APPENDIX E

GEOTECHNICAL AND GEOLOGIC EVALUATION REPORT

GEOTECHNICAL AND GEOLOGIC EVALUATION REPORT FOR STADIUM RECONSTRUCTION PROJECT SAN DIEGO, CALIFORNIA

Prepared for:

City of San Diego Development Services 1222 First Avenue San Diego, California 92101

AECOM Project No. 60431885

July 29, 2015



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July 29, 2015

Ms. Kris Shackelford 1222 First Avenue City of San Diego San Diego, California 92101

Subject: Geotechnical and Geologic Evaluation Report for Stadium Reconstruction Project San Diego, California AECOM Project No. 60431885

Dear Ms. Shackelford:

AECOM is pleased to provide this geotechnical and geologic evaluation for the proposed Stadium Reconstruction Project. This report was prepared in support of the Environmental Impact Report for the Project.

The primary purpose of this report is to provide a summary of the geologic and subsurface conditions at the Project site for use in evaluating potential impacts and to develop geotechnical engineering considerations for design and construction.

We appreciate the opportunity to work with you on this study. If you have any questions regarding this report, please contact us.

Sincerely,

AECOM

Kelly C. Giesing, G.E. 2749 Senior Project Geotechnical Engineer Michael E. Hatch, C.E.G. 1925 Principal Engineering Geologist

TABLE OF CONTENTS

Section 1	Intro	duction	1-1
	1.1	Proposed Development	
	1.2	Development History	1-1
Section 2	Avail	able Subsurface Information	2-1
Section 3	Site (Conditions	3-1
	3.1	Physiographic and Geologic Setting	
	3.2	Tectonic Setting	
	3.3	Local and Regional Faults	
	3.4	Historical Seismicity	
	3.5	Surface Conditions	
	3.6	Subsurface Conditions	
	3.7	Groundwater	
	3.8	Mineral Resources	
	3.9	Soils	
Section 4	Geol	ogic and Seismic Hazards	4-1
	4.1	Fault Rupture	
	4.2	Strong Ground Motion	
	4.3	Liquefaction and Secondary Effects	
	4.4	Slope Stability	
	4.5	Expansion and Collapse Potential	
	4.6	Subsidence and Settlement	
	4.7	Corrosive Soils	
	4.8	Tsunamis and Seiches	
	4.9	Flooding	
	4.10	Erosion	
Section 5	Geot	echnical Considerations	5-1
	5.1	Seismic Design Considerations	5-1
	5.2	Foundation Considerations	
	5.3	Earthwork Considerations	
	5.4	Groundwater Considerations	
Section 6	Alter	native Project Site	6-1
Section 7	Limit	ations	7-1
Section 8	Refe	rences	8-1

Tables

Table 1	Fault Characteristics for Primary Active Faults in Region	3-2
Table 2	Summary of Mapped Soil Units	3-9

Figures

Figure 1	Vicinity Map
Figure 2	Site Geologic Map
Figure 3	Regional Geologic Map
Figure 4	Regional Faults and Epicenters



SECTION 1 INTRODUCTION

This report presents a geotechnical and geologic evaluation for the proposed Stadium Reconstruction Project in support of the Environmental Impact Report (EIR) for the Project. This report was prepared by AECOM for the City of San Diego. The existing Qualcomm Stadium and surrounding property are located in the Mission Valley area of the City of San Diego, as shown in Figure 1 Vicinity Map.

1.1 PROPOSED DEVELOPMENT

The proposed Project would be constructed near the northeast corner of the Qualcomm Stadium property, as shown in Figure 2 Site Geologic Map. Alternative projects are being considered and are discussed in Section 6 of this report. The proposed Project would cover an area of approximately 750,000 square feet (approximately 17 acres). It would be a steel-framed structure with a maximum height of 250 feet above the ground surface (including lighting and architectural features). Qualcomm Stadium would likely be demolished after completed construction of the new stadium.

The principal elements of the structure would be supported on deep foundations. The volume of imported fill material to raise grades above existing levels in the immediate stadium area is estimated at 490,000 cubic yards. Approximately 920,000 cubic yards of material would need to be removed from the site after demolition of the existing Qualcomm Stadium.

1.2 DEVELOPMENT HISTORY

Qualcomm Stadium, originally "San Diego Stadium" and later, "Jack Murphy Stadium" was constructed in the mid-1960s and opened in 1967.

Qualcomm Stadium and surrounding parking areas were constructed within the floodplain of the San Diego River. Fill needed for placement below the stadium structure, and to a lesser degree for general site grading and channelizing the river, was formational material sourced from the hillside north and northwest of the stadium property. The field level was established at elevation +50 feet (Mean Sea Level), primarily based on shallow groundwater concerns, as discussed in Section 3.7. Below the perimeter of Qualcomm Stadium, about 30 feet of fill was placed to establish the raised grades at the seating areas. The remainder of the parking area was graded to close to original elevations.

The Qualcomm Stadium structure and the retaining walls around the field are supported on steel H-Piles that were driven to refusal in the formational material below the fill and alluvium. Based on a review of the as-built foundation drawings from the original construction (Frank L. Hope & Associates 1967), the majority of the pile sizes are HP 8x36, 12x53, 12x74, and 14x102.¹ Tip elevations of the piles supporting the main structure vary considerably due to the depth to formational materials, while pile cut-off elevations and lengths also vary within each section of the stadium due to the slope of the base of the structure and underlying fill wedge, which is considerably thicker around the perimeter of the structure. Piles on the south side of the structure, where the formation is shallower, are typically 66 to 77 feet long with tip elevations ranging from +1 to +9 feet. On approximately the north half of the structure where the

¹ HP piles are H-shaped steel piles, where the first number refers to the approximate width of the pile in inches, and the second number refers to the weight of a linear foot of the pile in pounds.

formation is deeper, pile lengths vary from about 70 to 104 feet in length, with tip elevations of about -12 to -24 feet. The piles were driven about 10 to 20 feet into the formational material, and gain support in the formation and overlying dense sands and gravels. Driven steel batter piles were used to support lateral loads. Shallow foundations were used to support the smaller support buildings surrounding the stadium.

In 1983/1984, lower deck seating was added to the open (east) side of Qualcomm Stadium. Documentation of foundation types from the 1984 addition was not available for this review; however, it is likely supported on shallow foundations. A larger expansion was completed in 1997, which completed the enclosure of the stadium, except at the scoreboard. Based on a review of the geotechnical report and the structural drawings (Ninyo & Moore 1996, Leo A Daly 1997), the new structure associated with the 1997 expansion is supported on drilled shafts ranging from 36 to 72 inches in diameter. The shafts were designed to be end bearing, with a minimum of 5 feet embedment into formational materials or the overlying dense gravels at tip elevations ranging from -9 to +12.6 feet (an as-built geotechnical report was not available to confirm final tip elevations). Drilled shaft lengths range from about 70 to 95 feet in length.



SECTION 2 AVAILABLE SUBSURFACE INFORMATION

The information presented in this report is based on a review of published geologic maps and other geologic sources, planning documents and hazard maps, previous geotechnical reports for the stadium property and nearby developments, and subsurface data from logs of monitoring well installations across the property. Specific references associated with mineral resources and soil classification were also reviewed.

Published geologic maps include:

- "Geologic Map of the 30X60 Minute Quadrangle, California," by Kennedy and Tan, 2008.
- "Geology of the San Diego Metropolitan Area, California," by Kennedy, 1975.

Geotechnical information for the stadium property includes geotechnical reports for Qualcomm Stadium, the East Stadium Expansion, and as-built plan sheets presenting logs of test borings for the Mission Valley West LRT Extension. The geotechnical reports include:

- "Soils Investigation, Geology and Hydrology, Phase I, Proposed All-American Stadium, Southwest of Friars Road and Murphy Canyon Road, San Diego, California," by Benton Engineering, Inc. (Benton), Benton Project No. 65-7-16A, dated August 4, 1965.
- "Soils Investigation, Phase II, Proposed All-American Stadium, Southwest of Friars Road and Murphy Canyon Road, San Diego, California," by Benton, Benton Project No. 65-7-16A, dated October 15, 1965.
- "Geotechnical Report, Proposed East Stadium Expansion, San Diego Jack Murphy Stadium, San Diego, California" by Ninyo & Moore, Project No. 1031222-01, dated March 19, 1996.

The combined Benton study included advancing 18 borings to various depths, within and adjacent to the footprint of the Qualcomm Stadium. The approximate locations of the borings by Benton are shown in Figure 2 Site Geologic Map. A series of 12 borings were performed at the east end of the Stadium for the 1997 expansion and 19 geotechnical borings and 17 cone penetrometer tests were performed along the trolley alignment located along the southern margin of the Stadium area (Metropolitan Transit Development Board, 1999).

Numerous monitoring wells have been drilled across the stadium property due to the presence of a groundwater contamination plume from the Kinder Morgan Energy Partners Mission Valley Terminal northeast of the property based on California State Water Resources Control Board (CSWRCB) information. Approximately 50 well logs were reviewed from the GeoTracker website (CSWRCB 2015). The well logs include soil and rock stratigraphy, groundwater depth measurements, and limited blow count data to support soil density/consistency evaluations. Quarterly groundwater elevation data (in addition to other data associated with the contamination) are available in quarterly monitoring reports prepared by Arcadis (2014).

All references reviewed are listed in Section 7.

SECTION 3 SITE CONDITIONS

The summary of site and geologic conditions presented in this section was developed from a review of available previous investigations on and nearby the site, a review of available geologic data, historic aerial photography, and documentation from the Qualcomm Stadium construction.

3.1 PHYSIOGRAPHIC AND GEOLOGIC SETTING

The Project site is located in the coastal plain subprovince of the Peninsular Ranges physiographic province. The Peninsular Ranges are an elongate, northwest-trending mountain range formed by Mesozoic-age crystalline rocks. Following the mountain building event there was uplift, tilting, and erosion of the western margin of the Peninsular Ranges. These processes led to the formation of low relief topography west of the mountains. During the Tertiary period, marine and nonmarine strata were widely deposited across the erosional surface and capped by early Quaternary terrace deposits. These broad mesa surfaces were incised by westerly trending drainages, including the San Diego River.

Qualcomm Stadium is located in Mission Valley along the northern margins of the former floodplain of the San Diego River and near the outlet of Murphy Canyon, a south-trending subsidiary drainage. A regional geologic map of the area is shown in Figure 3 and is based on published regional geologic mapping (Kennedy and Tan 2008). The immediate site area is mapped as older alluvial deposits (Qoa). These older alluvial deposits are overlain locally by younger alluvial and colluvial deposits associated with the Murphy Canyon drainage and the adjacent hillslopes. The alluvial and colluvial deposits are overlain by fill soils placed during development of Qualcomm Stadium. Site-specific mapping of the floodplain was performed for the Qualcomm Stadium design (Benton 1965a). This mapping provides some geomorphic detail with a delineation of three terrace levels within the floodplain alluvial deposits. It also maps a small landslide to the northwest of the Project site along the slopes of the canyon approximately 1,000 feet to the west of Mission Village Drive. A Site Geologic Map is presented as Figure 2.

The alluvial deposits are underlain by Tertiary-age sedimentary deposits of the Friars Formation below the Project site. The nearby hillslopes bordering Friars Road expose the Friars Formation and the overlying Stadium Conglomerate (Kennedy 1975). Both formations have a gentle southwesterly dip based on geologic mapping of exposures in the area as shown in Figure 3. The Stadium Conglomerate consists mostly of cobble conglomerate in a sandstone matrix. The Friars Formation underlies the Stadium Conglomerate and consists of interbedded sandstone, siltstone, and claystone.

The late Pleistocene geologic history of the site involves the San Diego River and subsidiary drainages such as Murphy Canyon downcutting (incising) their respective channels into the underlying sedimentary formations during sea level low stands. During subsequent transgressions (sea level rises), the river and larger tributaries backfilled their channels with alluvial deposits including silt, sand, and gravel. Buried gravel-filled channels associated with the San Diego River and Murphy Canyon are present in the subsurface in the general site area. These buried channels are cut into the Eocene-age Friars Formation.

3.2 TECTONIC SETTING

The tectonic setting of the San Diego area is influenced by plate boundary interaction between the Pacific and North American lithospheric plates. This crustal interaction occurs along a broad zone of northwest-striking, predominantly right-slip faults that span the width of the Peninsular Ranges and extend offshore into the California Continental Borderland Province. At the latitude of San Diego, this zone extends from the San Clemente fault zone, located approximately 60 miles offshore of the San Diego coastline, to the San Andreas fault, located about 70 miles east of San Diego (see Figure 4, Regional Faults and Epicenters).

Geologic, geodetic, and seismic data indicate that the faults along the eastern margin of the plate boundary, including the San Andreas, San Jacinto, and Imperial faults, are currently the most active. These active faults are located in the Imperial Valley and are the dominant structures in accommodating the majority of the motion between the two adjacent plates. A smaller portion of the relative plate motion is being accommodated by northwest-striking active faults to the west, including the Elsinore, Newport-Inglewood-Rose Canyon, and offshore faults. The offshore faults include the Coronado Bank, San Diego Trough, and San Clemente fault zones.

3.3 LOCAL AND REGIONAL FAULTS

Faults in the region include the major active faults discussed above, as well as potentially active faults and inactive faults. The major active faults in the region are presented in Table 1, which presents the fault characteristics including fault length, maximum magnitude, slip rate, and distance to the proposed Project.

Fault Name	Approximate Distance To Project (miles) (b,d)	Slip Rate (millimeters/ year) (a,e,c)	Fault Length (miles) (a,b,c,e,f)	Estimate Magnitude (Maximum Moment Magnitude [Mw]) (a)
Newport-Inglewood-Rose Canyon Fault Zone	4	1.5	130	7.2
Coronado Bank Fault Zone (offshore)	16	3.0	115,	7.6
San Diego Trough Fault Zone (offshore)	25	1.5	106	7.5
San Miguel-Vallecitos Fault Zone (Northern Baja California)	34	0.2	100	6.9
Elsinore Fault Zone	36	5.0	190	7
San Clemente Fault Zone (offshore)	53		129	7.7
San Jacinto Fault Zone	57	4.0	152	6.8
Southern San Andreas Fault Zone	84	25	140	7.2

Fable 1. Fault	Characteristics for	or Primary	Active Faults i	in Region
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Notes:

Table references include (a) CDMG 2002; (b) CGS 2010; (c) Hirabayashi and others 1996;
(d) Kahle and others 1984; (e) Ryan and others 2012; and (f) USGS 2015c

The nearest active fault is the Rose Canyon fault, which is mapped approximately 4 miles west of the Project site near the intersection of the San Diego River and Interstate 5. An active fault (as defined by the City of San Diego 1999) is a fault that has had evidence of movement in Holocene time (last 11,000 years). These faults present the greatest risk of fault rupture hazard as well being the potential sources of strong ground shaking in the region. Active faults that also meet the criteria of being well expressed are zoned by the State of California within Alquist-Priolo Special Studies Zones, or Earthquake Fault Zones (EFZs) (Hart and Bryant 2007). Structures located within an EFZ are required to have building setbacks from the trace of an active fault. The proposed Project site is not within an EFZ or a City of San Diego delineated active fault. The nearest EFZs are located along the Rose Canyon fault in downtown San Diego and near Balboa Avenue, east of Mission Bay located at distances of approximately 4.7 to 5.1 miles.

Less hazardous faults include potentially active faults defined by the City as faults that have had surface displacement within the Quaternary period (past approximate 1.6 million years). The nearest potentially active fault of concern is the La Nacion fault mapped approximately 2 miles east. Other nearby potentially active faults include the Florida Canyon and Texas Street faults, mapped about 1.5 and 2 miles southwest of the Project site, respectively. These faults are listed as Quaternary (age undifferentiated) in the U.S. Geologic Survey (USGS) Fault and Fold Database (USGS 2015c).

Inactive faults are generally accepted as having had no movement in the Quaternary. Numerous minor inactive faults have been mapped throughout San Diego County. Local faults in this category in the site area include the Murphy Canyon and Mission Gorge faults, as discussed further below.

The three most important faults due to their proximity to the site and potential to generate a large earthquake are the Rose Canyon, La Nacion, and Elsinore faults, described below. Other local and more distant faults are also described below.

3.3.1 Rose Canyon Fault Zone

The Rose Canyon fault is a component of a fault zone that includes the Newport-Inglewood fault to the north at Long Beach and the Descanso fault to the south, offshore of Baja California, Mexico. Much of this extended fault zone is located in the offshore area between Orange County and Oceanside, and between San Diego Bay and northern Baja California. There was a historic earthquake event on the Newport Inglewood section of the fault in 1933 (Long Beach earthquake, Magnitude [M] 6.3) that caused considerable damage. The onshore portion of the Rose Canyon fault zone extends along the northeast flank of Mount Soledad and continues southward along the eastern margins of Mission Bay.

Detailed trenching along the main trace of the Rose Canyon fault in Rose Creek demonstrated Holocene displacement and a slip rate on the order of 1 to 2 millimeters/year (Rockwell 2010). The portion of the fault zone between Mt. Soledad and Balboa Avenue is designated as an EFZ. Between Mission Bay and San Diego Bay, the zone widens and diverges into the Spanish Bight, Coronado, and Silver Strand faults, which continue offshore toward Mexico.

The Downtown Graben is a zone of north-trending faults within the Rose Canyon fault zone mapped in the East Village area of downtown San Diego (Treiman 2002). Faults composing the zone appear to continue south beneath San Diego Bay, merging with more continuous offshore strands of the Rose Canyon fault zone. Trenching studies have documented Holocene displacement in the Downtown Graben² (Patterson and others 1986). The Downtown Graben is designated as an EFZ.

The Descanso fault appears to be a continuation of the Rose Canyon fault zone into the offshore area west of Rosarito Beach, Mexico. The maximum considered earthquake magnitude for the Rose Canyon fault is about M 7.2 based on a multiple segment rupture scenario.

3.3.2 La Nacion Fault

The La Nacion fault is the closest mapped potentially active fault to the site. The fault is a 15- to 20-milelong zone of down-to-the-west normal faults that forms the eastern boundary of the San Diego Embayment, a Pliocene-Pleistocene nested graben that is bounded on the east by the La Nacion fault and on the west by the east-side-down Point Loma fault, west of San Diego Bay (Marshall 1989). The embayment is thought to be an ancestral feature that predates the formation of the right-lateral Rose Canyon fault zone that presently bisects the graben.

Artim and Pinckney (1973) mapped the La Nacion fault from just south of Alvarado Canyon (near San Diego State University) to near the United States-Mexico border. A geomorphic analysis of the fault zone by Kahle (1988) finds little evidence at the surface for the fault extending north of Alvarado Canyon. To the south, the fault has subdued geomorphology expressed as benches, offset ridges, and tonal contrasts in places, and displaces the Lindavista terrace. Artim and Pinckney (1973) suggest a total vertical offset of 1,600 feet, a Pleistocene offset of 390 feet, and a possible 3-foot displacement of Holocene alluvium. However, radiocarbon dating of unfaulted alluvium by Hart (1974) and Elliot and Hart (1977) shows that the most recent movement on the La Nacion fault is older than Holocene. Based on these relationships, it is likely that the fault last moved in the late Pleistocene, making this fault potentially active and a less significant seismic hazard than the major active faults in the region. Based on the fault length, the maximum earthquake magnitude is estimated at M 6.7. It is uncertain if the La Nacion is capable of a seismogenic rupture of if it moves coseismically when the Rose Canyon fault ruptures.

3.3.3 Elsinore Fault Zone

The Elsinore fault zone is mapped about 36 miles east-northeast of the Project site near Julian. The fault zone consists of a 190-mile-long right-lateral strike-slip fault that runs along the west side of the Salton Trough from near the Mexican border northward to Corona where it branches into the Whittier and Chino faults. The central part comprises several segments, separated by step-overs, which include, from north to south, Glen Ivy, Temecula, Julian, and Coyote Mountain segments. Paleoseismic studies have shown prehistoric fault rupture on the Temecula, Julian, and Coyote Mountain segments (Vaughn and others 1999; Rockwell and Pinault 1986). The Laguna Salada fault extends from the southern end of the Elsinore fault into Mexico. Estimates of the maximum earthquake for individual segments of the Elsinore Fault range M 6.8 to 7.1 (Cao and others 2003).

² A graben is a down-dropped block bounded by steeply dipping faults

The recent El Mayor-Cucapah earthquake in 2010 was felt by many people in the San Diego metropolitan area. The epicenter for this M 7.2 event was located in Mexico approximately 60 miles to the south of Mexicali. The earthquake ruptured the ground surface along a series of mapped faults including rupture along portions of the Laguna Salada fault with rupture extending northward to near the United States-Mexico border.

3.3.4 Distant Onshore and Offshore Faults

The San Andreas fault zone is the major strike-slip fault within the North American-Pacific tectonic plate boundary. The fault comprises four major segments along its 870-mile length, extending from the north end of the Gulf of California, through southern to northern California. The southern segment extends about 140 miles from San Bernardino to the Salton Sea. This segment has not experienced a major earthquake in historical time. Geologic relationships suggest over 500 years has elapsed since the most recent large earthquake on this segment.

To the west of the San Andreas fault, the San Jacinto fault is a 152-mile-long system of northwesttrending faults extending north from the Imperial Valley to merge with the San Andreas fault near Cajon Pass. The southern portion of the San Jacinto fault in the Imperial Valley steps over to the Superstition Hills fault. The San Jacinto fault has been associated with six earthquakes having magnitudes 6.0 and greater (Allen and Armand 1965). The Superstition Hills fault was the source of the 1968 Borrego Mountain earthquake.

The Imperial fault continues southerly from the Superstition Hills fault, extending into Mexico just east of Mexicali. The Imperial fault produced surface rupturing earthquakes in 1940 and 1979. The Imperial fault is related to the San Andreas fault through transform faulting and crusting spreading processes.

At the latitude of San Diego, three significant faults are present within about 45 miles offshore of the Pacific coast, including (from east to west) the Coronado Bank, San Diego Trough, and San Clemente faults. The Coronado Bank fault zone extends approximately 115 miles from offshore Baja California to the Palos Verdes peninsula, near Los Angeles. The San Diego Trough fault is approximately parallel to the Coronado Bank fault and is nearly as long. The San Clemente fault is approximately 129 miles long, and is one of the longest and most continuous offshore faults in southern California. Slip rate estimates on the major offshore faults are largely based on geologic trenching studies on the related onshore portion of the fault as it passes offshore (e.g., Rockwell and others 1987). Based on their mapped length and tectonic expression, the offshore faults are considered capable of generating large magnitude earthquakes, M 6.5 or greater.

Major active fault zones onshore in Baja California include the active San Miguel fault and the Agua Blanca fault. In 1956, the San Miguel fault generated four large earthquakes about 50 miles southeast of Tijuana with M 6.1 to 6.8 (Brune and others 1979). The Agua Blanca fault cuts west-northwesterly across Baja California to the Pacific Coast near Maneadero (south of Ensenada). Some previous large earthquakes east of Ensenada thought to have occurred on the Agua Blanca fault have been reassigned to the San Miguel fault (Brune and others 1979). No large historical earthquakes are known to have occurred on the Agua Blanca fault.

3.3.5 Other Mapped Faults in or Near Mission Valley

The Texas Street fault is a north-trending fault mapped from just north of State Route 94 to the south rim of Mission Valley (Threet 1977). About 0.5 mile to the west, the Florida Canyon fault is another north-trending fault extending from the south end of Florida Canyon near Pershing Drive to the south rim of Mission Valley (Treiman 1993). Both faults are considered potentially active (City of San Diego 1999).

Other faults either mapped or suspected in the site vicinity include several undifferentiated Quaternaryage faults including the Murphy Canyon and Mission Gorge faults. These are minor faults and are not considered active or seismogenic, i.e., capable of generating an earthquake. Moreover, there is some question whether the Mission Gorge fault exists.

The Murphy Canyon fault extends northward from a point east of the Project site and on the east side of Interstate 15. The fault is mostly mapped as concealed (i.e., covered or buried) or only approximately located (Kennedy 1975). The Mission Gorge fault was originally mapped by Kennedy (1975) as a concealed fault possibly due to the northeast-southwest linear trend of the upper reach of the San Diego River downstream of Mission Gorge. The Mission Gorge fault is an inferred fault not included on all regional fault maps because of the uncertainty of the presence or absence of a fault within the San Diego River Valley.

Some very early geologic maps of San Diego County (e.g., Weber 1963) had postulated concealed faults extending approximately east-west along the general trend of the San Diego River in Mission Valley. A fault had been hypothesized to account for the apparent mismatches of the Tertiary sedimentary formations from the north to the south side of the valley. The presence of a fault in Mission Valley (i.e. the Mission Gorge fault) was debunked by Threet (Benton 1965a) who explained how the south dipping formations have thickness differences, which do not indicate a fault. It is possible that the ancestral course of the river may have followed the trend of what are presently deeply buried bedrock faults or fractures. However, within the present tectonic setting, an east-west-trending deeply buried fault, if present, would not be accumulating strain and would not be capable of an earthquake.

3.4 HISTORICAL SEISMICITY

The available record of large (M 6 and greater) historical earthquakes, dating back to the late 1700s, for coastal San Diego is probably as complete as any other region in California (Anderson and others 1989). The historical seismicity of the San Diego area is low; only a limited number of small earthquakes have been reported. In contrast, the surrounding region of southern California has experienced a higher rate of seismic activity with many, moderate to large earthquakes having occurred during historical time. The epicentral locations of recorded seismicity since 1932 in southern California and northern Baja California are shown in Figure 4.

San Diego has experienced strong shaking and minor damage from several local and distant earthquakes, but none has been very destructive (Agnew and others 1979; Toppozada and others 1981). Most of these earthquakes apparently originated at long distances from San Diego, generally from locations in the Imperial Valley or northern Baja California. Earthquakes in 1800, 1862, and 1892 are believed to have produced the strongest intensities in the San Diego area.

Seismographs were established in San Diego in the early 1930s. Since then, San Diego Bay has been the location of repeated "swarms" of small to moderate magnitude earthquakes. A 1985 series of earthquakes (largest event M 4.7) was generally centered about 0.6 mile south of the San Diego Coronado Bay Bridge (Reichle and others 1985). A similar series of small earthquakes in 1964 was also generally located beneath southern San Diego Bay (Simons 1977). In July 1986, an M 5.3 earthquake occurred about 44 miles offshore and northwest of San Diego, near Oceanside, California. This area has been characterized by an abundance of small aftershocks since 1986 (Hauksson and Jones 1988). Although the 1986 "Oceanside earthquake" was felt strongly in many areas of San Diego, it did not cause significant damage in the area.

3.5 SURFACE CONDITIONS

The 166-acre Qualcomm Stadium property is bounded by Friars Road to the north, Interstate 15 to the east, and the San Diego River to the south. The Project site is separated from commercial developments to the west by Qualcomm Way, an internal access road that traverses the west and south sides of the property.

The central portion of the property is occupied by the existing Qualcomm Stadium, which is surrounded by asphalt-paved parking areas. The Qualcomm Stadium MTS Trolley station is located on the south side of the stadium, and the elevated trolley line traverses the parking lot in a roughly east-west direction.

The ground surface generally slopes gradually down toward the south and southwest toward the San Diego River. High points exist at the northwest corner of the property, which has a maximum elevation of about +95 to +100 feet, and around Qualcomm Stadium, where fill was placed as high as about elevation +85 feet. At the proposed Project location, the existing ground surface ranges from about +55 to +75 feet. Along the San Diego River, the stadium parking lot elevation is +50 to +55 feet toward the east and +45 to +50 toward the west.

3.6 SUBSURFACE CONDITIONS

Available borings and well logs indicate the Qualcomm Stadium property is underlain by fill soils, alluvium, and the Friars Formation. As discussed in Section 1.2, fill was placed across the property in 1966 as part of the original site grading. Fill was sourced from cutting into the hills to the north and northwest of the Qualcomm Stadium property. This material consisted primarily of Stadium Conglomerate (clayey sand and gravel) and some of the underlying Friars Formation (likely clay, silt, and sand). Original ground surface elevations across the property prior to construction of Qualcomm Stadium generally ranged from +53 to +60 feet, with some lower elevations near the south side of the property where significant sand and gravel mining had occurred, and higher elevations at the northwest corner of the property. Based on comparisons with existing ground surface elevations, fill thicknesses are estimated to be as high as 35 feet (more in localized areas) around the perimeter of Qualcomm Stadium. In the area of the proposed Project, cuts and fills appear to have been minor, on the order of about 5 feet or less. Cuts of about 15 feet up to about 35 feet were excavated in the northwestern quadrant of the property and the elevation of Friars Road in this area was lowered on the order of 30 to 40 feet during its realignment. It is likely existing fill was placed and compacted in accordance with the project recommendations (Benton 1965b); however, compaction records were not available for review at the time of this study.



The fill overlies recent alluvial deposits that exhibit considerable variation in composition and thickness. The source of the alluvium is the San Diego River to the south and the Murphy Canyon Creek to the north. In general, the alluvium is primarily sandy with some gravel, silt, and clay interbeds. The sands and gravels vary from loose to dense, and the fine-grained materials vary from soft to stiff. The lower 5 to 10 feet of the alluvium (significantly greater thickness in some areas) typically consists of dense gravel.

In the vicinity of the proposed Project site, the alluvium is about 55 to 60 feet thick and is primarily sand and silty sand, with interbeds of clay and silt concentrated in the upper approximately 25 feet, and about 10 feet of gravel at the base of the alluvium. Little data is available on the density/consistency of the alluvium; however, zones of loose and soft material are expected to be present.

The alluvium overlies the Friars Formation at the site. The Friars Formation encountered was primarily medium-grained sandstone, with some gravel layers and siltstone and claystone beds. The top of the formational material was encountered at elevations ranging from about +26 to -14 feet across the Qualcomm Stadium property. Formation elevations are lowest on the west side of Qualcomm Stadium and near the southwest corner of the property. This area is underlain by a deeper erosional channel. The highest top of formation elevations in the boring and well logs reviewed were recorded near the northwest (elevation +26.5 feet) and southeast (elevation +25 feet) corners of the stadium property. In the area of the proposed Project, the top of the formation is expected to be at elevations typically ranging from about +2 to +9 feet.

3.7 GROUNDWATER

Numerous groundwater elevation measurements have been made in wells that have been installed across the stadium property based on information from the CSWRCB website (CSWRCB 2015). The wells are concentrated in the north/northeast portion of the property, with numerous wells also present around and southwest of Qualcomm Stadium.

During the original geotechnical investigation for Qualcomm Stadium (Benton 1965a), groundwater was measured at elevations ranging from +41 to +44 feet, with the highest elevations measured northeast of the existing stadium, and the lowest elevations in open pits on the south side of the site. Groundwater measurements made during installation of the wells reviewed (CSWRCB, GeoTracker website) suggest that groundwater surface was generally encountered between about elevation +36 and +47 feet. Stabilized groundwater elevation readings made in 2014 (Arcadis 2014) show elevations typically ranging from +38 to +42 feet. In both sets of data, the general trend shows the groundwater elevation dropping toward the southwest.

Groundwater elevations will fluctuate depending on variations in rainfall, stream flow, and other conditions. Groundwater elevations are typically lowest during the months of October through January. Measurements made during the early 1900s showed an average annual fluctuation of the groundwater level in the San Diego River Valley to be about 3.5 feet (USGS 1919). Benton (1965a) estimated that fluctuations of 5 to 6 feet could be expected at Qualcomm Stadium between wet and dry years. The originally proposed field elevation for Qualcomm Stadium was +45 feet; however, based on measured groundwater elevations and expected variations, Benton recommended a minimum field elevation of +50 feet.



3.8 MINERAL RESOURCES

Data from the USGS Mineral Resource Data System shows that there were two previous quarries on the Project site (USGS 2015a). One was the H.G. Fenton Material Company, located near the northeast corner of Qualcomm Stadium. The quarry produced sand and crushed gravel and was active from before the 1930s to about 1959. The second mine in the area was the Mission Valley Operation Plant, located on the western edge of the current stadium property. It was active from 1940 until about 1959. This quarry also produced sand and crushed gravel (CDMG 1963).

Based on the City of San Diego General Plan 2008 report (City of San Diego 2008b), the Project area is mapped in Mineral Resource Zone 2 (MRZ-2). MRZ-2 is described as areas underlain by mineral deposits where geologic data show that significant measured or indicated resources are present. A typical MRZ-2 area would include an operating mine, or an area where extensive sampling has indicated the presence of a significant mineral deposit.

Because the Stadium property has been fully developed and is in a highly urbanized area, it is not considered available for future mining activities.

3.9 SOILS

The National Resource Conservation Service (NRCS) is the branch of the United States Department of Agriculture (USDA) that maps and summarizes general information regarding soils in the United States. Based on the NRCS data, the soil map units in the Project site area include predominantly Made Land with a minor area of Riverwash to the south of Qualcomm Stadium. The soil survey data includes hydrologic group and soil drainage class as presented below in Table 2. The soil of the Project area is not classified relative to hydrologic group or soil drainage because the Made Land map unit is disturbed by development and considered highly variable (USDA 1973).

Soil Map Unit Name	Map Unit Symbol	Hydrologic Group	Soil Drainage Class	Approximate Percentage of Stadium Property	
Made Land	Md	Not Reported	Not Reported	89	
River Wash	Rm	D	Excessively Drained	11	

Table 2Summary of Mapped Soil Units

SECTION 4 GEOLOGIC AND SEISMIC HAZARDS

The primary geologic hazard at the Project site is the potential for strong ground motion from a seismic event centered on a nearby or more distant active fault, and the resulting potential for liquefaction and associated effects. Evaluations of fault rupture, seismic shaking, liquefaction, slope stability, expansive and corrosive soils, subsidence, and other potential hazards are discussed in detail below.

4.1 FAULT RUPTURE

The closest known active fault is the Rose Canyon section of the Newport-Inglewood-Rose Canyon fault zone, which is approximately 4.3 miles to the west of the Project site. The proposed Stadium Reconstruction Project site is not underlain by any active or potentially active faults. Therefore, the potential for surface fault rupture to affect the Project is very low.

4.2 STRONG GROUND MOTION

The vicinity of the Project will likely be subject to moderate to severe ground shaking in response to a local or more distant large-magnitude earthquake occurring during the expected life of the proposed Project. The USGS indicates the Peak Ground Acceleration (PGA) for a level of shaking associated with a probability of exceedence of 2 percent in 50 years is 0.46 g (percentage of gravity) (USGS 2015b). The Project should be designed in accordance with the current version of the California Building Code (CBC 2013). Based on the 2013 CBC, the Maximum Considered Earthquake Geometric Mean (MCE_G), which would be used for evaluation of liquefaction, is 0.45 g (ASCE 2010). Both the USGS and CBC PGAs are associated with Site Class D (stiff soil). During Project design, a site-specific evaluation considering actual subsurface conditions, including the potential for liquefaction (see Section 4.3) would likely be required.

4.3 LIQUEFACTION AND SECONDARY EFFECTS

Liquefaction is a phenomenon where loose, saturated coarse-grained soils (with less than 50 percent passing the No. 200 sieve) lose their strength and acquire some mobility from strong ground motion induced by earthquakes. The secondary effects of liquefaction include sand boils, settlement, reduced soil shear strength, lateral spreading, and global instability (flow slides in areas with sloping ground). Seismic settlement can also occur in dry sands.

4.3.1 Liquefaction Potential

Hazard maps generated by the City of San Diego and intended for planning purposes categorize the Project area as having a high potential for liquefaction (Zone 31) (City of San Diego 2008a). Liquefaction-induced settlement at the ground surface is possible given the character of the alluvium and shallow groundwater conditions at the Project site.

Some subsurface data (borings and well logs) **are** available that include resistance of the soil (blow counts). These data were evaluated and suggests that the potential for liquefaction within the sandy alluvium at the **new stadium** footprint is moderate to high. Based on the available data, assessments

made for other sites in the Mission Valley area, and experience, **it was** estimate that the ground surface at the site could experience on the order of 2 to 6 inches of settlement as a result of liquefaction.

4.3.2 Settlement of Dry Sands

Strong ground motion can cause the densification of soils, resulting in settlement of the ground surface. This phenomenon is known as seismically induced settlement or seismic compaction, which typically occurs in dry, loose cohesionless soils. During an earthquake, soil grains may become more tightly packed due to the collapse of voids or pore spaces, resulting in a reduction in the thickness of the soil column. Available subsurface data suggests that zones of loose sand could be present above the groundwater table within the Stadium Reconstruction Project footprint, and therefore the potential for seismic compaction at the site is moderate.

4.3.3 Lateral Spreading and Flow Slides

Lateral spreading and flow slides are phenomena where surficial soil displaces along a shear zone that has formed within an underlying liquefied layer. Upon reaching mobilization, the surficial blocks are transported downslope or in the direction of a free face by earthquake and gravitational forces. Lateral spreading is thought to occur on slopes as level as 0.5 percent, or on level ground with a "free face", such as a stream bank. Flow slides occur when conditions are favorable for liquefaction to occur and lead to a state of unlimited flow. A contributing factor to large scale lateral spreading and flow slides is the presence of stratified soil in which pore pressures build up within potentially liquefiable layers that are confined by low permeability layers. The associated significant reductions in shear strength can result in large lateral deformations and flow failure.

The slope of the ground surface at the Project site varies significantly, but in general slopes down toward the south/southwest, and a free face is present at the San Diego River. Given that there is likely a potential for liquefaction, as well as sloping ground, the potential exists for lateral spreading to occur at the Project site. However, site data indicates that the stratification within the alluvium is highly variable, with discontinuous fine-grained soil layers and denser sand and channelized gravel layers. Potentially liquefiable layers do not appear to be laterally continuous across the Qualcomm Stadium property. Further, the Project is more than 1,000 feet from the river channel. Therefore, the potential for lateral spreading or flow slides to affect the proposed Stadium Reconstruction Project is low due to the lack of continuity of liquefiable layers or overlying confining fine-grained layers that could increase the potential for global movement.

4.3.4 Strength Loss in Fine-Grained Soil

The loss of shear strength in fine-grained soil from strong ground shaking can adversely impact the performance of foundations and slopes. While limited data is available on the fine-grained soil layers at the Project site, some strength loss could occur. However, the effects of strength loss on the foundations are expected to be small compared with the liquefaction-induced settlements discussed above.



4.4 SLOPE STABILITY

The Project site has a gradual slope with no abrupt changes in grade and the proposed grading around the new stadium would create slopes similar to those around Qualcomm Stadium, which are on the order of 5 percent (about 1:20, horizontal:vertical). Therefore, the existing and proposed conditions at the Project site are not considered to have a potential for slope instability.

The northern edge of the Qualcomm Stadium property is about 250 feet from the base of the hills bordering the north side of Mission Valley. The City of San Diego Seismic Safety Study, Geologic Hazards and Faults map (City of San Diego 2008a) shows that immediately north of the Project area, Friars Formation is exposed from the base of the hill to an elevation of about +200 feet. The map classifies the Friars Formation in this area as having "neutral or favorable geologic structure." The formational material overlying the Friars Formation is classified as "Other level areas, gently sloping to steep terrain, favorable geologic structure, Low risk." Based on this mapping, combined with a general geologic assessment and the distance of the Project from the hill, the potential for slope instability of the adjacent hills to impact the Project is low.

4.5 EXPANSION AND COLLAPSE POTENTIAL

Expansive soil generally consists of clayey materials that can shrink and swell in response to changes in moisture content, with the potential to damage near-surface improvements, such as foundations and flatwork. Near-surface material is primarily granular in nature, consisting of sand and gravel, although some clay soils are present within the alluvium and possibly within the fill. Limited data is available on the fine-grained material at the Project site, although there is some potential for expansive soil. If expansive soil is encountered within the Project footprint during design-level studies, it could be locally removed and replaced with nonexpansive material.

Loose granular soils can be subject to collapse due to wetting and/or inundation. Collapse can occur in dry granular soils that have an unstable soil structure due to deposition or irrigation processes, typically with a skeletal structure that is weakly cemented by soluble salts or clay. Increases in moisture content can cause the interparticle cementation to reduce, causing changes in volume (collapse), especially when loaded. The existing fill materials are expected to be relatively dense and the underlying alluvial soils are not known to have a collapse potential. The proposed Project is likely to maintain and/or improve the hardscape at the site, which limits the potential for the soil below to become saturated. Therefore, the potential for collapse is low.

4.6 SUBSIDENCE AND SETTLEMENT

Before the 1939, groundwater withdrawal in the Mission Valley area provided a significant source of water in San Diego (USGS 1919). Other sources of groundwater largely replaced the Mission Valley well field and currently no significant water withdrawal is taking place in the Project vicinity. The potential for subsidence of the ground surface in the Project area due to current groundwater pumping is low.



The placement of significant thicknesses of fill could cause underlying loose and soft alluvial soil layers to consolidate, resulting in ground surface settlement. For Qualcomm Stadium, Benton (1965b) estimated that 2 to 6 inches of settlement could occur due to placement of 30 to 50 feet of fill.

4.7 CORROSIVE SOILS

Limited corrosivity laboratory test data (including Ninyo & Moore 1996) suggests that moderately corrosive soils may be present at the Project site. If potentially corrosive soil is present at the site, the Project design would implement controls (steel and concrete) to minimize the impact on the proposed Project.

4.8 TSUNAMIS AND SEICHES

The Qualcomm Stadium property is at elevations of about +55 feet or higher and is outside of the tsunami inundation area. The nearest area that is mapped to potentially be inundated by a tsunami is greater than 5 miles to the west near the intersection of Interstate 5 and Interstate 8 (CalEMA, CGS, and USC 2009). Therefore, the potential for tsunami inundation at the Project site is low.

A wave created by earthquake shaking in an enclosed body of water is called a seiche. There are no significant bodies of water near the Project site. Therefore, the potential for flooding at the site as a result of a seiche is very low.

4.9 FLOODING

The Project area is within both the mapped 100-year and 500-year Federal Emergency Management Agency flood zones. Details of the hydrologic setting of the Project site and the flood hazard are presented in Section 4.8 Hydrology and Water Quality of the Stadium Reconstruction Project EIR.

4.10 EROSION

With the exception of a sports field at the southwest corner of the property, the Project area is fully hardscaped and/or disturbed. For this reason, the Stadium Reconstruction Project should not increase the potential for wind or water erosion at the site outside of the construction and demolition phases.



SECTION 5 GEOTECHNICAL CONSIDERATIONS

In AECOM's opinion, the Project site is geotechnically suitable for the proposed stadium reconstruction. The primary geotechnical consideration for design and construction is the presence of granular soils with low relative density combined with a shallow groundwater level. These conditions, coupled with the potential for strong ground shaking during the life of the Project, create a moderate to high potential for liquefaction. Where estimated liquefaction-induced settlements cannot be tolerated by the proposed structures, liquefaction potential is commonly mitigated by using ground improvement and/or deep foundations.

A comprehensive geotechnical investigation would be needed to further evaluate these conditions and provide recommendations for design and construction. This investigation should be completed according to the latest City of San Diego Guidelines.

The following sections provide further discussion and conclusions regarding foundation design, as well as seismic design, earthwork, and groundwater considerations. These conclusions are based on literature research and professional judgment and should be considered preliminary. No subsurface exploration was completed as part of this study.

5.1 SEISMIC DESIGN CONSIDERATIONS

The Project would be designed in accordance with the current version of the CBC (currently the 2013 California Building Code), which includes provisions for seismic design. The available data indicate Site Class F (potentially liquefiable soil) would be used for design according to the CBC. However, AECOM expects design of the Project would include a site response analysis and developing a site-specific response spectrum to support the structural design.

5.2 FOUNDATION CONSIDERATIONS

Liquefaction-induced settlement would be estimated as part of design-level geotechnical studies for the Project. Depending on the magnitude of the settlement and the sensitivity of the structure, lightly loaded improvements can likely be supported on shallow foundations; stiffening elements can be incorporated into the design if required.

Ground improvement may be used independently to support the lightly loaded elements of the Project or in combination with deep foundations to support the more heavily loaded elements of the Project. Various methods of ground improvement are available to mitigate liquefaction potential. Stone columns and deep dynamic compaction are some of the more commonly used types of ground improvement. Deep dynamic compaction is typically used for projects encompassing larger areas. However, the method could cause damage to Qualcomm Stadium, which would still be in use during construction. Stone columns alone may not develop sufficient vertical resistance in the ground to support a heavy stadium structure and can be used with deep foundations to support higher axial loads. There are a variety of other methods of ground improvement, the discussion of which is beyond the scope of this report since those methods are proprietary to specialist subcontractors.



Deep foundations transfer the structure loads to the formational materials underlying the site and mitigate the potential for liquefaction. Deep foundations would also need to resist the downdrag loads from liquefaction-induced settlement. Both driven steel piles (original construction in the 1960s) and drilled shafts (1997 expansion) were used to support Qualcomm Stadium.

Drilled shafts can support large vertical and lateral loads. Construction would require casing or drilling fluid to keep the holes open during drilling through the loose alluvial material. Further, large volumes of soil and groundwater (or drilling fluid) would require disposal, which could be expensive considering previous contamination issues at the site.

Driven, steel piles (H-Piles or pipe piles), precast concrete piles, and Cast-In-Steel Shell (CISS) piles could also support large axial and lateral loads, although lateral load resistance is diminished. Driven piles would cause some vibrations during driving. The presence of cobbles within the alluvium should be considered with respect to driving obstructions.

Other pile types, such as auger cast piles and displacement auger cast piles, are often proprietary to specialist subcontractors. These piling systems often do not create significant vibrations, do not require a separate casing or drilling fluid stabilization system, and create very little spoils.

5.3 EARTHWORK CONSIDERATIONS

The placement of significant volumes of fill is expected to be part of the Project. A source of the fill material would require identification and selection, and disposal of fill from Qualcomm Stadium would also be required. The Project location is relatively flat, and the fill configuration would likely be similar to Qualcomm Stadium, with fill placed roughly in a "ring" around the new stadium perimeter.

While the placement of existing fill was likely documented by Benton (see Section 3.6 Subsurface Conditions), some removal and recompaction of the existing soil could be required prior to placement of new fill. Removal and recompaction depths could range from 5 to 10 feet, depending on the results of design-level geotechnical studies that would identify the density of the fill within the proposed Stadium Reconstruction Project footprint.

5.4 GROUNDWATER CONSIDERATIONS

The high groundwater elevation considered for the design of existing Qualcomm Stadium was elevation +47 to +48 feet (Benton 1965a). Since the proposed Project location is farther north (upgradient) than the existing Stadium, the high groundwater level could be slightly higher than previously considered. For planning purposes, a design groundwater level of +50 feet is recommended.

Proposed grades in the vicinity of the Project are expected to be 10 to 20 feet above the preliminary recommended groundwater elevation. Shallow excavations made during construction should be above the groundwater level, although deeper excavations for elevator pits and other below-grade elements may extend below the groundwater table. Localized dewatering could be required, and relatively fast infiltration rates could occur due to the primarily granular nature of the alluvium.

Groundwater would also likely be encountered within the depths of the foundation elements, as discussed in Section 5.2.

SECTION 6 ALTERNATIVE PROJECT SITE

The alternative site for the Stadium Reconstruction Project is located in the northwestern quadrant of the Qualcomm Stadium parking area. The current ground surface in this area slopes down in a south and southeasterly direction from elevations near +100 feet down to roughly elevation +52 feet, at an approximately 5 percent slope. A limited number of well logs are available at the alternate Project location; these suggest the alluvial material is on the order of 35 to 40 feet thick and may be primarily clayey above the groundwater table with sand below the water table. It is estimated that the top of formation in this area could range from elevations +20 to +100 feet, and slope rather steeply down toward the southeast.

The geology of the alternative Project site is somewhat different than the proposed Project site, primarily due to the higher elevation and primarily clayey upper soil. While difficult to evaluate due to the limited subsurface data available, the clayey soil is likely to be colluvial material sourced from the hills to the north. However, Benton (1965a) mapped a landslide in this vicinity (see Figure 2). The landslide is not mapped on the State or City Hazard Maps or regional geologic map, and is not mentioned in the other literature reviewed for the proposed Project. If a landslide was present at this location prior to the development of Qualcomm Stadium, the subsequent grading, which lowered Friars Road and the northwest corner of the Stadium property on the order of 30 to 50 feet, essentially removed the driving force. Fill placed for Qualcomm Stadium at the toe of the mapped feature would also act to buttress the landslide debris, if present.

Other than the remote potential for landslide deposits to exist, geologic hazards associated with the alternative Project site are essentially the same as the Project site. If formational materials are shallower, and the alluvium is thinner at the alternative site, the potential for liquefaction may be somewhat reduced, although some hazard is likely present along the southern and eastern margins of the alternate site.

Since the slope of the formation surface may slope steeply; highly variable pile lengths could be required. Due to the slope of the existing ground, a cut/fill configuration may be required, with cuts on the northwest side, and fills on the southeast side. This could reduce the requirements for fill volumes as compared with the Project, although there could be a need for retaining structures on the northwest side.



SECTION 7 LIMITATIONS

AECOM prepared this report based on published data and previous studies performed at the Project site. The conclusions presented in this report are based on the assumption that soil and geologic conditions do not deviate appreciably from those observed during previous studies.

Design-level details related to the Project are not available at this time. Geotechnical considerations presented in this report are intended for Project planning, permitting, and preliminary design considerations. Subsurface investigation would be required to support Project design.

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on AECOM's understanding of the potential future construction, and partly on our general experience. AECOM's engineering work and judgments rendered meet current professional standards; we do not guarantee the performance of previous or future projects in any respect.



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Geotechnical and Geologic Evaluation Report, City of San Diego Stadium Reconstruction Project

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Geotechnical and Geologic Evaluation Report, City of San Diego Stadium Reconstruction Project

Site Geologic Map



Scale: 1 = 48,000; 1 inch = 4,000 feet

Geotechnical and Geologic Evaluation Report, City of San Diego Stadium Reconstruction Project

	Kt
Geologic Legend	
Qaf, Artificial fill	
Qls, Landslide deposits undivided	3
Qmo, Undivided marine deposits in offshore region	
Qya, Young alluvial flood plain deposits	
Qyc, Young colluvial deposits	
Qoa, Old alluvial flood plain deposits undivided	
Qop6, Old paralic deposits, Unit 6	70
Qop2-4, Old paralic deposits, Units 2-4 undivided	
Qvop, Very old paralic deposits undivided	
Qvop11, Very old paralic deposits, Unit 11	
Qvop10, Very old paralic deposits, Unit 10	
Qvop9, Very old paralic deposits, Unit 9	
Qvop8, Very old paralic deposits, Unit 8	
Qvop7, Very old paralic deposits, Unit 7	1
Qvop6, Very old paralic deposits, Unit 6	
Qvop5, Very old paralic deposits, Unit 5	
Qvop4, Very old paralic deposits, Unit 4	
Tsd, San Diego Formation	
Tsdss, San Diego Formation, fossiliferous marine sands	tone
Tp, Pomerado Conglomerate	
Tmv, Mission Valley Formation	t
Tst, Stadium Conglomerate	
Tf, Friars Formation	10
Tsc, Scripps Formation	
Ta, Ardath Shale	5. 17 -
Tmss, Mount Soledad Formation, sandstone	
Tmsc, Mount Soledad Formation, cobble conglomerate	1
Kgu, Granodiorite and tonalite undivided	
Mzu, Metasedimentary and metavolcanic rocks undivide	ed
Qvop	~
Tsdss	
Tadas Tau	Tmv
Qya	

Figure 3 Regional Geologic Map



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Scale: 1 = 950,400; 1 inch = 15 miles

Figure 4 Regional Faults and Epicenters

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