APPENDIX A-1d: Geotechnical Considerations

ALISO CREEK MAINSTEM
ECOSYSTEM RESTORATION STUDY
Orange County, California

September 2017

US Army Corps of Engineers

Orange County Public Works
Environmental Resources
Department

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General Geologic Conditions, Geologic Concerns and Geotechnical Considerations for Proposed Improvements

1. GENERAL GEOLOGIC CONDITIONS

The Aliso Creek watershed area is situated within the San Joaquin Hills, which are at the northwesterly corner of the Peninsular Ranges. The Mainstem Ecosystem Restoration study area occupies much of the southerly portion of the watershed, and extends from Pacific Park Drive downstream to the portion of the creek that flows alongside the SOCWA Treatment Plant (a little more than a mile northeast of the creek's outlet at the coast of the Pacific Ocean).

Along Aliso Creek, the slopes of the San Joaquin Hills are, for the most part, composed of sedimentary bedrock of Miocene to Pliocene age. Within the study area, these slopes are underlain by bedrock that has been assigned to the Topanga formation, San Onofre Breccia, Monterey formation, Capistrano formation and Niguel formation. The creek itself, is underlain by alluvial deposits that are as much as 100 feet in thickness (Engineering Science, 1961).

Sedimentary bedrock of the Topanga formation is of marine origin and Miocene age. These rocks underlie most of the slopes that descend to the creek within the southerly portion of the study area. Typically, they consist of sandstones and interbedded clayey siltstones and shales that are moderately well consolidated and range from somewhat massive to well bedded. Where they consist of well bedded clayey siltstones and shales, clay seams along bedding are planes of weaknesses along which landslides frequently develop.

The San Onofre Breccia consists of sedimentary bedrock of marine origin and Miocene age. These rocks underlie some of the upper portions of the slopes that rise to the east of the creek within the study area and limited portions of the slopes that rise to the west of the creek. Typically, they consist of schist breccia with lesser amounts of interspersed sandstones and siltstones. The breccia is, for the most part, massive, variably cemented, hard and well consolidated. Where unweathered, the breccia exhibits relatively high shear strength and is generally not susceptible to deep seated sliding and slope failure. However, residual soils derived from weathering of the breccia are prone to erosion and surficial slumping.

Sedimentary bedrock of the Monterey formation is of marine origin and Miocene age. These rocks underlie many of the slopes that descend to the northerly portion of the study area. Typically, they consist of clayey shales and siltstones, with interspersed sandstones. They are moderately well consolidated and poorly to well bedded. Where they are well bedded, clay seams are common along bedding, and are planes of weaknesses along which landslides frequently develop.

Sedimentary bedrock of the Capistrano formation is of marine origin and Miocene age. These rocks underlie much of the slopes that rise to the east of Aliso Creek within the northerly portion of the study area. Typically, they consist of clayey siltstones and silty claystones with occasional interspersed beds of silty sandstones. They are moderately consolidated and not well bedded.

Sedimentary bedrock of the Niguel formation is, for the most part, of marine origin and Pliocene age. These rocks underlie some of the upper portions of the slopes that rise to the west of Aliso Creek within the middle portion of the study area. Typically they consist of siltstones and sandstones. They, for the most part, are situated at higher elevations, and have not been mapped along the creek itself.

The bedrock slopes that rise from Aliso Creek display considerable evidence of instability. Within the study area, numerous ancient landslides have been mapped within the slopes that rise from Aliso Creek. These are shown on an illustrations prepared by Tetra Tech (see Appendix A1-e) and are discussed further in Section 3c.

In the prehistoric past, Aliso Creek was deeply eroded and incised into the adjacent slopes. Most of the ancient landslides within those slopes occurred when the creek was deeply incised. Since then, changes in the hydrologic regime resulted in deposition of significant quantities of alluvium into the creek. The alluvium that was deposited now provides support for the landslides. The alluvial deposits that have accumulated within the creek were, for the most part, derived from erosion and transport of near surface soils and weathered sedimentary bedrock within the flanks of the slopes that rise from the creek. Typically, they consist of sandy clays to clayey sands to sandy silts. For the most part, they are poorly consolidated, and variably expansive.

More recently, changes in the hydrologic regime have resulted in erosion and scour of the creek bed so that the current channel of Aliso Creek is incised into the alluviated surface.

2. SURFICAL SOILS AND SUBSURFACE CONDITIONS

The predominant surficial soil types in the study area are Calleguas clay loam, riverwash, Capistrano sandy loam, Sorrento loam, Soper gravelly loam, and Cieneba gravelly loam (NRCS 2009).

Subsurface geotechnical investigations consisting of ten boreholes and 23 geophysical survey profiles were conducted and detailed in the *Geotechnical Data Report (Diaz Yourman, 2009)*. The subsurface soils encountered generally consisted of silty sands, clayey sands, silts and clays. The upper 30 feet was characterized as loose to medium dense; below 30 feet, the soils were generally dense to very dense. A hard bedrock layer was found in five of the eleven boreholes, ranging in depth from 27 to 46 feet below ground surface.

3. EVALUATION OF GEOLOGIC / GEOTECHNICAL RISKS

3a. Groundwater

Groundwater is likely to be encountered within the slopes that rise from Aliso Creek and within the alluvium along Aliso Creek. Groundwater within the slopes that flank Aliso Creek will have a significant impact upon the stability of those slopes and should be evaluated in conjunction with evaluation of their stability (both temporary and permanent). Groundwater within the creek can be expected to approach the current invert grade of the channel. As such, excavations made below the current invert will likely require dewatering.

Groundwater encountered during the 2009 investigations reveal levels at depths ranging from about 14 to 45 feet below ground surface (or about 5 to 35 feet below the creek bed). This level was recorded during the initial drilling of the borehole and was not allowed to equilibrate within the hole.

3b. Seismicity

The project site has the potential to experience strong ground shaking from local and regional faults. The dominant active fault systems nearest the study area are Newport-Inglewood (4 miles), Whittier-Elsinore (20 miles), San Jacinto (43 miles), and the San Andreas (50 miles). The Newport-Inglewood Fault is interpreted as having the potential for generating the highest onsite ground accelerations at the site location (magnitude 6.9).

The California Seismic Hazards Zone Map indicates that there is potential for liquefaction within the study area where saturated, unconsolidated silts, sands, and silty sands are present. This is confined primarily to the alluvial sediments with the floodplain of Aliso Creek.

3c. Landslides and Potential Slope Instability

As previously described, a number of landslides are evident in the slopes that rise from Aliso Creek. Their presence confirms that the slopes within the study area are potentially unstable or in marginal equilibrium. Most of these landslides occurred within the bedrock that has been assigned to the Topanga formation or to the Monterey formation. Many are deep seated and are thought to have developed within the weaker siltstones and shales of these formations. Some probably developed within clay seams along bedding, which are planes of weakness along which sliding frequently occurs.

In many instances, mapped landslides are ancient. They occurred along slip surfaces that daylighted into the creek before significant quantities of alluvium accumulated along the creek. They are now inactive and are in marginal equilibrium because the alluvium that has accumulated in the creek provides support against continued landslide movement.

Because the slopes in which these landslides have occurred are marginally stable, cuts made into them or removal of alluvium that provides support for them could trigger reactivation and movement of the landslides. As they move, improvements within these landslides, and above and below these landslides could be severely damaged and result in significant liability. By contrast, raising of grades by filling of existing low areas could be expected to result in a reduction of risks.

Even where landslides are not currently mapped, cuts made into the slopes that rise from the creek could daylight adversely oriented bedding. Where bedding planes dip toward such cuts, landslides could develop along these bedding planes.

Geotechnical investigations will be conducted during the Pre-Construction Engineering Design (PED) phase to supplement those conducted during the feasibility phase. These investigations will be necessary to better address the existing level of stability and reduce any potential risk of reactivation of identified ancient slope failures (landslide masses), or destabilization of some other areas currently unaffected by sliding, as a result of the planned excavations and grading of alluvial soils associated with the channel alignment.

3d. Alluvial Soils

Alluvial soils that underlie the Aliso Creek are generally poorly consolidated and susceptible to consolidation, and hence settlement, when subjected to additional loads. While fills of modest thickness are not likely to induce significant settlement, deeper or thicker fills could. Because the depth and distribution of these soils vary, the extent to which settlement will occur will vary. Resultant uneven or differential settlement could cause distress to overlying improvements. The extent to which additional fills can be placed upon the alluvium without causing significant settlement should be determined by geologic and geotechnical investigation during the PED phase.

Some of the alluvial soils within Aliso Creek can be expected to be expansive. The effects of soil expansion should be considered during design of proposed foundations and retaining structures.

4. CONSIDERATION OF PROPOSED IMPROVEMENTS

A number of improvements or changes within the Aliso Creek study area are currently being considered. Geologic and geotechnical concerns and constraints with respect to their implementation are described and discussed below. Where the stability of the slopes that rise from Aliso Creek will impact these concerns and constraints, some additional consideration during the development of the agency recommended plan is warranted and detailed geologic and geotechnical investigation during the PED phase will be required.

4a. Channel Reconstruction

Plans for ecosystem restoration will likely include modifications of the Aliso Creek channel. Modifications of the channel will necessitate cutting into the alluvium within the channel and may require at least partial filling of the channel. The potential impact of cuts made into the alluvium on the adjacent slopes should be considered in conjunction with development of the agency recommended plan and should be evaluated by comprehensive geologic and geotechnical investigation during PED design. Cuts should not be made below or near existing landslides until the stability of nearby slopes has been confirmed by additional geologic and geotechnical investigation. PED investigations are necessary to better address the existing level of stability and reduce any potential risk of reactivation of identified ancient slope failures (landslide masses), or destabilization of some other areas currently unaffected by sliding.

4b. Excavations

The stability of excavations, both temporary and permanent, made to accommodate construction of proposed structures and improvements, should be evaluated by geotechnical analysis, and should be designed in accordance with geotechnical criteria determined by analysis. Permanent excavations should not be made below existing landslides and below slopes where adverse geologic structure (bedding planes that dip out of slope) is encountered. Within these areas, temporary excavations should only be made after adequate shoring (designed on the basis of further analysis) has been installed.

For temporary construction, the alluvial soils (away from landslides) should be excavated at gradients no steeper than 1.5:1, horizontal to vertical. Acceptable gradients for temporary construction into bedrock should be determined by further investigation.

4c. Permanent Slopes

The stability of permanent channel slopes and upper slopes should be determined on the basis of further geotechnical investigation and analysis during the PED phase. The proposed unlined, naturally vegetated, side slopes within the 10-year flood channel should not be made at gradients steeper than 3H:1V. Where channel slopes are graded below anticipated high groundwater levels, permanent slopes may need to be laid back to flatter gradients, as determined by appropriate analysis of slope stability (including evaluation of the effects of rapid drawdown). The current feasibility study alternatives project plans show some engineered slopes above the 10-year flood level as steep as 2H:1V to accommodate constraints such as encroaching infrastructure. Slopes steeper than 3H:1V that may experience inundation by channel flows present a risk of slope instability. Detailed geotechnical studies will be needed during PED phase to establish the appropriate stable slope gradient at each location of the project. Where slopes are not found to be adequately stable, designs will be modified to either flatten the slopes, add reinforcement or revetment, add biotechnical stabilization measures, or some other stabilizing measures.

4d. Expansion Potential

Alluvial soils within the Aliso Creek area may be subject to expansion with wetting. Suitability for excavated expansive soils as fill materials, for example in streambed raising, will need to be established. Unsuitable materials for channel fill would be considered for the designated on-site disposal area, if deemed appropriate, or hauled off-site and properly disposed.

4e. Retaining Structures and Foundations

Retaining structures and foundations should be designed on the basis of geotechnical design criteria developed by additional investigation and analysis. Where appropriate, these should be designed to resist the potential effects of expansion.

4f. Sheet Piles

Information obtained from subsurface exploration performed by Diaz Yourman (2009) at the behest of the USACE indicates that sheet piles can, for the most part, be driven through the alluvial soils that underlie Aliso Creek. By contrast, driving of sheet piles through the underlying bedrock promises to be, at the very least, difficult to accomplish. In conjunction with the construction of rock riffles that are necessary to provide grade control for alternatives that raise the invert elevation, each riffle structure location will include a sheetpile, or other anchoring means, as a failsafe feature in case of damage to, or loss of, a riffle structure due to a storm event higher than the design level of the structure. The presence of possible weathered bedrock was identified in some borings in close proximity to the thalweg, The ability to achieve adequate pile penetration depths may present an issue along more downstream reaches of the project where invert fill depths are less.

4g. Disposal of Excess Material

This project involves a significant amount of earthwork in both excavation and fill quantities. A large percentage of the excavated material is expected to be transferred within the project limits to be reused as fill material. However, any excess material that cannot be reused will need to be disposed of on the adjacent floodplains to the extent possible in order to minimize costly hauling and off-site disposal.

The final feasibility design or PED refinements will consider the potential reduction of the amount of excess sediment for disposal as refinements in alignments may provide a more favorable cut/fill balance. Also, final design and construction specifications can be prepared to require the contractor to mix the excess soils well before placing, including scarifying the receiving sites to a specified minimum depth and mixing those soils with the excess materials, and also providing adequate drainage capability. Specifications should consider preferential separation of any excavated high clay materials to be set aside and only utilized as fill for streambed raising; this would limit the need for mixing these materials at the disposal receiving sites or for potential hauling off-site. Any materials deemed unsuitable for fill purposes should be disposed of at a commercial landfill or other approved site.

Further consideration of the potential disposal sites yielded two preferred sites: the first large site is located just upstream of Wood Canyon Creek confluence and the second is the larger site adjacent to the abandoned oxbow. These two sites were evaluated for potential impacts to the existing landslides in the project area as part of the preliminary landslide evaluation conducted. The proposed areas are not in locations that would negatively impact the existing bedrock landslides. They would typically add to the buttressing effect of the existing overburden and increase the stability of the existing landslide features.

4h. Diversion and Control of Water

Control of surface water flow will be necessary during construction as Aliso Creek is a perennial stream. Due to the length of the project, implementation will be divided into multiple construction reaches and phased, with work efforts generally initiating from the downstream end. At the upstream end of each construction reach, the entire channel flow will likely be diverted out of the channel by means of a diversion pipe. It is expected that dewatering efforts will also be necessary for construction related to the placement of riffle structures and streambank protection foundation (toe-down). Dewatering can be accomplished by use of sump pumps, and supplemented as needed with dewatering wells. The development of a plan for diversion and control of water will be the responsibility of the construction contractor, and subject to review and approval by the Corps prior to commencement of construction activities.

5. CONCLUSIONS

A geotechnical appendix will be prepared in conjunction with finalization of the IFR. The geotechnical appendix will consolidate a detailed discussion of geologic and geotechnical conditions within the study area, concerns and constraints, and potential means of mitigation of adverse geologic and geotechnical conditions and discussions of further investigation that will be required during the PED phase. It will include a composite Geologic Map showing soil and geologic conditions within the entire study area and the locations of all subsurface investigations within the study area, representative cross sections showing the surface and subsurface distribution of rock and soil materials, and the results of any laboratory testing. A summary of the findings of the preliminary qualitative evaluation of the impacts of existing landslides to the proposed alternatives (Tetra Tech, 2015) will also be included. The appendix will also address design considerations specific to settlement, erodibility, expansive soils, temporary excavation and corrosivity, rock riffle structures, buried streambank protection, installation of single sheet piles and sheet pile walls, and construction considerations associated with excavatibility of materials and suitability/management for fill uses. The geotechnical appendix will also address HTRW assessment and recommendations to pursue during the PED phase.

References

Diaz Yourman, 2009. Geotechnical Data Report, Aliso Creek Environmental Restoration Project. November 2009.

Engineering Science, 1961. Report on Comprehensive Planning for Conservation of Water and Soil Resources for the Aliso Creek Watershed. December 1961.

Tetra Tech, 2015. Aliso Creek Ecosystem Restoration Study, Orange County; Preliminary Engineering Geologic Evaluation of Existing Bedrock Landslides. July 2015.