4.4 Geology and Soils

This section evaluates the potential for impacts relating to geology and soils from implementation of the OC River Walk Project (project).

The analysis in this section is based on the Preliminary Geotechnical Evaluation prepared by Ninyo & Moore (2024). A complete copy of the report is included in Appendix F, Geotech Report.

4.4.1 Environmental Setting

4.4.1.1 Regulatory Setting

This section describes the federal, state, and local regulatory framework adopted to address geology and soils.

Federal

National Earthquake Hazards Reduction Act

The National Earthquake Hazards Reduction Act was passed to reduce the risks to life and property resulting from earthquakes. The act established the National Earthquake Hazards Reduction Program (NEHRP). The mission of NEHRP includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. The NEHRP designates the Federal Emergency Management Agency as the lead agency of the program and assigns planning, coordinating, and reporting responsibilities. Other NEHRP agencies include the National Institute of Standards and Technology, National Science Foundation, and the U.S. Geological Survey.

Antiquities Act (16 USC 431–433)

The Antiquities Act of 1906 states, in part, the following:

> That any person who shall appropriate, excavate, injure or destroy any historic or prehistoric ruin or monument, or any object of antiquity, situated on lands owned or controlled by the Government of the United States, without the permission of the Secretary of the Department of the Government having jurisdiction over the lands on which said antiquities are situated, shall upon conviction, be fined in a sum of not more than five hundred dollars or be imprisoned for a period of not more than ninety days, or shall suffer both fine and imprisonment, in the discretion of the court.

Although there is no specific mention of natural or paleontological resources in the act itself or in the act's uniform rules and regulations (43 CFR 3), the term "objects of antiquity" has been

interpreted to include fossils by the National Park Service, Bureau of Land Management, U.S. Forest Service, and other federal agencies. Permits to collect fossils on lands administered by federal agencies are authorized under this act. However, due to the large gray areas left open to interpretation due to the imprecision of the wording, agencies are hesitant to interpret this act as governing paleontological resources.

State

Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code, Section 2621 et seq.)

The Alquist-Priolo Earthquake Fault Zoning Act was signed into state law in 1972. Its primary purpose is to mitigate the hazard of fault rupture by prohibiting the location of structures for human occupancy across the trace of an active fault. The act delineates "Earthquake Fault Zones" along faults that are "sufficiently active" and "well defined." The act also requires that cities and counties withhold development permits for sites within an earthquake fault zone until geologic investigations demonstrate that the sites are not threatened by surface displacement from future faulting. Pursuant to this act, structures for human occupancy are not allowed within 50 feet of the trace of an active fault.

California Building Code (California Code of Regulations, Title 14, Part 2)

Current law states that every local agency enforcing building regulations, such as cities and counties, must adopt the provisions of the California Building Code (CBC) within 180 days of its publication. The publication date of the CBC is established by the California Building Standards Commission, and the code is also known as Title 24, Part 2, of the California Code of Regulations. The most recent building standard adopted by the legislature and used throughout the state is the 2019 version of the CBC (effective January 1, 2020), often with local, more restrictive amendments that are based on local geographic, topographic, or climatic conditions. These codes provide minimum standards to protect property and public safety by regulating the design and construction of excavations, foundations, building frames, retaining walls, and other building elements to mitigate the effects of seismic shaking and adverse soil conditions. The CBC contains provisions for earthquake safety based on factors including occupancy type, types of soil and rock on site, and strength of ground shaking with specified probability of occurring at a site.

California Code of Regulations, Title 14, Division 3, Chapter 1

California Code of Regulations, Title 14, Division 3, Chapter 1, prohibits any person from destroying, disturbing, or mutilating geological features including paleontological resources. This applies to excavation and grading activities that would be performed under the project.

Natural Hazards Disclosure Act (California Civil Code, Section 1103.2)

The Natural Hazards Disclosure Act requires that sellers of real property and their agents provide prospective buyers with a Natural Hazard Disclosure Statement when the property being sold lies within one or more state-mapped hazard areas, including a seismic hazard zone. California law also requires that, when houses built before 1960 are sold, the seller must give the buyer a completed earthquake hazards disclosure report and the booklet The Homeowners Guide to Earthquake Safety. This publication was written and adopted by the California Seismic Safety Commission.

Seismic Hazard Mapping Act (California Public Resources Code, Sections 2690–2699.6)

The Seismic Hazard Mapping Act was adopted by the state in 1990 to protect the public from the effects of non-surface fault rupture earthquake hazards, including strong ground shaking, liquefaction, seismically induced landslides, or other ground failure caused by earthquakes. The goal of the act is to minimize loss of life and property by identifying and mitigating seismic hazards. The California Geological Survey prepares and provides local governments with seismic hazard zone maps that identify areas susceptible to amplified shaking, liquefaction, earthquake-induced landslides, and other ground failures. The act requires responsible agencies to only approve projects within seismic hazard zones following a site-specific investigation to determine if the hazard is present, and if so, the inclusion of appropriate mitigation. In addition, the act requires real estate sellers and agents at the time of sale to disclose if a property is in one of the designated seismic hazard zones.

California Code of Regulations, Title 14, Article 10, Seismic Hazards Mapping (Section 3720 et seq.)

These regulations require city, county, and state agencies to identify and amp seismic hazard zones and to mitigate seismic hazards to protect public health and safety in accordance with the provisions of the Public Resources Code, Section 2690 et seq. (Seismic Hazards Mapping Act). Within seismic hazard zones, a project is approved only when the nature and severity of the seismic hazards at the site have been evaluated in a geotechnical report and appropriate mitigation measures have been proposed.

Division of Mines and Geology, Special Publication 117

With the implementation of the Seismic Hazards Mapping Act in California, general guidelines for evaluating and mitigating seismic hazards in California were published by the California Department of Conservation, Division of Mines and Geology in 1997 as Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California. This document constitutes the guidelines for evaluating seismic hazards other than surface fault rupture, and for recommending mitigation measures as required by Public Resources Code, Section 2695(a). The objectives of these guidelines are two-fold: 1) To assist in the evaluation and mitigation of earthquake-related hazards for projects within designated zones of required investigations; and 2) to promote uniform and effective statewide implementation of the evaluation and mitigation elements of the Seismic Hazards Mapping Act.

Soils Investigation Requirements

California Health and Safety Code, Sections 17953–17955, and CBC Section 1802 include requirements for soils investigations for subdivisions requiring tentative and final maps and for other specified types of structures. Testing of samples from subsurface investigations, such as from borings or test pits, is required. Studies must be done as needed to evaluate slope stability, soil strength, position and adequacy of load-bearing soils, the effect of moisture variation on load-bearing capacity, compressibility, liquefaction, differential settlement, and expansiveness.

Local

Anaheim Municipal Code, Title 17

Title 17 of the Anaheim Municipal Code, Land Development and Resources, outlines the City of Anaheim's (City's) procedures, necessary permits, and standards with regard to development, which projects are subject to. This includes risk reduction with regard to geological hazards.

Anaheim General Plan Safety Element

The Safety Element of the General Plan has established the following policies related to development in areas with various geological conditions.

- Minimize the risk to life and property through the identification of potentially hazardous geologic areas.
- Require geologic and geotechnical investigations in areas of potential seismic or geologic hazards as part of the environmental and/or development review process for all structures.
- Enforce structural setbacks from faults and other geologic hazards identified during the development review process.
- Enforce the requirements of the California Seismic Hazards Mapping and Alquist Priolo Earthquake Fault Zoning Acts when siting, evaluating, and constructing projects within the City.
- Require that lifelines (i.e., water, sewer, electrical, gas facilities, and communication and transportation facilities that are needed in the event of a hazard event or natural disaster) crossing a fault or located within a geologic hazard be designed to resist damage resulting from a hazard event.
- Require new construction, redevelopment, and major remodels located within potential landslide areas be evaluated for site stability, including the potential impact to other properties, during project design and review.

City of Orange Municipal Code

The City of Orange, Municipal Code, Chapter 16.40, Grading Requirements, incorporates the City of Orange Manual of Grading and the Guidelines for Landform Grading and Planting to set

forth the rules and regulations to control erosion, water quality, excavation, grading and earthwork construction, including cuts and fills; establishes the administrative procedure for the issuance of grading permits and provides for review and approval of plans and the inspection of grading construction.

City of Orange General Plan Public Safety Element

The Safety Element of the General Plan has established the following goal and policies to protect residents from seismic hazards and other geologic constraints.

- **Goal 1.0:** Protect residents and businesses from seismic hazards and other geologic constraints.
  - **Policy 1.1:** Minimize the potential loss of life and damage to structures that may result from an earthquake.
  - **Policy 1.2:** Educate and train individuals and neighborhoods how to respond to emergency situations.
  - **Policy 1.3:** Participate in federal, state, and local earthquake preparedness and emergency response programs.

4.4.1.2 Existing Conditions

The following existing conditions are based on the Preliminary Geotechnical Evaluation, Appendix F of this Draft Environmental Impact Report (EIR), which mainly reviewed readily available existing geotechnical information and as-built drawings pertinent to the project and provided engineering analyses of the compiled data. Numerous previous geotechnical studies have been prepared near the project site that include exploratory borings and laboratory testing, and their results are included as part of the Preliminary Geotechnical Evaluation. It should be noted that a supplemental geotechnical engineering analyses will be performed, and an updated geotechnical evaluation report will be prepared once site-specific borings are performed according to the approved Drilled Program Plan.[1]

Regional Geology

The project site is located within the southerly portion of the Los Angeles Basin, which is included in the Peninsular Ranges Geomorphic Province. The Los Angeles Basin has been divided into four structural blocks, which are generally bounded by prominent fault systems, and includes the Northwestern Block, the Southwestern Block, the Central Block, and the Northeastern block. The project site is located within the Central Block, which is bordered on the west by the Newport-Inglewood fault, on the east by the Whittier-Elsinore fault, on the north by the Malibu Coast-Santa

[1] To conduct borings within earth embankments under the jurisdiction of the U.S. Army Corps of Engineers (USACE), approval of a Drilling Program Plan by USACE is required. Niyon & Moore prepared the Drilling Program Plan for the project on March 31, 2023. However, since the plan has not yet been approved by USACE, no subsurface exploration has been performed within the earth embankment.

Monica-Raymond fault, and on the south by the San Joaquin Hills and the Santa Ana Mountains. The Central Block is characterized by thick sequences of alluvium overlying basement rocks at depth. Basement rocks exposed in some oil wells along the margins of the Central Block consist of sedimentary Jurassic-age rocks, late Cretaceous-age plutonic rocks, and late Cretaceous to Pleistocene-age sedimentary rocks. Regional geologic mapping indicates that the area is underlain by Holocene-age alluvial wash and fan deposits generally consisting of gravel, sand, and silt. The Holocene-age alluvial sediments have an estimated thickness of approximately 110 to 130 feet.

Project Site Geology

The subsurface stratigraphy of the project site generally consists of artificial fill underlain by alluvium. Artificial fill materials are variable and generally consist of sand, sand with silt, silty sand, sandy silt, silt, clayey silt, and silty clay with varying densities and consistencies. The alluvium is comprised of coarse to fine sediments ranging from silty sand, sand with silt, sand, gravelly sand, silty gravel, clayey gravel, and sandy gravel, with scattered cobbles, and clay, silty clay, clayey silt, silt, and sandy silt. The materials are generally moist to wet with consistencies that ranged from very loose to very dense in the granular non-plastic soils and very soft to hard in the fine plastic soils. The soils comprising the existing fill and alluvial deposits can vary significantly both laterally and with depth.

Faulting and Seismicity

The project site is not within the Alquist-Priolo Special Studies Zone. The nearest mapped active fault to the project site is the Peralta Hills fault located approximately 3 miles north of the project site.

Seismically Induced Ground Shaking

The project site is in a seismically active area, as is the majority of Southern California. Considering the proximity of the project site to active faults capable of producing a maximum moment magnitude of 6.0 or more, the project site has a high potential for experiencing strong ground motion.

Liquefication

Liquefaction is the phenomenon in which loosely deposited, saturated granular soils (located below the water table) undergo rapid loss of shear strength due to development of excess pore pressure during strong earthquake-induced ground shaking. Ground shaking of sufficient duration results in the loss of grain-to-grain contact due to rapid rise in pore water pressure and it eventually 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. Liquefaction is also known to occur in relatively fine-grained soils (i.e., sandy silt and clayey silt). 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. As shown on Figure 8 of the Geotechnical Evaluation (included in

Appendix F of this Draft EIR), the project site is located in an area mapped as being potentially susceptible to liquefaction per the State of California Seismic Hazard Zones maps.

Lateral Spreading

Lateral spreading of the ground surface during an earthquake usually takes place along weak shear zones that have formed within a liquefiable soil layer. Lateral spread has generally been observed to take place in the direction of a free-face (i.e., retaining wall, slope, and channel), but has also been observed to a lesser extent on ground surfaces with very gentle slopes. It typically results when ground shaking moves soil toward an area where soil integrity is weak or unsupported. For sites located in proximity to a free-face, the amount of lateral ground displacement is strongly correlated with the distance of the site from the free-face. The project site is located within the free-faces of the Santa Ana River, and there is a potential for seismically induced lateral spread at the site.

Landslides

A landslide is defined as the movement of a mass of rock, debris, or earth down a slope. It can happen suddenly or more slowly over long periods of time. Landslides occur when slopes become destabilized, typically after heavy rains. If precipitation saturates soils, they can become unstable, or landslides can occur when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned face a greater risk from rain induced landslides, as the loss of vegetation can de-stabilize the earth. Earthquakes may also be a source of landslides as the shaking can destabilize steep hillsides covered in loose soils and weak rock layers. The project site is not identified as being within high landslide susceptibility areas mapped by the California Geological Survey with Deep Seated Landslide Potential (Anaheim 2022; Orange 2022).

Subsidence

Ground subsidence is the gradual settling or sinking of the ground, usually associated with the extraction of oil, gas, or groundwater from below the ground surface or the organic decomposition of peat deposits with a resultant loss in volume. The principal causes of subsidence are aquifer-system compaction, drainage of organic soils, underground mining, and natural compaction. The City of Anaheim Local Hazard Mitigation Plan (2022) and the City of Orange Local Hazard Mitigation Plan (2016) do not identify subsidence as a hazard of concern for either city.

Expansive Soils

Soils with a high expansion potential increase in volume with the addition of water. Soil expansion can be detrimental to foundations, concrete slabs, flatwork, and pavement. The Preliminary Geotechnical Evaluation (Appendix F to the Draft EIR) indicated that non-expansive can be defined as soils having an expansion index of 20 or less in accordance with ASTM D 4829. According to previous laboratory testing results included as part of the Preliminary Geotechnical Evaluation, soils for nearby projects had very low expansion potential with zero expansion index.

4.4.2 Thresholds of Significance

According to Appendix G of the California Environmental Quality Act (CEQA) Guidelines, the project would have a significant impact on geology and soils if it would:

- **Threshold GEO-1:** Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:
    i. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42.
    ii. Strong seismic ground shaking.
    iii. Seismic-related ground failure, including liquefaction.
    iv. Landslides.
- **Threshold GEO-2:** Result in substantial soil erosion or the loss of topsoil.
- **Threshold GEO-3:** Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- **Threshold GEO-4:** Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property.
- **Threshold GEO-5:** Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.
- **Threshold GEO-6:** Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.

The Initial Study (Appendix A to the Draft EIR) determined that the following thresholds would have less than significant or no impact, and these environmental topics will not be addressed further in this section of the Draft EIR.

- Threshold GEO-5
- Threshold GEO-6

4.4.3 Plans, Programs, and Policies

This section addresses plans, programs, and policies related to geology that are relevant to the project.

PPP GEO-1 The project will be designed and constructed in accordance with the California Building Code (CBC) adopted by the City of Anaheim and the City of Orange. The project shall comply with applicable development standards and ordinances and by the most recent building and seismic codes in effect at the time of project design for the respective cities. In accordance with Section 1803.2 of the CBC, a

geotechnical investigation is required that must evaluate soil classification, slope stability, soil strength, position and adequacy of load-bearing soils, the effect of moisture variation on soil-bearing capacity, compressibility, liquefaction, and expansiveness, as determined by the applicable approval authority. The geotechnical investigation must be prepared by registered professionals (i.e., California Registered Civil Engineer or Certified Engineering Geologist). Recommendations of the report pertaining to structural design and construction recommendations for earthwork, grading, slopes, foundations, pavements, and other necessary geologic and seismic considerations must be incorporated into the design and construction of the project.

PPP GEO-2 The project will be designed and constructed by incorporating recommendations contained in the Preliminary Geotechnical Evaluation prepared by Ninyo & Moore dated October 11, 2024 (Appendix F to the Draft Environmental Impact Report) and any subsequent updates prepared for the project to implement PPP GEO-1. In addition to the specific earthwork-, foundations-, retaining walls, pavement-, trails-, corrosivity-, concrete placement-, and drainage-related recommendations, the Preliminary Geotechnical Evaluation also contains the following construction monitoring programs to monitor ground vibrations, ground surface settlement, and lateral movement of shoring support systems. These monitoring programs will be in-place and conducted prior to the start of construction and the resulting data will be reviewed and evaluated during construction and be shown on all grading and building plans.

Documentation of Existing Conditions. Conduct pre-construction condition surveys on structures and railroad crossings within approximately 50 feet of the proposed excavations prior to construction. This distance will be extended to 100 feet adjacent to proposed excavations if driven and vibratory sheet or soldier piles are installed. This survey will include locating existing cracks and measuring widths of cracks, in combination with video documentation of existing conditions.

Interviews will be conducted with utility owners so that existing knowledge about the age, type, and maintenance history of affected utilities is available prior to construction.

Construction Vibrations. Monitor the vibration by using seismographs in the early stages. Seismographs will be located near structures and improvements next to the construction activities. Additional seismographs will be located at various structures and improvements farther from the construction activities to monitor vibrations as a function of distance from the sites. Periodic vibration monitoring will be conducted during other construction activities. After review of the data

obtained, reduce the number of seismographs at the discretion of the governing/approval agencies/entities and the qualified geotechnical consultant.

Ground Surface Settlement. Install arrays of ground surface settlement points around the proposed excavations. The construction contractor will submit a monitoring plan showing the proposed locations of settlement points for review and approval by the Project Engineer. The construction contractor will be responsible for maintaining total settlement at any survey point to less than 0.5 inch. If the settlement reaches this limit, further review of construction methodologies be performed and appropriate changes be made.

Lateral Movement for Shoring Support System. Install inclinometers or establish survey points behind excavations next to existing slopes. The inclinometers or survey points will be monitored and evaluated daily during excavation activities to provide an advanced warning system of potential problems. The shoring system will be designed to limit the ground settlement behind the shoring system to 0.5 inch or less to reduce the potential for distress to adjacent structures/improvements. If settlements reach 0.25 inch, a review of the construction contractor's methods will be performed and appropriate changes be made, if needed.

Groundwater Monitoring. If construction dewatering is performed, the construction contractor will install groundwater monitoring wells to monitor water levels outside the excavations. The monitoring wells will be installed at locations that will be accessible during construction. The groundwater levels will be monitored daily during dewatering as appropriate.

PPP GEO-3 All bridges shall be designed and constructed in accordance with the latest edition of the American Association of State Highway and Transportation Officials Load and Resistance Factor Design Bridge Design Specifications with California Amendments, the latest versions of the California Department of Transportation Standard Plans, Seismic Desing Criteria, and Geotechnical Manual, as required for various elements of the project, as determined by the applicable approval authority.

PPP HYD-1 The project is required to be developed in compliance with the following state, regional, and local regulations concerning grading, stormwater, and water quality control, as determined by the applicable approval authority:

- National Pollutant Discharge Elimination System General Construction Permit: Notice of Intent and Storm Water Pollution Prevention Plan Requirements
- State Water Resources Control Board General Industrial Activities Storm Water Permit

- Santa Ana Regional Water Quality Control Board Waste Discharge Permits and Water Quality Certifications
- Orange County Grading Manual
- Orange County Grading and Excavation Code
- Orange County Municipal Separate Storm Sewer Systems Permit
- Orange County Model Water Quality Management Plan and Technical Guidance Document
- Orange County Drainage Area Management Plan: New Development/ Significant Redevelopment Program
- Orange County Hydrology Manual and 1996 Addendum
- Orange County Water District Groundwater Replenishment Program
- Orange County Flood Control District Local Implementation Plan 2019
- City of Anaheim and City of Orange Municipal Codes
- City of Anaheim Grading Design Manual
- Anaheim Master Plan of Drainages North and West Santa Ana Tributaries
- American Association of State Highway and Transportation Officials Load and Resistance Factor Design Bridge Design Specifications with California Amendments
- California Department of Transportation Standard Plans
- California Department of Transportation Seismic Desing Criteria
- California Department of Transportation Geotechnical Manual

4.4.4 Environmental Impacts

The following sections address various potential impacts relating to geology and soils that could result from implementation of the project.

4.4.4.1 Threshold GEO-1.i: Exposure to Seismic-Related Hazards – Rupture of a Known Earthquake Fault

Impact Analysis

The Alquist-Priolo Special Study Zone Map does not delineate any known earthquake fault on the project site (Ninyo & Moore 2024; City of Anaheim 2022; City of Orange 2010). Therefore, the project would not directly or indirectly cause substantial adverse effects involving rupture of a known earthquake fault as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map.

Level of Significance Before Mitigation: No impact.

Mitigation Measures: No mitigation measures are required.

4.4.4.2 Threshold GEO-1.ii: Exposure to Seismic-Related Hazards – Ground Shaking

Impact Analysis

As with all Southern California, the project site has the potential for strong seismic shaking. The nearest mapped active fault to the project site is the Peralta Hills fault located approximately 3 miles north of the project site. Although no active faults are located within the project site, there are other regionally active faults that could produce ground shaking at the project site during an earthquake (Ninyo & Moore 2024). However, the project involves impoundments, storm drain diversions, embankments, retaining walls, pump stations, trails and undercrossings, trail improvements, bridges, and enhanced community amenities, which would not involve development of any habitable structures. Additionally, the project would be constructed using appropriate foundation methods for the planned improvements, shallow foundations[2] for impoundment structures, pump stations, retaining walls, amphitheater seating walls, drop structures, and grade control structures, and steel HP pile or cast-in-drilled-hole (CIDH) pile foundations for the bridges. During construction of proposed improvements, remedial grading consisting of the excavation and recompaction of the existing undocumented fill or loose natural materials would be required pursuant to the recommendations contained in the Preliminary Geotechnical Evaluation (Appendix F) or any subsequent updates. In addition, requirements of the appropriate governing jurisdictions and applicable building codes would be considered in the design of the structures for seismic safety, such as ground shaking. Some of the applicable building and infrastructure regulations include the CBC, American Association of State Highway and Transportation Officials Load and Resistance Factor Design Bridge Design Specifications with California Amendments, the latest versions of the California Department of Transportation Standard Plans, Seismic Desing Criteria, and Geotechnical Manual, California Public Utilities Commission's General Orders, Rules of Practice and Procedures, Public Utilities Code, and the Manual on Uniform Traffic Control Devices, the City of Anaheim Municipal Code, and the City of Orange Municipal Code. Therefore, impacts from strong ground shaking would be less than significant.

Level of Significance Before Mitigation: Less than significant.

Mitigation Measures: No mitigation measures are required.

[2] A shallow foundation is a type of foundation that transfers building loads to the earth near the surface, typically at a depth less than 3 meters (or less than the width of the foundation), rather than relying on deeper soil or rock layers Shallow foundations, including spread footings and mat foundations are proposed. Spread footings consist of concrete slabs or pads that support individual columns or walls. They are typically suitable for light to moderate loads and stable soils with adequate bearing capacity. Mat foundations, also known as raft foundations, are a type of shallow foundation that covers the entire area of the structure. They act as a single unit that supports multiple columns or walls. They are typically suitable for heavy loads and poor soils with low bearing capacity.

4.4.4.3 Threshold GEO-1.iii: Exposure to Seismic-Related Hazards – Liquefaction

Impact Analysis

The project site is located in an area mapped as being potentially susceptible to liquefaction per the State of California Seismic Hazard Zones maps (Ninyo & Moore 2024). The project involves impoundments, storm drain diversions, embankments, retaining walls, pump stations, trails and undercrossings, trail improvements, bridges, and enhanced community amenities that require ground-disturbing activities, including but not limited to excavation, recompaction, mat and spread footing foundations, and steel H-pile or CIDH pile installation for the pedestrian bridge foundations.

Pursuant to California Code of Regulations, Section 3724, the project is required to be designed and constructed in compliance with the recommendations of the geotechnical evaluations prepared for the project, the Preliminary Geotechnical Evaluation (Appendix F).

The Preliminary Geotechnical Evaluation indicates that the project would require remedial grading and recompaction of the existing undocumented fill or loose natural materials for the purposes of bridge foundations. Excavation and recompaction would extend to the depth of the undocumented fill to expose firm and unyielding alluvium or to a depth that will provide 2 to 3 feet of compacted fill below the bottom of the proposed foundations, whichever is deeper. For improvements constructed within the Santa Ana River channel, it is anticipated that the base of the improvements would extend approximately 2 feet below the potential scour depth unless the improvements are designed to prevent scour. If the remedial grading bottom is unstable under heavy equipment loads, additional excavation would be provided as needed to stabilize the bottom. Recompaction of materials would increase the stability of existing soil and reduce susceptibility to liquefaction. The Preliminary Geotechnical Evaluation also recommended that the removal and recompaction work include scarifying, moisture-conditioning, and compacting the exposed subgrade soils to a depth of 8 inches or more, and placing the excavated materials back as compacted fill. Trenches and excavations would be designed and constructed in accordance with the Occupational Safety and Health Administration (OSHA) regulations that provide shoring design parameters for excavations and trenches up to 20 feet deep based on the soil types encountered. Although not anticipated, if trenches over 20 feet deep are needed, they would be designed by the contractor's engineer based on site-specific geotechnical analyses. The project would be designed in accordance with structural considerations and recommendations contained in the Preliminary Geotechnical Evaluation.

The Preliminary Geological Evaluation determined that the project is feasible from a geotechnical perspective. In addition, the project is required to adhere to the requirements of the appropriate governing jurisdictions and applicable building codes, including geologic stability for liquefaction.

Some of the applicable building and infrastructure regulations include the CBC, American Association of State Highway and Transportation Officials Load and Resistance Factor Design Bridge Design Specifications with California Amendments, the latest versions of the California

Department of Transportation Standard Plans, Seismic Desing Criteria, and Geotechnical Manual, California Public Utilities Commission's General Orders, Rules of Practice and Procedures, Public Utilities Code, and the Manual on Uniform Traffic Control Devices, the City of Anaheim Municipal Code, and the City of Orange Municipal Code. Therefore, impacts from liquefaction would be less than significant.

Level of Significance Before Mitigation: Less than significant.

Mitigation Measures: No mitigation measures are required.

4.4.4.4 Threshold GEO-1.iv: Exposure to Seismic-Related Hazards – Landslide

Impact Analysis

The Preliminary Geotechnical Evaluation (Appendix F) concluded that the project site is not located in an area considered susceptible to landsliding. The project site is not identified as being within high landslide susceptibility areas mapped by the California Geological Survey with Deep Seated Landslide Potential (Anaheim 2022, Orange 2022). Therefore, no impacts from landslide would occur.

Level of Significance Before Mitigation: No Impact.

Mitigation Measures: No mitigation measures are required.

4.4.4.5 Threshold GEO-2: Soil Erosion or Topsoil Loss

Impact Analysis

Erosion is a natural process of the movement of soil from place to place. The main natural agents of erosion in the region are flowing water and wind. Erosion can be accelerated dramatically by ground-disturbing activities if effective erosion control measures are not used. Soil can be carried off construction sites or bare land by wind and water and tracked off construction sites by vehicles. The project has the potential to result in soil erosion impacts during construction and operation.

Construction-Related Erosion

Various project-related improvements would result in ground-disturbing activities during construction, exposing soils and potentially result in in the loss of topsoil. The project involves more than one-acre of ground-disturbing activities within and adjacent to Santa Ana River, riverbed, and embankments on both sides of the river. However, the project is required to comply with the National Pollutant Discharge Elimination System permit from the State Water Resources Control Board, including submittal of a Notice of Intent and preparation of a Storm Water Pollution Prevention Plan, which will specify best management practices (BMPs) to minimize stormwater pollution from project construction, including erosion and sediment. The project construction contractor would implement the specified BMPs to manage erosion, fugitive dust, and stormwater related issues. With

implementation of standard construction BMPs in accordance with a Storm Water Pollution Prevention Plan, the project's construction would result in less than significant impacts related to soil erosion and loss of topsoil. Additionally, the project would comply with the City of Anaheim General Plan Green Element Policies 7.1-1 and 7.1-2, and the City of Orange Natural Resources Element Policies 2.13 through 2.15 to reduce erosion, siltation, and other run-off impacts. With these mandatory BMPs, construction-related stormwater impacts would be less than significant.

Operational Impacts

According to the Preliminary Geotechnical Evaluation (Appendix F of this EIR), soils on the project site and surrounding area vary in susceptibility to water erosion. This is due to the variation in soil stratigraphy, and site-specific borings would be required to prior to grading activities.

Following construction, the project site would consist of paved and landscaped areas. As identified in the Preliminary Geotechnical Evaluation, the project site is located within a "Zone A" designated flood area (FEMA 2009). Specifically, the lower terrace path, and portions of the middle terrace path and amphitheater seating are planned at elevations that are lower than the 100-year flood level. Soil and topsoil located in these areas of the project site may be lost in severe storms or 100-year flood events.

The project also includes components that aim to reduce runoff and maintain water quality during operation. The project site would be developed with two river impoundment structures, modifications to the existing Santa Ana River embankment slopes, walkways and other paved areas, and landscaping. The two river impoundments would create two ponded water surface areas totaling approximately 38 acres that would allow for year-round infiltration of stormwater and infiltration of purified water during operation. The project would require modifications to the existing turnout structure, allowing to discharge into either the pipeline leading to the south impoundment pump station or directly into the river. This would supply ultra-pure Groundwater Replenishment System water to the impoundments.

During dry weather operation, the impoundment water levels would be maintained using groundwater replenishment system (GWRS) water supplied by OCWD. To address impoundment water quality concerns, dry weather nuisance flows in all adjacent tributary storm drain lines would be captured/diverted by gravity. These nuisance flows would be pumped to Orange County Sanitation District sewer lines and treatment facilities, with a few storm drain lines on the east side of the project discharged to the river channel downstream of the lower impoundment. This would minimize the possibility of any dry weather flows reaching the impoundments and mixing with GWRS water. In this operational condition, the impoundments would be filled to within 6 to 12 inches of the impoundment overflow elevation and maintained with the ability to bypass a portion of the water through a bypass structure containing a modulating weir so water levels and discharge flow can be controlled.

A low flow event is defined as a precipitation event that produces expected flow volumes at the project site of less than 200 acre-feet (the volume of water retained by the two impoundments). During a rain event, the dry weather nuisance diversion systems are turned off, allowing flow from the tributaries to enter the river. Flows to the project site would consist of a combination of flows from the surrounding tributaries and from Prado Dam releases. Generally, in low flow conditions the GWRS water supply to the impoundments would be halted, and the GWRS water would be allowed to infiltrate or may be pumped to Burris Basin, an off-river basin operated by OCWD. Santa Ana River flows, either tributary or from Prado Dam, would fill the impoundments up to the 200-acre-foot capacity. In any event where flows over the rubber dam reach a 6-inch nappe (approximately 320 cfs), the inflatable dams would be deflated.

High flow events are defined as events where the flows reaching the project site, which include tributary runoff and flows from Prado Dam, are 200 acre-feet or greater. In these conditions, both impoundments would be evacuated, and the rubber dams would be deflated to allow complete storm conveyance in the Santa Ana River channel. For this operation, GWRS inflows to the impoundments would be halted and allowed to fully infiltrate, which takes approximately 10 days, or the GWRS water would be drained and pumped to Burris Basin, which is anticipated to take approximately 3 days. The impoundments would then be fully deflated to maintain peak flood capacity of the Santa Ana River channel. In the later parts of the storm, the rubber dams would be reinflated with the intent of capturing the full operation volume, or 200 acre-feet, in both impoundments. During any event, regardless of expected volume, when the flow exceeds 320 cfs (6-inch nappe) over the dams, they would automatically deflate as a safety mechanism to prevent damage. There would be no changes to other segments of the Santa Ana River. Therefore, the impoundments would not result in additional erosion or siltation impact compared to the existing conditions.

The existing levee embankment within the project site consists of riprap-lined riverbank. The riverbank protection is comprised of loose and grouted riprap at a 2(H):1(V) slope. The project would modify the existing riprap with soil cement bank protection, reinforced concrete terraces and steps and new riprap, therefore, no erosion and siltation would occur during operation. Also, once constructed, surface drainage in the project site would primarily remain the same, with the river trails and surrounding areas draining to the Santa Ana River. The trail and trail improvement design would include various impervious surface materials and landscaping, and there would be no exposed soils with risk of substantial soil erosion or siltation. Additionally, a water quality management plan will be developed to address the required water quality components of the project elements. The project would be designed to comply with the North Orange County TGD and Model water quality management plan to achieve MS4 permit compliance.

Therefore, operational impacts related to substantial soil erosion or loss of topsoil would be less than significant.

Level of Significance Before Mitigation: Less than significant.

Mitigation Measures: No mitigation measures are required.

4.4.4.6 Threshold GEO-3: Geologic Stability

Impact Analysis

Unstable soils impact related to on- or off-site landslide is addressed under Threshold GEO-1.iv and liquefaction or collapse is addressed under Threshold GEO-1iii. The following discussion of the potential for lateral spreading and subsidence is summarized from the Preliminary Geotechnical Evaluation, as applicable (Appendix F).

Lateral Spreading

The project site is located within the free-faces of the Santa Ana River; therefore, there is a potential for seismically induced lateral spread. Lateral spreading is directly associated with areas of liquefaction, which is discussed in Threshold GEO-1.iv. As discussed under Threshold GEO-1.iv, similar to impacts from liquefaction, impacts from lateral spreading would be reduced to a less than significant level with the required compliance with the recommendations contained in the Preliminary Geotechnical Evaluation and requirements of the appropriate governing jurisdictions and applicable building codes that would be considered during the structural design and construction of the project. Impacts would be less than significant.

Subsidence

The City of Anaheim Local Hazard Mitigation Plan (2022) and the City of Orange Local Hazard Mitigation Plan (2016) do not identify subsidence as a hazard of concern for either city. Additionally, the project would be designed and constructed by adhering to the site-specific recommendations contained in the Preliminary Geotechnical Evaluation and requirements of the appropriate governing jurisdictions and applicable building codes that would be considered during the structural design and construction of the project. Therefore, impacts from subsidence would be less than significant.

Slope Stability

The project involves embankment improvements that required a slope stability analysis to evaluate the stability of the proposed embankment slopes based on the north impoundment area. The slope stability evaluation determined that while the proposed embankment slopes with a slope ratio of 2:1 (horizontal to vertical) would have adequate slope stability, the embankment slopes placed at a slope ratio of 1.5:1 (horizontal to vertical) may not result in adequate slope stability under certain scenarios. The slope stability analysis indicated that by removing the outer portion of the slope and replacing with a stabilization fill slope with an approximately 15-foot-wide soil cement zone, the slope stability safety level would increase to adequate levels. The project would be designed and constructed in

compliance with the CBC standards and recommendations contained in the Geotech investigation to be reviewed and approved by the applicable governing entities. (PPP GEO-1). Therefore, the project would not be impacted by slope instability to result in adverse environmental impacts.

Level of Significance Before Mitigation: Less than significant.

Mitigation Measures: No mitigation measures are required.

4.4.4.7 Threshold GEO-4: Expansive Soils

Impact Analysis

The project site's expansion index has not been tested. However, the Preliminary Geotechnical Evaluation (Appendix F) included results from previous geotechnical evaluations in the nearby area, which identified an expansion index of "0." Also, the Preliminary Geotechnical Evaluation concluded that the on-site soils are generally suitable for use as embankment fill and trench backfill as long as they are free of trash, debris, roots, vegetation, deleterious materials, and contamination. Therefore, it is anticipated that expansion potential for on-site soils is minimal, and impacts would be less than significant.

Level of Significance Before Mitigation: Less than significant.

Mitigation Measures: No mitigation measures are required.

4.4.5 Cumulative Impacts

This section addresses various potential cumulative impacts relating to geology and soils that could result from implementation of the project.

Geology and soil-related impacts are generally site-specific and are determined by on-site soil characteristics, proximity to faults, topography, and proposed land uses. Development projects are analyzed on an individual basis and must comply with established requirements of the applicable jurisdiction's development standards and the CBC as they pertain to protection against known geologic hazards and potential geologic and soil-related impacts.

4.4.5.1 Cumulative Threshold GEO-1.i Through GEO-1.iv: Exposure to Seismic-Related Hazards

Cumulative effects related to geology resulting from the implementation of the project as well as surrounding areas could expose more people and property to potential impacts due to seismic activity. Long-term impacts related to geology include the exposure of people to the potential for seismically induced ground shaking and seismic-related ground failure. Implementation of other cumulative projects would incrementally increase the number of people and structures subject to a seismic event. Seismic and geologic significance is considered on a project-by-project basis through

the preparation of design-level geotechnical studies and implementation of recommendations contained therein. The potential for any project to be affected by or any project to exacerbate an existing geotechnical hazard would be reduced to a less than significant level through strict engineering guidelines as they pertain to protection against known geologic hazards and potential geologic and soil-related impacts such as rupture of a known earthquake, ground shaking, liquefaction, and landslide. Therefore, cumulative impacts related to seismic-related hazards, would be less than significant.

4.4.5.2 Cumulative Threshold GEO-2: Soil Erosion or Topsoil Loss

With respect to erosion, as discussed under Threshold GEO-2, regulatory requirements mandate that the project incorporate BMPs during construction and long-term operation to ensure that significant erosion impacts do not occur. Other development projects in the vicinity of the project would be required to comply with the same regulatory requirements as the project to reduce substantial adverse water and wind erosion impacts. Because the project and other cumulative projects would be subject to similar mandatory regulatory requirements to control erosion hazards during construction and long-term operation, the project would not result in a cumulatively considerable contribution to a significant cumulative impact related to erosion.

4.4.5.3 Cumulative Threshold GEO-3: Geologic Stability and Threshold GEO-4: Expansive Soils

Development of the project as well as other cumulative projects in the surrounding areas would be required to be constructed in accordance with the latest edition of the CBC and to adhere to all current earthquake construction standards, including those relating to soil characteristics set forth by the City. Therefore, no elements of the project would contribute to any cumulatively considerable geologic and soils impacts.

4.4.6 Level of Significance Before Mitigation

Upon implementation of the plans, programs, and policies, the following threshold would be less than significant:

- **Threshold GEO-1i:** Implementation of the project would not cause a substantial adverse impact involving rupture of a known earthquake fault.
- **Threshold GEO-1ii:** Implementation of the project would not cause substantial adverse impact involving strong seismic ground shaking.
- **Threshold GEO-1iii:** Implementation of the project would not cause substantial adverse impact involving liquefaction.
- **Threshold GEO-1iv:** Implementation of the project would not cause substantial adverse impact involving landslide.

- **Threshold GEO-2:** Implementation of the project would not cause a substantial adverse impact involving soil erosion or the loss of topsoil.
- **Threshold GEO-3:** Implementation of the project would not result in adverse impacts related to unstable geologic units or soils.
- **Threshold GEO-4:** Implementation of the project would not result in adverse impacts related to expansive soil.

4.4.7 Mitigation Measures

No mitigation measures are required.

4.4.8 Level of Significance After Mitigation

Not applicable.