentary formations, including Monterey, Topanga and Capistrano Formations and the San Onofre Breccia. Some slope areas have been mapped as large bedrock landslides. No active faulting is known to be present crossing the proposed alternative alignments.

The proposed alignments may be susceptible to various geologic hazards. Geologic hazards that could impact the pipeline include creek erosion, creek embankment stability, landslides and liquefaction. These conditions and other geotechnical aspects of the project are discussed in the following sections with regards to the proposed alternative alignments.

12.1 Creek Erosion and Stability

The issues of creek erosion and stability have been addressed in the separate draft report 'Lower Aliso Creek Erosion Assessment'.

12.2 Landslides

The proposed alignment (FM-1) on the eastern side of the creek crosses a significant area where large landslides have been mapped. No prior subsurface evaluations were performed on these landslides. Two landslides were mapped along the western edge of the AWMA Road, near the CTP. These landslides were previously evaluated with subsurface exploration. The landslides are complex and considered to be relatively old features. The base of the slopes includes a mantle of slope wash and alluvial deposits. The landslides were not exposed in the current creek alignment. The toe of the landslide is expected to be below the creek channel.

Reactivation of landslides could damage existing pipelines, as well as a new force main. No ground cracks, scarps, seepage, or other signs of recent landslide movement were observed. The basal rupture surfaces of these large landslides are anticipated to be relatively deep below the creek bottom. Shallower rupture surfaces and fracture zones may be present, which could be relatively unstable. In general, minor grading for the pipeline construction should not impact the stability of the large landslides, but trenching for new pipeline could expose rupture zones, fractured material, or other unstable conditions.

To further evaluate the landslides impacting the proposed pipeline alternative, subsurface exploration will be required. Depending on the subsurface conditions, it may be reasonable to design the improvements as to reduce the impact of the new force main to the stability of the hillside. This design would include limited excavations and fills, as well as implementing suitable drainage provisions. Alternatives to trench excavation may include pipe bursting within the existing sludge lines or horizontal directional drilling through the landslide deposits.

12.3 Liquefaction

Previous subsurface exploration indicated that alluvium along the alignment is comprised predominantly of relatively clayey soils with a low potential for soil liquefaction. Some potentially liquefiable sandy alluvial layers are, however, anticipated at some locations. Seismic liquefaction may result in settlement and slumping of channel banks which could impact the pipeline. Creek bank stabilization may be performed to mitigate potential for seismic induced slope failures. Liquefaction may also result in soil settlement and sand boils.

12.4 Compressible Soils

Undocumented fill and loose natural soils are expected along the alignments. The fill and loose natural soils are considered to be potentially compressible under future loading from new fills or force main improvements. To provide suitable support of the force main, some removal and recompaction of potentially compressible soils below the force main may be required.

12.5 Groundwater

In general, no groundwater seepage or active springs were observed near the base of the canyon slopes or in accessible areas of the creek channel slopes. Significant water flows were observed from the drainage tributary along the Aliso Trail, south of the drop structure of the creek crossing. Groundwater was previously encountered in borings drilled on the eastern and western sides of the creek at depths varying between 6.5 and 39.0 feet at the time of the drilling. In general, groundwater is expected to be near the elevation of the adjacent stream level. Groundwater levels along the alignments can vary with seasonal storms, change in topography, stratigraphy, runoff and other environmental changes.

12.6 Grading

Grading is anticipated to include relatively shallow cuts and fills. Considering the potential slope stability challenges near mapped landslide areas, the force main will need to avoid excavations of more than 5 feet in those areas. As design plans become available, detailed geotechnical evaluation of landslide areas will be performed to evaluate grading impacts. Future excavations and fill areas will be evaluated on a case by case basis.

12.7 Excavation Characteristics

Excavations are expected to be within the alluvial materials along the alignment and may be accomplished with conventional backhoe, excavators, or other trenching equipment. The materials along the alignments are expected to consist predominantly of clays and silts with lesser amounts of sands. In addition, gravel and cobbles may be encountered during the trenching and/or tunneling operations. Excavations in the bedrock materials (Topanga and Monterey Formations), as well as the bedrock landslides exposed in the slope areas, may be difficult and may require heavy ripping.

12.8 Drainage

Drainage tributaries from the canyon slopes crossing the alignments may undermine the proposed pipeline and impact the stability of the creek embankments. Erosion protection and drainage improvements will be required where these tributaries cross the proposed force main alignment.

13 COST OPINIONS FOR PROJECT ALTERNATIVES

Opinions of probable construction cost are provided for the three alternatives, to establish the order of magnitude cost for each alternative. The cost opinions are based on the quantities and unit price models developed from the preliminary design, quotations from manufacturers, general contractors and site conditions. In addition, a project complexity factor is incorporated into the unit price to adjust for expected difficulties based on site and work conditions.

The cost opinions are based on a preliminary design, equivalent to 30 percent plan and profile of alignments, and are considered Class 3, AACE (ref.: Association for the Advancement of Cost Engineering International Recommended Practice 18R-97) cost opinions (see Table 13-1). Class 3 cost opinions are prepared to form a basis for budget authorization and/or funding. Typically, engineering is between 10 and 40 percent complete for Class 3 cost opinions. Class 3 cost opinions are used for project budget definition until replaced by more detailed cost opinions based on subsequent design completion. As such, the accuracy range of Class 3 cost opinions are typically between -20 and +30 percent. Based on our understanding of the project, a 30 percent contingency has been applied to develop the cost opinions in this report.

Table 13-1 Cost Opinion Classifications

Estimate Class	Primary Characteristic	Secondary Characteristic			
	Level of Project Definition Expressed as % of Complete Definition	End Usage Typical Purpose of Estimate	Methodology Typical estimating method	Expected Accuracy Range Typical Variation In Low And High ranges (a)	Preparation Effort Typical Degree of effort relative To Least Cost Index of 1(b)
Class 5	0% to 2%	Concept Screening	Capacity Factored. Parametric Models. Judgment or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Fusibility	Equipment Factored or Parametric Model	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to40%	Budget Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15"% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes: (a) *The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.*

(b) *If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the Project and the quality of estimating data and tools.*

13.1 Costing Methodology

Developed construction cost estimates use current budgetary quotes for major materials, temporary equipment and major process equipment, as detailed in the preliminary design submittal. Minor materials and equipment costs were developed using recent similar project bid data. The cost opinions incorporate certain assumptions as to the means and methods predicted to be utilized during construction, and those assumptions are reflected in the cost opinions for a complete and operable Export Sludge force main or trucking alternative.

13.1.1 Equivalent Annual Costs

The alternatives have been compared based on an equivalent annual cost. The equivalent annual cost considers annual O&M cost, annual capital costs, and project life. The differing project lives can be accounted for by crediting the residual salvage value at the end of the project analysis period.

The equivalent annual cost factors used in this analysis are given in Table 13-2.

Table 13-2 Equivalent Annual Cost Factors

Cost Factor	Value
Project Analysis Period	20 years
Structural and Pipeline Life	50 years
Mechanical Life	20 years
Depreciation	Straight Line
Interest Rate	6 percent

The expected O&M costs have been estimated for the three main alternatives. The O&M costs include labor, maintenance, power, chemicals, and transportation. The costs are based on the factors reported in Table 13-3.

Table 13-3 Operations and Maintenance Cost Factors

Cost Factor	Unit Cost
Labor	$35 per hour
Electrical Power	$0.09 per kWhr
Diesel Fuel	$4.50 per gallon
Polymer	$1.80 per pound

13.2 Bidding Assumptions

Construction activities for the Export Sludge Force Main Replacement will require a California Contractor’s Class A Contractor’s (General Engineering Contractor) license.

For the purposes of estimating cost escalation, to the mid-point of construction, an escalation factor has been included. Assuming an escalation factor of 3 percent per year, an increase of 3 percent has been factored to reflect an anticipated construction duration of nine months, which is expected between the development of this estimate and midpoint of construction.

13.3 Construction Schedule

The schedule for construction, including Contractor mobilization/demobilization, is projected to be approximately 250 working days with work assumed to begin in the spring of 2013.

13.4 Engineer's Opinion of Probable Construction Cost

Based on the above cost opinion assumptions and construction conditions, the preliminary design cost opinions for the alternative Export Sludge force main alignments are as follows:

Alternative TRI	$ 6,583,000
Alternative FM-1	$ 5,235,000
Alternative FM-2	$ 5,630,000

Based on information developed in Sections 5 and 6 of this PDR, Table 13-4 defines the equivalent annual cost of the sludge hauling alternative (Alternative TR-1). It is noted that the sludge hauling costs are based on a 7-day hauling schedule and a single truck purchase, as defined in Section 5.

Table 13-4 Cost Summary for Alternative TR-1

Cost Element	Cost
Capital Costs	
• Sludge Hauling	$ 260,000
• Sludge Thickening	$ 527,000
• Sludge Equalization	$2,750,000
• Bridge Replacement	$3,000,000
• Truck Replacement (PW)	$ 46,000
• Present Worth of Total Salvage Value	$ 1,960,000
Total Annual Costs	$ 220,000
Equivalent Annual Cost[1]	$ 623,100[2]

Note: [1] *Calculated at 6 percent over 20 years*

[2] *Annual Cost = $390,000 without bridge replacement*

Similarly, Table 13-5 and 13-6 summarize the equivalent annual cost opinions for Alternatives FM-1 and FM-2. Detailed construction cost opinions for Alternatives FM-1 and FM-2 are provided in Appendix E. Environmental permitting, mitigation, biological and cultural monitoring, and engineering costs are not included in these cost opinions. Section 11 discusses these impacts, as well as other non-monetary considerations.

Table 13-5 Cost Summary for Alternative FM-1

Cost Element	Cost
Pipeline Costs	$ 2,485,000
Sludge Equalization	$ 2,750,000
Present Worth of Total Salvage Value	$ 2,400,00
Total Annual Costs	$ 125,000
Equivalent Annual Cost[1]	$ 372,200

Note: [1] *Calculated at 6% over 20 years*

Table 13-6 Cost Summary for Alternative FM-2

Cost Element	Cost
Pipeline Costs	$ 2,880,000
Sludge Equalization	$ 2,750,000
Present Worth of Total Salvage Value	$ 2,450,000
Total Annual Costs	$ 125,000
Equivalent Annual Cost[1]	$ 402,300

Note: [1] *Calculated at 6% over 20 years*

Alternative preference is based on a variety of factors, with the preferred alternative providing the best balance between performance, constructability, reliability, access for maintenance, and overall project cost. Table 13-7 provides a comparison of each alternative (FM-1, FM-2 and TR-1) with respect to monetary and nonmonetary factors. Comparisons are included for a variety of factors including:

- Pipe length,
- Pipeline installed costs,
- Operation & maintenance,
- Reliability,
- Additional improvements required,
- Impacts to the existing plant access road,
- Pavement requirements,
- Environmental impacts and mitigation requirements,
- Risk of pipeline/roadway washout, and
- Overall project cost.

The cost analyses include life-cycle comparison, considering operation, maintenance, pumping costs versus the benefits of either trucked or pumped higher sludge concentration at the RTP.

Many of the non-monetary considerations are subjective in nature. However, these factors are considered in a comparative nature to provide a valid qualitative comparison.

It is not the intent of this PDR to identify the preferred alternative. Ongoing environmental compliance evaluations will further refine these alternatives, leading to SOCWA's selection of the preferred alternative for implementation. It is, however, the intent of this PDR to fully define and quantify the engineering requirements and costs of the three alternatives to facilitate the environmental compliance effort, and to provide SOCWA staff with valid comparative information for each alternative. Following review of the draft document, the design team will meet with SOCWA staff to define and document the conclusions and recommendations of this PDR.

Table 13-7 Alternative Summary[4]

Description	Units	Alternative FM-1	Alternative FM-2	Alternative TR-1
Non-Monetary Factors				
Side of Aliso Creek		East	West	West
Pipe Length (1)	LF	16,600	15,800	N/A
Additional Improvements Required (2)	-	Clear and grub, potential creek bank stabilization, Sludge Equalization	Roadway, biking and hiking trail, potential creek bank stabilization, Sludge Equalization	Potential creek bank stabilization, Sludge Equalization
Plant Access Road Impacted During Construction	-	Yes, Construction Traffic Access, minimal	Yes, Construction and Lane Closures, extensive	Additional Vehicle Traffic on AWMA Road
Cultural Resource Disturbance Potential	-	Medium	High	Low
Permitting/Interagency Agreement Difficulty	-	Low	Medium	Low
Environmental Impacts	Acres	11.5	3.0	0.5
Environmental Mitigation Requirements	Acres	11.5	3.0	0.5
Paving or Repaving Required	SF	2,000	128,000	0
Monetary Factors				
Construction Cost	Thousand $	$ 5,235	$ 5.630	$ 6,583
Cost for Environmental Mitigation	Thousand $	$ 200	$ 50	$ 20
Cost for Cultural Monitoring	Thousand $	$ 20	$ 70	$ 0
Engineering Admin (20%)	Thousand $	$ 1,100	$ 1,280	$ 1,330
Estimated Total Project Cost	Thousand $	$ 6,555	$ 7,030	$ 7,933
Annual Costs	Thousand $	$ 125	$ 125	$ 220
Equivalent Annual Cost	Thousand $	$ 372	$ 402	$ 623

Notes: 1) New piping requirements are rounded to the nearest 100 lf.
2) Creek bank stabilization is address in TetraTech report titled 'Lower Aliso Creek Erosion Assessment'.
3) Itemized costs for pipeline costs are provided in Appendix E.
4) Summary is for comparative purposes only. Detailed analyses are provided in the project PDR and EIR documents.

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APPENDIX A

FM-1 Plan & Profiles

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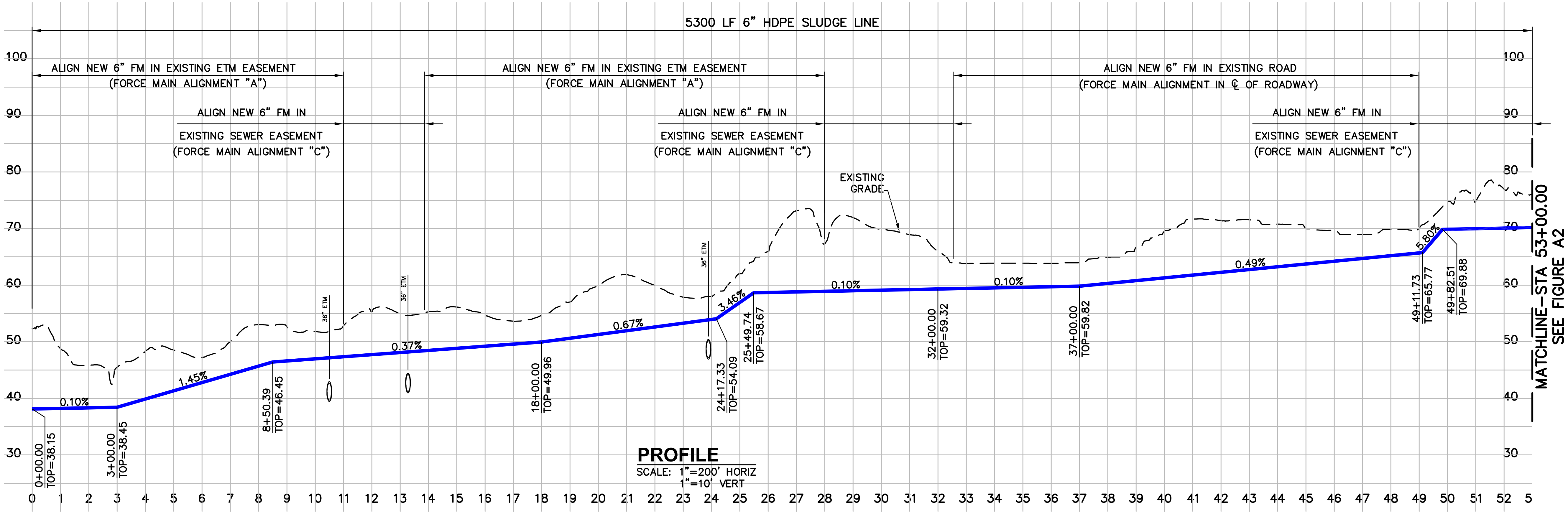

PROFILE

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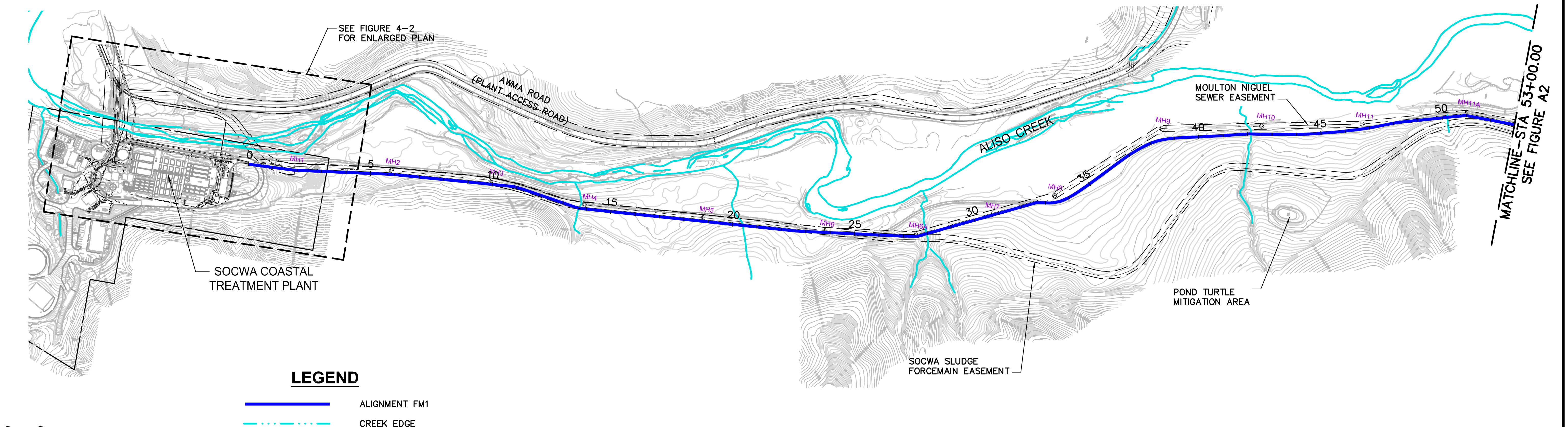
1"=10' VERT



LEGEND

ALIGNMENT FM1

CREEK EDGE

GRAPHIC SCALE

0 200' 400'

SCALE: 1" = 200'

PLAN

SCALE: 1"=200'

FIGURE A1

Proposed Alignment FM 1

Plan and Profile

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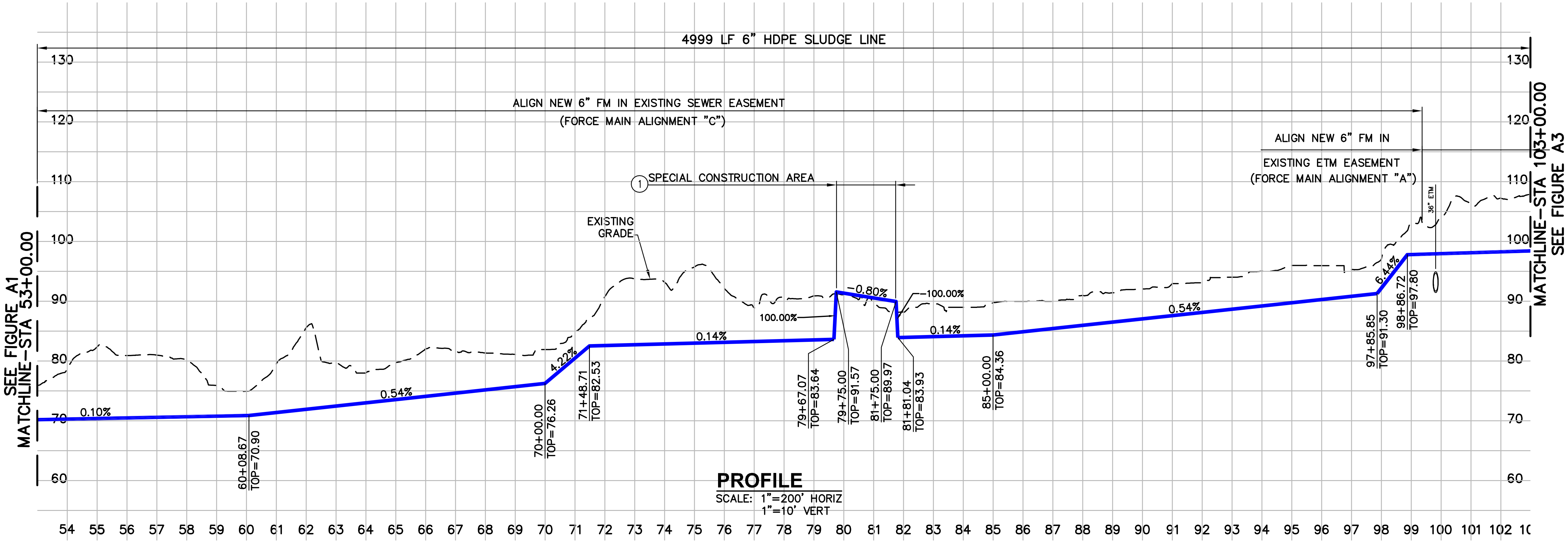
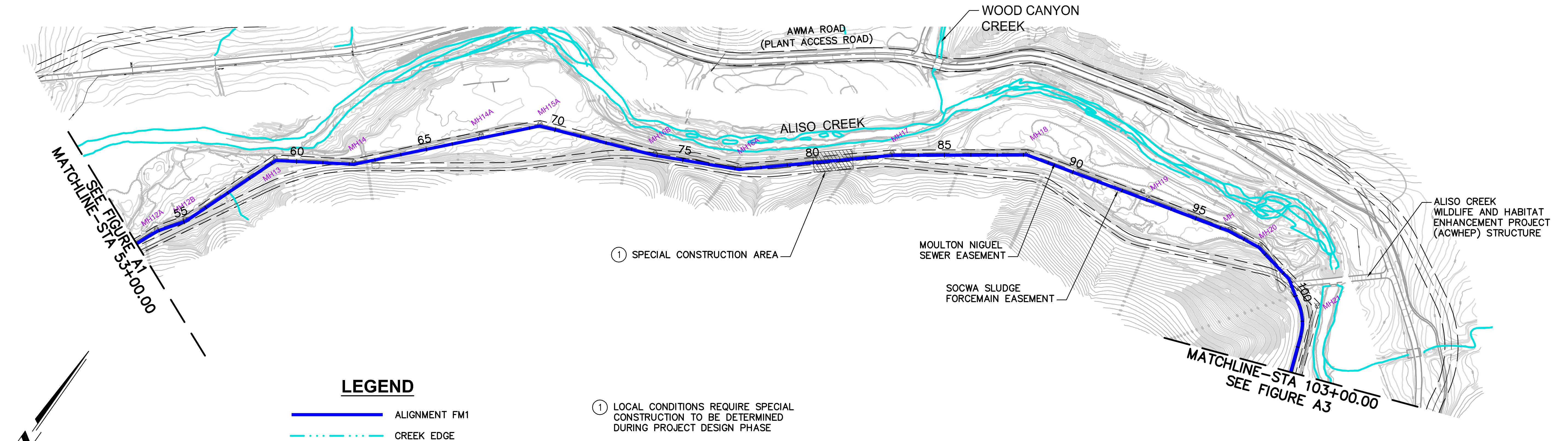


PROFILE

SCALE: 1"=200' HORIZ
1"=10' VERT



① LOCAL CONDITIONS REQUIRE SPECIAL
CONSTRUCTION TO BE DETERMINED
DURING PROJECT DESIGN PHASE

PLAN

SCALE: 1"=200'

GRAPHIC SCALE
0 200' 400'
SCALE: 1" = 200'

FIGURE A2
Proposed Alignment FM1
Plan and Profile

DUDEK

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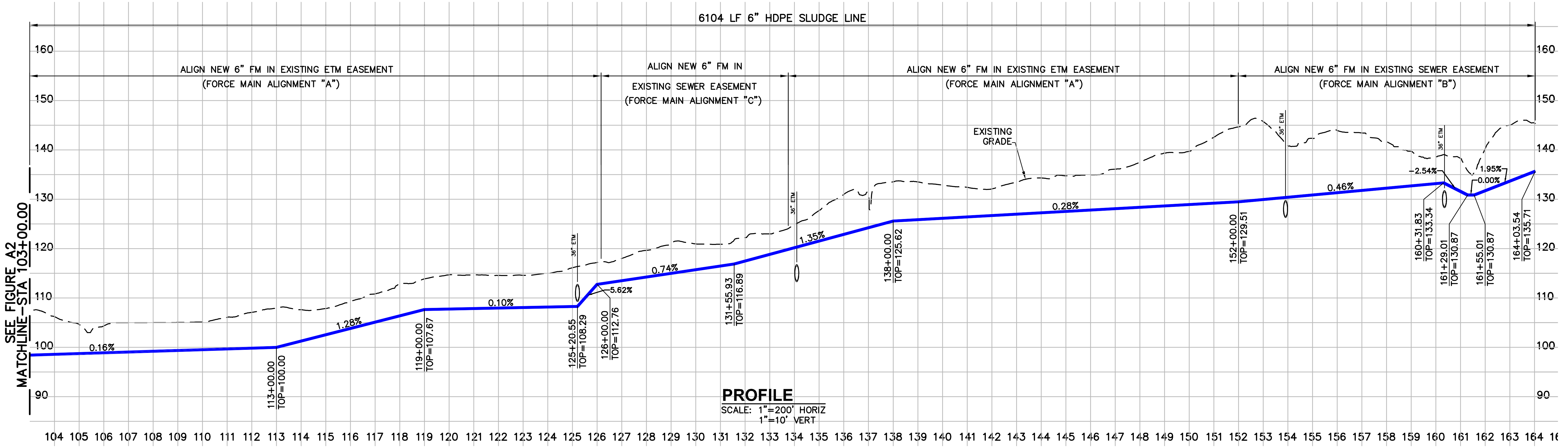

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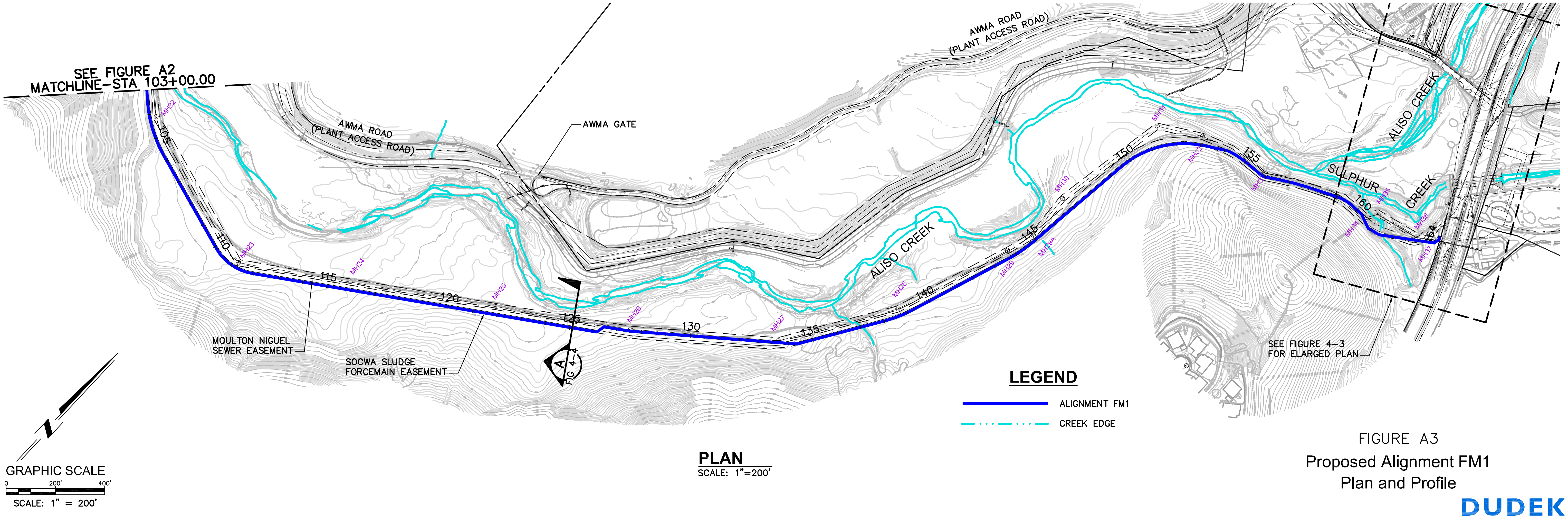

PLAN
SCALE: 1"=200'

FIGURE A3
Proposed Alignment FM1
Plan and Profile

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APPENDIX B

FM-2 Plan & Profiles

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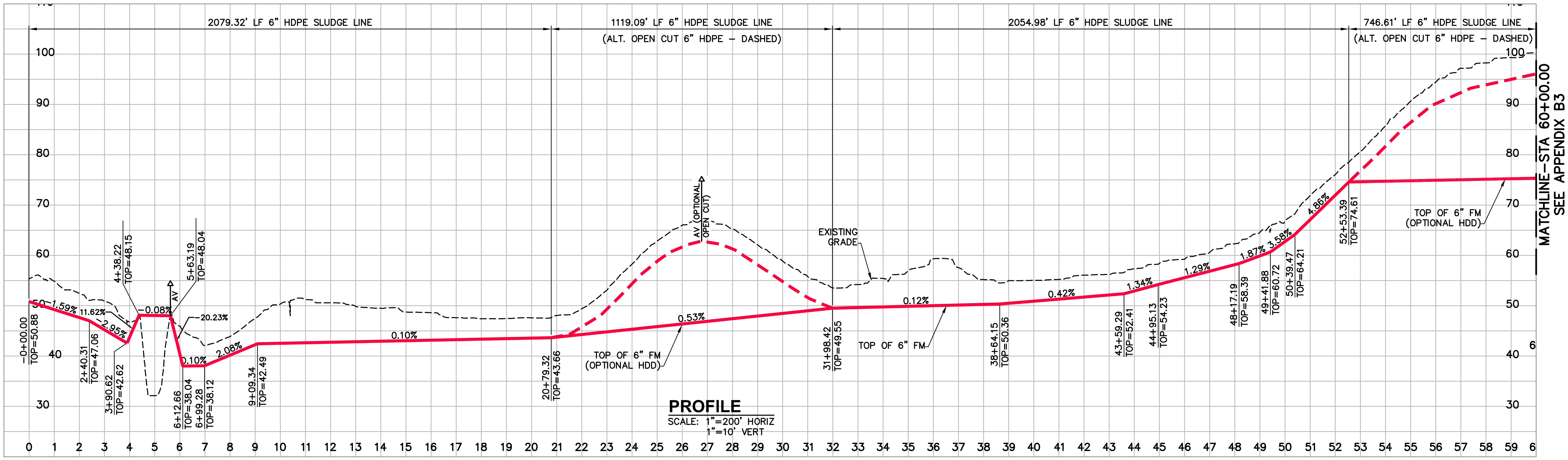

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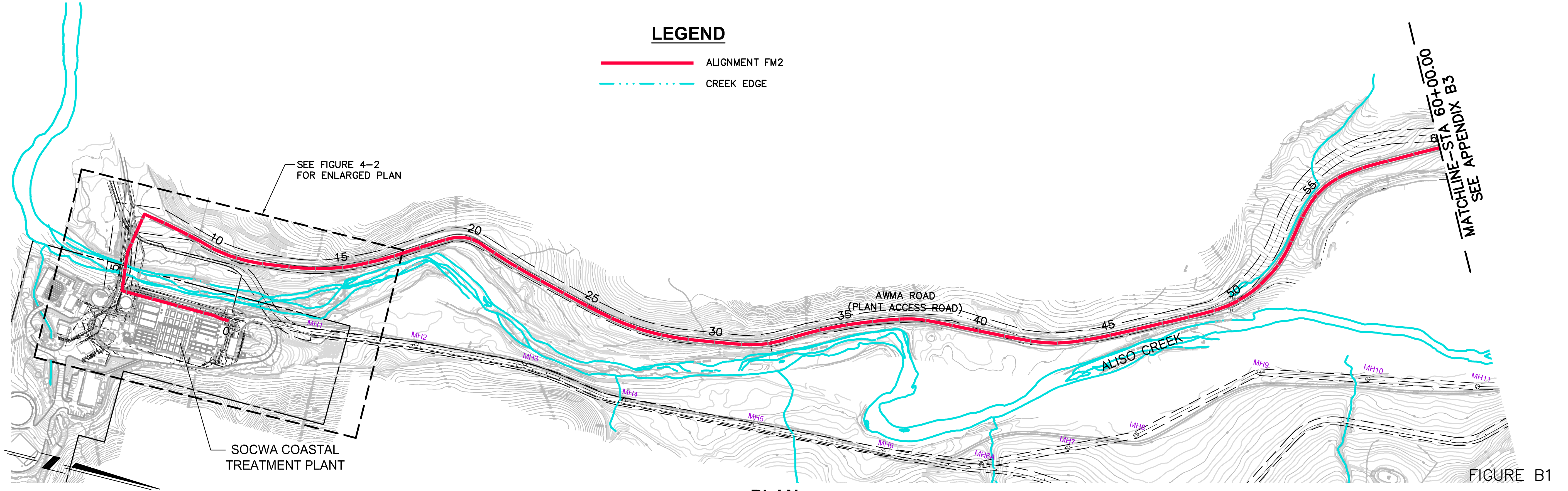

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GRAPHIC SCALE
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SCALE: 1" = 200'

FIGURE B1
Proposed Alignment FM2
Plan and Profile

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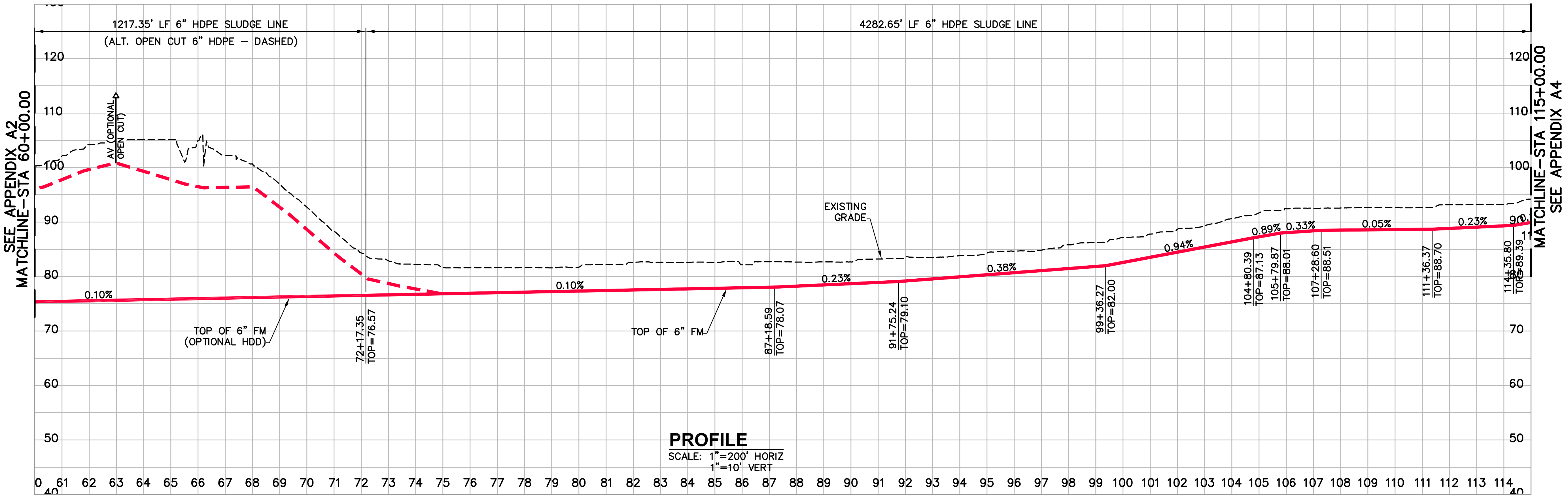

FIGURE B2
Proposed Alignment FM2
Plan and Profile

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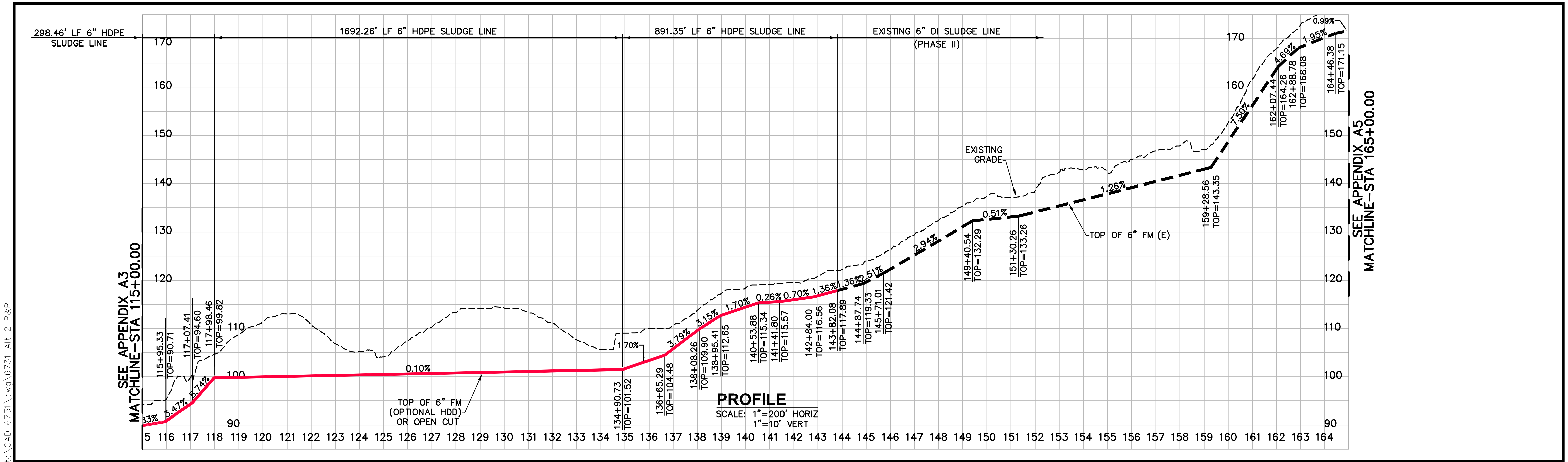

PROFILE

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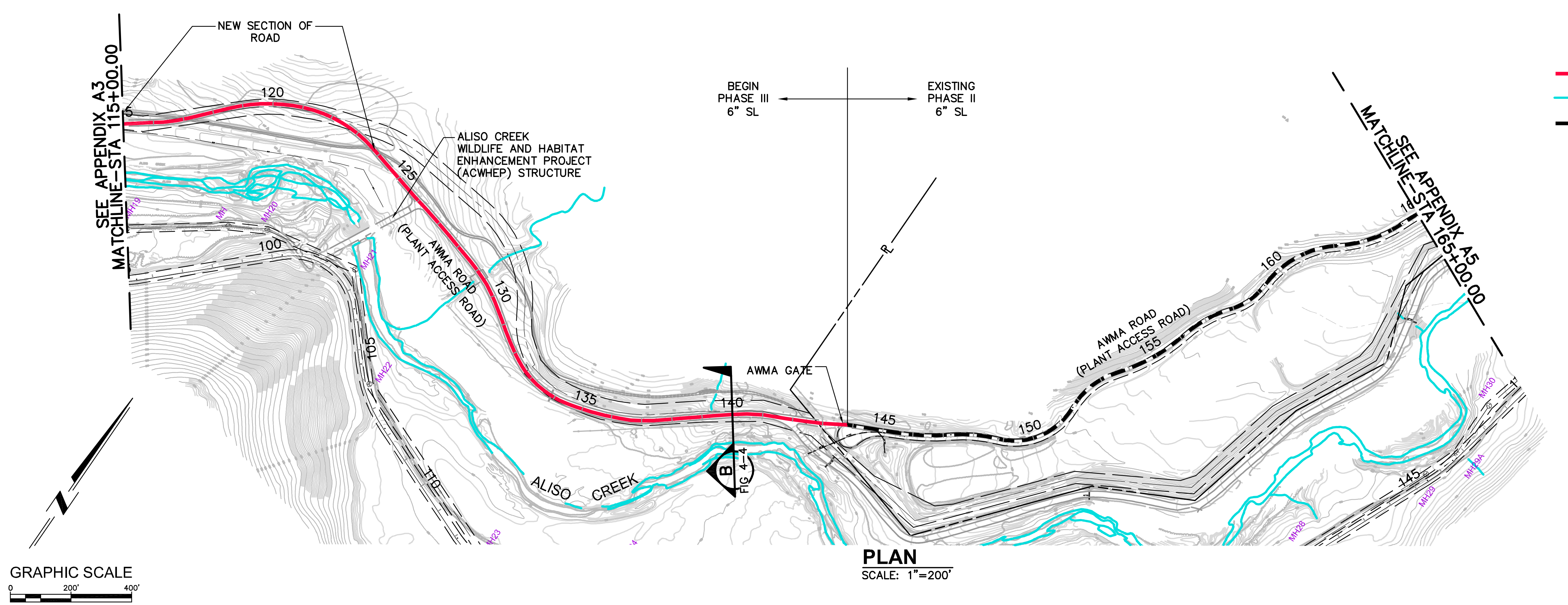
1"=10' VERT



PLAN

SCALE: 1"=200'

LEGEND

━━	ALIGNMENT FM2
–··–··–	CREEK EDGE
━ ━ ━	EXISTING 6" SLUDGE LINE

FIGURE B3

Proposed Alignment FM2
Plan and Profile

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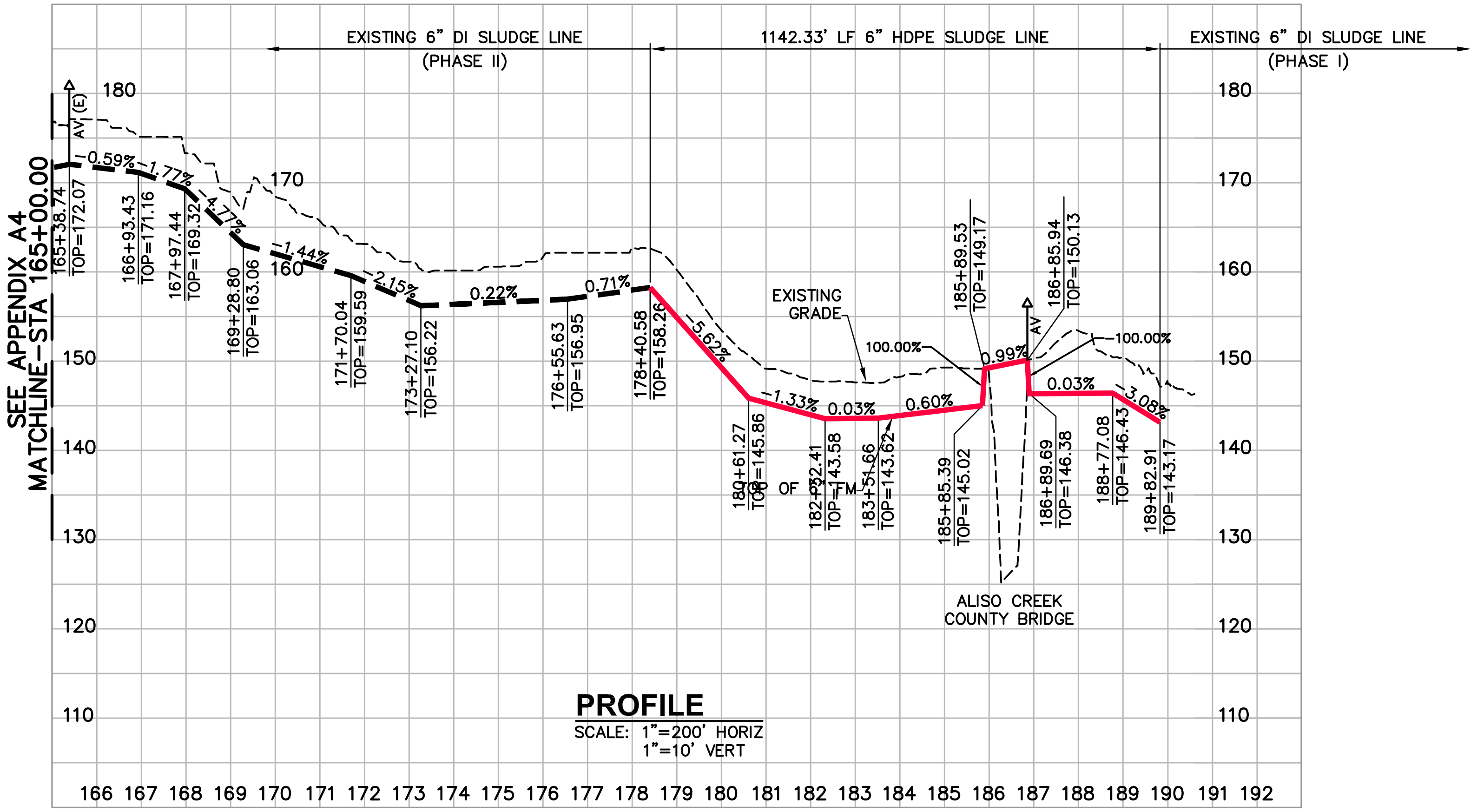

PROFILE
SCALE: 1"=200' HORIZ
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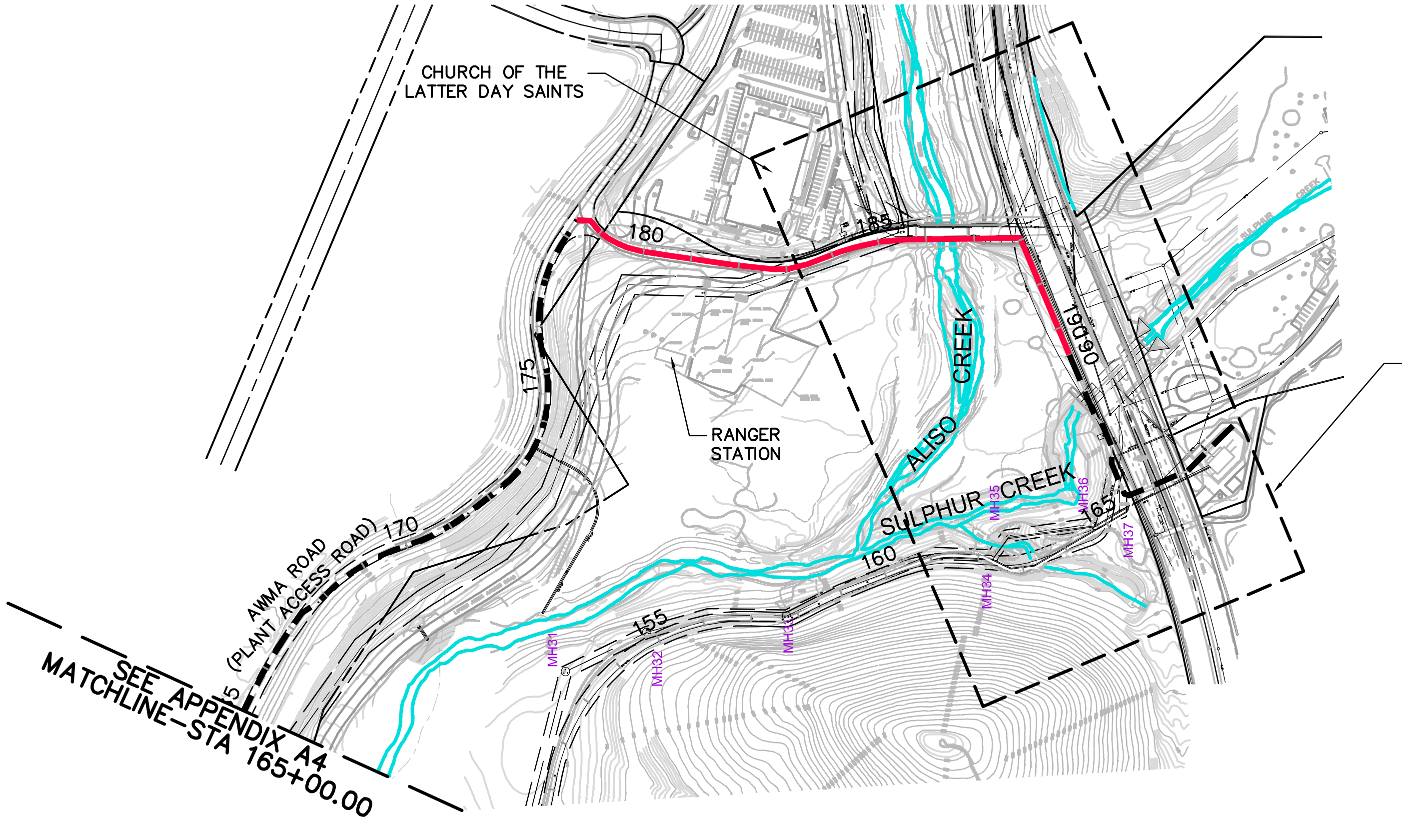

PLAN
SCALE: 1"=200'

LEGEND

- 🟥 ALIGNMENT FM2
- -··-··- CREEK EDGE
- — — — EXISTING 6" SLUDGE LINE

GRAPHIC SCALE
0 200' 400'
SCALE: 1" = 200'

FIGURE B4
Proposed Alignment FM2
Plan and Profile

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APPENDIX C

Sludge Export Agency Interview Results

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South Orange County Wastewater Authority
Coastal Treatment Plant Sludge Export Pipeline
Phone Interview Summary

Agency: Olas Virgines Municipal Water District
Contact Name: Brett Dingman **Contacted By:** Jeff Weishaar
Phone No.: 818-251-2330 **Contact Date:** 11/15/2011

Pipe Characteristics:

Diameter (in): 8 Length (ft): 4 miles
Material: Ductile iron pipe
Lining: glass

Sludge Characteristics:

Digested Raw [✓ Primary] [✓ WAS]
Solids Content (%): 2.7 to 3

Cleaning

Pigging Frequency: 3 to 4 months Station Spacing
Pig Type Soft pigs made of hard foam
Comments:

Typically takes 24 hours for pigging. Will flush line overnight, and pigging takes 3 to 4 hours. Then flush.
Store in raw sludge wet well during pigging. Draw down well priorto pigging.
Pigs have missed receiving station and are found in receiving wet well during cleaning.
Never lost a pig in the pipeline.

Flushing Frequency Flow Rate
Comments: Prior to pigging

Chemical Cleaning Frequency Chemical
Dose
Comments:

Add ferric chloride continually. Have been able to reduce dosing significantly without adverse effect.

South Orange County Wastewater Authority
Coastal Treatment Plant Sludge Export Pipeline
Phone Interview Summary

General Operation and Other Comments:
Have 2 lines. Original line, 6-inch diameter DIP, went to holding tanks and sludge ponds. Line has been used when composting facility was shutdown for maintenance in 2003.
Main line constructed in 1994 as part of composting facility. Main line had external corrosion failure in 2002/2003 from improperly maintained french drain. Performed pipe bursting to replace section with HDPE.

Pumped for 8 hours per day after break, approximately 200 to 250 gpm.
Have gone back to 24-hour pumping, prefered method. Pump 80 to 90 gpm at 150 to 200 psi.
High pressure shut-off at 220 psi.
Use Monyo progressive cavity pumps.

Maintenance includes daily walk/drive of pipeline.
5 isolation valves are installed along the line.

Wet wells at both plants ue centrifugal pumps for mixing. They do not work very well. Will be one with positive displacement or progressive cavity pump. Debris build up at bottom of wet well clogs pump, pump then runs dry and does not mix.
Have had issues with epoxy coating, it is falling off.

Utilize flow meters on discharge pumps and at wet wells for differential flow metering to alarm for potential leak.

South Orange County Wastewater Authority
Coastal Treatment Plant Sludge Export Pipeline
Phone Interview Summary

Agency: Inland Empire Utilities Agency
Contact Name: Randy Lee **Contacted By:** Jeff Weishaar
Phone No.: 909-993-1600 **Contact Date:** 11/15/2011

Pipe Characteristics:
Diameter (in): 6 Length (ft): 2 miles & less than 1 mile
Material: DIP on-site, PVC off-site
Lining: DIP is glass or cement mortar lined.

Sludge Characteristics:
Digested Raw [✓ Primary] [✓ WAS]
Solids Content (%): Primary at 05 percent, WAS at 0.7 percent

Cleaning
Pigging Frequency: Annually Station Spacing
Pig Type
Comments:

Two plants, Carbon Canyon WRF and RP-5, pump primary and WAS to RP-2. Primary and WAS lines are separate for each plant. Carbon Canyon WRF primary ludge line is pigged annually or when pressure reached 40 psi.

Pigging requires 6 hours: 1 hour of preparation, 4 hours of high-rate utility water flushing, and 1 hour to clean-up.

Other lines have not been pigged in several years.

Flushing Frequency Flow Rate
Comments: Do not flush

Chemical Cleaning Frequency Chemical
Dose
Comments:

Both plants have Chemically Enhanced Primary Treatment (CEPT). Do not add additional chemicals.

South Orange County Wastewater Authority
Coastal Treatment Plant Sludge Export Pipeline
Phone Interview Summary

General Operation and Other Comments:

Carbob Canyon WRF: Flows of .25 mgd for primary and 0.1 mgd WAS at pressures from 25 to 35 psi.

RP-5: Primary flow of 0.12 mgd and WAS flow of 0.12 to 0.19 mgd. Pressures at 10 to 12 psi.

South Orange County Wastewater Authority
Coastal Treatment Plant Sludge Export Pipeline
Phone Interview Summary

Agency: City of San Diego
Contact Name: Dwight Corria
Contacted By: Jeff Weishaar
Phone No.: 858-614-5505
Contact Date: 11/17/2011

Pipe Characteristics:

Diameter (in): 12 & 14
Length (ft): 5 miles (12") & 7 miles (14")
Material: Ductile iron with mechanical joints
Lining: Polyethylene in 12-inch pipe, polyurethane in 14-inch pipe

Sludge Characteristics:

Digested Raw [✓ Advanced Primary] WAS
Solids Content (%): 2 to 2.5 average, 3.5 max

Cleaning

Pigging
Frequency: Only at startup
Station Spacing
Pig Type
Comments: Ran pig only for training during start-up

Flushing
Frequency
Flow Rate
Comments: None

Chemical Cleaning
Frequency
Chemical
Dose
Comments: None

South Orange County Wastewater Authority
Coastal Treatment Plant Sludge Export Pipeline
Phone Interview Summary

General Operation and Other Comments:
Pipelines constructed as two projects
Design pressure is 575 psi
Typically run at 850 to 1,000 gpm and 205 to 210 psi.

Corrosion control stations and corrosion monitoring are the main maintenance concerns

Air valves are constructed along the line. The valves at the end of the line continually release air and do not seat properly. This is thought to be due to the pipe elevation here being the same as the receiving station and not enough pressure to seat.

No other major issues.

Pumps are custom Abel diaphragm pumps. Heavy duty "Huge" pumps.

APPENDIX D

Geotechnical Review

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Geotechnical and Environmental Sciences Consultants

PRELIMINARY GEOTECHNICAL EVALUATION
COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
SOUTH ORANGE COUNTY
WASTEWATER AUTHORITY
LAGUNA NIGUEL, CALIFORNIA

PREPARED FOR:
Dudek & Associates
750 Second Street
Encinitas, California 92024

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
475 Goddard, Suite 200
Irvine, California 92618

November 18, 2011
Project No. 202426005

Ninyo & Moore
Geotechnical and Environmental Sciences Consultants

November 18, 2011
Project No. 202426005

Mr. Ed Matthews
Dudek & Associates
750 Second Street
Encinitas, California 92024

Subject: Preliminary Geotechnical Evaluation
Coastal Treatment Plant Export Sludge System
South Orange County Wastewater Authority
Laguna Niguel, California

Dear Mr. Matthews:

In accordance with your authorization, Ninyo & Moore has performed a preliminary geotechnical evaluation for the preliminary design of the Coastal Treatment Plant Export Sludge System located in Laguna Niguel, California. The purpose of our geotechnical consulting services was to evaluate the soil and geologic conditions along the pipeline alignments and to provide geotechnical input to assist in the alignment selection and preliminary pipeline design.

We appreciate the opportunity to be of service on this project.

Sincerely,
NINYO & MOORE

James J Barton

JAMES J. BARTON
No. 1301
Exp. 11/30/13

James J. Barton, PG, CEG
Senior Geologist

Daniel Chu, PhD, PE, GE
Chief Geotechnical Engineer

Lawrence Jansen

DANIEL C. CHU
No. [illegible]
Exp. 03/31/13

Lawrence Jansen, PG, CEG
Principal Geologist

JJB/LTJ/DC/lr

Distribution: (1) (Addressee via-email)

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1. INTRODUCTION

In accordance with your request, we have performed a preliminary geotechnical evaluation for the preliminary design of the Coastal Treatment Plant Export Sludge Force System for the South Orange County Wastewater Authority (SOCWA). The purpose of our geotechnical services was to evaluate the soil and geologic conditions along the pipeline alignments and to provide geotechnical input to assist in the alignment selection and preliminary pipeline design.

The project includes alignment selection and preliminary design of a new sludge force main pipeline between the Coastal Treatment Plant and Alicia Parkway in the Aliso and Wood Canyons Wilderness Park area (Figure 1). The new pipeline will replace two existing deteriorating 4-inch sludge pipelines constructed along the east side of Aliso Creek in 1982. Replacement of the pipelines has been planned since the early 1990’s and the South Coast Water District constructed two of three phases of a replacement pipeline in early 2000. The third phase and final link of the replacement pipeline was not completed and the two pipelines constructed have not been placed into operation.

Several factors have impacted the design and construction of the replacement pipeline. In 2000, the replacement sludge force main pipeline was combined with the planned Aliso Creek Emergency Sewer (ACES) project along the west side of the Aliso Creek. This project was designed, but not constructed. In addition, the County of Orange has presented various plans for park improvements, which impact the pipeline construction and maintenance. The County of Orange and the Army Corps of Engineers are also involved in studies of environmental restoration in the wilderness park. Design and construction of these improvements is uncertain and SOCWA has decided to initiate the design process for the replacement sludge force main to replace the existing force mains.

The alignment alternatives currently considered include following the alignment of the existing force mains along the east side of the creek or following the existing AWMA Road on the west side of the creek to the Coastal Treatment Plant. The east side alignment would cross Sulphur Creek near Alicia Parkway and connect to the existing force main in Alicia Parkway. The preliminary design may consider a pipe bridge crossing the Sulphur Creek or an Arizona Crossing (concrete encasement) along the east side. The west side alignment would connect to the existing force main located in AWMA Road near the gated entry to the Wilderness Park. Depending on ground surface elevations, the invert of the pipe would generally be approximately 4 feet deep. In some areas, the pipe could be as deep as 24 feet. The pipe would generally be a 6-inch-diameter ductile iron pipe. Due to the depth of the pipe in some areas, direction drilling may be considered. If directional drilling is considered, the pipe would consist of 8-inch-diameter high density polyethylene pipe. The feasibility of pipe bursting the existing 4-inch mains will also be evaluated. The preliminary design will be performed to a level equivalent to a 30 percent design.

2. SCOPE OF SERVICES

Our scope of services for this geotechnical evaluation was performed in accordance with our proposal dated July 12, 2010, and included the following:

- Review of our files regarding previous work performed along the alignment area including geologic maps, topographic maps, aerial photographs, boring logs, laboratory test results, and existing pipeline plans.
- A field reconnaissance by our engineering geologist on September 22, 2011 of the project alignment to evaluate the current site conditions.
- Preparation of this report summarizing the geologic conditions along the alignment and the geotechnical aspects of the pipeline project. Geotechnical design and construction considerations are presented for preliminary planning purposes.

Our services included review and summary of previous work along the alignments. This report is intended as a preliminary geotechnical evaluation of the proposed pipeline alignment for planning purposes. Evaluation of creek erosion and its effects on the existing embankments adjacent to the force main alignments was not performed. We understand that creek erosion and the potential for seasonal flooding will be evaluated by others and mitigation recommendations will be developed at a later date. Detailed evaluation of landslides along the alignment was not included in the scope of work for this study.

3. BACKGROUND

Ninyo & Moore has performed several geotechnical evaluations along east and west sides of Aliso Creek between 2000 and 2009. Previous geotechnical evaluation reports are referenced in Section 13 of this report.

Our initial work was associated with the ACES project in 2000 and 2001. This work included three phases of subsurface exploration for a geotechnical evaluation of the planned pipeline alignment along the west side of Aliso Creek. In 2003 we performed a preliminary evaluation for the Rehabilitation of the East Aliso Creek Emergency Sewer (REACES) project. This evaluation included geologic mapping along the east side of Aliso Creek, preliminary assessment of the stability of the existing pipelines with regard to creek embankments, and an aerial photographic survey along the alignment. Subsurface exploration was not performed. A separate hydrologic study was performed by Rivertech, Inc. (2009), to evaluate stabilization of the east bank of the creek from the perspective of river mechanics. In 2005, a slope failure along the west side of the creek encroached into the existing AWMA Road. The road was realigned approximately 100 feet west of the failure (Ninyo & Moore, 2005). In 2009 we performed a preliminary evaluation for the Coastal Treatment Plant Access Road Realignment Study. This evaluation included limited subsurface exploration along the east side of Aliso Creek to provide geotechnical data for preliminary design considerations.

4. SITE DESCRIPTION

The project alignments are located in the Aliso Canyon Wilderness Park. The pipeline alignment generally parallels Aliso Creek which meanders through Aliso Canyon with relatively steep hillsides ascending to residential developments. Canyon slopes are on the order of 400 or more feet above the canyon floor. Aliso Creek is generally a north-south trending tributary. Near Alicia Parkway, the creek branches to the east-west trending Sulphur Creek. The slopes bordering the canyon include several smaller drainages which merge with Aliso Creek.

The creek has incised below the valley bottom to depths of approximately 4 to 25 feet. Elevations along the creek bottom range from approximately 120 feet above mean sea level (MSL) at the north end (near Alicia Parkway) to approximately 32 feet above MSL at the south end near the Coastal Treatment Plant (CTP). Some of the creek channel embankments are near vertical. At some locations channel slumping has occurred and rip-rap has been placed to mitigate erosion. Vegetation along the creek embankments and valley floor consist of moderate to thick cover of weeds, shrubs and some trees. A brief description of the east and west sides of the creek are presented below.

4.1. East Side

The east side of the creek includes an unpaved access road that roughly parallels the creek from Aliso Parkway to the CTP. The access road is gently inclined with an elevation of approximately 140 feet above MSL at the entrance from Alicia Parkway to approximately 50 feet MSL at the CTP. Several east-west trending drainage gulleys are present incising the canyon slopes. These gullies are interrupted by the access road and/or drain to the creek. A concrete lined rip-rap gulley up to about 7 feet in depth crosses the access road between Manholes 27 and 28 (Figure 2). Smaller concrete lined drainage swales are also present crossing the road. A concrete access road and drop structure, (ACWHEP Dam Access), crosses the creek near Manhole 21 (Figure 3). The drop structure descends from the road near the center of the creek approximately 20 feet. The unpaved access road is relatively close (within 20 feet) to the western edge of the creek embankment near Sulfur Creek and south of the drop structure at several locations (Figures 2 through 7).

Based on our review of available plans for existing pipelines along the east side of the creek, the pipelines from closest to farthest from the creek consist of one 18-inch-diameter VCP sewer line, two 4-inch diameter force sewer mains (sludge) and one 36- to 39-inch RCP ocean outfall sewer line (Boyle Engineering, 1978). The pipelines are roughly parallel and generally within 10 feet of each other. Manholes for the 18-inch VCP are numbered from 1 to 34 beginning near the treatment plant as referenced on the plan and profile sheets (Boyle Engineering, 1968). The force mains and outfall line trend away from the 18-inch line between Manhole Nos. 6A and 11A and roughly parallel the base of the canyon slopes (Figures 5 and 6). The force mains and outfall line trend parallel and within approximately 20 to 40 feet of the 18-inch line approximately between

Manhole Nos. 22 and 31 (Figures 2 and 3). The force mains are shown within approximately 5 feet of the 18-inch sewer line between Manhole Nos. 32 and 34 (Figure 2). The force main extends to depths generally ranging from 2 to 10 feet deep. In areas where the pipelines trend below the canyon slopes, the depth of the lines extends down to about 24 feet deep (between Manhole Nos. 16A and 16, Figure 4). The 36-inch RCP changes to a 39-inch RCP northeast of Manhole No. 14, (Figures 4 and 5). In addition, an abandoned 18-inch PVC irrigation pipe is present roughly parallel to the east channel slopes of the creek, south of Manhole 14 (Figure 5). An additional abandoned 8-inch PVC pipe is present at the base of the hillside east of Manhole Nos. 18 and 19 (Figure 4). The limits of the abandoned pipes are unknown.

4.2 West Side

The west side of the creek is bordered by an asphalt concrete paved access road referred to as AWMA Road. The road roughly parallels the creek from Woods Canyon to the CTP. North of the Woods Canyon, the road branches at a cul-de sac into a lower AWMA and upper AWMA Road. Topographically, AWMA Road is relatively flat from the cul de sac at an elevation of approximately 118 feet above MSL to approximately 83 feet near the base of the adjacent hillsides (Figure 5). The road then follows the base of the hillside with gentle slopes up and down to the CTP at an elevation of approximately 50 feet MSL. The area adjacent to the road is occupied by undeveloped parkland of the Aliso and Wood Canyons Wilderness Park. Existing sewer lines are present under the paved portion of the upper AWMA Road extending to the cul de sac where a gate is present. Details regarding the sewer lines were not available at the time of this report. Several storm drains consisting of 12 to 36-inch-diameter steel pipes cross the road from smaller drainage tributaries. In particular, three, 36-inch-diameter storm drains within a concrete apron cross the road near the Aliso Creek Trail (Figure 4). The slope below the outlet was covered with rip-rap extending down 15 or more feet along the east side of the road. At the time of our visit, water was flowing through the pipes. South of this drainage culvert, a 24-inch-diameter PVC pipe was exposed parallel to the east side of the road.

5. SUBSURFACE EXPLORATION AND LABORATORY TESTING

Subsurface exploration was previously conducted on both sides of the creek. The exploration consisted of several small and large diameter borings and continuous core borings to depths ranging from approximately 16½ to 85 feet below the ground surface with a truck-mounted drilling equipment. The approximate locations of the previous borings are shown on Figures 2 through 7. Logs of the borings are included in Appendix A.

6. GEOLOGY AND SUBSURFACE CONDITIONS

6.1. Geologic Setting

The project site is situated in the San Joaquin Hills, within the northwestern portion of the Peninsular Ranges Geomorphic Province of California (Norris and Webb, 1990). The San Joaquin Hills consist of a series of generally northwest trending hills bounded by the Los Angeles Basin on the north, the Pacific Ocean on the southwest, and the Santa Ana Mountains and San Juan Creek on the east and south. The roughly north-south Aliso Creek meanders through a deep canyon surrounded by moderate to steeply sloped hillsides. Alluvium derived from the surrounding highlands has filled the bottom of the valley to variable depths and has been incised by the Aliso Creek to form paired stream terraces adjacent to the active stream channel.

Based on our field reconnaissance and the referenced geologic maps of the area, the hillsides surrounding the site are underlain by bedrock of the Miocene-age Topanga, Monterey and Capistrano Formations, which consist of interbedded siltstones and sandstones (Figure 8). The San Onofre Breccia is also present in the hillside areas. A few natural slopes adjacent to the alignment include thick outcrops of resistant, strongly cemented sandstone. Regional mapping of the bedrock structure indicates that bedding of the Topanga Formation generally dips towards the south at approximately 8 to 22 degrees. Bedding of the Monterey Formation generally dips towards the east at approximately 8 to 25 degrees (Morton and others, 1974).

Materials that have washed and/or mass-wasted from the surface of the hills have collected at the base of the hills to form slope wash deposits. Debris flow deposits are also present on the steeper hillsides. Large ancient landslides composed of disturbed bedrock material have also been mapped along the sides of the canyon.

6.2. Site Geology

Based on the results of our previous work and recent subsurface exploration, the alignment is underlain by variable thickness of Quaternary-age older alluvium and slope wash deposits over bedrock materials of the Miocene-age Topanga and Monterey Formations. Large bedrock landslides are mapped near the middle portions of the project alignment and near the CTP (Figure 3, 4, 5 and 7). Some minor fill soils associated with the access roads, maintenance of the creek channel and utility trenches are also present. Generalized descriptions of the geologic units observed during our evaluation are presented below.

6.2.1. Debris Flows

Evidence of shallow debris flows (scars) were observed along the hillsides east of the creek. Deposits from debris flows typically consist of topsoil, colluvium, or highly weathered bedrock materials that flow down slope when saturated from seasonal precipitation. Debris flow deposits were not observed crossing the existing pipeline alignment.

6.2.2. Alluvium (Qal)

Alluvium, consisting of recent deposits of unconsolidated sand, silt and clay along the active drainage tributaries, were observed near the surface. These materials are expected to be relatively shallow (less than 10 feet) where they cross the proposed alignments.

6.2.3. Older Alluvium and/or Slope Wash (Qoal/Qsw); Undifferentiated

Older alluvium and/or slope wash deposits (undifferentiated) were observed in exposures along both sides of the creek, as well as road cuts and within borings adjacent to the roadways. The older alluvium and/or slope wash deposits typically consist of mottled brown, grayish brown, and reddish brown, gray to black, damp to moist, firm to hard, clay and silt and very loose to medium dense, clayey sand. The alluvium and/or slope wash is expected to extend to depths of approximately 20 or more feet below the ground surface. Some recent slumping of the steep creek channel slopes were observed within the alluvial deposits.

6.2.4. Landslides (Qls)

Relatively large landslide complexes have been mapped near the alignment (Morton, 1974) and were observed in our photographic review and during our reconnaissance (Figure 3, 4, 5, and 7). No known subsurface exploration has been performed within the landslide complexes along the east side of the creek. Our previous work on the west side of the creek included subsurface exploration near the base of two mapped landslides along the AWMA Road. Landslide rupture surfaces were not encountered within the depth of our previous exploration. Based on the results of our previous exploration, the basal rupture surface of these two landslides (if present) is situated below the depths of coring of approximately 80.0 and 85.0 feet. A comprehensive evaluation of the ancient landslides and stability analysis of the landslide masses was beyond the scope of our previous work.

We did not observe outcrop exposures or failure planes of the landslide masses along accessible areas of the creek channel. In addition, we did not observe ground cracks, scarps, seeps or other signs of recent landslide movement. Based on previous work and our recent reconnaissance, the landslide complexes are relatively ancient and consist of a variety of translational block type failures within the bedrock materials. The landslide complexes are covered with an unknown thickness of topsoil, slope wash and/or alluvium. We anticipate that the basal failure planes of the landslides are relatively deep below the creek bottom. Shallower rupture surfaces and fracture planes may be present at relatively shallow depths, particularly where smaller landslides are mapped within large landslide features.

6.2.5. Topanga Formation

Based on regional mapping as well as our observations of limited exposures, the Topanga Formation is generally present south of Manhole 17 (Figure 4). Topanga Formation has also been mapped in the slopes west of the creek and south of the fork between the upper and lower AWMA Road (Figure 3). Where exposed or encountered during the previous subsurface exploration, the formation consists of yellowish and orange brown, weakly to strongly cemented, sandstone and some reddish brown and gray, weakly to moderately indurated siltstone.

6.2.6. Monterey Formation

Based on regional mapping as well as our observations of limited exposures and previous subsurface exploration, the Monterey Formation is present north of Manhole 24 (Figure 3). Where exposed, the formation consists of white to gray, weakly to moderately indurated, tuffaceous siltstones and gray, weakly to moderately cemented sandstone.

7. GROUNDWATER

No groundwater seepage or active springs were observed during our reconnaissance near the base of the canyon slopes or in accessible areas of the creek channel slopes. Groundwater was previously encountered in borings drilled on the east and west sides of the creek at depths varying between 6½ and 39 feet at the time of the drilling. In general, groundwater is expected to be near the elevation of the adjacent stream level. Groundwater levels along the alignment can vary with seasonal storms, change in topography, stratigraphy, runoff and other environmental changes.

8. FAULTING AND SEISMICITY

The tectonic structure of the Peninsular Ranges Geomorphic Province is dominated by northwest-trending, right-lateral, strike-slip fault systems. The site is considered to be in a seismically active area, as is the majority of southern California. There are, however, no known active fault traces crossing the alignment. Several older faults (pre-Pleistocene) are present in the vicinity of the alignment. A few of the mapped faults cross near the middle and end of the realignment (Figures 4 and 6). These faults are considered seismically inactive, but may be a concern with regard to excavation stability. Regional faults are presented on Figure 9.

Table 1 lists selected principal known active faults that may affect the subject site and the maximum moment magnitude (M_{max}) as published by Cao, et al. (2003) for the California Geological Survey. The approximate fault-to-site distances were calculated using the computer program FRISKSP (Blake, 2001) based on a location near the midway point of the creek.

Table 1 – Principal Active Faults

Fault	Approximate Fault to Site Distance miles[1] (km)	Maximum Moment Magnitude[2] (M_{max})
San Joaquin Hills Blind Thrust	0.1 (0.2)	6.6
Newport-Inglewood (Offshore)	4.5 (7.2)	7.1
Newport-Inglewood (L.A. Basin)	11.9 (19.1)	7.1
Chino-Central Ave. (Elsinore)	18.1 (29.1)	6.7
Elsinore (Glen Ivy)	19.8 (31.8)	6.8
Palos Verdes	19.8 (31.9)	7.3
Coronado Bank	22.1 (35.5)	7.6
Whittier	22.2 (35.7)	6.8
Elsinore (Temecula)	23.2 (37.3)	6.8
Rose Canyon	34.1 (54.9)	7.2

Notes:
[1] Blake, 2001
[2] Cao, et al., 2003

The principal seismic hazards considered at the subject site are surface ground rupture, ground motion, liquefaction and slope stability. A brief description of these hazards and the potential for their occurrences on site are discussed below.

8.1. Surface Rupture

The probability of damage due to surface ground rupture is low due to the lack of known active faults crossing the site. Surface ground cracking related to shaking from distant events is not considered a significant hazard, although it is a possibility.

8.2. Ground Motion

The 2010 California Building Code (CBC) recommends that the design of structures be based on the horizontal peak ground acceleration (PGA) having a 2 percent probability of exceedance in 50 years which is defined as the Maximum Considered Earthquake (MCE). The statistical return period for PGA_{MCE} is approximately 2,475 years. The probabilistic PGA_{MCE} for the site was calculated as 0.61g using the United States Geological Survey (USGS, 2011) Ground Motion Calculator (web-based). The design PGA was estimated to be 0.41g using the USGS Ground Motion Parameter Calculator. These estimates of ground motion do not include near-source factors that may be applicable to the design of structures on site.

8.3. Liquefaction Potential

Liquefaction is the phenomenon in which loosely deposited granular soils with silt and clay contents of less than approximately 35 percent and non-plastic silts located below the water table undergo rapid loss of shear strength when subjected to strong earthquake-induced ground shaking. Ground shaking of sufficient duration results in the loss of grain-to-grain contact due to a rapid rise in pore water pressure, and causes the soil to behave as a fluid for a short period of time. Liquefaction is known generally to occur in saturated or near-saturated cohesionless soils at depths shallower than 50 feet below the ground surface. Factors known to influence liquefaction potential include composition and thickness of soil layers, grain size, relative density, groundwater level, degree of saturation, and both intensity and duration of ground shaking.

The California Seismic Hazards Zones Map indicates the Aliso Creek and alignment are potentially liquefiable (Figure 10). Based on our previous work and recent subsurface evaluation, we anticipate that the majority of the older alluvial deposits at the site contain a high proportion of silt and clay and, therefore, are considered to have a low liquefaction potential. However, some beds of relatively loose, saturated, granular soils are also anticipated along the alignment that may be liquefiable.

8.4. Slope Stability

The project is situated adjacent to the active stream channel of Aliso Creek and is susceptible to damage by stream bank erosion and channel slumping. The erosion potential is relatively low during dry months, but is relatively severe during wet months and especially during large flood events. Erosion, (slow or catastrophic), may impact the long-term performance of the proposed pipeline. The following is a brief description of the two sides of the creek.

The mapped landslides (Figures 3, through 7), are located along both sides of the creek. These slope areas are also mapped as potentially susceptible to landslide hazards during earthquakes (Figure 10). These landslides are considered to be relatively old with rupture surfaces (basal failure plane) generally below the level of the creek channel. Shallower rupture surfaces and fracture planes may be present at relatively shallow depths, particularly where smaller landslides are mapped within large landslide features.

8.4.1. East Side

Rip-rap has been placed along steeper portions of the creek channel where the channel slopes are within approximately 20 feet of the existing 18-inch sewer line. Additional rip-rap may be present in other areas which are currently obscured by vegetation. The rip-rap observed consists of granitic rock boulders up to approximately 2 to 3 feet in thickness. The actual thicknesses of the rip-rap layers are unknown.

Based on our review of the existing pipeline alignment, the active creek channel is in close proximity (approximately 30 feet or less) to the existing pipelines near Manhole Nos. 32-34, 29A, 21, 20, 17, 16, 14, 13A, 10, (Figures 2, 3, 4 and 5). These channel embankment areas are generally considered to be marginally stable. Erosion provisions and some type of embankment stabilization may be appropriate.

8.4.2. West Side

The west side of the creek ranges from approximately 5 to more than 200 feet from the existing paved AWMA Road. Minor erosion gulleys crossing the road are present. The area west of Manhole 15A (Figure 4) as well as west of Manholes 8, 6, 2 (Figures 6 and 7), the road is within approximately 5 to 10 feet of the west embankment. These channel embankment areas are generally considered to be marginally stable. Erosion provisions and some type of embankment stabilization may be appropriate.

9. PRELIMINARY CONCLUSIONS

Based on the results of our geologic reconnaissance and limited geotechnical evaluation, it is our preliminary opinion that the proposed project is feasible from a geotechnical perspective, but the project area is susceptible to several geologic hazards. Geologic hazards that could impact the pipeline include creek erosion, creek embankment stability, landslides and liquefaction. These conditions and other geotechnical aspects of the project are discussed in the following sections:

- The existing creek channel is in proximity to some segments of the existing pipelines along the east side of the channel and adjacent to AWMA Road on the west side. Creek channel erosion mitigation should be performed to protect the proposed pipeline, as well as existing pipelines and road. The stability of creek embankments should also be evaluated on a case-by-case basis where the pipeline is close to creek embankments. In general, the pipeline should maintain a horizontal distance away from the creek channel so that the pipeline is outside a 2:1 (horizontal to vertical) prism extending up from the bottom of the channel. Where this setback is not possible, additional stabilization may be appropriate. The north end of the alignment is along the edge of a relatively steep channel slope with some areas containing rip rap. Embankment stabilization will also be appropriate in this area.

- Our subsurface exploration indicates that the alluvium along the alignment is comprised predominantly of relatively clayey soils with a low potential for soil liquefaction. Some potentially liquefiable sandy alluvial layers are, however, anticipated at some locations. Seismic liquefaction may result in settlement and slumping of channel banks which could impact the pipeline. Creek bank stabilization may be performed to mitigate potential for seismic induced slope failures. Liquefaction may also result in soil settlement and sand boils.

- The alignments cross areas where large landslides have been mapped. The landslides are complex and considered to be relatively old features. The base of the slopes includes a mantle of slope wash and alluvial deposits. The landslides were not exposed in the current creek alignment. Two landslides were exposed along the western edge of the AWMA Road on the west side of the creek near the CTP. Our previous exploration of these landslide areas did not reveal landslide rupture surfaces to the depths explored. The toe of the landslides are expected to be below the creek channel.

- Reactivation of landslides could damage existing pipelines, as well as a new pipeline. During our recent field reconnaissance and review of aerial photographs we did not observe ground cracks, scarps, seepage, or other signs of recent landslide movement. We understand that the existing pipelines and access roads have not been damaged by landslide movement. Based on our previous work in the area we anticipate that the basal rupture surfaces of these large landslides are relatively deep below the creek bottom. Shallower rupture surfaces and fracture zones may be present, which could be relatively unstable. In general, we do not anticipate minor grading for the pipeline construction will impact the stability of the large landslides, but trenching for new pipeline could expose rupture zones, fractured material, or other unstable conditions.

- In order to further evaluate the landslides impacting the proposed pipeline alternative, subsurface exploration will be required in these areas. Depending on the subsurface conditions, it may be reasonable to design the improvements so as to reduce the impact of the new pipeline to the stability of the hillside. This would include limited excavations and fills as well as implementing suitable drainage provisions. Alternatives to trench excavations could be pipe bursting within the existing sludge lines or horizontal directional drilling through the landslide deposits.

- Grading is anticipated to include relatively shallow cuts and fills. In light of the potential slope stability hazards near mapped landslide areas, we recommend that the pipeline avoid excavations of more than 5 feet in these areas. As improvement plans become available, a detailed geotechnical evaluation of landslide areas may be performed to evaluate grading impacts. Future excavations and fill areas should be evaluated on a case-by-case basis.

- Drainage tributaries from the canyon slopes crossing the alignment may undermine the proposed pipeline and impact the stability of the creek embankments. Erosion protection and drainage improvements should be considered where tributaries cross the proposed pipeline improvement.

- Undocumented fill and loose natural soils are expected at the site. The fill and loose natural soils are considered to be potentially compressible under future loading from new fills or pipeline improvements. In order to provide suitable support of the pipeline, some removal and recompaction of potentially compressible soils below the pipeline may be appropriate.

- Groundwater was previously encountered depths ranging from approximately 6½ to 39 feet below the ground surface at the site. Groundwater levels along the alignment can vary with seasonal storms, change in topography, stratigraphy, runoff and other environmental changes.

10. PRELIMINARY GEOTECHNICAL CONSIDERATIONS

The following geotechnical conditions are presented for preliminary planning purposes. The design and planning of the pipeline improvement should be based on a detailed geotechnical evaluation. The evaluation should be based on proposed finish grade elevations and improvements within the pipeline alignment.

10.1. Seismic Ground Shaking

The project site is situated in a seismically active area. During the design life of the pipeline, strong ground shaking may occur. The closest active fault is the Newport Inglewood fault zone approximately 4½ miles south of the site. An estimated earthquake magnitude of 7.1 could occur on this fault zone. Our analysis indicated that a peak horizontal ground acceleration of 0.61g with a statistical return period of 2,475 years could occur at the project site. Accordingly, structural improvements, if any, should be designed in accordance with the appropriate CBC seismic criteria.

As discussed, seismic ground shaking may also cause seismic induced landsliding and liquefaction. Prior to the design, a subsurface geotechnical evaluation, including laboratory testing, should be performed to further evaluate the potential risks associated with these hazards and evaluate mitigation alternatives.

10.2. Earthwork

Earthwork for the project should be performed in accordance with the CBC and local grading ordinances, as appropriate. We recommend that fill and/or trench backfill be compacted to 90 percent relative compaction in accordance with American Society of Testing Materials (ASTM 1557).

Based on our understanding of the project, the earthwork on the project may consist of minor cuts and fills for construction access. Existing fill and natural soils generated from excavations should be generally suitable for use in fills, provided unsuitable debris or oversized rock (larger than 6 inches) that may be present is removed. Fill soils to be used for backfill around utilities should be compacted to 90 percent relative compaction. Detailed earthwork recommendations should be provided in the design geotechnical report.

10.3. Excavation Characteristics

Based on our previous field exploration and experience, we anticipate that excavations within the fill and alluvial materials along the alignment may be accomplished with conventional backhoe, excavators, or other trenching equipment in good condition. Based on the results of our subsurface exploration, we anticipate that the materials along the alignment will consist predominantly of clays and silts with lesser amounts of sands. In addition, gravel and cobbles may be encountered during the trenching and/or tunneling operations. Excavations in the bedrock materials (Topanga and Monterey Formations) as well as the bedrock landslides exposed in the slope areas could be difficult and may require heavy ripping or blasting.

10.4. Temporary Excavations

Temporary excavations above groundwater up to approximately 5 feet in depth should be generally stable. Excavations which expose friable, cohesionless sands, however, may be subject to caving. Excavations that appear unstable, or deeper than 5 feet, should be shored or the sides of the excavation laid back to slope inclinations of approximately 1½:1 (horizontal to vertical). Friable sand zones which are subject to caving may warrant continuous shoring. For planning purposes, we recommend that the on-site soil be considered at Type C soil in accordance with the OSHA soil classification.

Excavations for jacking and receiving pits (if designed) may include temporary slopes and/or vertical side walls. We anticipate that driven sheet pile or soldier pile with laggings shoring systems will be appropriate for these excavations. Details regarding shoring system should be based on a detailed geotechnical evaluation including site specific subsurface exploration.

Settlement of the ground may occur behind the shoring system wall during excavation. The amount of settlement depends on the type of shoring system, contractor’s workmanship, and soil conditions. Settlement may cause distress to adjacent structures, if present. Possible causes of settlement that should be addressed include vibration during installation of the sheet piling, excavation for construction, construction vibrations, dewatering, and removal of the support system. We recommend that the potential settlement distress be evaluated carefully by the contractor prior to construction.

10.5. Construction Dewatering

Groundwater was previously encountered at depths of approximately 6½ feet or more during exploratory drilling. Depending on the location of the alignment and depth to invert elevation, groundwater may be encountered. As details become available regarding planned excavations and tunneling (if designed), the potential for construction dewatering should be evaluated. Considerations for construction dewatering should include anticipated drawdown, volume of pumping, potential for settlement, and groundwater discharge. Disposal of groundwater should be performed in accordance with guidelines of the Regional Water Quality Control Board.

10.6. Exavation Bottom Stability

In general, we anticipate that the bottom of the excavation in areas of bedrock should provide suitable support to the new pipelines. Excavations that encounter soft fill and/or unconsolidated alluvium at the bottom may involve overexcavation and replacement with a compacted fill or gravel mat beneath the bottom of the excavation to thicknesses of approximately 1 to 3 feet. Recommendations for stabilizing excavation bottoms should be based on evaluation in the field by the geotechnical consultant at the time of construction.

10.7. Slope Stability

Creek erosion should be mitigated to protect the pipeline alignment. Where the creek is close to the proposed pipeline, embankment stabilization may be appropriate, in addition to erosion control. Embankment stabilization may involve some type of retaining structure (gabion walls, rip rap, etc.) and/or reinforced earth slope construction. Slope stabilization should be designed and constructed along with the planned erosion protection system. The actual stabilization design should be based on further geotechnical evaluation. Prior to the subsurface exploration, a detailed topographic survey of the alignment and slope areas should be performed. The survey should include planned finish grade elevations, locations of existing pipelines, and new improvements such as drainage structures, if appropriate.

We understand that the pipeline alternative on the east side between Manholes Nos. 32 and 34 may involve cuts into the adjacent hillside. Based on regional geologic mapping and review of aerial photographs, the geologic structure is considered favorable to neutral. Based on our reconnaissance, a wedge of slope wash is present in this area. The slope wash is situated at the base of a relatively steep slope, underlain by formational materials. In order to excavate in this area, an appropriate shoring system should be considered. Details regarding the shoring system should be provided when detailed plans are available. Additional subsurface exploration may be appropriate at that time.

Planned fill slopes should be generally stable if constructed at inclinations of 2:1 (horizontal to vertical) or flatter. In addition to the mapped landslides, other slopes bordering the proposed road are relatively steep and may be subject to instability. During the design phase, additional geotechnical evaluations should be performed to obtain soil and geologic data along the slope areas. Mitigation measures for slopes with marginal stability may include retaining structures, stabilization fills, soil-cement slopes, rip-rap and/or a combination of methods.

10.8. Horizontal Directional Drilling

Depending on the elevations of the pipeline alternatives, some horizontal directional drilling may be appropriate in lieu of trenching. The directional drilling would be expected to be in areas underlain by sands, silts and clays (older alluvial soils) and/or interbedded sandstones and siltstones (bedrock and/or landslide). The alluvial soils may also contain some gravel and cobbles. In areas underlain by bedrock, hard drilling will be encountered where well-cemented sedimentary rock is present. Mix-phases drilling condition (drilling from alluvium to sedimentary rock) may also be encountered during construction. Details regarding the parameters for the directional drilling should be evaluated with a subsurface evaluation of the location of the proposed directional drilling.

10.9. Corrosive Soils

A preliminary evaluation of the corrosion potential of the near-surface soils was previously performed based on laboratory testing of a representative sample of the near surface soils obtained from our exploratory borings. Laboratory testing was performed to evaluate pH, minimum electrical resistivity, chloride and sulfate content. The laboratory results are presented in Appendix B.

The pH of the tested samples ranges from 6.6 to 8.5, the electrical resistivity ranges from approximately 330 to 3,960 ohm-centimeters, the chloride content ranged from 50 to 215 parts per million (ppm), and the sulfate content ranged from approximately 0.001 percent (i.e., 10 ppm) to 0.192 percent (i.e. 1,920 ppm). Based on the laboratory test results and Caltrans (2003) corrosion criteria, the near surface soils can be classified as a non-corrosive site, which is defined as having earth materials with less than 500 ppm chlorides, less than 0.20 percent sulfates (i.e., 2,000 ppm), a pH of 5.5 or less.

Based on our past experience, the soils may vary along the proposed alignment. Accordingly, additional corrosivity testing of the on-site soils, however, should be performed during the design phase. Corrosivity testing may also need to be considered for soils that are imported for use as fill during construction. The corrosion potential of soils will influence the type of construction materials that may be used for structures and pipelines on the project. Where corrosive soils are present, selection of corrosion resistant material types for underground improvements and/or providing corrosion protection to surfaces in contact with corrosive soils may be used. Concrete protection against sulfate bearing soils may include the use of corrosive resistant cement type and limiting the water-cement ratio of the concrete mix.

11. ADDITIONAL STUDIES

This geotechnical evaluation was performed for preliminary planning purposes. As indicated, it is our preliminary opinion that the proposed pipeline is feasible from a geotechnical perspective provided that erosion protection along the creek channel is implemented along with proper planning and design of the grading and improvements. Our work included a limited subsurface evaluation. Current plans for the pipeline are conceptual. No detailed improvement plans illustrating planned finish grade elevations, existing and new pipelines and drainage structures were available at the time of this report.

The proposed pipeline is located adjacent to several large landslide areas and is subject to risk of damage if the landslides are reactivated. Our preliminary evaluation did not indicate evidence of active landsliding or recent movement. We recommend that additional geotechnical exploration be performed to evaluate the soil and geologic conditions, address potential landslide risks, and develop detailed design criteria for slope stabilization. Prior to the supplemental exploration, discussions with the interested parties for the project, including the appropriate review agency, should be conducted to evaluate the proposed program as well as anticipated analysis. Grading plans including planned elevations and proposed improvements should be prepared prior to additional geotechnical exploration.

12. LIMITATIONS

The field evaluation and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through supplemental subsurface exploration. Subsurface evaluation will be performed upon request.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site can change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

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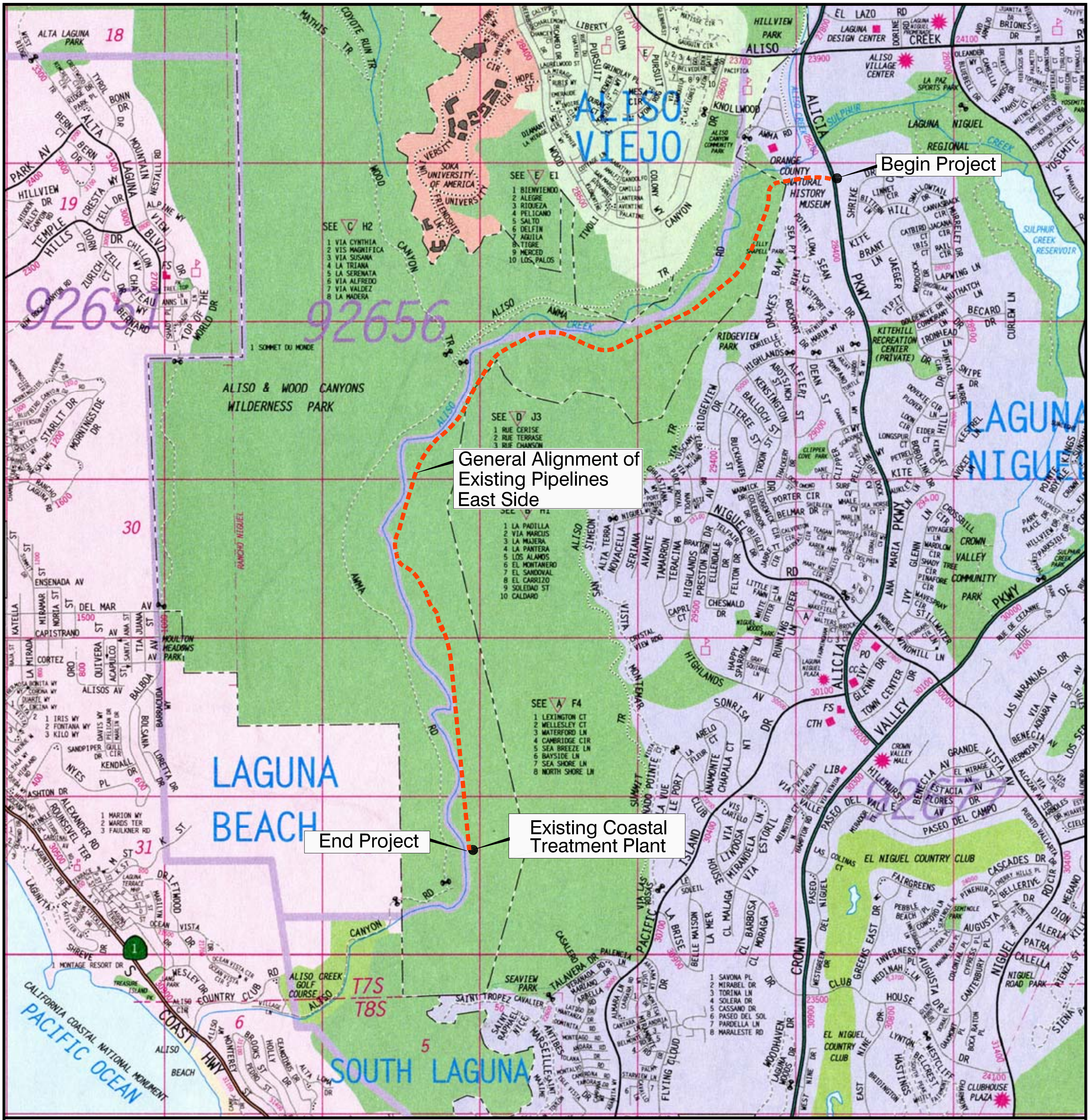
AERIAL PHOTOGRAPHS

Source	Date	Flight	Numbers	Scale
USDA	12-12-52	AXK-2K	130 through 134	1:20,000



REFERENCE: 2007 THOMAS GUIDE FOR LOS ANGELES/ORANGE COUNTIES, STREET GUIDE AND DIRECTORY

SCALE IN FEET

0 2400 4800

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Map © Rand McNally, R.L.07-S-129

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Ninyo & Moore

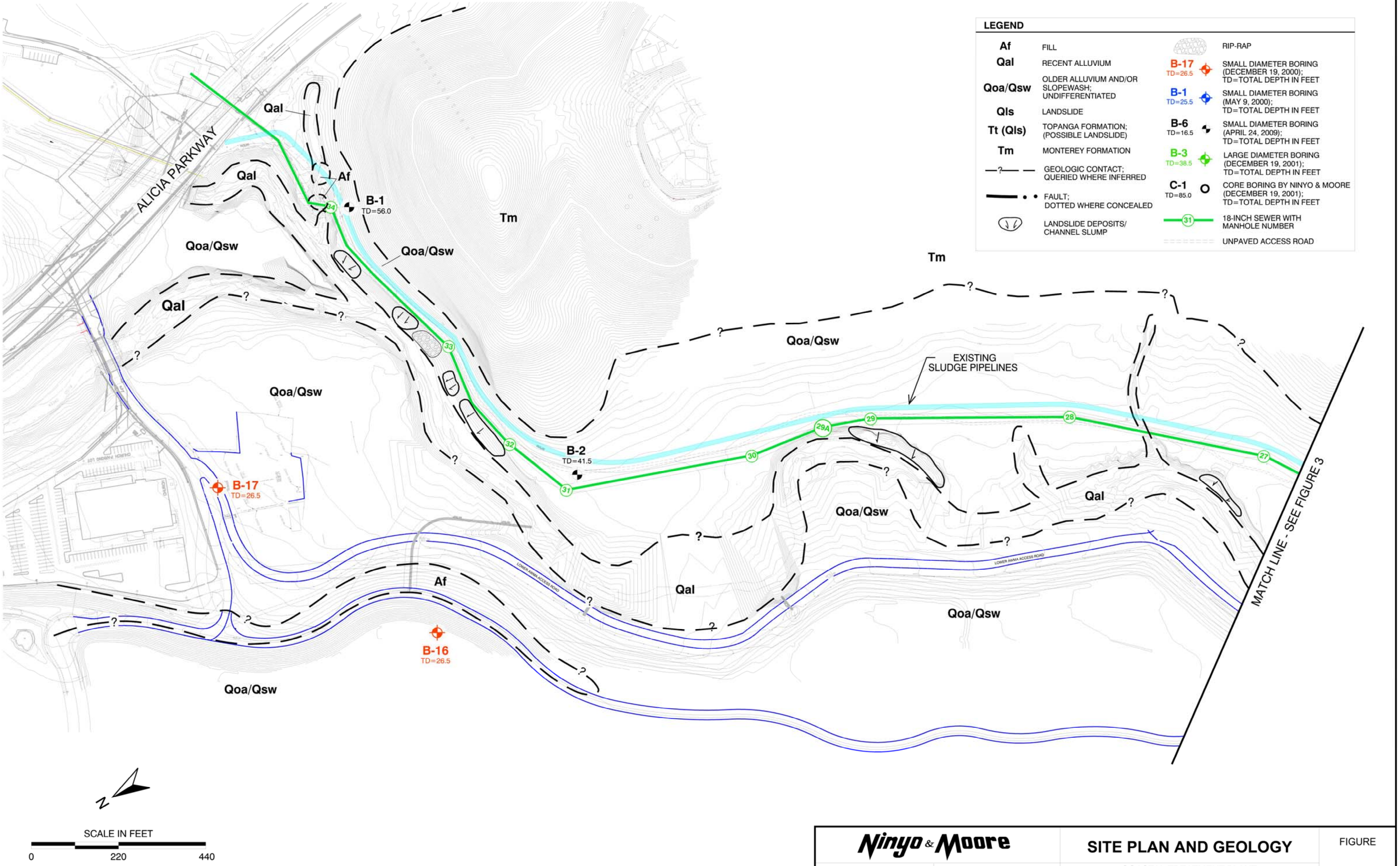
PROJECT NO.	DATE
202426005	11/11

SITE LOCATION

COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
LAGUNA NIGUEL, CALIFORNIA

FIGURE

1



NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: CAD TOPOGRAPHIC MAP PROVIDED BY DUDEK, DATED NOVEMBER 2011.

Ninyo & Moore

PROJECT NO.	DATE
202426005	11/11

SITE PLAN AND GEOLOGY

COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
LAGUNA NIGUEL, CALIFORNIA

FIGURE

2

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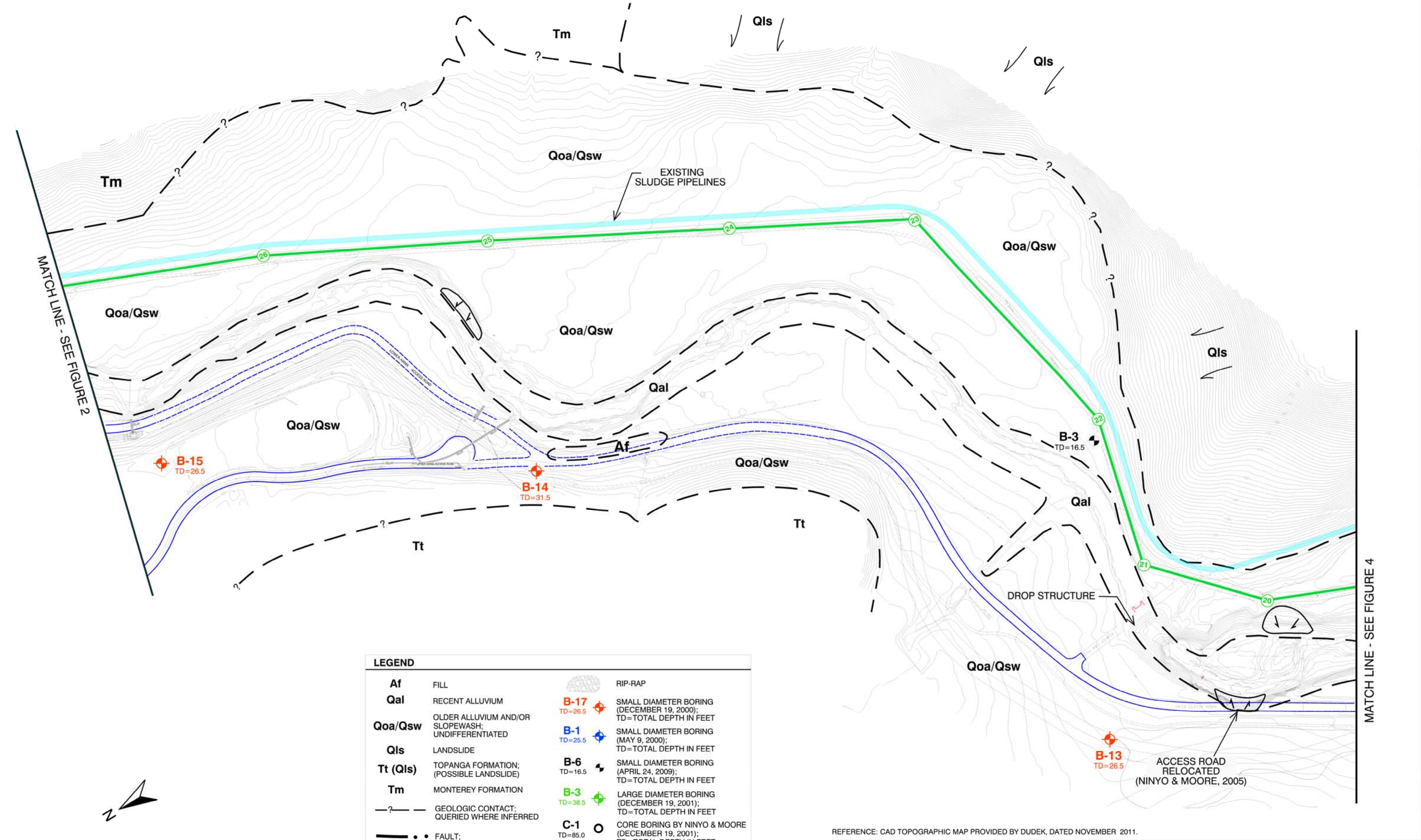

LEGEND

Af	FILL
Qal	RECENT ALLUVIUM
Qoa/Qsw	OLDER ALLUVIUM AND/OR SLOPEWASH; UNDIFFERENTIATED
Qls	LANDSLIDE
Tt (Qls)	TOPANGA FORMATION; (POSSIBLE LANDSLIDE)
Tm	MONTEREY FORMATION
—?— —	GEOLOGIC CONTACT; QUERIED WHERE INFERRED
▬ • •	FAULT; DOTTED WHERE CONCEALED
◡	LANDSLIDE DEPOSITS/ CHANNEL SLUMP
▨	RIP-RAP
B-17 TD=26.5 ⊕	SMALL DIAMETER BORING (DECEMBER 19, 2000); TD=TOTAL DEPTH IN FEET
B-1 TD=25.5 ⊕	SMALL DIAMETER BORING (MAY 9, 2000); TD=TOTAL DEPTH IN FEET
B-6 TD=16.5 ◆	SMALL DIAMETER BORING (APRIL 24, 2009); TD=TOTAL DEPTH IN FEET
B-3 TD=38.5 ⊕	LARGE DIAMETER BORING (DECEMBER 19, 2001); TD=TOTAL DEPTH IN FEET
C-1 TD=85.0 ○	CORE BORING BY NINYO & MOORE (DECEMBER 19, 2001); TD=TOTAL DEPTH IN FEET
—㉛—	18-INCH SEWER WITH MANHOLE NUMBER
=======	UNPAVED ACCESS ROAD

SCALE IN FEET

0 220 440

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: CAD TOPOGRAPHIC MAP PROVIDED BY DUDEK, DATED NOVEMBER 2011.

Ninyo & Moore		SITE PLAN AND GEOLOGY	FIGURE
PROJECT NO.	DATE	COASTAL TREATMENT PLANT EXPORT SLUDGE SYSTEM LAGUNA NIGUEL, CALIFORNIA	3
202426005	11/11		

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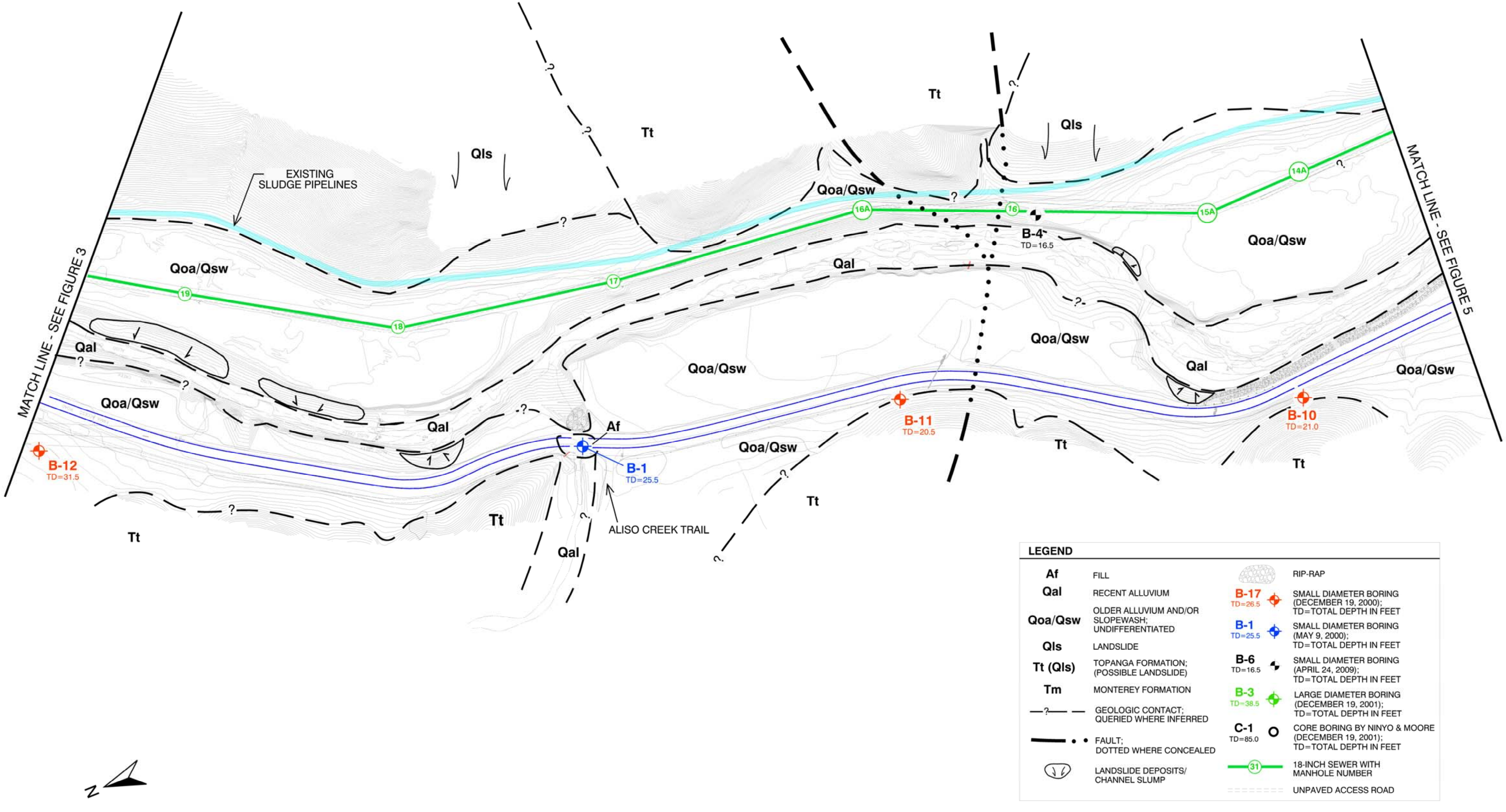

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: CAD TOPOGRAPHIC MAP PROVIDED BY DUDEK, DATED NOVEMBER 2011.

Ninyo & Moore

PROJECT NO.	DATE
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SITE PLAN AND GEOLOGY

COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
LAGUNA NIGUEL, CALIFORNIA

FIGURE

4

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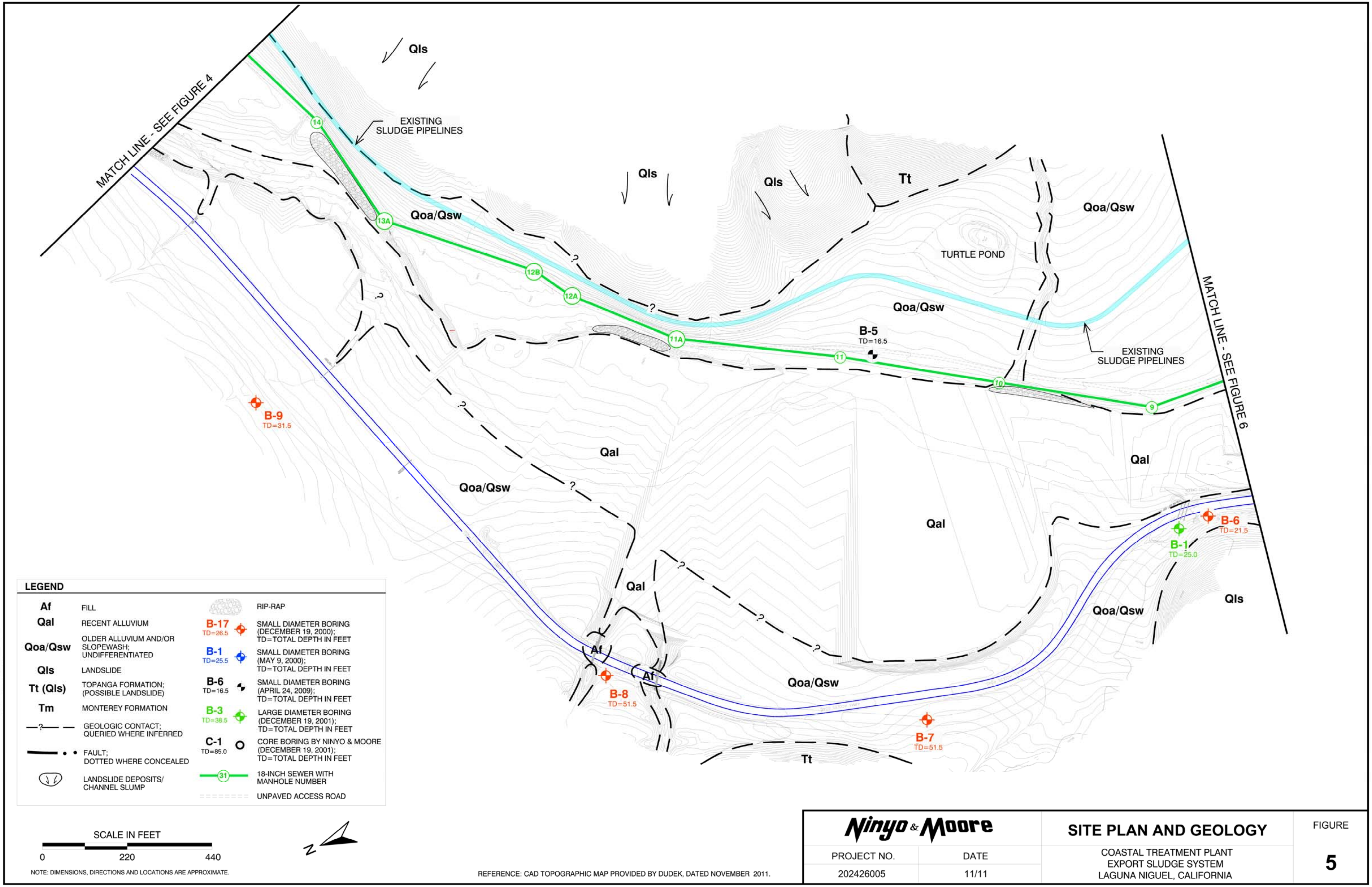

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: CAD TOPOGRAPHIC MAP PROVIDED BY DUDEK, DATED NOVEMBER 2011.

Ninyo & Moore

PROJECT NO.	DATE
202426005	11/11

SITE PLAN AND GEOLOGY

COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
LAGUNA NIGUEL, CALIFORNIA

FIGURE

5

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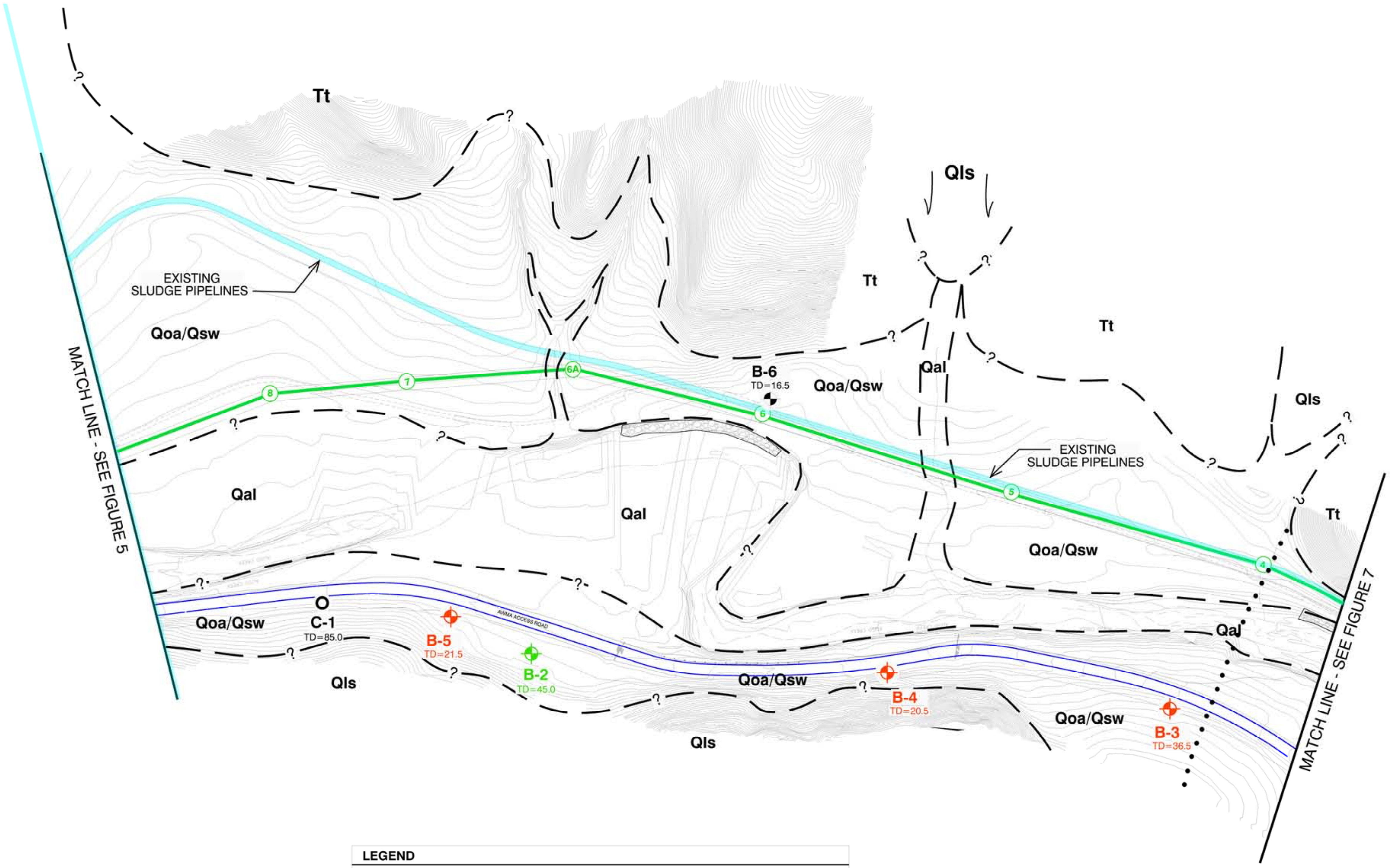

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SCALE IN FEET

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NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

Af	FILL		RIP-RAP
Qal	RECENT ALLUVIUM	**B-17** TD=26.5 ⊕	SMALL DIAMETER BORING (DECEMBER 19, 2000); TD=TOTAL DEPTH IN FEET
Qoa/Qsw	OLDER ALLUVIUM AND/OR SLOPEWASH; UNDIFFERENTIATED	**B-1** TD=25.5 ⊕	SMALL DIAMETER BORING (MAY 9, 2000); TD=TOTAL DEPTH IN FEET
Qls	LANDSLIDE	**B-6** TD=16.5 ◐	SMALL DIAMETER BORING (APRIL 24, 2009); TD=TOTAL DEPTH IN FEET
Tt (Qls)	TOPANGA FORMATION; (POSSIBLE LANDSLIDE)	**B-3** TD=38.5 ⊕	LARGE DIAMETER BORING (DECEMBER 19, 2001); TD=TOTAL DEPTH IN FEET
Tm	MONTEREY FORMATION	**C-1** TD=85.0 ○	CORE BORING BY NINYO & MOORE (DECEMBER 19, 2001); TD=TOTAL DEPTH IN FEET
—?—— ——	GEOLOGIC CONTACT; QUERIED WHERE INFERRED	——(31)——	18-INCH SEWER WITH MANHOLE NUMBER
▬ • •	FAULT; DOTTED WHERE CONCEALED	= = = =	UNPAVED ACCESS ROAD
	LANDSLIDE DEPOSITS/ CHANNEL SLUMP		

REFERENCE: CAD TOPOGRAPHIC MAP PROVIDED BY DUDEK, DATED NOVEMBER 2011.

Ninyo & Moore		**SITE PLAN AND GEOLOGY**	FIGURE
PROJECT NO.	DATE	COASTAL TREATMENT PLANT EXPORT SLUDGE SYSTEM LAGUNA NIGUEL, CALIFORNIA	**6**
202426005	11/11		

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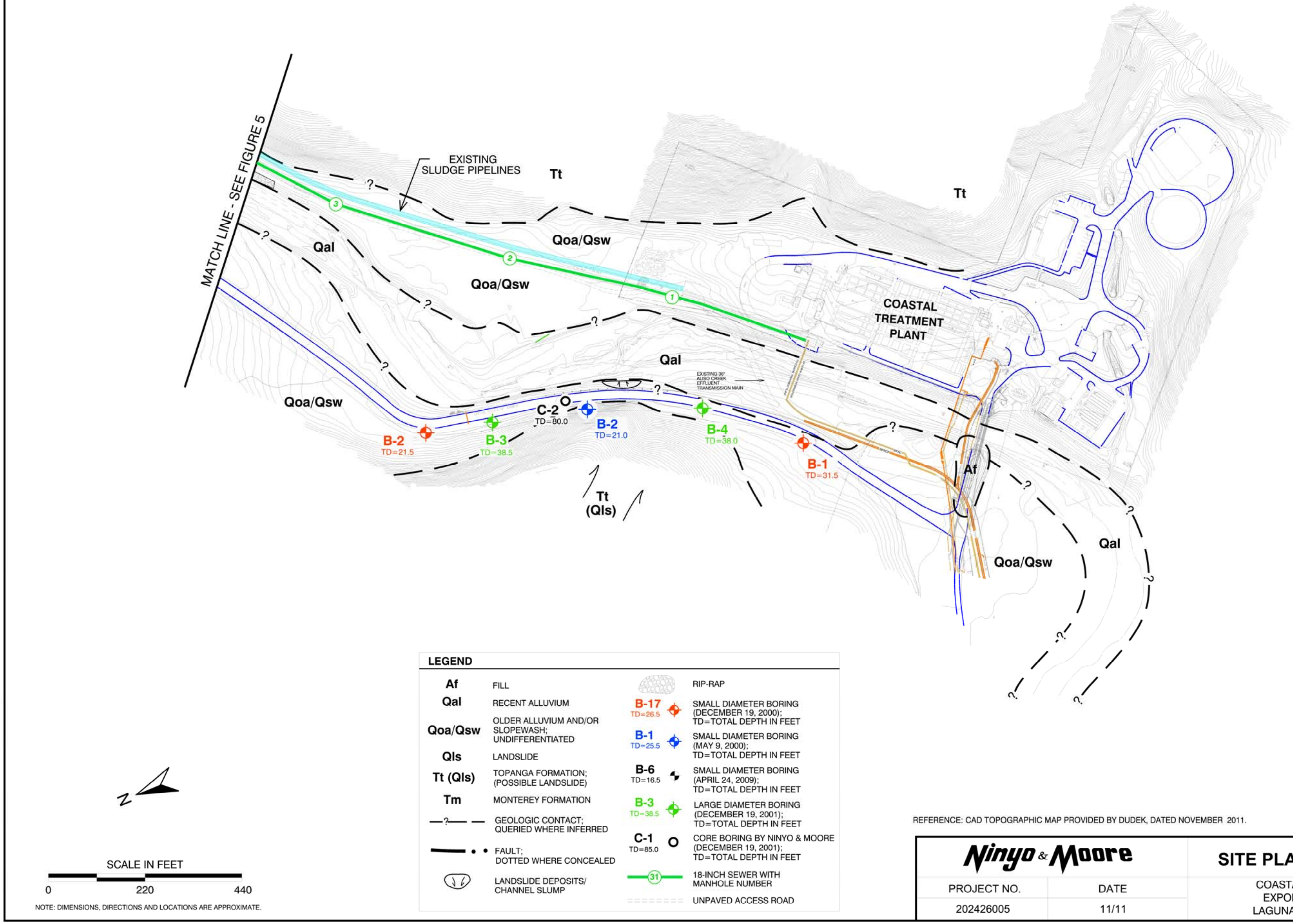

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

REFERENCE: CAD TOPOGRAPHIC MAP PROVIDED BY DUDEK, DATED NOVEMBER 2011.

Ninyo & Moore		SITE PLAN AND GEOLOGY	FIGURE
PROJECT NO.	DATE	COASTAL TREATMENT PLANT EXPORT SLUDGE SYSTEM LAGUNA NIGUEL, CALIFORNIA	7
202426005	11/11		

208030_B6.DWG......–G.K.

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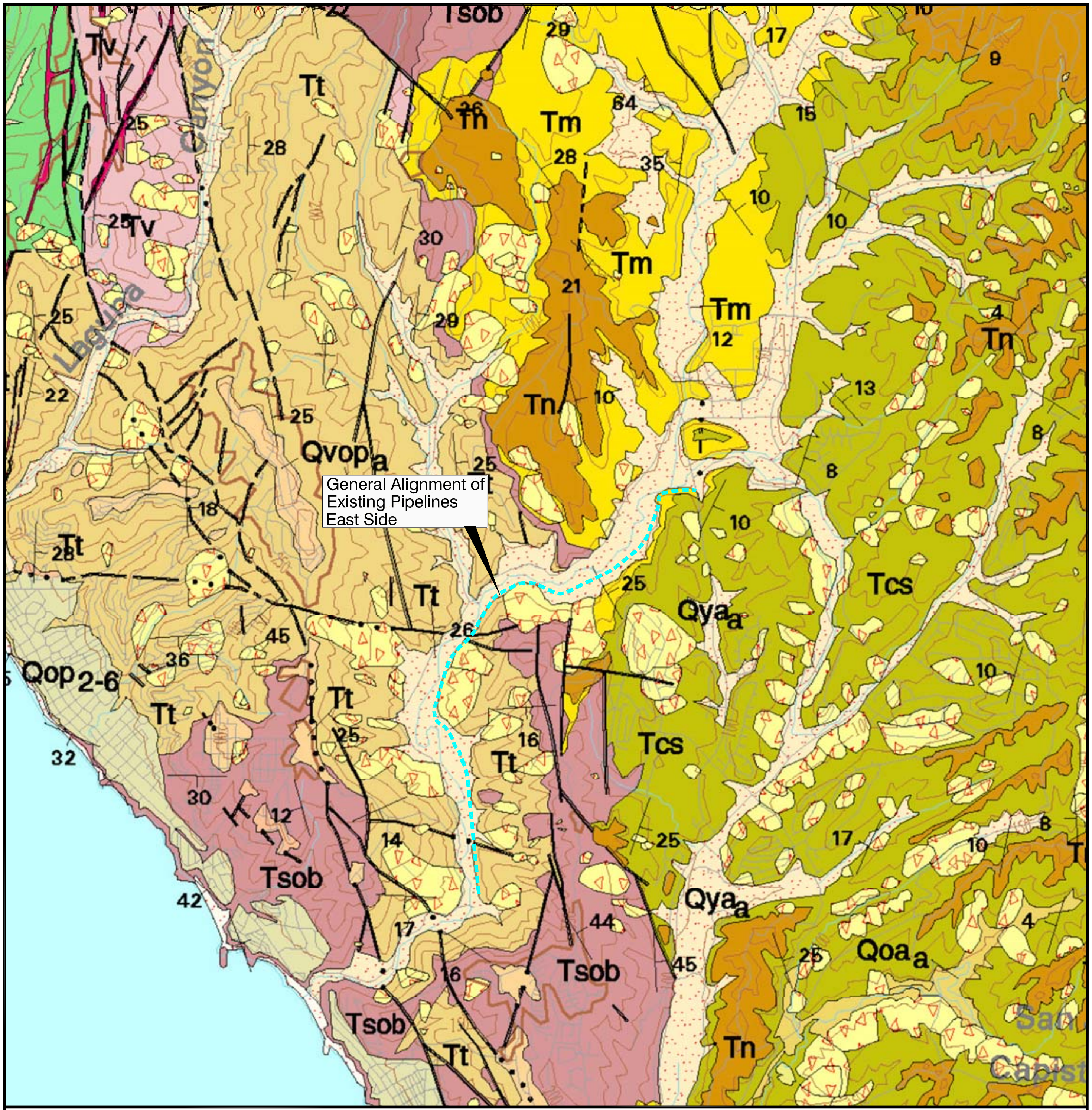
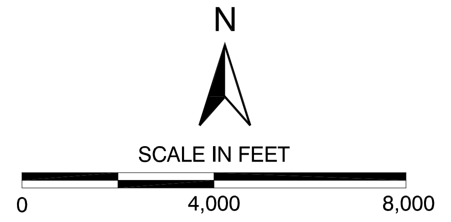


REFERENCE: USGS, D.M. MORTON GEOLOGIC MAP OF THE SANTA ANA 30x60 QUADRANGLE; SOUTHERN CALIFORNIA, DATED 2004.



NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

Tsob	SAN ONOFRE BRECCIA	Qoa	OLD AXIAL CHANNEL DEPOSITS
Tn	NIGUEL FORMATION	Qop	OLD PARELIC DEPOSITS
Tcs	CAPISTRANO FORMATION	Qvop	VERY OLD PARELIC DEPOSITS
Tm	MONTEREY FORMATION (MIOCENE)	Qya	YOUNG AXIAL CHANNEL DEPOSITS
Tt	TOPANGA FORMATION	△	LANDSLIDE DEPOSITS

202426_A3.DWG......GK

Ninyo & Moore

PROJECT NO.	DATE
202426005	11/11

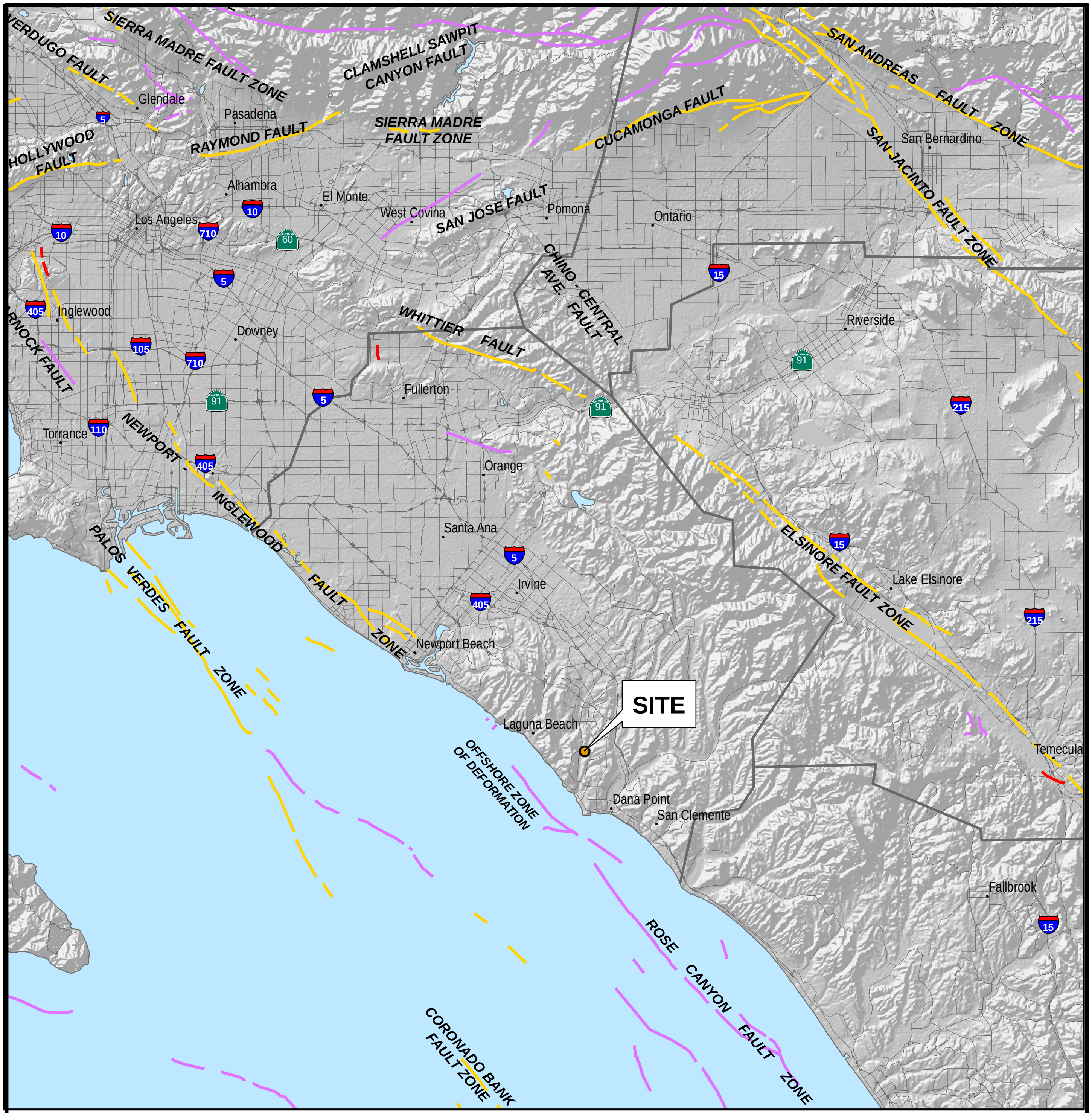
REGIONAL GEOLOGY

COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
LAGUNA NIGUEL, CALIFORNIA

FIGURE

8

202426005_a4.Fault Loc.........GK



GIS DATA SOURCE: CALIFORNIA GEOLOGICAL SURVEY (CGS); ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)
REFERENCE: JENNINGS, 1994, FAULT ACTIVITY MAP OF CALIFORNIA AND ADJACENT AREAS

LEGEND

FAULT ACTIVITY:

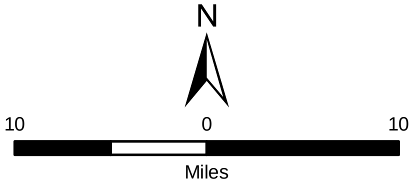
🟥 HISTORICALLY ACTIVE

🟨 HOLOCENE ACTIVE

━ COUNTY BOUNDARIES

🟩 LATE QUATERNARY (POTENTIALLY ACTIVE)

🟪 QUATERNARY (POTENTIALLY ACTIVE)



NOTE: DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE

Ninyo & Moore

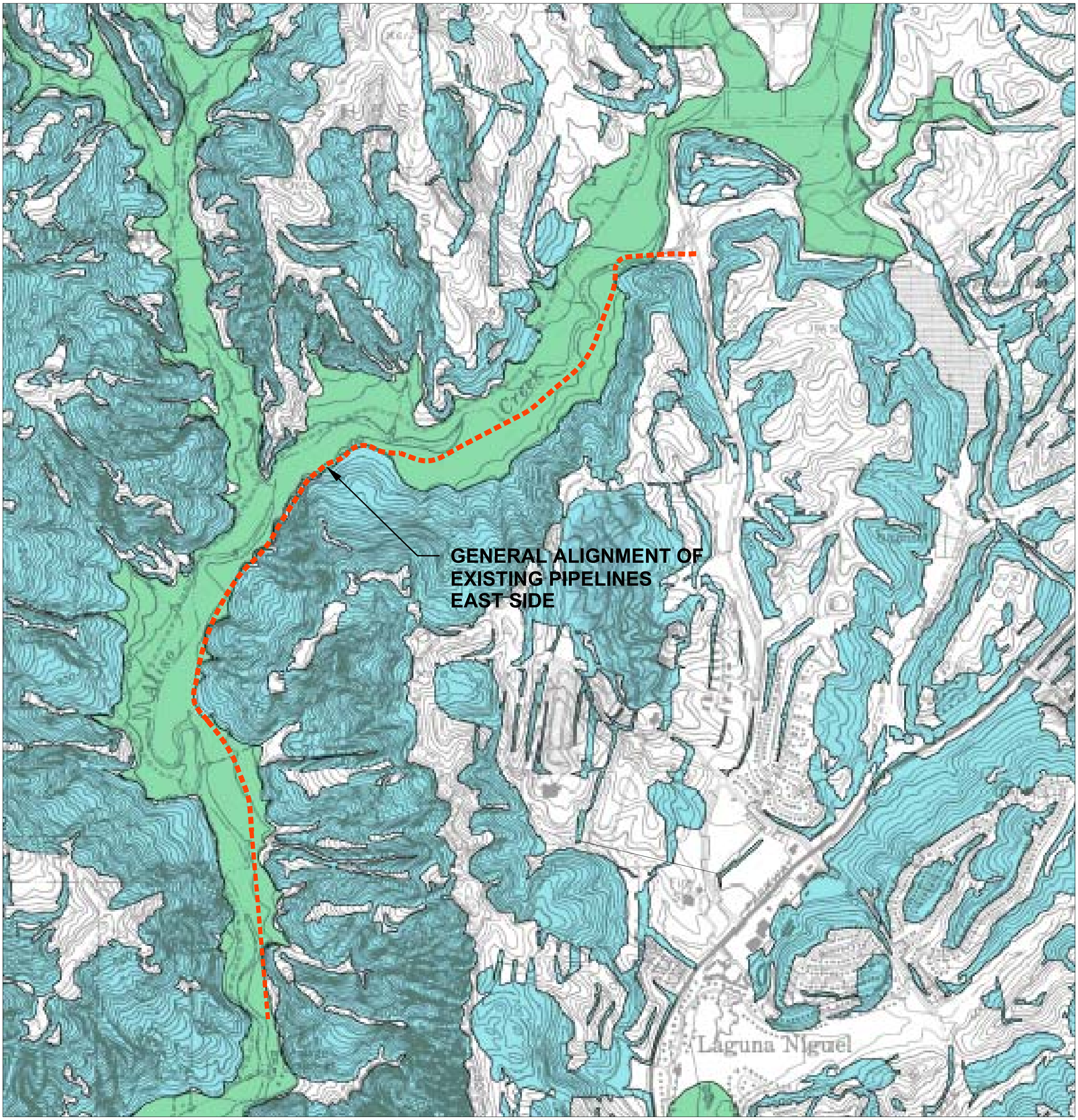
FAULT LOCATIONS

FIGURE

9

PROJECT NO.	DATE
202426005	11/11

COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
LAGUNA NIGUEL, CALIFORNIA



REFERENCE: STATE OF CALIFORNIA SEISMIC HAZARD ZONES, SAN JUAN CAPISTRANO QUADRANGLE, DATED DECEMBER 21, 2001.

SCALE IN FEET

0 2000 4000

N

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

🟩 Liquefaction
Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

🟦 Earthquake-Induced Landslides
Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

202426-A2.DWG.......GK

Ninyo & Moore

SEISMIC HAZARD ZONES

COASTAL TREATMENT PLANT
EXPORT SLUDGE SYSTEM
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE
202426005	11/11

FIGURE

10

APPENDIX A

BORING LOGS

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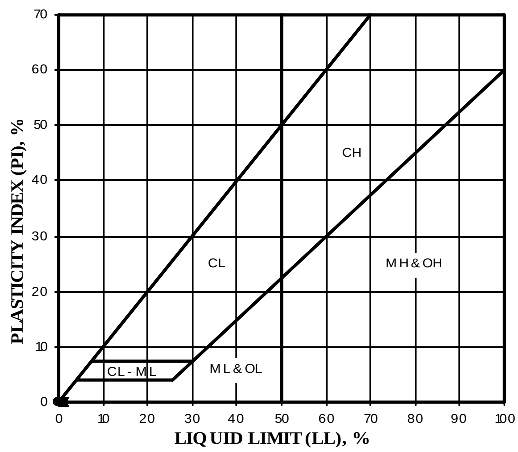
U.S.C.S. METHOD OF SOIL CLASSIFICATION

MAJOR DIVISIONS		SYMBOL		TYPICAL NAMES
COARSE-GRAINED SOILS (More than 1/2 of soil > No. 200 Sieve Size)	GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size	▨	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		▨	GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		▨	GM	Silty gravels, gravel-sand-silt mixtures
		▨	GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (More than 1/2 of coarse fraction < No. 4 sieve size	▨	SW	Well graded sands or gravelly sands, little or no fines
		▨	SP	Poorly graded sands or gravelly sands, little or no fines
		▨	SM	Silty sands, sand-silt mixtures
		▨	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (More than 1/2 of soil < No. 200 sieve size)	SILTS & CLAYS Liquid Limit <50	▨	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		▨	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		▨	OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS Liquid Limit >50	▨	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		▨	CH	Inorganic clays of high plasticity, fat clays
		▨	OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils

GRAIN SIZE CHART

CLASSIFICATION	RANGE OF GRAIN	
	U.S. Standard Sieve Size	Grain Size in Millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	306 to 76.2
GRAVEL	3" to No. 4	76.2 to 4.76
Coarse	3" to 3/4"	76.2 to 19.1
Fine	3/4" to No. 4	19.1 to 4.76
SAND	No. 4 to No. 200	4.76 to 0.075
Coarse	No. 4 to No. 10	4.76 to 2.00
Medium	No. 10 to No. 40	2.00 to 0.420
Fine	No. 40 to No. 200	0.420 to 0.075
SILT & CLAY	Below No. 200	Below 0.075

PLASTICITY CHART



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U.S.C.S. METHOD OF SOIL CLASSIFICATION

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	BORING LOG EXPLANATION SHEET
0	■							Bulk sample.
		■						Modified split-barrel drive sampler.
		☒						No recovery with modified split-barrel drive sampler.
		▮						Sample retained by others.
		◣						Standard Penetration Test (SPT).
5		◺						No recovery with a SPT.
		▯	XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
		◺						No recovery with Shelby tube sampler.
		▥						Continuous Push Sample.
				♀				Seepage.
10				▽				Groundwater encountered during drilling.
				▼				Groundwater measured after drilling.
						▦	SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
						▨	CL	Dashed line denotes material change.
15						▨		Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE
	Rev. 11/11	

DATE DRILLED 1/6/09 BORING NO. B-1

GROUND ELEVATION 139' ± (MSL) SHEET 1 OF 3

METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	CL	FILL: Dark brown, moist, stiff to very stiff, sandy CLAY.
5		■	14	12.3	109.0	▨	SC	ALLUVIUM: Dark brown, moist, medium dense, clayey SAND; scattered gravel.
10		◤	9			▨		
15		■	22	15.6	115.0	▨		
20		◤	1	▽		▨	SC	ALLUVIUM: (Continued) Brown to dark brown, saturated, very loose, clayey SAND.

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-1

DATE DRILLED 1/6/09 BORING NO. B-1

GROUND ELEVATION 139' ± (MSL) SHEET 2 OF 3

METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◤				▨		@20': Groundwater encountered during drilling.
				▼		▨		@23.75': Groundwater measured at the end of drilling.
25		■	16	20.0	108.1	▨		Medium dense; scattered gravel.
30		◤	2			▨		Olive brown; very loose.
35		■	11			▨		Light olive brown; loose.
40		◤	1	31.1		▨	CL	ALLUVIUM: (Continued) Olive and brown, saturated, very soft, sandy CLAY.

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-2

DATE DRILLED 1/6/09 BORING NO. B-1
GROUND ELEVATION 139' ± (MSL) SHEET 3 OF 3
METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)
DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"
SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
45		■	5	33.0	85.8	▨		Light olive brown; firm.
						▒		MONTEREY FORMATION: Dark brown, saturated, hard, sandy weathered SILTSTONE.
50		◤	63			▒		
55		■	70/10"			▒		Caliche.
								Total Depth = 56 feet. Groundwater encountered during drilling at approximately 20 feet. Groundwater measured at the end of drilling at approximately 23.75 feet. Backfilled with on-site soils on 1/6/09. Note: Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
60								

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-3

DATE DRILLED 1/6/09 BORING NO. B-2

GROUND ELEVATION 139' ± (MSL) SHEET 1 OF 3

METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▩	SC	FILL: Medium brown, damp, medium dense, clayey SAND.
5		◣	8			▩		Reddish brown and olive; scattered construction debris (woven fabric).
10		■	34			▩	SC	ALLUVIUM: Dark brown, damp, medium dense, clayey SAND with sandy CLAY lenses; caliche.
15		◣	2	23.2		▨	CL	Mottled olive and brown, damp to moist, soft, CLAY; caliche.
20		■	11	22.0	102.7	▨	CL	ALLUVIUM: (Continued) Dark brown, moist, stiff, sandy CLAY with scattered sandy SILT.

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-4

DATE DRILLED 1/6/09 BORING NO. B-2
GROUND ELEVATION 139' ± (MSL) SHEET 2 OF 3
METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)
DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"
SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		■				▨		
25		◣	4	∇		▨		@25': Groundwater encountered during drilling. Gray; wet to saturated; firm.
30		■	9			▩	SC	Gray, saturated, loose, clayey SAND.
				▼		▩		@33.3': Groundwater measured after completion of drilling.
						▤		MONTEREY FORMATION: Light yellowish brown, saturated, moderately soft, clayey SILTSTONE.
35		◣	7			▤		
40		■	39			▤		MONTEREY FORMATION: (Continued) Light yellowish brown, saturated, moderately hard, clayey SILTSTONE.
								Total Depth = 41.5 feet.

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-5

DATE DRILLED 1/6/09 BORING NO. B-2

GROUND ELEVATION 139' ± (MSL) SHEET 3 OF 3

METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								Groundwater encountered during drilling at approximately 25 feet. Groundwater measured at the completion of drilling at approximately 33.3 feet. Backfilled with soil cuttings on 1/6/09. Note: Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
45								
50								
55								
60								

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-6

DATE DRILLED 1/6/09 BORING NO. B-3
GROUND ELEVATION 103' ± (MSL) SHEET 1 OF 1
METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)
DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"
SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	CL	FILL: Dark brown, damp to moist, soft to firm, sandy CLAY.
5		■	6	22.8	98.9	▨	CL	ALLUVIUM: Dark brown to black, moist, firm to stiff, sandy CLAY with gravel.
				▼		▨		@6.5': Groundwater measured after completion of drilling.
10		◣	21			▨		Dark olive brown and dark reddish brown; saturated; very stiff.
						▨		Occasional cobble.
15		■	18			▦	SC	Light yellowish brown, saturated, medium dense, clayey SAND; scattered gravel.
								Total Depth = 16.5 feet. Groundwater measured at approximately 6.5 feet at the end of drilling. Backfilled with on-site soils on 1/6/09. Note: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
20								

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-7

DATE DRILLED 1/6/09 BORING NO. B-4
GROUND ELEVATION 89' ± (MSL) SHEET 1 OF 1
METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)
DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"
SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▦	SM	ALLUVIUM: Yellowish brown to brown, damp to moist, medium dense, silty SAND with scattered sandy clay lenses.
	■	■	20	10.0	108.0	▦		
5		◣	3			▨	CL	Dark yellowish brown, damp to moist, soft to firm, sandy CLAY; rootlets.
10		■	24	16.1	102.0	▨		Very stiff; caliche; rootlets.
15		◣	6			▨		Mottled yellowish brown and olive brown; firm to stiff.
								Total Depth = 16.5 feet. No groundwater encountered during drilling. Backfilled with on-site soils on 1/6/09. Note: Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
20								

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-8

DATE DRILLED 1/6/09 BORING NO. B-5
GROUND ELEVATION 75' ± (MSL) SHEET 1 OF 1
METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)
DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"
SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	CL	<u>FILL</u>: Brown, dry to damp, stiff, sandy CLAY.
5		◤	15	12.7	103.8	▩	SC	<u>ALLUVIUM</u>: Dark brown, damp, medium dense, clayey SAND; caliche.
10		◤	5			▩		Yellowish brown; loose.
15		■	21			▩		Very stiff sandy clay lens.
								Total Depth = 16.5 feet. No groundwater encountered during drilling. Backfilled with on-site soils on 1/6/09. <u>Note</u>: Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
20								

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BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-9

DATE DRILLED 1/6/09 BORING NO. B-6

GROUND ELEVATION 63' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 8 inch Hollow-Stem Auger (Martini Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY MCP LOGGED BY MCP REVIEWED BY JJB

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	SC	ALLUVIUM: Light yellowish brown, dry to damp, medium dense, clayey SAND with sandy CLAY; scattered gravel; rootlets.
	■	■	16	8.2	112.2	▨		
5		■	7			▨		Caliche; loose to medium dense.
10		■	11			▨		Loose; scattered gravel.
15		◣	3			▨	CL	Reddish brown, damp, soft to firm, sandy CLAY; rootlets.
								Total Depth = 16.5 feet. No groundwater encountered during drilling. Backfilled with on-site soils on 1/6/09. Note: Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
20								

Ninyo & Moore

BORING LOG

COASTAL TREATMENT PLANT ACCESS ROAD REALIGNMENT
LAGUNA NIGUEL, CALIFORNIA

PROJECT NO.	DATE	FIGURE
202426004	4/09	A-10

DATE DRILLED 11/15/01 BORING NO. B-1

GROUND ELEVATION 62' ± (MSL) SHEET 1 OF 2

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY LTJ LOGGED BY LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	SLOPE WASH/ALLUVIUM: Light brown, damp, loose, silty SAND.
							SC	Brown, moist, medium dense, clayey SAND with few gravel.
	■			16.8				
5								
	■			15.2				Light yellowish brown, scattered cobble to small boulder size sandstone and siltstone fragments.
10								
							SC+CL	Light yellowish brown, moist, medium dense, clayey SAND and sandy CLAY with few cobble size siltstone/sandstone fragments.
15	■			19.2				
				∇				@ 17.0': Groundwater encountered during drilling; boring subject to caving; saturated.
	■			20.5				Mottled olive brown and orangish brown.
20							SC+CL	SLOPE WASH/ALLUVIUM: Mottled olive brown and orangish brown, moist,

Ninyo & Moore

BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/15/01 BORING NO. B-1

GROUND ELEVATION 62' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY LTJ LOGGED BY LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
	■					▨	CL	dense, clayey SAND and sandy CLAY. @ 20.0': Cobble and boulder size siltstone fragments. Brown, saturated, stiff, sandy CLAY with gravel and cobbles.
	■					▤		<u>TOPANGA FORMATION (LANDSLIDE DEPOSITS)</u>: Light olive, moist, moderately weathered SILTSTONE. @ 22.0': difficult drilling; switched to bullet tooth flight auger bit; strongly cemented.
25								Total Depth = 25.0 feet. Drilling refusal in strongly cemented siltstone. Groundwater encountered during drilling at approximately 17.0 feet. Boring downhole logged to approximately 18.0 feet; caving and seepage encountered. Backfilled on 11/15/01.
30								
35								
40								

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/15/01 BORING NO. B-2

GROUND ELEVATION 54' ± (MSL) SHEET 1 OF 3

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY GMC LOGGED BY GMC/LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▥	ML	FILL: Light brown to brown, damp, firm, clayey SILT; abundant rootlets.
						▨	CL	SLOPE WASH/ALLUVIUM: Brown, damp to moist, firm, sandy CLAY; trace coarse sand and gravel; abundant rootlets.
5	■			9.6		▨		
10	■			22.4		▨		Moist to wet.
				▽		▨		@ 14.0': Groundwater encountered during drilling; saturated.
15	■			22.1		▨		@ 14.0 to 17.0': Borehole caving; downhole logging terminated.
20						▨		SLOPE WASH/ALLUVIUM (CONTINUED): Brown, saturated, firm, sandy CLAY; trace coarse sand and

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/15/01 BORING NO. B-2

GROUND ELEVATION 54' ± (MSL) SHEET 2 OF 3

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY GMC LOGGED BY GMC/LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
	■					▨		gravel; abundant rootlets.
25						▩	SC	Light brown and reddish brown, saturated, medium dense, clayey SAND; few to little gravel; few cobbles of reddish brown, strongly cemented, fine grained sandstone.
30 35	■					░		TOPANGA FORMATION (LANDSLIDE DEPOSITS): Yellowish brown, saturated, moderately cemented, moderately weathered, silty fine to medium-grained SANDSTONE; trace coarse sand and pebbles.
	■					▤		Reddish brown and grayish brown, moderately indurated SILTSTONE.
40						░		Bluish gray and white, weakly cemented, slightly weathered, fine to medium grained SANDSTONE; friable. TOPANGA FORMATION (LANDSLIDE DEPOSITS)(CONTINUED): Bluish gray, white and gray, weakly cemented, fresh to slightly weathered, fine to medium grained SANDSTONE; friable; planar and convoluted laminations.

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/15/01 BORING NO. B-2
GROUND ELEVATION 54' ± (MSL) SHEET 3 OF 3
METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)
DRIVE WEIGHT NA DROP NA
SAMPLED BY GMC LOGGED BY GMC/LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
						▨		
45								Total Depth = 45.0 feet. Groundwater encountered during drilling at approximately 14.0 feet. Borehole downhole logged to approximately 15.0 feet; seepage and caving encountered. Backfilled on 11/15/01.
50								
55								
60								

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/14/01 BORING NO. B-3

GROUND ELEVATION 45.5' ± (MSL) SHEET 1 OF 2

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY TPO LOGGED BY TPO/LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						░	SC	FILL: Gray, moist, medium dense, clayey SAND with trace gravel and fine roots.
	■			8.7		░		
						▨	CL	SLOPEWASH/ALLUVIUM: Olive brown, moist, stiff, sandy CLAY.
5	■			20.2		▨		
10	■			24.5		▨		
15	■			24.0		▨		@ 15.0': Few scattered lenses of fine sand.
				▽		▨		@ 18.0': Groundwater encountered during drilling, saturated. @ 18.0' to 24.0': Borehole caving; downhole logging terminated at approximately 19.0 feet.
20	■			22.6		▨	CL	SLOPE WASH/ALLUVIUM (CONTINUED): Olive brown, moist, stiff, sandy CLAY.

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/14/01 BORING NO. B-3

GROUND ELEVATION 45.5' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY TPO LOGGED BY TPO/LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
	■					▨		
						▦	SM	Light gray, saturated, medium dense, silty SAND.
						▨	CL	Olive brown, saturated, stiff, sandy CLAY with trace gravel.
25	■					▨		
30	■					▨		
						▨		@ 33.0': Boulders.
35	■					▨		
	■					░		<u>TOPANGA FORMATION (LANDSLIDE DEPOSITS)</u>: Gray, slightly weathered, very hard, strongly cemented SANDSTONE.
								Total Depth = 38.5 feet. Drilling refusal in strongly cemented sandstone. Groundwater encountered at approximately 18.0 feet during drilling. Boring downhole logged to approximately 19.0 feet; caving and seepage encountered. Backfilled on 11/14/01.
40								

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/14/01 BORING NO. B-4

GROUND ELEVATION 48.0' ± (MSL) SHEET 1 OF 2

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY TPO LOGGED BY TPO/LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▩	SC	<u>FILL</u>: Grayish brown, damp, clayey SAND with trace gravel; trace root hairs;
	■			8.4		▩	SC	<u>SLOPE WASH/ALLUVIUM</u>: Olive brown, moist, medium dense, clayey SAND with little gravel, cobbles.
5	■			6.0		▩		
						▨	CL	Dark brown, moist, stiff, sandy CLAY with cobble to boulder size shale fragments.
						░		<u>TOPANGA FORMATION (LANDSLIDE DEPOSITS)</u>: Yellowish brown, moderately weathered, weakly to moderately cemented, silty fine-grained SANDSTONE.
10	■			14.0		░		@ 10.5': Becomes strongly cemented; orange oxidation; bedding massive.
						░		@ 14.0': Fracture; N60°E, 60°NW; planar with approximately 1/16-inch clay infilling.
15	■			13.0		░		
						☰		Brown and gray, moderately weathered, clayey SHALE. @ 16.5': Bedding, N50°E;12°S @ 17.0': Fracture, N30°W, 60°NE; planar with approximately 1/16-inch clay infilling; fracture terminated between 16.5' and 18.0'.
						░		Gray to dark gray, strongly cemented, fine-grained SANDSTONE; moderately weathered; moderately cemented, massive.
20	■					░		<u>TOPANGA FORMATION (LANDSLIDE DEPOSITS)</u>: Gray to dark gray, strongly cemented, fine-grained SANDSTONE; moderately

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/14/01 BORING NO. B-4

GROUND ELEVATION 48.0' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING 30" Bucket Auger (San Diego Drilling)

DRIVE WEIGHT NA DROP NA

SAMPLED BY TPO LOGGED BY TPO/LTJ REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
	■							weathered; moderately cemented, massive.
								@ 21.5': Approximately 1-inch-thick brown shale layer: N60°W, 12°S.
								@ 22.0': Scattered discontinuous vertical fractures; tight.
				♀				@ 22.5': Slight seepage.
				♀				
25								@ 25.5': Bedding, N30°W, 10°SW.
								@ 26.0': Fracture, N30°W, 85°SW, tight.
								@ 26.5': Fracture, N20°W, 85°SW, tight.
				♀				@ 29.0': Fracture, N30°W, 50°SW; planar, tight, seepage becomes heavy.
30	■							@ 30.0': Drilling becomes difficult; alternating between bucket auger bit and bullet tooth flight auger.
								@ 31.0': Bedding, N30°E, 7°SW.
				♀				
35								
								Total Depth = 38.0 feet. Refusal encountered during drilling in strongly cemented sandstone. Groundwater seepage encountered during drilling from approximately 22.5 to 33.0 feet. Backfilled on 11/14/01.
40								

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/15/01 BORING NO. C-1

GROUND ELEVATION 56.0' ± (MSL) SHEET 1 OF 5

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▤	SM	SLOPE WASH/ALLUVIUM: Light brown, light gray, moist, medium dense, silty SAND; thin bands of reddish brown oxidation.
5		◣	17			▤		
10		◣	5			▤		Loose.
15		◣	12	▽		▤		@ 15.0': Groundwater encountered during drilling. Brown, saturated, medium dense.
						▨	SC	Brown, saturated, loose, clayey SAND; few coarse sand.
20		◣	5			▨	SC	SLOPE WASH/ALLUVIUM (CONTINUED): Brown, saturated, loose, clayey SAND; few coarse sand.

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/15/01 BORING NO. C-1

GROUND ELEVATION 56.0' ± (MSL) SHEET 2 OF 5

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
25			15					Light brown; medium dense; few thin interbeds of brown clay and light brown silty sand.
30			10					Brown to dark brown; mottled with reddish oxidation; increase in clay content; few coarse sand.
35			20					Dark reddish brown; few specks of reddish oxidation; trace organics.
							SC	Dark grayish brown, saturated, very stiff, sandy CLAY; trace fine gravel, few thin interbeds of light brown and brown, clayey fine sand.
40			17				SC	SLOPE WASH/ALLUVIUM (CONTINUED): Dark grayish brown, saturated, very stiff, sandy CLAY; trace fine gravel; few thin interbeds of light brown and brown, clayey fine sand; few medium sand; gradational contacts.

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/15/01 BORING NO. C-1

GROUND ELEVATION 56.0' ± (MSL) SHEET 3 OF 5

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
45			125					TOPANGA FORMATION (LANDSLIDE DEPOSITS): Light brown, saturated, weakly cemented, intensely weathered, soft SANDSTONE; interbedded with few thin beds of brown to dark brown, strongly indurated, moderately hard claystone and siltstone.
								Bluish gray, saturated, slightly weathered to fresh, moderately indurated, moderately soft SILTSTONE. Core Run @ 46.5' to 48.0'; Approximately 20% recovery; no RQD; sample disturbed during drilling. Core Run @ 48.0'to 50': Approximately 8% recovery; no RQD; sample disturbed during drilling.
50								Reddish brown, strongly cemented, extremely hard, sandstone in core shoe. Gray, fresh, strongly indurated, moderately hard; trace shells. Core Run @ 50.0' to 55.0': Approximately 89% recovery; RQD of 89%.
								Bluish gray, saturated, fresh, unfractured, moderately cemented, moderately hard, silty fine-grained SANDSTONE; few random shells; bioturbated.
55								Core Run @ 55.0'to 58.0': Approximately 67% recovery; RQD of 67%; very slightly fractured. @ 57.8': fracture; slightly open, smooth, planar, infilled with very thin clay at approximately 60 degrees. @ 58.0' to 63.0': 98% recovery; RQD of 98%.
60								TOPANGA FORMATION (LANDSLIDE DEPOSITS) CONTINUED: Bluish gray, saturated, fresh, unfractured, moderately cemented, moderately hard, silty fine-grained SANDSTONE; few random shells; bioturbated. Decrease in silt.

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DEPTH (feet) | SAMPLES Bulk Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S.

DATE DRILLED 11/15/01 BORING NO. C-1

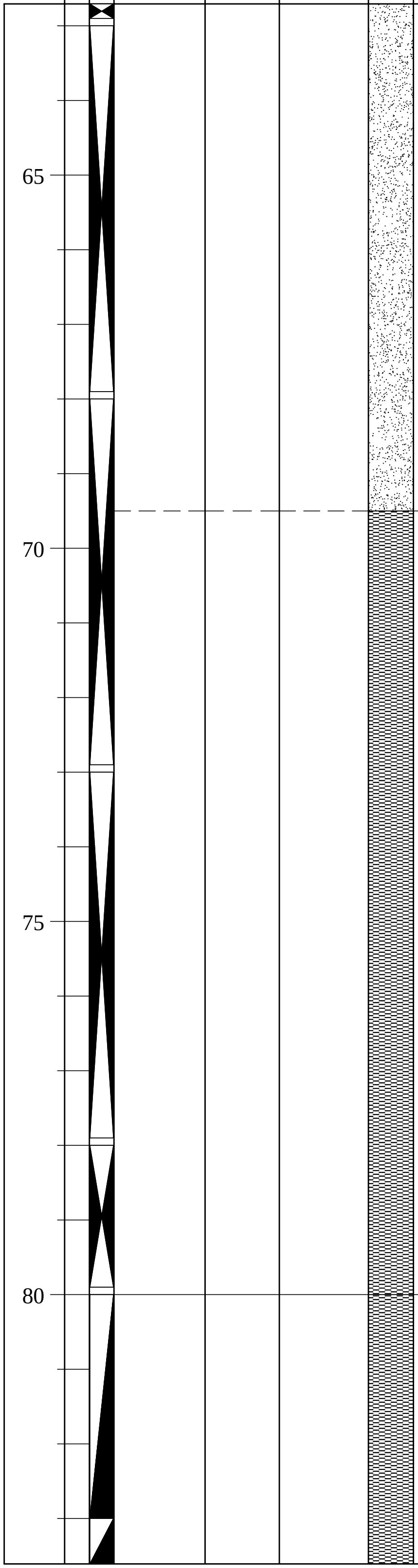
GROUND ELEVATION 56.0' ± (MSL) SHEET 4 OF 5

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DESCRIPTION/INTERPRETATION



Core run @ 63.0'-68.0': Approximately 98% recovery; RQD of 90%.
Light gray, strongly cemented, hard.

Gray, moderately cemented, moderately hard, trace coarse sand and shells; trace black laminae aproximately hairline to 1/32-inch thick.

Core @ 68.0' - 73.0': Aproximately 100% recovery; RQD of 92%.

Gray, fresh, strongly indurated, moderately hard, unfractured SILTSTONE.

Core Run @ 73.0'-78.0': Approximately 100% recovery; RQD of 100%.

@ 74.0'-75.5': Trace fine sand.

Light gray.

Core Run @ 78.0' to 83.0': Approximately 95% recovery; RQD of 95%.

@ 79.0' to 80.0': Sandy.

TOPANGA FORMATION (CONTINUED):
Light gray and gray, strongly indurated, moderately hard, unfractured SILTSTONE; few trace shells.

Core run @ 83.0'-85.0': Approximately 100% recovery; RQD approximately

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◢				▨		100%.
85								Total Depth = 85.0 feet. Groundwater encountered at approximately 15.0 feet during drilling. Backfilled on 11/16/01.
90								
95								
100								

DATE DRILLED 11/15/01 BORING NO. C-1

GROUND ELEVATION 56.0' ± (MSL) SHEET 5 OF 5

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/12/01 BORING NO. C-2

GROUND ELEVATION 46.5' ± (MSL) SHEET 1 OF 4

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								<u>ASPHALT CONCRETE</u>: Approximately 4 inches thick.
							ML	<u>FILL</u>: Reddish brown, moist, medium dense, sandy SILT.
								<u>TOPANGA FORMATION (LANDSLIDE DEPOSITS)</u>: Light yellowish brown, damp to moist, weakly cemented, moderately weathered, soft, silty fine SANDSTONE; few bands of orangish oxidation; dark red to black fracture surfaces; few fractures.
5								
			44					
								Few thin interbeds of light grayish brown, moderately to strongly cemented, very hard, silty fine sandstone.
			187					
10								
			301					
			500					
								Core Run @ 14.0'-18.0': Approximately 20% recovery; No RQD, sample disturbed during drilling.
15								
								Grayish brown; moderately cemented. Core Run @ 18.0'-23.0': Approximately 27% recovery; RQD of 23%.
20								<u>TOPANGA FORMATION (LANDSLIDE DEPOSITS)</u>: Yellowish brown, moderately weathered, weakly cemented, soft, silty fine

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 11/12/01 BORING NO. C-2

GROUND ELEVATION 46.5' ± (MSL) SHEET 2 OF 4

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								SANDSTONE; abundant reddish oxidation banding.
								Core run @ 23-28.0': Approximately 13% recovery; no RQD, sample disturbed during drilling. Light brown, moderately weathered, moderately cemented, moderately soft.
25								
								Gray to dark gray, moderately weathered, moderately cemented, moderately soft, SILTSTONE, trace fossils. Core Run @ 28-32.5': Approximately 77% recovery; RQD of approximately 20%, sample disturbed during drilling.
30								
								Bluish gray, slightly weathered, moderately to strongly cemented, moderately hard, moderately fractured SANDSTONE.
								Gray, moderately weathered, moderately cemented, moderately hard SILTSTONE. Core Run @ 32.5-35.0': Changed coring system,approximately 73% recovery; RQD of 62%. @ 33.5': fracture; slightly open, rough, undulating, dipping approximately 50 degrees.
35								@ 35.0-40.0': Approximately 100% recovery; RQD of 67%. Fresh, very thin interbed of strongly cemented, hard, fine-grained sandstone at top of core.
								@ 35.0-39.0': Intensely to moderately fractured.
40								<u>TOPANGA FORMATION (LANDSLIDE DEPOSITS) CONTINUED)</u>: Light gray, fresh, moderately to strongly cemented, moderately hard, intensely to moderately fractured, fine sandy SILTSTONE; fractures are subvertical, hairline to 1/32 inch wide, infilled with quartz, moderately

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DEPTH (feet) | SAMPLES Bulk Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S.

DATE DRILLED 11/12/01 BORING NO. C-2

GROUND ELEVATION 46.5' ± (MSL) SHEET 3 OF 4

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DESCRIPTION/INTERPRETATION

spaced, slightly open, rough undulating, dipping approximately 55 to 60 degrees.
Core Run @ 40-50.0': Approximately 92% recovery; RQD of 92%.

45

Gray, fresh, moderately to strongly cemented, moderately hard, moderately fractured, fine-grained SANDSTONE; fractures are infilled with very thin dark gray silt, fractures dip approximately 50 to 80 degrees.
@ 47.0': fracture; slightly open, moderately rough, planar fracture with polished surface, dipping at approximately 50 degrees.

50

Moderately fractured; trace pebbles.
Core Run @ 50.0'-55.0': Approximately 97% recovery; RQD of 95%.

Light gray; strongly cemented; hard; silty.

55

Gray; few subvertical to 60 degree fractures; tight to slightly open, smooth, planar, and infilled with very thin silt and quartz.
Core Run @ 55.0'-60.0': Approximately 92% recovery; RQD of 92%.

Subvertical, hairline to 1/16 inch-wide-fractures, infilled with quartz.

60

TOPANGA FORMATION (LANDSLIDE DEPOSITS) (CONTINUED):
Dark gray, strongly cemented, moderately hard, fine-grained SANDSTONE; subvertical hairline to 1/8 inch wide fracture, closed and filled with quartz, few medium to coarse grains; trace pebbles.
Core Run @ 60.0-65.0': Approximatley 98% recovery; RQD of 89%; slightly fractured.

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DEPTH (feet)	SAMPLES Bulk Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.

DATE DRILLED 11/12/01 BORING NO. C-2

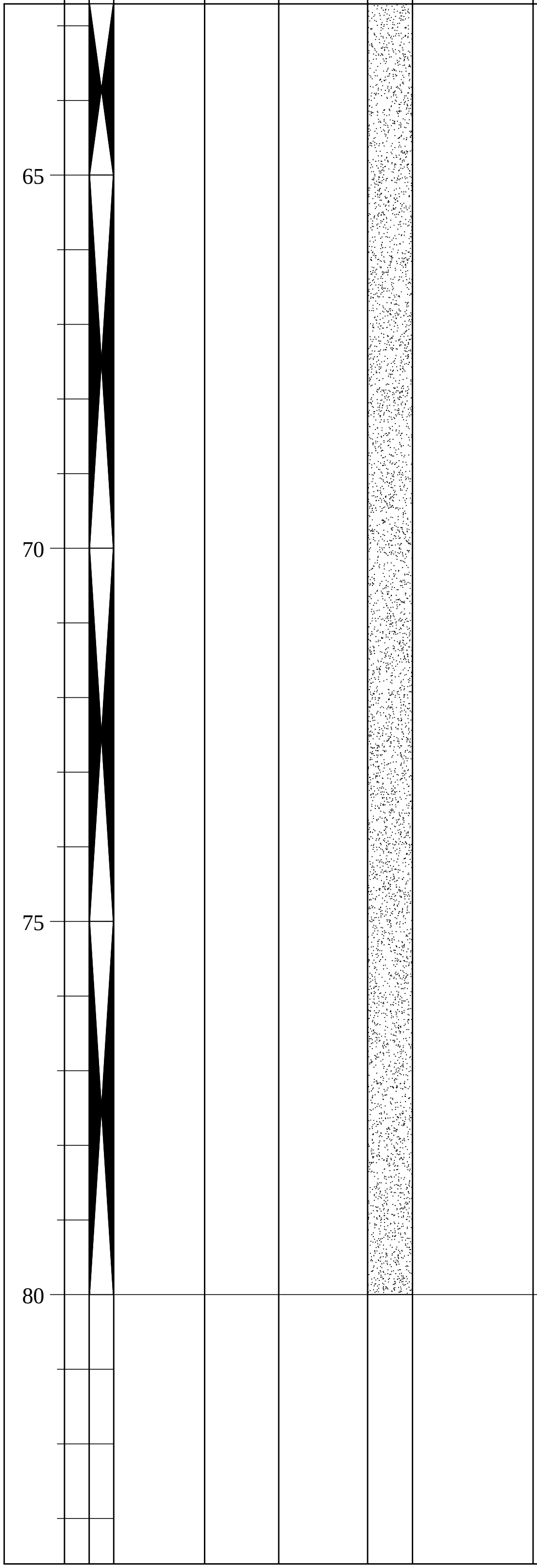
GROUND ELEVATION 46.5' ± (MSL) SHEET 4 OF 4

METHOD OF DRILLING 8" Hollow Stem Auger/Rock coring (Spectrum Drilling)

DRIVE WEIGHT 140 lbs. DROP 30"

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY LTJ/CAP

DESCRIPTION/INTERPRETATION



Core Run 65.0-70.0': Approximately 93% recovery; RQD of approximately 93%.

Moderately hard, trace shells.

@ 67.0-69.0': Subvertical fracture, tight.

@ 69.5'; fracture dipping approximately 45 degrees, with approximately 1/16-inch clay infill.

Core Run @ 70.0-75.0': Approximately 92% recovery; RQD of 86%.

Hard; unfractured; trace coarse sand, no pebbles.

Core Run @ 75.0-80.0': Approximately 64% recovery; RQD of 57%.

Total Depth = 80.0 feet.
No groundwater encountered during drilling.
Backfilled on 11/15/01.

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BORING LOG

Moulton Niguel Water District, Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426001	12/2001	

DATE DRILLED 3/16/00 BORING NO. B-1a

GROUND ELEVATION 87± (MSL) SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (THF Drilling)

DRIVE WEIGHT 140 lbs DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	FILL: Dark brown, moist, medium dense, silty SAND.
								Brown.
							SP	STREAM TERRACE DEPOSITS: Light brown, moist, medium dense, SAND.
5			27	17.2	112.2			
							SC/CL	Mottled, dark brown and grayish brown, moist to wet, very stiff, fine sandy CLAY to clayey SAND; trace veinlets of reddish oxidation.
							SP	Light brown, wet, dense, SAND.
10				▽				@ 10': Groundwater encountered during drilling. Sharp contact.
			33				SC	Light grayish brown, saturated, dense, clayey SAND.
15		☒	70/6"					TOPANGA FORMATION: Saturated, strongly cemented, SILTSTONE and SANDSTONE.
20		☒						TOPANGA FORMATION (CONTINUED): Saturated, strongly cemented, SILTSTONE and SANDSTONE.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	5/2000	

DATE DRILLED 3/16/00 BORING NO. B-1a

GROUND ELEVATION 87± (MSL) SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (THF Drilling)

DRIVE WEIGHT 140 lbs DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
						▨		
25		◣	80/5"			▨		Refusal at approximately 25.5 feet. Total Depth = 25.5 feet. Groundwater encountered during drilling at approximately 10.0 feet. Backfilled on 3/16/00.
30								
35								
40								

Ninyo & Moore

BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	5/2000	

DATE DRILLED 3/16/00 BORING NO. B-2a

GROUND ELEVATION 48± (MSL) SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (THF Drilling)

DRIVE WEIGHT 140 lbs DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▥	ML	<u>FILL</u>: Light brown, moist, loose, sandy SILT.
	■					●	GP	Brown, moist, medium dense, poorly-graded GRAVEL; few sand.
	■					░		<u>TOPANGA FORMATION</u>: Light yellowish brown, moist, moderately to strongly cemented, silty fine SANDSTONE.
5	■	■	100/3"	12.7	90.0	░		
	■					▤		Light grayish brown, moist, strongly cemented, fine, sandy SILTSTONE.
10		◤	84/6"			▤		Light reddish brown; moderately cemented; few yellowish oxidation.
						░		Light reddish brown, moist, strongly cemented, silty fine SANDSTONE; trace veinlets of black oxidation.
15		■	100/5"	13.9	86.5	░		
20		◤	70/5"			▤		<u>TOPANGA FORMATION (CONTINUED)</u>: Light gray, moist, strongly cemented, fine sandy SILTSTONE.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	5/2000	

DATE DRILLED 3/16/00 BORING NO. B-2a

GROUND ELEVATION 48± (MSL) SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (THF Drilling)

DRIVE WEIGHT 140 lbs DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								Refusal at approximately 21.0 feet. Total Depth = 21.0 feet. No groundwater encountered. Backfilled on 3/16/00.
25								
30								
35								
40								

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	5/2000	

DATE DRILLED 10/4/00 BORING NO. B-1
GROUND ELEVATION 49 ±MSL SHEET 1 OF 2
METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)
DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches
SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	OLDER ALLUVIUM: Brown, moist, medium dense, silty SAND; trace gravel.
			15					
5			23					
10			16				CL	Brown to dark brown, moist, very stiff, silty CLAY; few fine sand.
15			29				SM/ML	Brown, moist, medium dense, silty SAND to fine sandy SILT.
20			8				CL	OLDER ALLUVIUM (CONTINUED): Brown, moist, firm to stiff, silty CLAY; trace fine sand.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-1

GROUND ELEVATION 49 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◣				▨		
				▽		▨		@ 24': Groundwater encountered during drilling.
25		◣	31			▨		Hard; few to some sand.
30		◣	19			▨		Very stiff.
								Total Depth = 31.5 feet. Groundwater encountered during drilling at approximately 24.0 feet. Backfilled on 10/4/00.
35								
40								

Ninyo & Moore

BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-2

GROUND ELEVATION 46 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▦	SM	<u>FILL</u>: Light brown, damp, loose, silty fine SAND; abundant grass.
						▨	CL	<u>OLDER ALLUVIUM</u>: Brown and dark brown, moist, stiff CLAY; mottled; few caliche stringers.
5	■	■	16			▨		
10		◢	4			▨		Soft to firm.
						▨		Wet.
15		■	9			▨		Firm; trace pinhole porosity.
						▨		Stiff.
20		◢	10			▨	CL	<u>OLDER ALLUVIUM (CONTINUED)</u>: Brown and dark brown, moist to wet, stiff, silty CLAY; mottled; trace

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 10/4/00 BORING NO. B-2 GROUND ELEVATION 46 ±MSL SHEET 2 OF 2 METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling) DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP **DESCRIPTION/INTERPRETATION**
		◣				▨		pinhole porosity.
								Total Depth = 21.5 feet. No groundwater encountered. Backfilled on 10/4/00.
25								
30								
35								
40								

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-3
GROUND ELEVATION 64 ±MSL SHEET 1 OF 2
METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)
DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches
SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							ML	FILL: Dark brown, damp, loose, fine sandy SILT; abundant rootlets.
							CL	COLLUVIUM/SLOPE WASH: Reddish brown, moist, firm, silty CLAY; trace caliche veinlets and pinhole porosity; interbedded with few thin beds of silty sand.
5	■	■					SM	Brown, moist, loose, silty SAND.
	■	■	10	15.8	99.6		CL	Reddish brown, moist, firm to stiff, silty CLAY; trace caliche veinlets and pinhole porosity.
10		■	6					Firm; few caliche veinlets.
15		■	9					Brown.
20		■	7				CL	COLLUVIUM/SLOPE WASH (CONTINUED): Brown, moist, firm, silty CLAY; few caliche veinlets; trace pinhole

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-3

GROUND ELEVATION 64 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								porosity.
25			11					Stiff wet.
							CL	Cobbles of brown and olive brown, moist, highly weathered, weakly to moderately indurated, silty claystone.
30			12				CL+ML	Dark brown, wet, stiff CLAY interbedded with reddish brown SILT.
35			11	▽				@ 36': Groundwater encountered during drilling.
							SC	Brown, saturated, loose, clayey SAND.
								Total Depth = 36.5 feet. Groundwater encountered during drilling at approximately 36.0 feet. Backfilled on 10/4/00.
40								

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-4

GROUND ELEVATION 53 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▥	ML	<u>COLLUVIUM/SLOPE WASH</u>: Dark brown, moist, loose, SILT.
		■	19			▥		
5	■	■	15			▥		Medium dense.
10		■	30			▥		Moist to wet; few pieces of light brown friable sandstone; trace shells.
15	■	■	28			▒	SM	Orange-brown and bluish gray, moist, medium dense, silty fine SAND.
						░		<u>TOPANGA FORMATION</u>: Orange-brown, moist, weakly cemented, fine-grained SANDSTONE.
20		■	50/2"			░		<u>TOPANGA FORMATION (CONTINUED)</u>: Orange-brown, damp to moist, weakly cemented, fine-grained SANDSTONE.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-4

GROUND ELEVATION 53 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES		BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
	Bulk	Driven						
								Total Depth = 20.5 feet. No groundwater encountered. Backfilled on 10/4/00.
25								
30								
35								
40								

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-5

GROUND ELEVATION 54 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GP	FILL: Gray, damp, medium dense, poorly graded GRAVEL.
							SM	OLDER ALLUVIUM: Brown to dark brown, moist, loose, silty SAND; large pinhole voids up to approximately 2 millimeters in diameter.
5		■	10					
	■							
10		◣	9				CL	Dark brown, moist, stiff, silty CLAY.
15	■	■	26				SM	Brown, moist, medium dense, silty SAND.
							SC	Light yellowish brown, moist, medium dense, clayey SAND.
20		◣	22				SC/CL	OLDER ALLUVIUM (CONTINUED): Light yellowish brown, moist, medium dense, clayey SAND.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-5

GROUND ELEVATION 54 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◣				▨	CL	Yellowish brown, moist, very stiff, sandy CLAY.
								Total Depth = 21.5 feet. No groundwater encountered. Backfilled on 10/4/00.
25								
30								
35								
40								

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-6

GROUND ELEVATION 62 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▥	SM	FILL: Light brown, damp, loose, silty SAND; abundant rootlets; grass.
						▨	CL	OLDER ALLUVIUM: Olive to reddish brown, moist, hard, sandy CLAY; few pinhole voids; trace gravel of grayish brown, weakly indurated Siltstone.
5	■	■	55	13.3	117.3	▨		
	■					▨		
						▦	CL+SM	Brown, moist, very stiff CLAY; interbedded with thin beds of reddish brown, medium dense, silty SAND.
10		◤	20			▦		
						▨	CL+SC	Reddish brown and yellowish brown, moist, stiff CLAY; finely laminated; interbedded with thin beds of yellowish brown and gray, loose, clayey SAND.
15		■	17			▨		
				▼		▥	SM+SP	Brown, saturated, medium dense, silty fine SAND to poorly graded SAND. @ 18.5': Groundwater measured after drilling completed.
20		◤	17			▥	SM+SP	OLDER ALLUVIUM (CONTINUED): Brown, saturated, medium dense, silty fine SAND to poorly graded SAND.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-6

GROUND ELEVATION 62 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◣				▨		<u>TOPANGA FORMATION</u>: Reddish brown and gray, moist, moderately indurated, SILTSTONE. Total Depth = 21.5 feet. Groundwater measured after drilling at approximately 18.5 feet. Backfilled on 10/4/00.
25								
30								
35								
40								

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-7

GROUND ELEVATION 105 ±MSL SHEET 1 OF 3

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▦	SM	OLDER ALLUVIUM: Light yellowish brown, damp to moist, dense, silty fine SAND.
5		■	78			▦		Pinhole voids; rootlets.
10	■	■	50/1"			▦		No recovery; rock encountered.
						▦		Trace to few gravel.
15		■	19	5.8	113.5	▦		Loose.
						▦		Light brown.
20		■	31			▦	SM	OLDER ALLUVIUM (CONTINUED): Light brown, moist, dense, silty fine SAND.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-7

GROUND ELEVATION 105 ±MSL SHEET 2 OF 3

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
25			32					Rock in upper part of sample.
30			12					Medium dense; white stringers.
35			20					Loose; clayey; few coarse sand and fine gravel.
							ML/SM	Brown, moist, medium dense, fine sandy SILT to silty fine SAND.
40			18				ML/SM	OLDER ALLUVIUM (CONTINUED): Brown, moist, medium dense, fine sandy SILT to silty fine SAND.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-7

GROUND ELEVATION 105 ±MSL SHEET 3 OF 3

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
45		■	32			▨	CL	Brown, moist, very stiff, fine sandy CLAY.
50		▼	17			▨		
								Total Depth = 51.5 feet. No groundwater encountered. Backfilled on 10/4/00.
55								
60								

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-8

GROUND ELEVATION 104 ±MSL SHEET 1 OF 3

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							ML	OLDER ALLUVIUM: Olive brown, damp, loose, SILT; few sand; trace caliche stringers.
3	■							
5	■	■	10					Moist; little sand.
10		▲	6					
14	■							
15	■	■	24	12.6	105.4			Medium dense; few gravel.
								Grayish brown; fine sand.
20		▲	8				ML	OLDER ALLUVIUM (CONTINUED): Grayish brown, moist, loose, fine sandy SILT; few caliche stringers; few

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-8

GROUND ELEVATION 104 ±MSL SHEET 2 OF 3

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◤						interbeds of dark brown, clayey SILT; fine laminations.
							CL+SC	Dark reddish brown, moist, very stiff CLAY; trace medium sand; interbedded with clayey SAND and SILT.
25		■	26	13.6	116.7			
							CL+ML	Reddish brown, moist, very stiff, silty CLAY; interbedded and gradational with thin beds of SILT.
30		◤	16					
35		■	18	20.2	105.8			Stiff; wet; trace black organics.
				▽				@ 39': Groundwater encountered during drilling.
40		◤	10				CL+ML	OLDER ALLUVIUM (CONTINUED): Reddish brown, saturated, stiff, clayey SILT to silty CLAY; trace black organics.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-8

GROUND ELEVATION 104 ±MSL SHEET 3 OF 3

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
						▨		
							SM+ML	Reddish to yellowish brown, saturated, medium dense, silty fine SAND; interbedded with few very thin beds of SILT.
45		■	40					
							ML	Reddish brown, saturated, medium dense, fine sandy SILT; few clayey SILT beds.
50		◣	20					
								Total Depth = 51.5 feet. Groundwater encountered during drilling at approximately 39.0 feet. Backfilled on 10/4/00.
55								
60								

Ninyo & Moore

BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-9

GROUND ELEVATION 88 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							ML	<u>OLDER ALLUVIUM</u>: Brown, moist, loose, fine sandy SILT.
5		■	15					Rootlets; pinhole voids.
10		◣	8					
15	■	■	20					
20		◣	8				ML	<u>OLDER ALLUVIUM (CONTINUED)</u>: Brown, moist, loose SILT; trace clay.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-9

GROUND ELEVATION 88 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
25			10				ML/CL	Brown, moist, loose, clayey SILT to firm to stiff, silty CLAY.
30			11					Medium dense to stiff.
								Total Depth = 31.5 feet. No groundwater encountered. Backfilled on 10/4/00.
35								
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-10
GROUND ELEVATION 80 ±MSL SHEET 1 OF 2
METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)
DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches
SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▨	CL	<u>COLLUVIUM/SLOPE WASH</u>: Brown, damp to moist, firm CLAY; trace sand.
5	■	■	10	18.3	105.5	▨		Firm to stiff; moist.
						▒		<u>TOPANGA FORMATION</u>: Grayish brown, moist, weakly indurated, SILTSTONE.
10		◣	15			▒		
15		■	80/9"			▒		Sandy; moderately weathered; some reddish oxidation.
20		◣	65/11"			▒		<u>TOPANGA FORMATION (CONTINUED)</u>: Grayish brown, moist, moderately indurated, SILTSTONE; moderately

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.

DATE DRILLED 10/4/00 BORING NO. B-10

GROUND ELEVATION 80 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DESCRIPTION/INTERPRETATION

weathered; few thin interbeds of white, strongly indurated, SILTSTONE and light brown, moderately cemented, SANDSTONE.

Total Depth = 21.0 feet.
No groundwater encountered.
Backfilled on 10/4/00.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-11

GROUND ELEVATION 84 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▦	SM	COLLUVIUM/SLOPE WASH: Light brown, damp, loose, silty SAND; some organics.
						▨	CL	Brown, moist, stiff CLAY; trace mottling; trace black organics and pinhole porosity.
5		◣	15			▨		Stiff to very stiff.
						▦	SC/SM	Reddish brown mottled with gray, moist, medium dense, clayey to silty SAND; mottled with gray.
						▒		TOPANGA FORMATION: Yellowish brown, moist, moderately cemented, fine- and medium-grained SANDSTONE; interbedded with few very thin beds of grayish brown, moderately indurated, SILTSTONE.
10		■	50/5"			▒		
15		◣	50/5"			▒		
				▽		▒		@ 18': Groundwater encountered during drilling.
20		◸	50/4"			▒		TOPANGA FORMATION (CONTINUED): Yellowish brown, saturated, moderately cemented, fine- and medium-

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.

DATE DRILLED 10/4/00 BORING NO. B-11

GROUND ELEVATION 84 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DESCRIPTION/INTERPRETATION

grained SANDSTONE; interbedded with few very thin beds of grayish brown, moderately indurated, SILTSTONE.

Total Depth = 20.5 feet.
Groundwater encountered during drilling at approximately 18.0 feet.
Backfilled on 10/4/00.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-12

GROUND ELEVATION 102 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▥	ML	OLDER ALLUVIUM: Brown, damp to moist, medium dense SILT; trace sand.
5	■	■	11			▥		Thin, white stringers.
10		■	16			▥		Loose; clayey.
15		■	21			▨	CL+SP	Dark brown, moist, very stiff, CLAY; interbedded with brown, moist, medium dense, poorly graded, fine SAND; trace coarse sand.
						▥	ML	Brown, moist, stiff, clayey SILT.
20		■	15			▥	ML	OLDER ALLUVIUM (CONTINUED): Brown, moist, stiff to very stiff, clayey SILT.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/4/00 BORING NO. B-12

GROUND ELEVATION 102 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY DD LOGGED BY DD REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		■				▥		
25		◣	7			▥		Firm.
30		◣	12	▽		▥		@ 30': Groundwater encountered during drilling. Stiff; saturated.
								Total Depth = 31.5 feet. Groundwater encountered during drilling at approximately 30.0 feet. Backfilled on 10/4/00.
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-13
GROUND ELEVATION 105 ±MSL SHEET 1 OF 2
METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)
DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches
SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							ML	OLDER ALLUVIUM: Brown, damp, stiff, SILT.
5			19					Reddish brown; moist; few find sand.
							CH	Brown, moist to wet, stiff, silty CLAY; mottled with light brown; trace rootlets; abundant pinhole porosity.
10			10					
							ML	Brown to reddish brown, wet, stiff, clayey SILT; few grayish brown gravel of moderately indurated, Siltstone.
15			13	25.8 ▼	99.1			@ 16': Groundwater encountered during and measured after drilling; saturated.
							CL	Reddish brown, saturated, firm, silty CLAY.
20			8	22.8	94.8		CL	OLDER ALLUVIUM (CONTINUED): Redddish brown, saturated, firm to stiff, silty CLAY.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-13

GROUND ELEVATION 105 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◤				▨		
25		■	27			▨		Very stiff.
								Total Depth = 26.5 feet. Groundwater encountered during and measured after drilling at approximately 16.0 feet. Backfilled on 10/5/00.
30								
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-14

GROUND ELEVATION 118 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	FILL: Light brown, damp, dense, silty SAND; little gravel; few grass.
							CL	COLLUVIUM/SLOPE WASH: Dark grayish brown, moist, hard CLAY; abundant pinhole porosity; trace rootlets; trace coarse sand; trace caliche stringers.
5		■	39					
10	■	■	34	30.9	88.1			Very stiff.
							CL	OLDER ALLUVIUM: Reddish brown, moist, very stiff, silty CLAY; abundant pinhole porosity.
15	■	■	33					Hard; trace reddish oxidation; trace caliche stringers.
				▽				@ 19': Groundwater encountered during drilling. Saturated; very stiff.
20		■	22	22.8	94.8		CL	OLDER ALLUVIUM (CONTINUED): Reddish brown, saturated, very stiff, silty CLAY; abundant pinhole

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-14

GROUND ELEVATION 118 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		■				▨		porosity; trace reddish oxidation; trace caliche stringers.
25		◣	18			▨		Few thin interbeds of silt.
30		☒	31			▨		
								Total Depth = 31.5 feet. Groundwater encoutered during drilling at approximately 19.0 feet. Backfilled on 10/5/00.
35								
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-15

GROUND ELEVATION 132 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▨	CL	<u>OLDER ALLUVIUM</u>: Reddish brown, moist, stiff CLAY.
5	■	■	44			▨		Hard; silty.
10		◣	22			▨		Cobble of light gray, moist, moderately indurated SILTSTONE.
						▦	SM	Brown, moist, medium dense, silty SAND.
15		■	26			▦		
						░	SC	Reddish brown to brown, moist, medium dense,clayey fine SAND.
20		◣	17			░	SC	<u>OLDER ALLUVIUM (CONTINUED)</u>: Reddish brown to brown, moist, medium dense, clayey fine SAND.

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-15

GROUND ELEVATION 132 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◣				▨		Wet.
				▽		▥	ML+CL	@ 24': Groundwater encountered during drilling. Reddish brown, saturated, loose, fine sandy SILT; interbedded with CLAY.
25		◣	9			▥		
								Total Depth = 26.5 feet. Groundwater encountered during drilling at approximately 24.0 feet. Backfilled on 10/5/00.
30								
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-16
GROUND ELEVATION 144 ±MSL SHEET 1 OF 2
METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)
DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches
SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	FILL: Reddish brown, moist, medium dense, silty SAND; abundant grass and rootlets.
							ML	OLDER ALLUVIUM: Reddish brown, moist, dense, sandy SILT.
5			74				ML+SM	Dark grayish brown, moist, dense, SILT; trace organics; few sand; interbedded with few beds of silty SAND.
10			27					Black; medium dense; little sand.
							SC+CL	Gray and grayish brown, wet, medium dense, clayey SAND; mottled; few pinhole porosity; trace rootlets; few interbeds of CLAY.
15			26					
							CL	Dark gray and gray, moist to wet, stiff CLAY; mottled; few organics and pinhole porosity.
20			10				CL	OLDER ALLUVIUM (CONTINUED): Dark gray and gray, moist to wet, firm to stiff, CLAY; mottled; few

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-16

GROUND ELEVATION 144 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								organics and pinhole porosity; few sandy interbeds.
							SC+CL	Dark gray to black, wet, medium dense, silty SAND; interbedded with CLAY and clayey SAND.
25			25	▽				@ 25': Groundwater measured during drilling; saturated.
30			9					Loose.
								Total Depth = 31.5 feet. Groundwater measured during drilling at approximately 25.0 feet. Backfilled on 10/5/00.
35								
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-17

GROUND ELEVATION 145 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	FILL: Light brown, damp, dense, silty SAND; few to little gravel.
							ML	OLDER ALLUVIUM: Dark reddish brown, damp, medium dense, fine sandy SILT.
							SC	Grayish brown, moist, medium dense, clayey SAND.
5	■	■	18	▽ ▼				@ 6': Groundwater encountered during drilling. Saturated. @ 6.5': Groundwater measured after drilling.
							SM-SC	Grayish brown, saturated, very loose to loose, silty SAND; interbedded with brown clayey SAND.
10		■	4					
							CL	Gray, light brown and reddish brown, saturated, stiff, CLAY; convoluted laminations; trace pinhole porosity.
15		■	13					
							ML	Reddish brown and brown, saturated, stiff, SILT; trace caliche stringers.
20		■	15				ML	OLDER ALLUVIUM (CONTINUED): Reddish brown and brown, saturated, stiff to very stiff, SILT; trace

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-17

GROUND ELEVATION 145 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◣				▨		caliche stringers.
						▨	CL	Dark grayish brown, saturated, stiff to very stiff, silty CLAY; trace caliche stringers; trace pinhole porosity.
25		☒	55			▨		Hard.
								Total Depth = 26.5 feet. Groundwater encountered during drilling at approximately 6.0 feet. Groundwater measured after drilling at approximately 6.5 feet. Backfilled on 10/5/00.
30								
35								
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-18

GROUND ELEVATION 151 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	FILL: Light brown, damp, medium dense, silty SAND.
	■						SM	OLDER ALLUVIUM: Dark reddish brown, moist, medium dense, silty SAND.
5		■	18	6.7	102.5			Yellowish brown; loose.
				▽				@ 8': Groundwater encountered during drilling.
							SC+CL	Brown, saturated, loose, clayey SAND; interbedded with dark grayish brown, firm CLAY.
10		◣	6					
				▼				@ 11.5': Groundwater measured after drilling.
							CL	Reddish brown, brown and gray, saturated, stiff, silty CLAY; mottled; trace pinhole porosity.
15		■	14	26.4	97.3			
							SC+CL	Brown, saturated, medium dense, clayey SAND; interbedded with reddish brown, stiff, CLAY; trace pinhole porosity.
20		◣	12				SC+CL	OLDER ALLUVIUM (CONTINUED): Brown, saturated, medium dense, clayey SAND; interbedded with reddish

BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-18
GROUND ELEVATION 151 ±MSL SHEET 2 OF 2
METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)
DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches
SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
								brown, stiff CLAY; trace pinhole porosity.
25			30					
							SC+SM	Brown, saturated, dense, clayey SAND; interbedded with yellowish brown, silty SAND.
30			40					
								Total Depth = 31.5 feet. Groundwater encountered during drilling at approximately 8.0 feet. Groundwater measured after drilling at approximately 11.5 feet. Backfilled on 10/5/00.
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-19

GROUND ELEVATION 159 ±MSL SHEET 1 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						■		ASPHALT CONCRETE: Approximately 4½ inches thick.
						⁘	GP	AGGREGATE BASE: Light brown, moist, dense, poorly graded GRAVEL; little to some sand; approximately 5 inches thick.
						▨	CL	COLLUVIUM/SLOPE WASH: Dark grayish brown to black, moist, stiff, silty CLAY; trace sand; trace rootlets and caliche.
5	■	■	13			▨		
						▨	CL	OLDER ALLUVIUM: Reddish brown and brown, moist, very stiff, silty CLAY; mottled trace coarse sand.
10		◤	18			▨		Few thin sandy interbeds.
15		■	10	22.3	102.2	▨		Brown, wet, firm to stiff, sandy CLAY.
				▼		▨		@ 18.5': Groundwater measured after drilling.
						▨	CL+SC	Brown, saturated, stiff, sandy CLAY; interbedded with few thin beds of clayey SAND.
20		◤	9			▨	CL+SC	OLDER ALLUVIUM (CONTINUED): Brown, saturated, stiff, sandy CLAY; interbedded with few thin beds of

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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

DATE DRILLED 10/5/00 BORING NO. B-19

GROUND ELEVATION 159 ±MSL SHEET 2 OF 2

METHOD OF DRILLING 8" Hollow Stem Auger (Cal Pac Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cable) DROP 30 inches

SAMPLED BY GMC LOGGED BY GMC REVIEWED BY CAP

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
		◣				▨		clayey SAND.
				▽		▨		@ 23': Groundwater encountered during drilling.
25		■	28			▨		Very stiff.
						▨	ML+CL	Reddish brown and brown, saturated, medium dense, sandy SILT; interbedded with thin beds of sandy CLAY.
30		◣	12			▨		
35		⊠	30			▨		
								Total Depth = 36.5 feet. Groundwater encountered during drilling at approximately 23.0 feet. Groundwater measured after drilling at approximately 18.5 feet. Backfilled on 10/5/00.
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BORING LOG

Aliso Creek Emergency Sewer
Laguna Niguel, California

PROJECT NO.	DATE	FIGURE
202426-01	12/2000	

APPENDIX E

Construction Cost Detail Sheets

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Project: Export Sludge Forcemain Pre-Design
Client: South Orange County Wastewater Authority
Location: Dana Point, CA
Date: 10/2/2012

Job No.: 6731-01
Estimate by: K. Streams
Job Status: Pre-Design
Checked: M. Metts
Notes: Cost estimate codes refer to Means Construction
Estimate Class: AACE Class 3

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Item	Item Description		Alignment FM1 Total Net Cost $	Alignment FM2 Total Net Cost $
	Division 1 - General Requirements		**350,000**	**445,900**
1	Mobilization/Demobilization		116,850	145,500
2	Surveying		38,950	48,500
3	Clean-up and Disposal		77,900	97,000
4	Testing		38,950	48,500
5	Traffic Control		25,000	30,000
6	Traffic Control Per Day		21,000	45,000
7	Construction Schedule		1,000	1,000
8	Contractor's Staging Area		2,000	2,000
9	Sanitation Facilities		1,350	1,350
10	Project Signs		1,000	1,000
11	Temporary Fencing		2,000	2,000
12	Specialized Inspections		2,000	2,000
13	Inspection/Encroachment Fees		2,000	2,000
14	Subsurface Investigation		20,000	20,000
	Division 2 - Sitework		**1,198,300**	**842,700**
1	Demolition and Removal		26,718	8,580
2	Clearing and Grubbing		43,200	2,160
3	Site Preparation, Excavation, and Earthwork		57,000	1,000
4	Stormwater Runoff and BMP		30,000	30,000
5	Potholing		10,000	10,000
6	AC Pavement Removal		800	38,400
7	Asphalt Conc. Paving avg 3" thick		616	266,112
8	6" Drainage Layer		211	80,832
9	Sanitary Sewer System Testing		50,000	50,000
10	Temporary Handling of Sewage Flows		4,000	4,000
11	24-hour Pump Watch		2,880	2,880
12	Bank Stabilization		822,750	218,852
13	Trench Backfill		123,500	78,000
14	Pipe Bedding		26,600	16,800
	Division 15 - Mechanical		**132,800**	**670,200**
1	6" HDPE		132,800	86,400
2	6" 22.5-degree DI Bend		0	0
3	6" 45-degree DI Bend		0	480
4	6" 90-degree DI Bend		0	320
5	Furnish and Install New 6” In-line DIP Gate Valve		0	0
6	Air & Vacuum Valve 2"		0	7,000
7	Horizontal Directional Drilling		-	576,000
	Totals		**1,682,000**	**1,959,000**
	Project Level Allowance	30%	504,600	587,700
	Insurance	1.50%	24,725	28,797
	Profit	10%	168,200	195,900
	Bond	1%	16,820	19,590
	Escalation to Midpoint (3%/yr x 1 yr)	3%	88,155	88,155
Total			**2,485,000**	**2,880,000**

FM1 Cost Estimate - Export Sludge Forcemain Pre-Design

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Project: CTP Export Sludge Forcemain Thickening Alternatives
Client: South Orange County Wastewater Authority
Location: Laguna Niguel **Estimate Class: 4**
Carollo Job # 8538A.10

Coastal Treatment Plant: Summary of Thickening Alternative Costs

Summary of Cost Components						30%		20%	
Alternative	**Primary**	**WAS**	**Primary Treatment Modifications Construction Cost**	**WAS Treatment Modifications Construction Cost**	**Direct Cost**	**Estimating Contingency**	**Total Construction Cost**	**Project Costs**	**Total Project Cost**
No. 1	No Modifications	Add Polymer	$0	$46,000	$46,000	$14,000	$60,000	$12,000	$72,000
No. 2	Demo DAFT Equip, Install Gravity-Thickening, Re-route Primary Sludge Piping	Install Disk Thickeners, Re-route WAS to Disks, Need TWAS Pumps, Add Polymer	$516,000	$811,000	$1,327,000	$398,000	$1,725,000	$345,000	$2,070,000
No. 3	Add DAF	Add Polymer	$923,000	Included in Primary Cost	$923,000	$277,000	$1,200,000	$240,000	$1,440,000
No. 4	Install Drums, Reroute Primary Piping, Sludge Pumps	Add Polymer	$893,000	$46,000	$939,000	$282,000	$1,221,000	$244,000	$1,465,000
Recommended Alternative	Add Drum Thickener to Equalization Basin	Add Polymer	$292,000	$46,135	$338,135	$101,000	$439,135	$88,000	$527,135
Note: Direct Cost includes 20% General Conditions & 15% Contractor OH&P									

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DETAILED COST ESTIMATE

Project: CTP Export Sludge Forcemain Thickening
Client: South Orange County Wastewater Authority
Date : 11/15/2011
Location: Laguna Niguel
By : JAW
Element: 01 Disc Thickening
Reviewed: DKW

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Division 02 - Site Construction					
02300	Cat 235 Trackhoe 1.50Cy Bucket, Class B (Medium Digging), 0-20' D	711.11	CY	$3.12	$2,222	
02300	10 Cy Dump Truck, 30 Miles/Round Trip	592.59	CY	$15.66	$9,282	
02300	Native Trench Backfill/Unconfined Struct. Bf, Class B Material	118.52	CY	$14.90	$1,765	
02300	Imported Pipe Bed & Zone/Confined Structure Backfill, Class B Material	118.52	CY	$68.08	$8,069	
	Total					**$21,337**
	Division 03 - Concrete					
03300	12"T X 36"W Straight Continuous Footing	44.44	CY	$403.95	$17,952	
	Total					**$17,952**
	Division 04 - Masonry					
04220	Full Grout (All Cells)	1,200.00	SF	$1.31	$1,566	
04220	Bond Beam Adder	1,200.00	SF	$1.09	$1,313	
04220	Seismic Reinforcement Adder	1,200.00	SF	$1.43	$1,716	
04220	Standard Concrete Block, 8"	1,200.00	SF	$16.33	$19,596	
	Total					**$24,191**
	Division 10 - Specialties					
10000	Canopy Structure & Foundation, including Earthwork	1.00	EA	$72,520.00	$72,520	
	Total					**$72,520**
	Division 11 - Equipment					
11000	Disc Thickener	2.00	EA	$145,868.80	$291,738	
11242	Polymer Blending Unit w/ Pumps	2.00	EA	$11,017.47	$22,035	
11312	10Hp Progressive Cavity Pump	2.00	EA	$22,012.79	$44,026	
	Total					**$357,798**
	Division 15 - Mechanical					
15000	Piping	0.40	EA	$25,900.00	$10,360	
15052	WAS Piping Modifications	1.00	EA	$28,490.00	$28,490	
	Total					**$38,850**
	Division 16 - Electrical					
16000	Electrical	1.00	EA	$31,080.00	$31,080	
	Total					**$31,080**
	Division 17 - Instrumentation and Controls					
17000	Instrumentation & SCADA	1.00	EA	$23,828.00	$23,828	
	Total					**$23,828**
	Grand Total					**$587,556**

DETAILED COST ESTIMATE

Project: CTP Export Sludge Forcemain
Client: South Orange County Wastewater Authority
Date : 11/15/2011
Location: Laguna Niguel
By : JAW
Element: 02 Drum Thickening
Reviewed: DKW

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Division 02 - Site Construction					
02300	Native Trench Backfill/Unconfined Struct. Bf, Class B Material	118.52	CY	$14.90	$1,765	
02300	Imported Pipe Bed & Zone/Confined Structure Backfill, Class B Material	118.52	CY	$68.08	$8,069	
02300	Cat 235 Trackhoe 1.50Cy Bucket, Class B	711.11	CY	$3.12	$2,222	
02300	10 Cy Dump Truck, 30 Miles/Round Trip	592.59	CY	$15.66	$9,282	
	Total					**$21,337**
	Division 03 - Concrete					
03300	12"T X 36"W Straight Continuous Footing	44.44	CY	$403.95	$17,952	
	Total					**$17,952**
	Division 04 - Masonry					
04220	Full Grout (All Cells)	1,200.00	SF	$1.31	$1,566	
04220	Bond Beam Adder	1,200.00	SF	$1.09	$1,313	
04220	Seismic Reinforcement Adder	1,200.00	SF	$1.43	$1,716	
04220	Standard Concrete Block, 8"	1,200.00	SF	$16.33	$19,596	
	Total					**$24,191**
	Division 10 - Specialties					
10000	Canopy Structure & Foundation, including Earthwork	1.00	EA	$72,520.00	$72,520	
	Total					**$72,520**
	Division 11 - Equipment					
11000	Drum Thickener	2.00	EA	$170,940.00	$341,880	
11242	Polymer Blending Unit	2.00	EA	$11,017.47	$22,035	
11312	10Hp Progressive Cavity Pump	2.00	EA	$22,012.79	$44,026	
	Total					**$407,941**
	Division 15 - Mechanical					
15000	Piping	0.40	EA	$25,900.00	$10,360	
15052	Primary Sludge Piping Modifications	0.75	LS	$50,764.00	$38,073	
	Total					**$48,433**
	Division 16 - Electrical					
16000	Electrical	1.00	EA	$31,080.00	$31,080	
	Total					**$31,080**
	Division 17 - Instrumentation and Controls					
17000	Instrumentation & SCADA	1.00	EA	$23,828.00	$23,828	
	Total					**$23,828**
	Grand Total					**$647,282**

DETAILED COST ESTIMATE

Project: CTP Export Sludge Forcemain
Client: South Orange County Wastewater Authority
Date : 11/15/2011
Location: Laguna Niguel
By : JAW
Element: 03 DAF Thickening
Reviewed: DKW

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Division 02 - Site Construction					
02000	General Sitework & Demo	1.00	EA	$36,260.00	$36,260	
	Total					**$36,260**
	Division 10 - Specialties					
10000	DAF No. 3	380.13	SA	$1,449.88	$551,146	
	Total					**$551,146**
	Division 11 - Equipment					
11242	Polymer Blending Units w/ Pumps	2.00	EA	$11,017.47	$22,035	
	Total					**$22,035**
	Division 15 - Mechanical					
15052	Polymer Piping Replacement	1.00	LS	$11,396.00	$11,396	
	Total					**$11,396**
	Division 17 - Instrumentation and Controls					
17000	Instrumentation & SCADA	2.00	EA	$23,828.00	$47,656	
	Total					**$47,656**
	Grand Total					**$668,493**

DETAILED COST ESTIMATE

Project: CTP Export Sludge Forcemain
Client: South Orange County Wastewater Authority
Date : 11/15/2011
Location: Laguna Niguel
By : JAW
Element: 04 Gravity Thickening
Reviewed: DKW

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Division 02 - Site Construction					
02000	Demo DAF Thickeners	2.00	EA	$17,504.21	$35,008	
02000	Demo Air Compressors	2.00	EA	$1,830.93	$3,662	
02000	Demo Recirculation Pumps	2.00	EA	$2,350.93	$4,702	
	Total					**$43,372**
	Division 11 - Equipment					
11353	Gravity Thickener Mechanism	2.00	EA	$139,752.21	$279,504	
	Total					**$279,504**
	Division 15 - Mechanical					
15052	Primary Sludge Piping Modifications	1.00	LS	$50,764.00	$50,764	
	Total					**$50,764**
	Grand Total					**$373,641**

DETAILED COST ESTIMATE

Project: CTP Export Sludge Forcemain
Client: South Orange County Wastewater Authority
Date : 11/15/2011
Location: Laguna Niguel
By : JAW
Element: 05 Polymer Facility
Reviewed: DKW

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Division 11 - Equipment					
11242	Polymer Blending Units	2.00	EA	$11,017.47	$22,035	
	Total					**$22,035**
	Division 15 - Mechanical					
15052	Polymer Piping & Appurtenance Replacement	1.00	LS	$11,396.00	$11,396	
	Total					**$11,396**
	Grand Total					**$33,431**

DETAILED COST ESTIMATE

Project: CTP Export Sludge Forcemain
Client: South Orange County Wastewater Authority
Date : 11/15/2011
Location: Laguna Niguel
By : JAW
Element: 06 Drum for EQ Basin
Reviewed: DKW

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL
	Division 11 - Equipment					
11000	Drum Thickener	1.00	EA	$170,940.00	$170,940	
	Total					**$170,940**
	Division 15 - Mechanical					
15000	Piping	0.50	EA	$25,900.00	$12,950	
	Total					**$12,950**
	Division 16 - Electrical					
16000	Electrical	0.50	EA	$31,080.00	$15,540	
	Total					**$15,540**
	Division 17 - Instrumentation and Controls					
17000	Instrumentation & SCADA	0.50	EA	$23,828.00	$11,914	
	Total					**$11,914**
	Grand Total					**$211,344**