GEOTECHNICAL/SEISMIC HAZARD STUDY FOR THE SAFETY ELEMENT OF THE SANTEE GENERAL PLAN

CITY OF SANTEE
COUNTY OF SAN DIEGO, CALIFORNIA

GEOCON
INCORPORATED

GEOTECHNICAL
ENVIRONMENTAL
MATERIALS

PREPARED FOR

CITY OF SANTEE, CALIFORNIA
INCORPORATED 1980

MARCH 29, 2021
PROJECT NO. G2647-52-01

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City of Santee
10601 Magnolia Avenue
Santee, California 92071-1266

Attention: Mr. Scott A. Johnson

Subject: GEOTECHNICAL/SEISMIC HAZARD STUDY FOR
THE SAFETY ELEMENT OF THE SANTEE GENERAL PLAN
CITY OF SANTEE, COUNTY OF SAN DIEGO, CALIFORNIA
PURCHASE ORDER 53273

Mr. Johnson:

In accordance with your authorization of our proposal No. LG-20433 dated September 29, 2020, we prepared this Geotechnical/Seismic Hazard Study for the City of Santee, California. The accompanying report presents the findings of our study for inclusion into the Safety Element of the Santee General Plan.

Should you have questions regarding this report, or if we may be of further service, please contact the undersigned at your convenience

Very truly yours,

GEOCON INCORPORATED

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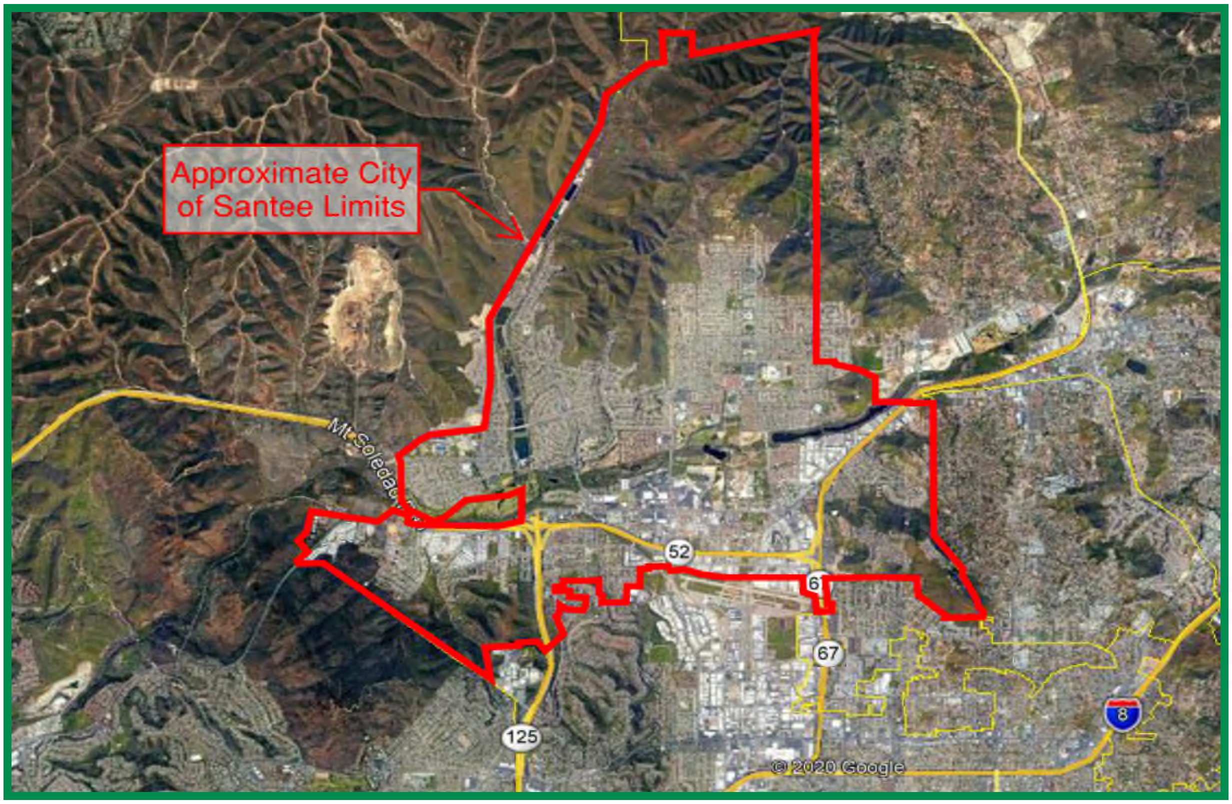
GEOTECHNICAL/SEISMIC HAZARD STUDY FOR THE SAFETY ELEMENT OF THE SANTEE GENERAL PLAN

1. INTRODUCTION/EXECUTIVE SUMMARY

This report presents the results of a Geotechnical/Seismic Hazard Study for the Safety Element of the Santee General Plan. The Area Map presents the general area of the City of Santee.



City of Santee Area Map

We identified three general categories of hazards related to seismicity and geologic conditions within the City of Santee. These hazards could, under certain circumstances, result in property damage and disruption of essential services, bodily injury and loss of life. The three main seismically induced hazards specific to the City of Santee include:

1. **Landsliding and Slope Instability:** caused by the presence of ancient landslides, bedding plane shears and weak claystone beds within the Friars Formation; ground shaking.
2. **Liquefaction:** typically occurs within the alluvial deposits of the San Diego River. Liquefaction can cause settlement, lateral spreading, loss of nearing strength and sand boils.
3. **Dam Inundation:** failure of the three major dams located upstream of the City could be considered a hazard. We did not identify areas of potential surface fault rupture within the city limits based on published geologic maps.

This Geotechnical/Seismic Hazard Study identifies the potential natural and man-made hazards and sets forth goals and policies that will serve the public welfare and reduce the risks associated with these hazards.

The data used in preparing this study are derived mainly from published geologic literature, reports prepared by Geocon Incorporated and other firms for projects within the Santee city limits, and our field experience in the study area and the San Diego County area in general. A complete listing of the published reports and studies utilized is presented in Appendix C, List of References.

2. PURPOSE AND SCOPE OF WORK

A Safety Element of the General Plan is required by the California Legislature for all cities and counties in the state. The State of California Government Code, Section 65302 (g) states the General Plan shall include the following:

A safety element for the protection of the community from any unreasonable risks associated with the effects of seismically induced surface rupture, ground shaking, ground failure, tsunami, seiche, and dam failure; slope instability leading to mudslides and landslides; subsidence; liquefaction; and other seismic hazards identified pursuant to Chapter 7.8 (commencing with Section 2690) of Division 2 of the Public Resources Code, and other geologic hazards known to the legislative body; flooding; and wildland and urban fires. The safety element shall include mapping of known seismic and other geologic hazards. It shall also address evacuation routes, military installations, peak-load water supply requirements, and minimum road widths and clearances around structures, as those items relate to identified fire and geologic hazards.

This Geotechnical/Seismic Hazard Study includes only geologic and seismic hazards. This report does not address flooding, wild land and urban fires or emergency preparedness requirements of the Safety Element. These requirements will be addressed separately by others and will be included along with this report into the Safety Element of the General Plan. This report contains a Geologic Map (**Figure 1**), Geotechnical/Seismic Hazard Map (**Figure 2**), an Inundation Map (**Figure 3**) depicting areas that could be affected by failure of local reservoirs and dams and a Characteristic Geology Section of the Santee Area (**Figure 4**). This report is consistent with the current building code and this report should govern if there is a discrepancy between the two documents. The City of Santee can request additional information from private development submittals, as necessary, to address the geologic requirements of the project.

The scope of our services includes an inventory and review of available literature, development of new geologic hazard and inundation maps, and preparation of this report. The literature reviewed included a report prepared by Geocon Incorporated, entitled *Geotechnical/Seismic Hazard Study for the Safety Element of the Santee General Plan*, dated October 31, 2002.

3. RECOMMENDED GENERAL PLAN GOALS

The overall Seismic Safety Element Goal is to minimize the loss of life and destruction of property in the City of Santee caused by seismic and geologic hazards. The implementation of information contained in this study, as well as information to be generated in future studies, is discussed herein. It includes a discussion on application of geologic data to land use studies, guidelines for type of reports necessary for projects in areas of different geologic hazards, and recommendations for a peer review procedure.

In addition, properties that are planned for development should address the three seismic hazard categories as follows:

1. **Landsliding and Slope Instability:** Performing background research and site-specific studies, geologic explorations (e.g. large-diameter drilling), laboratory testing and engineering analyses to properly characterize the existing geologic conditions on the property.

2. **Liquefaction:** Performing map reviews and site-specific studies, field explorations (e.g. cone penetrometer testing or mud-rotary drilling), laboratory testing and engineering analyses to properly characterize the existing geologic conditions on the property.

3. **Dam Inundation:** Performing background research to properly identify if dam inundation is a potential hazard to the planned development (e.g. hazard map review).

4. RECOMMENDED GENERAL PLAN OBJECTIVES AND POLICIES

The objectives of this report are to identify and evaluate the geotechnical and seismic hazards in the City of Santee, and to establish policies and guidelines to reduce the risks from the three hazard categories discussed herein. These hazards may result in damage to public and private property, disruption of essential services, bodily injury and loss of life. Suggested objectives of the General Plan for each of the three hazard categories could include:

Objective 1 – Awareness. Increase awareness of geotechnical and seismic hazards within the City of Santee in order to avoid or minimize the effects of the hazards during the planning process for new development or redevelopment, and to mitigate the risks for existing developments.

Policy 1. Utilize existing and evolving geologic, geophysical, and engineering knowledge to distinguish and delineate those areas that are particularly susceptible to damage from the three hazard categories.

Objective 2 – Project Review. Assure that the project review process allows for consideration of the seismic and geologic hazard categories as early as possible.

Policy 2. For projects proposed in areas identified within the geologic hazard category area, the geologic/geotechnical consultant shall establish either that the unfavorable conditions do not exist in the specific area in question or that they can be mitigated through proper design and construction.

Objective 3 – Essential Facilities, Hazardous Facilities, and Special Occupancy Structures. Ensure that essential facilities, hazardous facilities and special occupancy structures are located and designed to be functional in the event of a disaster. These facilities and structures include fire and police stations, hospitals, communication centers, schools, churches and other high occupancy structures.

Policy 3. As shown in Table A-1 (Appendix A), *Determination of Geotechnical Studies Required*, Group I facilities require a Geotechnical Investigation, a Geologic Investigation, and a Seismic Hazard Study specific to the project. Additionally, the State of California requires reports for public schools, hospitals, and other critical structures to be reviewed by the State Architect.

An analysis of each of the three policies is delineated herein.

4.1 Policy 1 – Awareness

The enclosed Geotechnical/Seismic Hazard Map (**Figure 2**) and Dam Inundation Map **(Figure 3**) were compiled from published maps from the California Geologic Survey and from the Poway, La Mesa, El Cajon, and San Vicente Quadrangles. In addition, geotechnical reports, in-house and on file at the City of Santee, were integrated into the map.

4.2 Policy 2 – Project Review

The City shall require that the potential geologic hazards be investigated and evaluated at the environmental review stage prior to project approval. Such investigations shall include those identified in Table A-1 (Appendix A), *Determination of Geotechnical Studies Required*, as may be warranted by results of the Initial Environmental Study. The City of Santee may request additional studies depending on the project location, project type and possible updated information.

4.2.1 Application of Data to Site- Specific Land Use Studies

The discussion presented herein is intended to inform the governing agencies as to the level of geologic risk or hazard in a particular area and to provide a basis for design considerations with regard to types of structures and proposed location. The factors requiring consideration are:

- The type and/or function of a structure,
- The presence of geological hazards at the proposed site, and
- The level of risk that can be accepted. For instance, in areas of potentially higher risk or where structures that are more critical are planned, special design considerations will be necessary to reduce the level of risk to an acceptable factor.

The intent is not to discourage a particular type of structure or to condemn an area as being impossible to develop. The intent of the recommendations is to provide a basis for evaluating specific site and structure combinations and to discourage those that are unfavorable.

Table A-1 (Appendix A) indicates the minimum suggested level of geotechnical study for various combinations of site location and type of structure or development. Table A-2 (Appendix A) gives a description of each type of study including Geologic Reconnaissance, Geologic Investigation, Geotechnical Investigation and Seismic Hazard Study. Proposed structures should be evaluated based on the type of structure and proposed building use. Table 4.2.1 presents a summary of the group/risk categories in general accordance with American Society of Civil Engineers (ASCE), *ASCE 7-16, Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 7-16). Required site-specific geologic studies will vary in detail and scope, based upon the type of land use proposed by an applicant and the existing geologic conditions of the subject property to ensure public safety.

TABLE 4.2.1
ASCE 7-16 RISK CATEGORIES

Group / Risk Category	Building Use	Examples
I	Low risk to Human Life at Failure	Parks, Open Spaces, Golf Courses, Agricultural Land, Landfills, Barn, Storage Shelter
II	Nominal Risk to Human Life at Failure (Buildings Not Designated as I, III or IV)	Residential, Commercial and Industrial Buildings, Warehouses, Apartment Buildings, Motels, Secondary Roadways
III	Substantial Risk to Human Life at Failure	Theaters, Lecture Halls, Dining Halls, Schools, Churches, Prisons, Small Healthcare Facilities, Infrastructure Plants, Storage for Explosives/Toxins, Main Roads High-Rise Buildings, Large Structures Intended for Human Occupancy
IV	Essential Facilities	Hazardous Material Facilities, Hospitals, Fire and Rescue, Emergency Facilities and Shelters, Police Stations, Power Stations, Aviation Control Facilities, National Defense, Water Storage

Depending on the site, potential landfill areas may require more investigation than the other types of developments in order to address environmental concerns.

The types of report required for site-specific studies typically include:

1. **Geologic Reconnaissance.** Normally a desktop study that summarizes the potential geologic hazards on a property based on research on existing geologic map and previously performed geotechnical studies in the vicinity.

2. **Geologic Investigation.** Includes mapping and exploratory excavations to confirm/identify the existing geologic hazards on a property.

3. **Geotechnical Investigation.** Provides a summary of the geologic hazards and design recommendations for the proposed development.

These reports can be preliminary (such as feasibility analyses) or detailed studies including extensive subsurface investigation, laboratory data testing generation, and engineering-geologic analysis.

Consideration should be given to developing *Guidelines for Geotechnical Reports* that would set technical standards for all reports submitted to the City of Santee. References for developing *Guidelines for Geotechnical Reports* including:

1. California Department of Conservation, Division of Mines and Geology, *DMG Note 48 Checklist for the Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals, and Essential Services Buildings*, November 2019.

2. City of San Diego, *Guidelines for Geotechnical Reports*, 2018.

3. *2019 California Building Code*, Chapter 18 and 18A, Effective January 1, 2020.

Concerning Seismic Hazard Studies for critical structures, very thorough investigations should be conducted. These studies should be performed in accordance with the following guidelines:

1. California Department of Conservation, Division of Mines and Geology, *DMG Note 42, Earthquake Fault Zones, A Guide for Government Agencies, Property Owners / Developers, and Geoscience Practitioners for Assessing Fault Rupture Hazards in California*, Revised 2018.

2. California Department of Conservation, California Geologic Survey, Special Publication 117A, *Guidelines for Evaluating and Mitigating Seismic Hazards in California*, Revised and Re-adopted September 11, 2008.

These reports are updated from time to time and the latest version should be used at the time of the submittal and review process, as accepted by the City of Santee.

4.2.2 Review Procedures

Consideration should be given to establishing a review procedure for site-specific geotechnical reports submitted to the City with applications for development. The procedure would consist of a review to check that pertinent geologic and geotechnical considerations have been adequately addressed. The reviewer could be geotechnical personnel employed directly by the City or private geotechnical consulting firms under contract to the City specifically in a review capacity to conduct Third Party Reviews.

4.3 Policy 3 – Essential Facilities, Hazardous Facilities, and Special Occupancy Structures

Land uses in Group I and II risk categories identified in Table 4.2.1 are considered low and nominal risk to human life. Group III and IV land uses in Table 4.2.1 require special study because they are in higher-risk categories. Group III includes special occupancy structures including schools; churches; main roads; large commercial and industrial structures; mid- to high-rises; and other high occupancy structures. Group IV includes essential facilities; critical facilities including hospitals, fire and police facilities; power generating stations; communication facilities; and dams. Hazardous facilities include structures housing or using toxic or explosive chemicals or substances.

Group III and IV structures require a Geotechnical Investigation, a Geologic Investigation, and a Seismic Hazard Study even in areas which are generally or moderately stable.

4.4 Additional Policies

Additional land use policies can be made to reduce the risk of geotechnical and seismic hazards on an individual project basis as directed by the City of Santee. These may include limiting development in the floodplain, requiring seismic retrofitting or demolition of older buildings and unreinforced masonry structures, or scaling the development to reduce the amount of risk.

4.5 Further Study

As additional geotechnical studies are conducted in the Santee area, the Seismic Safety Study should be periodically updated and refined as new information concerning the location of landslides, faults and potentially liquefiable areas is obtained.

Review and update of the Zoning Ordinance should be periodically undertaken to ensure that it adequately addresses seismic safety issues, geologic site conditions, and geotechnical mitigation procedures identified in the General Plan.

5. DESCRIPTION OF EXISTING CONDITIONS

5.1 General Location

The City of Santee encompasses approximately 16.6 square miles (10,641 acres) and is located approximately 11 miles northeast of downtown San Diego, 13 miles east of the Pacific Ocean, and 19 miles north of the Mexican border. The majority of the City is located in Township 15 South, Range 1 West of the San Bernardino Meridian. The City of Santee is bound by the City of San Diego on the west, Mission Trails Regional Park on the southwest, and the United States Marine Corps Air Station Miramar on the northwest. The City of El Cajon is located to the south, and unincorporated areas of the County of San Diego are located to the east and north as shown in the Vicinity Map.

Vicinity Map

5.2 Soil and Geologic Conditions

5.2.1 General

This section describes the geologic and seismic setting of the Santee area including a brief description of the study area and a discussion of the stratigraphy and geologic structure of the geologic units within the area.

The City of Santee lies near the junction of the coastal plain and the Peninsular Ranges geologic provinces of southwestern California. The eastern portion of the coastal plain is located within the west, south and north portions of the city and consist of a series of Tertiary-age formational sedimentary rocks that are deeply incised by canyons and tributaries, including the San Diego River and Sycamore Creek. The San Diego River generally bisects the City of Santee. The drainage area of the San Diego River upstream of West Hills Parkway on the western edge of Santee is approximately 368 square miles. Downstream, the San Diego River flows through Mission Trails and Mission Valley in the City of San Diego and drains into the Pacific Ocean. Much of Santee is located within the gently gradient of the San Diego River Valley. Sycamore Creek is located along the western boundary of the City and flows southward into Santee Lakes and the San Diego River. In the southeastern and eastern portions of the City, the sedimentary rocks and alluvial valley province end abruptly in the foothills of the Peninsular Ranges exposing granitic rock. The formational units are covered by surficial soils as described herein.

The geologic stratigraphy of Santee consists of several surficial soil types and formational units. The surficial soil deposits consist of man-made soil (undocumented fill and previously placed fill) and naturally occurring soil (topsoil, colluvium, young alluvium/debris flows, landslide deposits, and old alluvial flood-plain deposits). In general, naturally occurring surficial soils are found in drainage areas such as the San Diego River valley and Sycamore Creek and generally overlying undisturbed formational materials.

Formational materials within the City include sedimentary rock units of the Eocene-age Pomerado Conglomerate, Stadium Conglomerate and Friars Formation, and the hard rock units of the Mesozoic-age (Cretaceous and Jurassic) granitic and volcanic rocks associated with the Peninsular Ranges. The claystone portions of the Friars Formation are typically weak, fractured, and prone to landsliding.

Each of the surficial soil types and formational units within the City is described herein in order of increasing age. A geologic map showing the lateral extent of the geologic units is included on **Figure 1**. The Geologic Map, **Figure 1**, is a combination of two California Geologic Survey (CGS) maps by different authors; therefore, the nomenclature is not always consistent. In addition, no corrections or additions to the published maps shown on **Figure 1** was performed, even if more detailed geotechnical field studies show the limits of the geologic units were different or landslides are known to exist. Geologic units shown on **Figure 1** outside the City limits are not included in our discussion. A discussion of the relationships between the units is presented in the Geologic Structure section of this report (Section 5.3). A generalized cross-sectional depiction of the geologic characteristics is presented on **Figure 4**.

5.2.2 Undocumented Fill (Unmapped)

In many areas of the City, fill soils presumed to be undocumented exist and have been mapped in certain site-specific geotechnical reports. An example of an undocumented fill deposit is located in an undeveloped area located north of the northern terminus of Strathmore Drive in the northwestern corner of the city. These types of deposits typically contain a wide range of soil types including silt, sand, clay, and rock derived from the local geologic formations.

Undocumented fills typically are poorly compacted and often are underlain by potentially compressible topsoil or alluvium. Consequently, where these deposits are located in areas of proposed development, 1they require special evaluation and recommendations. Normally, the undocumented fill materials are removed, moisturized as necessary and placed as compacted fill.

5.2.3 Previously Placed Fill (Unmapped)

The majority of the central and southern portions of the City have been developed. Some of the largest master developments include Black Horse Estates, Cajon Park, Carlton Country Club, Carlton Hills, Carlton Oaks, Castlerock, Dakota Ranch, Deer Park, Fanita Corona, Fanita Rancho, Fanita Terrace, Los Ranchos, Mission Creek, Mission Trials Vista, Mountain Meadow, Rancho Fanita, Riderwood – The Heights, Santana North, Shadow Hill Terrace, Silver Country Estates, Sycamore Hills, Town Center, Vista Monte, Sky Ranch, Woodglen, and Woodside Industrial Park. Developments will typically include infrastructure improvements associated with roadways, parks, underground utilities, pump stations that are provided for the City. Other previously placed fill within city limits is associated with Caltrans controlled roadways not under the purview of the City.

Previously placed fill generally consists of materials that were properly placed and compacted using the testing and observation services of a geotechnical engineering consultant. The fill materials placed during development of these projects generally consist of silty and clayey sand and sandy clay with gravel and cobble mixtures. Prior to grading or constructing additional improvements in previously graded areas, specific geotechnical evaluations and update reports should be performed to address the potential impacts to existing or proposed improvements underlain by these deposits. The existing fill materials should be tested to evaluate its suitability to support proposed structures and improvements.

5.2.4 Topsoil (Unmapped)

In undeveloped areas, naturally developed topsoil blankets the majority of the formational units and range in thickness from approximately 1 to 3 feet. The topsoil is generally characterized as brown to dark brown, silty/clayey, fine to medium sands and sandy clays. Topsoil that overlies the Stadium Conglomerate at higher elevations are generally thinner than overlying the Friars Formation and have a greater percentage of gravel and cobble clasts. Topsoil is typically considered compressible in its natural state and ordinarily require remedial grading in areas planned to receive structural fill and/or settlement sensitive structures. The clayey topsoil characteristically overlying sedimentary units has a “medium” to “high” expansion potential (expansion index of 51 to 130), and, when present, commonly require remedial grading to help mitigate their impacts prior to construction operations.

5.2.5 Colluvium (Qu - Undivided)

Colluvial soils are relatively deep natural deposits of soil that have accumulated on the face and base of natural slopes through the weathering and erosion of exposed materials at higher elevations that accumulate from soil-creep processes. Colluvial deposits are typically thicker in the gentle, low-lying, bottom of slope areas near alluvial drainages. The Geologic Map, **Figure 1**, indicates areas of undifferentiated Quaternary-age young alluvium and colluvium designated as map symbol Qu within the southern portion of the City. Other areas of unmapped colluvium are present near the base of natural sloping ground across the City. Typically, these materials are deepest in areas underlain by the Friars Formation; however, they are also present, but typically thinner, in areas underlain by Stadium Conglomerate and granitic rock. Colluvial materials can also be present on landslide deposits, particularly in graben zones near the head or upper portions of the slides. The thickness of the colluvium is typically about 5 to 10 feet and locally can be thicker. These deposits generally possess "medium" to "high" expansion potential (expansion index of 51 to 130), are poorly consolidated, and often require remedial grading in areas of planned development.

5.2.6 Alluvium (Qya and Qu - undivided) and Debris Flows

Holocene- to late Pleistocene-age young alluvium is typically present in drainage areas, such as the San Diego River channel, Sycamore Creek, and smaller natural tributary drainages. The San Diego River alluvium is relatively deep (locally up to 80 feet), and near the surface, typically consists of clean, medium-grained sands that have historically been mined as a source of concrete sand. Alluvial soils cover a relatively large portion of the City while debris flows have limited exposure. Alluvial soils generally consist of relatively loose/soft, silty/clayey sands and sandy clays with little gravel and cobble and will be saturated below groundwater. However, larger size and higher cobbles and boulder contents are typical within the San Diego River drainage due to higher flows.

Debris flows are present on upper portions of steeper gradient drainages within Stadium Conglomerate and Friars Formation created by weathering, slope creep and saturation of surface materials. Some of the known debris flows are indicated as symbol C2 on **Figure 2**, Geotechnical/Seismic Hazard Map. It appears that most of the mapped debris flow deposits are located at higher elevations and are generally located north of the San Diego River. The majority of these deposits consists of silty/clayey, sandy gravel and cobble deposits.

The alluvial and debris flow deposits are often poorly consolidated, compressible, and typically require remedial grading or special design considerations. Where development is planned in main drainage channels, such as the San Diego River floodplain, soil improvement techniques and structural reinforcement to remediate the effects of potential liquefaction may be necessary. Within secondary drainage areas, the compressible young alluvium is usually removed and replaced as properly compacted fill. Where groundwater exists within the upper approximately 50 feet, the young alluvium is typically considered to possess a potential for liquefaction and related geologic hazards.

5.2.7 Landslide Deposits (Qls)

Several confirmed landslides (Qls on **Figure 1** and D1 on **Figure 2**) and suspected ancient landslides (D2 on **Figure 2**) have been identified during this study and previous geotechnical investigations. The presence of inferred landslide deposits is based on topographic evaluation during field reconnaissance, interpretation of aerial photographs and topographic maps, and maps published by the California Geological Survey.

The landslides encountered within the City occur on gentle to moderate sloping ground within the Friars Formation and generally below an elevation of approximately 600 feet above MSL. On the southern portion of the City, landslides generally occur between elevations of 400 and 600 feet above MSL. Characteristic landslide morphology consists of a steep back-scarp; bulging, hummocky, distorted topography; and deflected drainages. Some landslide areas express a more subdued topography suggestive of incipient or older eroded landslide deposits.

The landslide deposits observed are characterized as deep-seated, relatively intact, block type movements or as shallow to deep-seated bedrock slides with a varying degree of slip plane development and slide mass disturbance. The thickness of landslide material is estimated to be approximately 45 to 50 feet; however, can thicken toward the head scarp perhaps as much as 100 feet. The landslide debris varies from dense sandstone/claystone blocks to a variable mixture of intensely sheared and pulverized claystone breccia suspended in a stiff clay matrix. Highly disturbed cobble clay mixtures resembling debris flow materials have also been encountered and are known to exist within graben zones.

The majority of the landslides appear to have occurred along inherently weak, previously sheared, low-angle, pre-existing bedding plane shears as part of a weak, thinly laminated claystone within the Friars Formation. This is suggested by the relatively uniform, near-horizontal slip surfaces typically observed along the base of the landslides, and because of the general correlation within exploratory borings at which bedding plane shears are present within the Friars Formation outside the limits of the landslides at the same elevation as the landslide basil shear zone. Further discussion of this correlation and an apparent regional zone of bedding plane shears within the Friars Formation are discussed in the Geologic Structure section of this report.

In general, new developments should be planned to avoid or mitigate ancient landslide deposits, where possible. Where landslide materials are present below proposed fill embankments, or exposed in cut slopes or building pad areas, remedial grading is often required to properly buttress the existing landslides or proposed slopes. Some landslides will require complete removal, while other landslides will only require partial removals of the loose and compressible portions to be replaced with new compacted fills. Localized areas of deeper removals may be required in looser graben zones and/or more pulverized portions of the landslides. Still other landslides will require only minor processing of the surficial materials prior to placing fill embankments. Slope stability analyses of landslide materials are typically included in geotechnical reports.

Cut slopes exposing landslide materials or basil slip planes, or areas where basal slip surfaces occur near finish grade, typically require stabilization by construction of stability fills, drained earthen buttresses, shear keys, shear pins or other means. A discussion of slope stability issues is presented in the Geologic Hazard section of this report.

5.2.8 Older Alluvium (Qoa)

Older alluvial flood-plain deposits of Pleistocene-age exist within former flood-plain areas and are exposed at the surface between the younger alluvial deposits and formational sedimentary or rock units. The older alluvium was deposited during previous geologic stream flow events with the soils typically consolidated by burial, cemented, and subsequently eroded to current valley floor elevations. These deposits are generally located within the flatter portions of the valleys and consist of slightly cemented, clayey sands with little gravel and cobble. These materials are generally dense to very dense and do not possess a potential for liquefaction or significant settlement.

5.2.9 Stadium Conglomerate (Tst) and Pomerado Conglomerate (Tp)

The Stadium Conglomerate (middle to late Eocene age) occurs throughout the southwestern, central, and northern parts of the City. The Pomerado Conglomerate has a limited extent and is located in the northern portion of the City. These geologic units have similar characteristics and are difficult to distinguish between each other unless separated by the Mission Valley Formation. However, the Mission Valley Formation is not present within the City limits, and therefore, the Pomerado Conglomerate conformably overlies the Stadium Conglomerate above an elevation of roughly 1,000 feet MSL. The Stadium Conglomerate conformably overlies the Friars Formation at elevations ranging from approximately 610 to 1,000 feet MSL. The inferred thickness of this deposit within the City varies from approximately 40 feet when eroded to an estimated 375 feet on less eroded ridgelines. Geomorphically, the Stadium Conglomerate forms characteristic resistant, dissected ridges within the upper elevations of the City. Localized, steeply eroded scars occur within this formation where debris flows originated at the head of tributary canyons.

The Stadium Conglomerate generally consists of dense to very dense, slightly cemented, sandy to clayey, gravel and cobble conglomerate with interbedded silty sandstone. The cobble content of the Stadium Conglomerate can sometimes be up to about 60 percent with diameters up to 24 inches. The Stadium Conglomerate is regionally part of the upper Eocene Poway Geologic Group that also includes the Mission Valley Formation and Pomerado Conglomerate.

Moderate to very heavy excavation effort should be anticipated during grading and trenching within the Stadium Conglomerate due to its cementation and high cobble size and percentage and randomly occurring highly cemented zones. Cut or fill slopes composed of the Stadium Conglomerate generally possess adequate slope stability characteristics.

5.2.10 Friars Formation (Tfr)

The Friars Formation was deposited on an irregular erosion surface formed on the crystalline basement rock of the Southern California Batholith. The Friars Formation may be observed overlying granitic rocks in the southern and north-central parts of the City. This unit generally occupies the gentler, lower portions of valley slopes below elevations ranging from 600 to 700 feet MSL depending on the locality. The age of the Friars Formation is considered to be middle to late Eocene-age based on vertebrate fossil evidence (Kennedy and Moore, 1971). In the southwestern portion of the City, this unit is exposed between Cuyamaca Street and the eastern base of Cowles Mountain and throughout the northern part of the City except the most northeasterly section.

Numerous large, ancient landslides occur within the Friars Formation. These are discussed in detail in the Geologic Hazards section of this study. The Friars Formation consists of relatively flat-lying lagoonal and alluvial claystone, sandstone, and conglomerate units. Specifically, weak, waxy claystone, and thinly laminated siltstone/claystone, sandstone, and conglomerate occur in the northern undeveloped portion of Santee below an approximate elevation of 610 to 630 feet MSL. Translational landslides are common throughout areas underlain by this geologic formation. Most of these landslides are remnants of wetter climatic conditions that occurred in late Pleistocene to early Holocene time (last 30,000 years).

As seen in the undeveloped area of Santee (see **Figure 4**), the Friars Formation comprises a relatively continuous sequence of characteristic subunits consisting of thinly bedded sandstone/siltstone, underlain by relatively thin lenses of gravel/cobble conglomerate, which are in turn underlain by massive sandstone. A generally weak, fractured, waxy claystone unit containing abundant bedding plane shear zones underlies this sequence. It is likely the inherently weak nature of this basal claystone unit in combination with the presence of pre-existing shear zones is the causation of landsliding and landslide-prone hillsides.

With the exception of the sandstone, and portions of the conglomeratic facies, soils derived from the Friars Formation typically possesses a “medium” to “high” expansion potential (expansion index of 51 to 130) and relatively low shear strength. Portions of the Friars Formation possess a “very high” expansion potential (expansion index of greater than 130) and require specialized grading and foundation recommendations. Where exposed in cut slopes, the claystone facies of the Friars Formation can be prone to surficial instability, and often requires stabilization measures. Bedrock creep zones and areas of deeply weathered material also exist in the Friars Formation. During development, where weak, waxy, or highly weathered portions of this unit are exposed in embankments and/or “toe key” areas of proposed fill slopes; deeper remedial grading is typically required to provide a competent surface to support embankments.

Bedding plane shears are relatively common within the Friars Formation and are significant in that they represent inherent planes of weakness within the formation. Bedding plane shears have recently also been called Bedding Parallel Shears by Hart, 2020 (see reference). As the term implies, these shear zones are typically parallel to the bedding and are characterized by thin seams of very soft, wet, remolded plastic clay. During development, where the shears are anticipated to "daylight" in cut slopes, stabilization measures such as drained stability fills, buttresses and/or shear pins are necessary.

5.2.11 Granitic Rock (Kgu, Kgh, Kgr, Kt) and Santiago Peak Volcanics (Ksp, Mzu)

Cretaceous-age granitic rocks have a wide variety of compositions based on the percentage of quartz, plagioclase and mafic mineralogy. Granitic rock also has a wide range of weathering and can vary from highly weathered decomposed granitic soils to hard fresh rock. Granitic rock can be classified as quartz-diorite, tonalite and granodiorite with their finer-grained equivalents occurring in some areas. The granitic rocks that are deeply weathered can form extensive deposits of residuum or decomposed granitic rock that are locally mined for DG soils. The less weathered, more resistant rock has been utilized in the past as quarry stone and can be observed as large, rounded boulders on the hills east of Gillespie Field, near Carlton Oaks Golf Course, on Cowles Mountain and the eastern part of the City. These hard rock units would require blasting prior to excavation and would require specialized grading techniques.

Santiago Peak Volcanic rock also called Mesozoic Metavolcanic rock from the lower Cretaceous and upper Jurassic Geologic Period is exposed in limited areas on the southwest corner and east portion of the City.

5.3 Geologic Structure

Bedding within the Eocene-age sediments is nearly horizontal or gently dipping. In general, strata within the Friars Formation and Stadium Conglomerate units dip very gently at inclinations of less than 5 degrees to the west and southwest. On the northern, undeveloped portion of the City, the Friars Formation/Stadium Conglomerate contact dips generally south-southwest, and varies in elevation from approximately 610 to 630 MSL. Locally, bedding dip directions may vary, or even reverse, depending on configuration of ancient buried topography or other geologic structures. High-angle depositional contacts are also common locally between the sedimentary formations and underlying granitic rocks.

A high percentage of bedding plane shears and weak claystone materials were found to occur within this relatively narrow elevation range. A similar, less prominent grouping of shear zones was observed at other elevations within the Friars Formation. The elevations at which bedding plane shears occur in bedrock material, and the elevation of basal slip surfaces in landslide areas are generally similar. This correlation has been observed on other projects in San Diego County where the Friars Formation is present.

Regionally, the marine terraces within coastal plain westerly of the Peninsular Ranges is underlain by flat-lying sediments with a few notable exceptions occurring near the coast. In the City of San Diego to the west of Santee, the terraces are broken in many areas by Tertiary and Pleistocene-age active and potentially active faults. In Santee, however, there are no known active or potentially active faults (movement within the last 1.8 million years) which cut Pleistocene-aged materials nor are there any known major faults which cut Eocene or Cretaceous-age rocks.

Bedding plane shears or more recently called bedding parallel shears (a term applied to minor shears within parallel bedding surfaces) are common in the Friars Formation and are believed to be a significant factor in landsliding processes, both in the geologic past, and at present. These features do not represent a seismic hazard; however, they are a significant geotechnical consideration in the analysis of slope and landslide stability.

6. GEOLOGIC HAZARDS

This section presents a discussion of the potential geologic hazards anticipated in the study area. Included is a discussion of landslides and potential slope instability as a result of reactivated ancient landslides, bedding plane shears, and weak claystone beds of the Friars Formation. A general description of the mechanism of landsliding and the locations of ancient landslides are also presented. Additional or lesser hazards within the area such as mud flows or debris flows, colluvial soils, and others are discussed. A discussion of groundwater and seepage related problems is also presented.

6.1 Ancient Landslides/Slope Stability

A landslide is defined as a mass movement of earth occurring below the limits of the soil mantle caused by shear failure along one or several surfaces. Ancient landslides have been dated by radiocarbon methods as being 8 to 30 thousand years old in the southern California area by Stout (1969) and others. They are believed to have occurred primarily as a response of weak claystones exposed to intense rainfall causing high water table conditions in slopes during late Pleistocene and early Holocene time.

Landslides occur throughout the area underlain by the Friars Formation. The approximate locations of known or suspected landslides are shown on the Geologic Map and the Geotechnical/Seismic Hazard Map, **Figures 1 and 2**, respectively. The largest of the ancient landslides are typically 1,000 to 1,500 feet in width and length (as in Carlton Hills and Fletcher Hills) and extend to depths of 20 to 100 feet below the ground surface. Landslide complexes or clusters of more than one individual slide component are common in the Fanita Ranch and Fletcher Hills regions. **Figure 4** presents a characteristic geologic section of the Santee area typically prone to landsliding.

The reactivation of ancient landslides and the creation of new landslides have been most commonly caused by grading activities, a rise in groundwater level in a slide area, or areas containing bedding plane shears, or by seismic activity. Identification of slide prone areas through detailed geotechnical studies is of primary importance in predicting future slope failure and landslides. The most common method of stabilizing landslides and landslide prone areas is through remedial grading or buttressing and installation of subdrains and drainage panels to reduce the potential for buildup of excessive hydrostatic pressures. Other development options may include structural setbacks or stabilizing shear pins.

The landslide areas within the City can usually be mitigated using generally accepted remedial grading techniques and buttresses. These techniques may consist of partial or complete removal and compaction of the deposits, or stabilizing them with earthen buttresses, shear keys, stability fills or other means such as shear pins or retaining structures. Similar remedial grading procedures could be required where landslides are not present but where weak claystone beds, bedding plane shears, or thick surficial soil deposits are encountered. Such areas should be generally limited to where the Friars Formation will be exposed in cut slopes.

Reactivation of ancient landslides have been responsible for either partial or complete loss of 20 to 30 homes in the Santee area. Geotechnical firms that possess experience in landslide evaluation and stabilization should evaluate the potential for additional loss in areas already developed when building additions are proposed.

6.2 Debris Flow Deposits

A debris flow is a rapid downslope movement of saturated soil and near surface rock debris. Numerous debris flows or mudflows have occurred within the Stadium Conglomerate. The locations of some of the larger flows identified are shown on **Figure 2**.

The debris flows or mudflows are initiated near the crests of very steep ridges underlain by Stadium Conglomerate and probably occur as a result of high intensity rainfall. As the near surface soils become saturated and pore water pressure increases, the soils lose strength and fail relatively rapidly to form a river of mud and rock with considerable destructive power. These deposits consist of the accumulation of topsoil, colluvium and debris derived from formational “parent material” near the base of moderate to steep slopes caused by rapid flow of saturated near-surface soils.

The physical appearance of these features indicates that they are relatively young compared to the ancient landslides. Most appear to be only a few hundred years old or less and are easily eroded. While the causes of debris flows are generally well understood, specific details concerning these events make them difficult to predict. Several well-formed debris flows can be observed on the north side of Highway 52 west of the City. High rainfall, loss of vegetation cover through fire or other causes, and the steepness of the slope appear to be the main causative factors.

The primary difference, in terms of the potential for activation, between ancient landslides and debris flows is that, by definition, debris flows do not possess a basal slip surface. Thus, they are much less likely than ancient landslides to become reactivated by grading. In areas of proposed development, mitigation of debris flow deposits is typically similar to that for alluvium and colluvium, and the presence of these materials are not likely to significantly affect development unless directed toward the boundary of the site.

6.3 Groundwater and Seepage

Groundwater and seepage conditions are significant factors in assessing engineering and geologic hazards. Groundwater is typically found in the deep alluvial drainage areas (such as the San Diego River and Sycamore Creek) but may also be found in shallower drainages as a result of storm water infiltration (such as the Santee Lakes area). Because of fluctuating water levels in a given area, as a result of seasonal variations in surface water runoff, the prediction of groundwater occurrence is difficult.

Seepage is typically the result of a groundwater table or perched water, either seasonal or permanent, being exposed. However, some man-made seepage conditions can develop in rural areas downslope of septic systems. Seepage conditions in slopes, either graded or natural, are usually the result of water flowing at the contact between materials of widely different permeabilities with the water perched on an underlying, less permeable layer. When the water flow encounters a slope face, it is manifested as seepage.

In addition to the nuisance caused by minor seepage from new slopes in residential areas, groundwater and seepage caused by excess irrigation are a major contributing factor to landsliding in San Diego County, especially in the reactivation of old landslides. As pore pressures rise along an old slip surface as a result of rainfall or heavy landscape irrigation, the factor of safety against sliding will decrease.

The potential for groundwater and seepage conditions should be addressed in geotechnical reports submitted to the City for new developments and improvements. Procedures for mitigation for the water related problems, such as canyon subdrains and proper grading procedures, should also be addressed. Groundwater conditions typically increase as a result of development primarily due to increased irrigation. Groundwater related problems may develop in areas where no problem was previously evident.

Perched groundwater or seepage has been encountered during previous investigations in the City of Santee within alluvial drainages, hillside areas and landslide zones. The groundwater/seepage in drainage courses is presumed to be associated with surface runoff of rainwater along the natural watershed. Subdrain systems are often necessary in areas of proposed development to intercept and convey seepage migrating along impervious strata. In particular the main drainages, stability/buttress fill areas, and possibly where impervious layers daylight near the ultimate graded surface, typically require subdrains. Specific subdrain locations and design details should be provided with the detailed grading plans for the site. Seepage conditions also occur in bedrock materials, and at the base of landslide areas perched on relatively impervious strata within the Friars Formation and ancient landslide deposits. Additionally, relatively minor natural surface seeps were observed in the northern portion of the city at the Friars Formation/Stadium Conglomerate contact. The existing perched groundwater levels in alluvial areas can be expected to fluctuate seasonally and may affect remedial grading.

7. SEISMIC HAZARDS

This section presents a discussion of the seismic hazards anticipated to affect the City of Santee. Seismic hazards are caused by earthquake-induced ground shaking, specifically, liquefaction potential and seismically-induced settlement and landsliding. A discussion of local and regional faulting and its impact on the City of Santee is also presented. Although not strictly a seismically related hazard, a brief discussion of flooding as a result of dam failure is also included in this section.

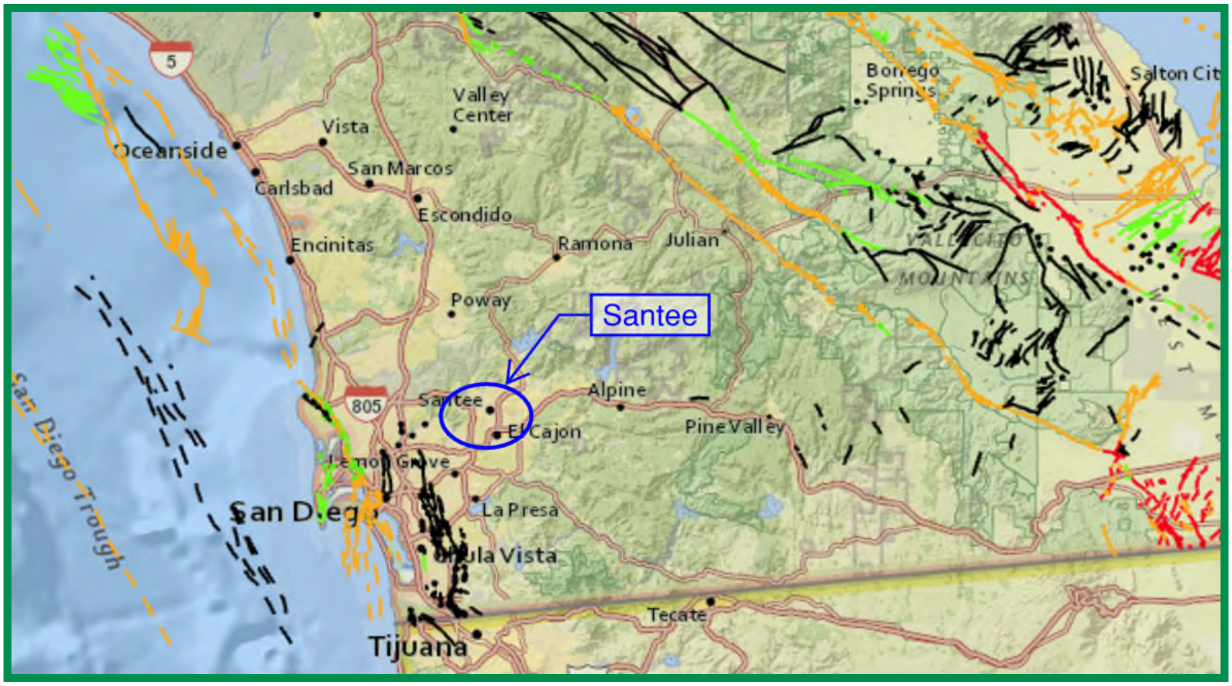
7.1 Local and Regional Faulting and Associated Ground Shaking

Seismic hazards pertain to threats to life and property caused by earthquake-induced ground shaking. Based on current maps prepared by the State of California and local geology maps, active or potentially active faults are not known to occur within or adjacent to the City of Santee. However, the City is similar to all other areas in California in that it is subject to periodic seismic shaking due to earthquakes along remote or regional active faults.

A review of geologic literature indicates that there are no known active or potentially active faults crossing the city. An active fault is defined by the California Geological Survey (CGS) as a fault showing evidence for activity within the last 11,700 years. The Rose Canyon/Newport Inglewood Fault Zone, located approximately 10 miles west of the City of Santee, is the closest known active fault. The CGS has included portions of this Fault Zone within the State of California (Alquist-Priolo) Earthquake Fault Zone. Currently, restrictions on development due to faulting (i.e., fault setback zones) related to the State of California requirements are not present in the City of Santee.

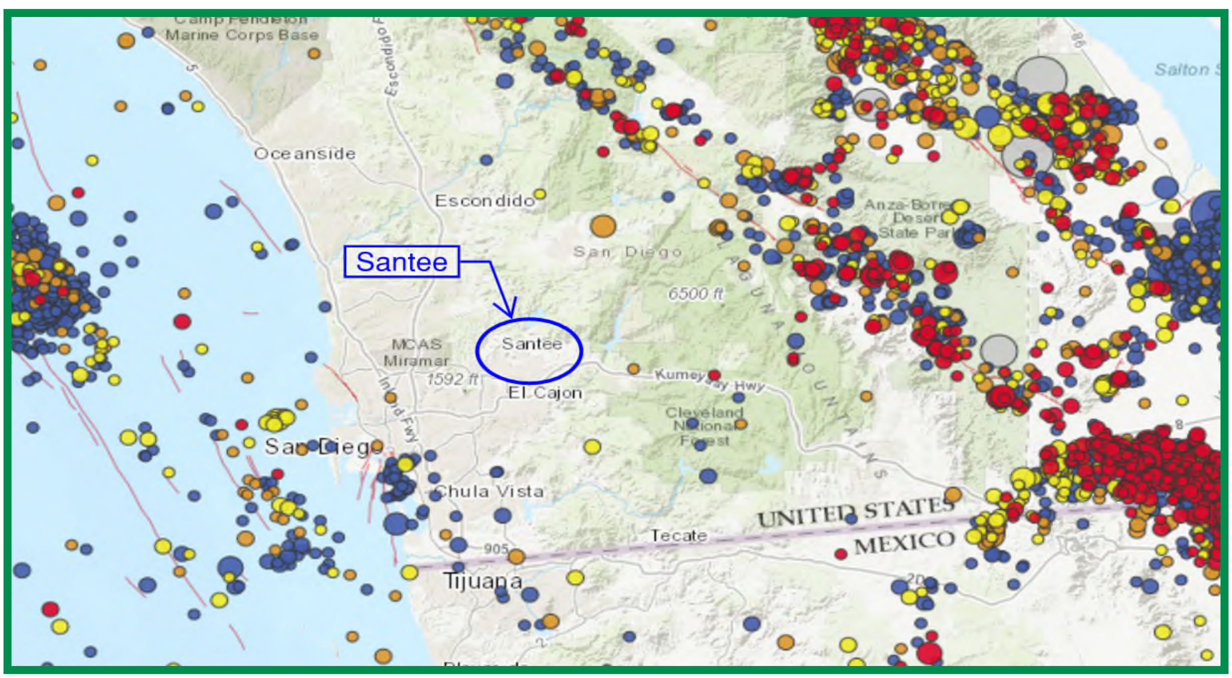
Considerations important in seismic design include the frequency and duration of motion and the soil conditions underlying the site. Seismic design of structures should be evaluated in accordance with the most recent applicable California Building Code (CBC) guidelines currently adopted by the local agency.

The USGS has developed a program to evaluate the approximate location of faulting in the area of properties. The following figure shows the location of the existing faulting in the San Diego County and Southern California region. The fault traces are shown as solid, dashed and dotted that represent well-constrained, moderately constrained and inferred, respectively. The fault line colors represent faults with ages less than 150 years (red), 15,000 years (orange), 130,000 years (green), 750,000 years (blue) and 1.6 million years (black).



Faults in Southern California

The County of San Diego and Southern California region is seismically active. The following figure presents the occurrence of earthquakes with a magnitude greater than 2.5 from the period of 1900 through 2015 according to the Bay Area Earthquake Alliance website. The occurrence of earthquakes are generally aligned along active faults.



Earthquakes in Southern California

The 2020 Earthquake Engineering Research Institute's (EERI) publication (see references) includes earthquake planning scenario maps. These maps include seismic intensity distributions, location of schools, fire stations, government and healthcare facilities, and impact scenario maps to water and wastewater systems, electrical power systems, transportation systems, fuel transportation systems, and federal infrastructure that are located within the City of Santee and San Diego County in general.

7.1.1 Seismic Design Criteria

The California Building Code (CBC) establishes the seismic design criteria for site-specific analysis. At the time of this report, the 2019 CBC (based on the 2018 International Building Code [IBC] and ASCE 7-16), Chapter 16 Structural Design, Section 1613 Earthquake Loads is the latest adopted standard.

Proposed developments and improvements should be designed using the applicable design procedures outlined in the current versions of the CBC and ASCE 7 documents (or other applicable design guidelines). The following tables include the estimated peak ground accelerations in accordance with the 2019 CBC seismic design criteria. Four locations are selected within the City of Santee to evaluate the general estimated ground accelerations as shown in Table 7.1.1.

TABLE 7.1.1
SELECTED SITES WITHIN THE CITY OF SANTEE FOR GROUND ACCELERATION ESTIMATES

Site	Directional Area of the City	Closest Street Locations	Site Latitude (Degrees)	Site Longitude (Degrees)
1	NW	Cadwell Road & Lasso Way	32.869663	-116.993656
2	NE	Oak Creek Drive & Ohana Way	32.896980	-116.957457
3	SW	Willowgrove Avenue & Willowgrove Court	32.842774	-116.994441
4	SE	Magnolia Avenue & Cottonwood Avenue	32.847362	-116.970412

The computer program U.S. Seismic Design Maps, provided by the Structural Engineers Association (SEA) was used to estimate the ground accelerations assuming a risk category of II. The Site Classes evaluated are based on the discussion in Section 1613.2.2 of the 2019 California Building Code (CBC), Table 20.3-1 of ASCE 7-16, and on the varying geologic units across the City of Santee. Table 7.1.2 presents the site class designations.

TABLE 7.1.2
SITE CLASSIFICATION

Site Class	Soil Type	Shear Wave Velocity, v_S (Feet/Second)	Blow Counts (N Values)	Undrained Shear Strength, S_U (psf)
A	Hard Rock	5,000+	NA	NA
B	Rock	2,500 to 5,000	NA	NA
C	Very Dense Soil and Soft Rock	1,200 to 2,500	50+	2,000+
D	Stiff Soil	600 to 1,200	15 to 50	1,000 to 2,000
E	Soft Clay Soil	Less Than 600	Less Than 15	Less Than 1,000
	Plasticity Index 20+ / Moisture Content 40%+ / SU<500			
F	Liquefiable Soil	Site Response Analysis Required		

Table 7.1.3 presents the estimated Mapped MCE_G Peak Ground Acceleration (PGA in accordance with ASCE 7-16, Figure 22-7), Site Coefficient, (F_{PGA} in accordance with ASCE 7-16, Table 11.8-1) and the Site Class Modified MCE_G Peak Ground Acceleration (PGA_M in accordance with ASCE 7-16, Section 11.8.3 – Eqn 11.8-1).

TABLE 7.1.3
ESTIMATED PEAK GROUND ACCELERATIONS

Site	Mapped MCE_G Peak Ground Acceleration (PGA)	Site Class	Site Coefficient (FPGA)	Site Class Modified MCE_G Peak Ground Acceleration (PGA_M)
1	0.332g	A	0.8	0.265g
		B	0.9	0.299g
		C	1.2	0.399g
		D	1.268	0.421g
2	0.335g	A	0.8	0.268g
		B	0.9	0.301g
		C	1.2	0.402g
		D	1.265	0.423g
3	0.331g	C	1.2	0.398g
		D	1.269	0.42g
		E	1.537	0.51g
4	0.329g	C	1.2	0.395g
		D	1.271	0.418g
		E	1.542	0.507g

The estimated PGA_M across the city of Santee ranges from 0.265g to 0.51g as listed in Table 7.1.3. Table A-4 (Appendix A) lists the Modified Mercalli Intensity (Damage) Scale. This scale. composes of increasing levels of intensity with corresponding expected levels of damage based on the Peak Ground Acceleration (PGA) and the surrounding built environment. Based on Table A-4, that range categorizes the city to expect an intensity value *VII: Damage slight in specially designed structures, considerable in ordinary substantial buildings, with partial collapse, great in poorly built structures; panel walls thrown out of frame structures; fall of chimneys, factory stacks, columns, monuments, walls; heavy furniture overturned; sand and mud ejected in small amounts; changes in well water; persons driving motor cars disturbed.*

7.2 Soil Liquefaction

Liquefaction typically occurs when a site is located in a zone with seismic activity, onsite soils are cohesionless or silt/clay with low plasticity, groundwater is encountered within 50 feet of the surface and soil densities are less than about 70 percent of the maximum dry densities. If the four previous criteria are met, a seismic event could result in a rapid pore water pressure increase from the earthquake-generated ground accelerations.

Within the City of Santee, the soil deposits that may be susceptible to liquefaction are the young alluvial soils found in the San Diego River and its deeper tributary channels such as Sycamore Creek. The general extent of the liquefaction-susceptible materials is shown on Geotechnical/Seismic Hazard Map, **Figure 2**. Although the major deposits of alluvial soils have been shown on **Figure 2** as being susceptible to liquefaction, some areas may have a water table sufficiently deep or may have particular soil conditions that result in a very low potential for liquefaction based on the anticipated maximum intensity of shaking for the area. In general, for deposits with a water table below a depth of 50 feet, a seismic event would have to be especially strong for liquefaction to occur and, therefore, these deposits will have a low potential for liquefaction as a result of the maximum events anticipated. The evaluation of liquefaction should be performed on a project specific basis by the geotechnical engineer of record.

Liquefaction-related distress could range from small, localized areas, wherein specially designed structures may experience damage; to liquefaction covering a large area, resulting in lateral movement of the near-surface deposits and subsequent heavy damage to any affected structures. The potential risk to a structure should be evaluated whenever development is proposed in a liquefaction susceptible area. Liquefaction studies should conform to the recommendations of the 2008 CGS Special Publication 117A titled *Guidelines for Evaluating and Mitigating Seismic Hazards in California* or other approved publications.

Sand boils occur where liquefiable soil is extruded upward through the soil deposit to the ground surface. Providing an increase in overburden pressure and a compacted fill mat can mitigate surface manifestation. Proposed projects that possess a potential for liquefaction should also include an evaluation of the likelihood of sand boils.

Lateral spreading occurs when liquefiable soil is in the immediate vicinity of a free face such as a slope. Factors controlling lateral displacement include earthquake magnitude, distance from the earthquake epicenter, thickness of liquefiable soil layer, grain size characteristics, fines content of the soil and SPT blow counts. Lateral spreading should be evaluated on projects where liquefaction potential exists.

The mitigation of potential hazards due to liquefaction can be accomplished by the densification or removal of the potentially liquefiable soil or the use of foundation systems that still provide acceptable structural support should liquefaction occur. Soil densification can be accomplished by compaction grouting, vibrocompaction, soil mixing, and deep dynamic compaction (among others). Soil densification is generally used to increase the density and provide liquefaction mitigation of sensitive soil to relatively shallow depths over large areas. Deep foundation systems may be used to transmit structural loads to bearing depths below the liquefiable zones and may consist of driven piles or drilled piles. Deep foundations are designed to mitigate damage to the structures supported on the piles; however, they do not generally reduce the potential for damage to underground utilities and peripheral site improvements. The effects of differential settlement between rigid structures and attached settlement-sensitive surface improvements can be mitigated by designing the utilities to accommodate differential movement at the connections.

7.3 Seismically-Induced Settlement

Settlement due to seismic shaking can occur on sites if liquefaction potential exists or not (e.g. loose sands). As with the susceptibility to liquefaction, the soils most susceptible to seismically-induced settlement within the Santee area are the loose alluvial soils of the San Diego River and its tributaries. The limits of these soils are indicated on **Figure 2** as soils susceptible to liquefaction. Site-specific studies should be performed in these areas to evaluate the settlement potential during anticipated maximum seismic events.

7.4 Seismically-Induced Landslides and Rock Falls

Seismically induced landslides and rock falls are common in areas of high seismicity near the earthquake source. Over 11,000 such landslides occurred during the 1994 Northridge earthquake and mostly occurred in the mountains surrounding the Santa Clara River Valley. Seismically-induced landslide and rock fall studies should be performed in accordance with current and applicable design standards (e.g. CGS, 2008).

7.5 Tsunamis and Seiches

A tsunami is a series of long period waves generated in the ocean by a sudden displacement of large volumes of water. Causes of tsunamis include underwater earthquakes, volcanic eruptions, or offshore slope failures. Wave heights and run-up elevations from tsunamis along the San Diego Coast have historically fallen within the normal range of the tides. The City of Santee is not included within a high-risk tsunami hazard area due to the elevation and distance from the Pacific Ocean.

A seiche is a run-up of water within a lake or embayment triggered by fault- or landslide-induced ground displacement. Seiches may be a hazard when located adjacent to the bodies of water within the City of Santee limits. Site-specific evaluations and discussions would be required for proposed site developments located adjacent to the inland bodies of water.

7.6 Inundation Due to Dam Failure

The central portion of the City of Santee is located in the San Diego River Valley downstream of three major dams in San Diego County. These include the San Vicente Dam, the El Capitan Dam, and the Chet Harritt Dam (Lake Jennings Reservoir). The Earthquake Engineering Research Institute (EERI) San Diego Chapter's publication *San Diego Earthquake Planning Scenario, Magnitude 6.9 on the Rose Canyon Fault Zone* expects these dams to remain in service due to recent seismic retrofit and their distance from any major active faults. A seismic stability analysis, reviewed by the California Department of Water Resources, Division of Safety of Dams (DSOD), establishes the operating requirements to properly and safely operate the dam. The DSOD and the County of San Diego classify these dams as possessing an "extremely high" downstream hazard and "high" hazard rating, respectively.

The San Vicente Dam is a concrete gravity structure located approximately 3½ miles northeast of the City. The dam was originally constructed in 1943 with a capacity of 90,200 acre-feet and then raised an additional 117 vertical feet in 2016 using roller-compacted concrete, expanding its capacity to 245,000 acre-feet.

The El Capitan Dam is a hydraulically-filled earth structure located approximately 9 miles east of Santee. It has a capacity of 112,800 acre-feet and was built in 1934.

The Chet Harritt Dam (Lake Jennings) is an earth-filled dam located approximately 3 miles east of Santee. Lake Jennings, which is retained by the dam, has approximately 9,790 acre-feet of capacity. The dam was built in 1962 and was constructed by procedures to resist seismic damage.

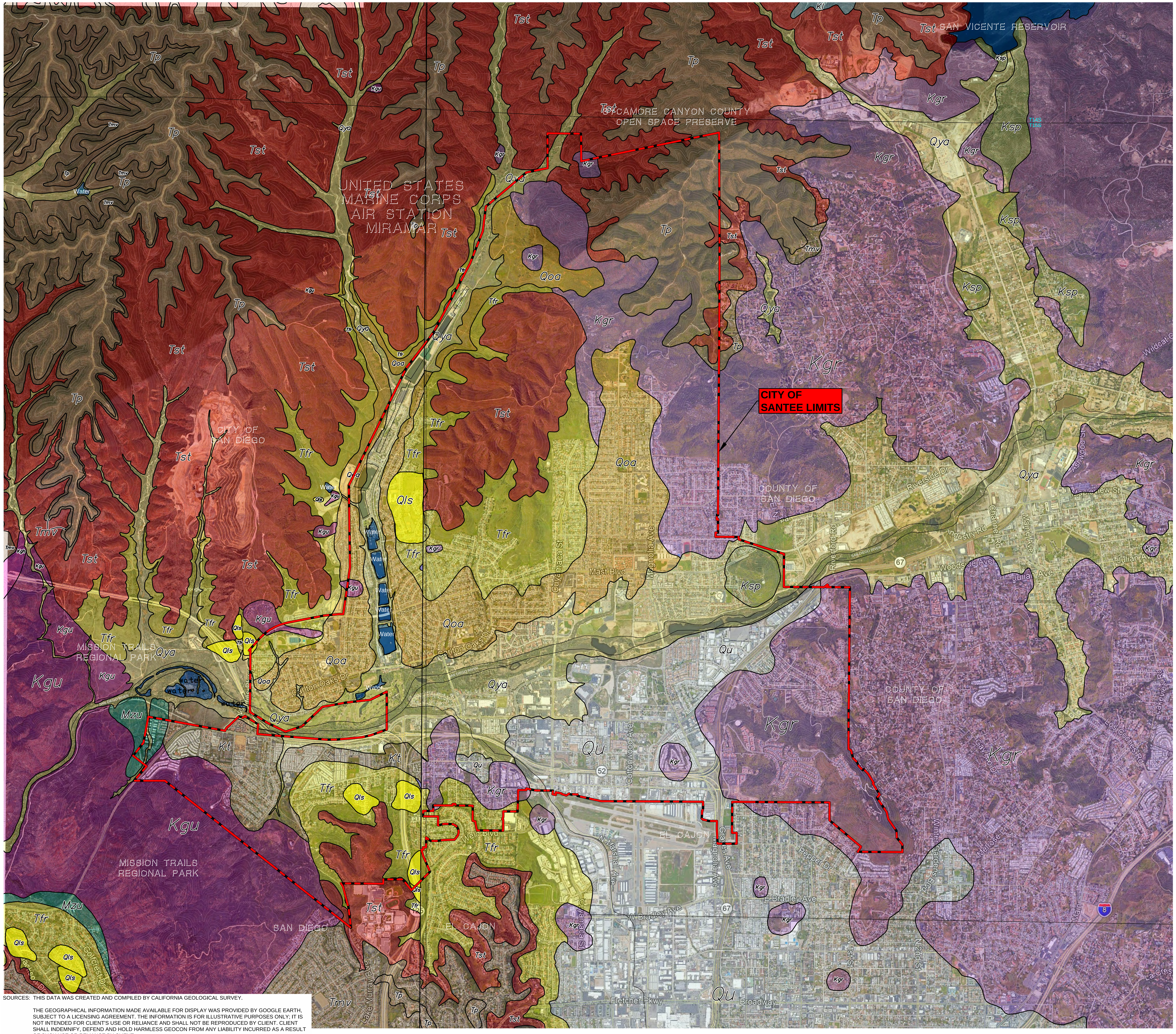
Studies of the potential for, or the consequences of dam failure are beyond the scope of this study. Information regarding dam failure risk can be found in the County of San Diego's "Multi-Jurisdictional Hazard Mitigation Plan" dated Maps prepared by the DSOD showing areas of inundation in the event of dam failure can be found online. The inundation limits for each of the three dams located upstream of the City of Santee have been reproduced on the Dam Inundation Map included herein (See **Figure 3**). The inundation map for the Chet Harritt (Lake Jennings) Dam was generated on October 19, 2018; the El Capitan Dam map was generated on March 15, 2019; and the San Vicente map was generated on May 13, 2020. Information concerning the safety of these dams, which is reviewed annually by the DSOD may be obtained from that department. In addition, Annex Q of the County of San Diego's Office of Emergency Services' "Operational Area Emergency Operations Plan" outlines the evacuation procedures in the event of a dam failure.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. The findings of this report pertain only to the City of Santee area and are based on the assumption that the soil conditions do not deviate from those disclosed herein. If any variations or undesirable conditions are encountered during future studies, we should be notified so that supplemental discussion can be provided, as necessary. The evaluation or identification of the potential presence of hazardous or corrosive materials was not part of the scope of services provided by Geocon Incorporated.

2. This report is issued with the understanding that it is the responsibility of the owner or his representative to ensure that the information contained herein are brought to the attention of the architect and engineer for the project and incorporated into the plans. The property owners and developers should evaluate their projects on a site-specific basis. This report should not be relied upon for design recommendations for proposed developments. This report should be considered a general guideline

3. The findings of this report are valid as of the present date. However, changes in the conditions of an area can occur with the passage of time, whether they be due to natural processes or the works of man on this or adjacent properties. In addition, changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and should not be relied upon after a period of 10 years.



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0' 1,500' 3,000' 4,500' 6,000'

SCALE 1"=1,500' (On 42x30)

LEGEND

Qls	LANDSLIDE DEPOSITS
Qya	YOUNG ALLUVIAL FLOOD-PLAIN DEPOSITS
Qu	ALLUVIAM AND COLLUVIUM, UNDIVIDED
Qoa	OLD ALLUVIAL FLOOD-PLAIN DEPOSITS, UNDIVIDED
Tp	POMERADO CONGLOMERATE
Tmv	MISSION VALLEY FORMATION
Tst	STADIUM CONGLOMERATE
Tfr	FRIARS FORMATION
Kl	LUSARDI FORMATION
Kgu	GRANODIORITE AND TONALITE, UNDIVIDED
Kgh	HYPABYSSAL ROCKS, UNDIVIDED
Kgr	GRANITOID ROCKS
Kt	TONALITE, UNDIVIDED
Ksp	SANTIAGO PEAK VOLCANICS
Mzu	METAMORPHOSED AND UNMETAMORPHOSED VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED
(line)	GEOLOGIC CONTACT

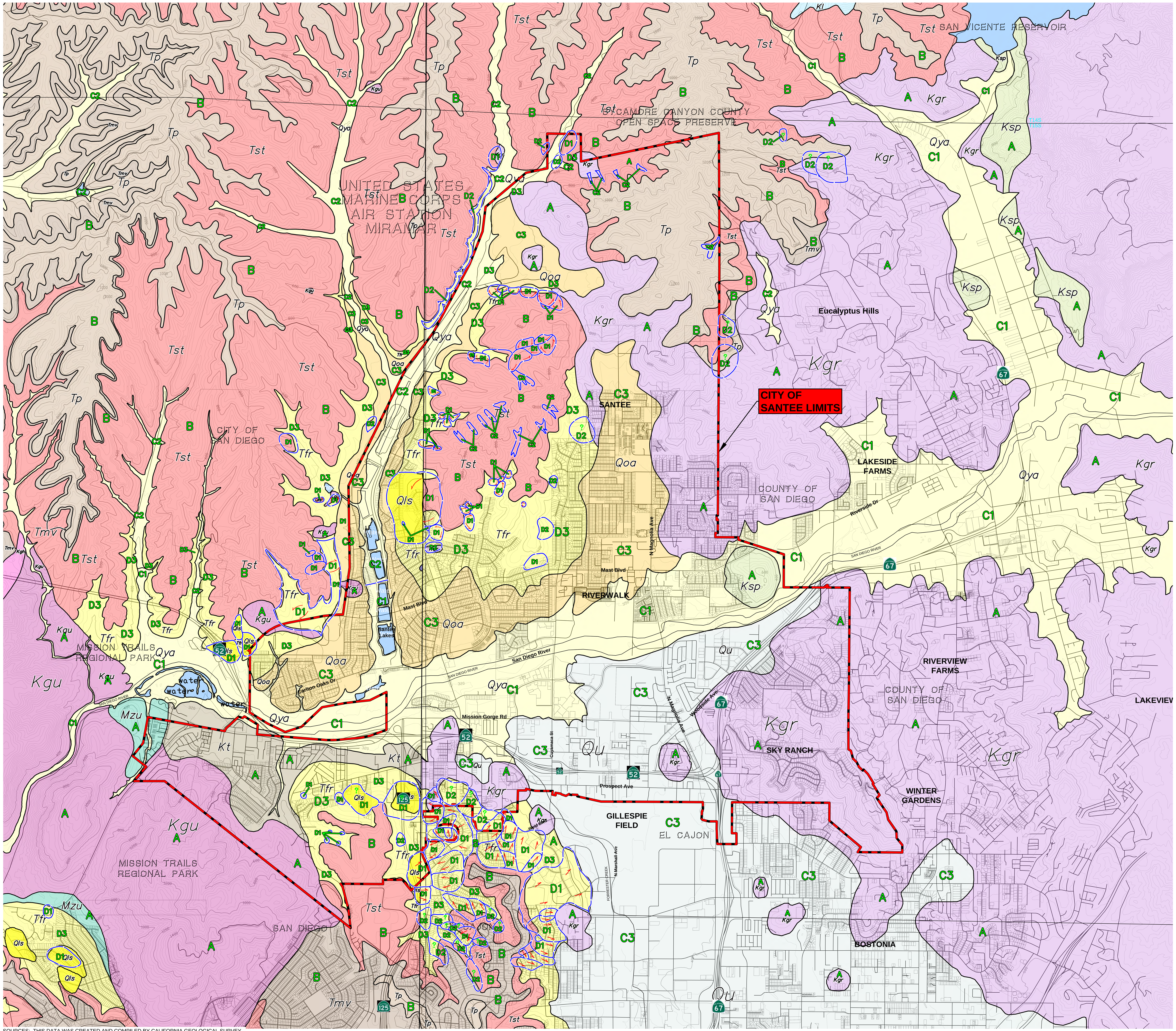
GEOLOGIC MAP

CITY OF SANTEE SEISMIC SAFETY STUDY
SANTEE, CALIFORNIA

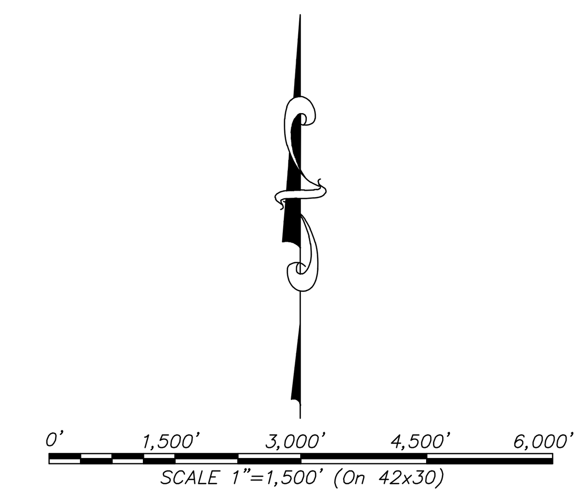
GEOCON INCORPORATED
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS
6960 FLANDERS DRIVE - SAN DIEGO, CALIFORNIA 92121 - 2974
PHONE 858 558-6900 - FAX 858 558-6159

SCALE 1" = 1,500'	DATE 03 - 29 - 2021	FIGURE 1
PROJECT NO. G2647 - 52 - 01		
SHEET 1 OF 1		

Plotted:03/29/2021 1:41PM | By:RUBEN AGUILAR | File Location:Y:\PROJECTS\G2647-52-01 Santee Seismic Safety Study\SHEETS\G2647-52-01 SanteeSeismicSafetyStudy-GeologicMap.dwg



SOURCES: THIS DATA WAS CREATED AND COMPILED BY CALIFORNIA GEOLOGICAL SURVEY.



LEGEND

- Qls ....LANDSLIDE DEPOSITS
- Qya ....YOUNG ALLUVIAL FLOOD-PLAIN DEPOSITS
- Qu ....ALLUVIAM AND COLLUVIUM, UNDIVIDED
- Qoa ....OLD ALLUVIAL FLOOD-PLAIN DEPOSITS, UNDIVIDED
- Tp ....POMERADO CONGLOMERATE
- Tmv ....MISSION VALLEY FORMATION
- Tst ....STADIUM CONGLOMERATE
- Tfr ....FRIARS FORMATION
- Kl ....LUSARDI FORMATION
- Kgu ........GRANODIORITE AND TONALITE, UNDIVIDED
- Kgh ....HYPABYSSAL ROCKS, UNDIVIDED
- Kgr ....GRANITOID ROCKS
- Kt ....TONALITE, UNDIVIDED
- Ksp ....SANTIAGO PEAK VOLCANICS
- Mzu ........METAMORPHOSED AND UNMETAMORPHOSED VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED
- ....APPROX. LOCATION OF GEOLOGIC CONTACT
- ....APPROX. LOCATION OF GEOLOGIC CONTACT-LANDSLIDES/ DEBRIS FLOW (C2, D1, D2)
- ....APPROX. DIRECTION OF LANDSLIDE MOVEMENT
- ? ....POSSIBLE LANDSLIDE

GEOTECHNICAL/SEISMIC HAZARD MAP LEGEND

Legend	Soil Type	Location	Relative Landslide Susceptibility	Liquefaction Hazard	Expansion Condition
A	Granitic Rock	Hard Rock Outcrops and Decomposed Granitics, Northern Slopes (Fanita Ranch), Central Area (Ramsgate Way), Southwestern Area (Rancho Fanita Drive, Cowles Mountain)	Least Susceptible	Nominal	Very Low
B	Stadium Conglomerate	Northwestern and Northern Slopes (Fanita Ranch), Southern Undeveloped Area	Marginally Susceptible (Generally Susceptible to Debris Flow)	Nominal	Low
C1	Alluvium	Main Drainage Channels, Possible Shallow Groundwater, San Diego River	Marginally Susceptible	Moderate to High	Variable
C2	Alluvium/Debris Flow on steep slope	Secondary Drainage and Tributary Channels, Fluctuating Groundwater	Variable	Nominal to Low	Moderate
C3	Terrace Deposits/ Older Alluvium	Gentle Slopes Western Area, Flanks of the San Diego River (Carlton Oaks Drive), Central Area (Woodpark Drive)	Generally to Marginally Susceptible (Where underlain by Friars Formation)	Low to Moderate	Variable
D1	Landslides Confirmed	Sloping Southern Area (Route 125 and Fanita Drive), Fanita Ranch, Carlton Hills, Castlerock	Most Susceptible	Nominal	Moderate to High
D2	Landslides Possible	Various Areas Throughout Friars Formation	Most Susceptible	Nominal	Moderate to High
D3	Friars Formation	Northern Slopes (Cuyamaca Street, Lake Canyon Road, Fanita Ranch) and Southern Slopes (Mesa Heights Road, Route 125)	Most Susceptible	Nominal	Moderate to High
--	Unmapped Surficial Deposits: Undocumented Fill, Topsoil, Colluvium	Undeveloped Areas	Variable	Variable	Variable
--	Unmapped Surficial Deposits: Previously Placed Fill	Developed Areas	Variable	Variable	Variable

GEOTECHNICAL/SEISMIC HAZARD MAP
CITY OF SANTEE SEISMIC SAFETY STUDY
SANTEE, CALIFORNIA

GEOCON INCORPORATED
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS
6960 FLANDERS DRIVE - SAN DIEGO, CALIFORNIA 92121 - 2974
PHONE 858 558-6900 - FAX 858 558-6159

SCALE 1" = 1,500' | DATE 03 - 29 - 2021
PROJECT NO. G2647 - 52 - 01 | FIGURE 2
SHEET 1 OF 1

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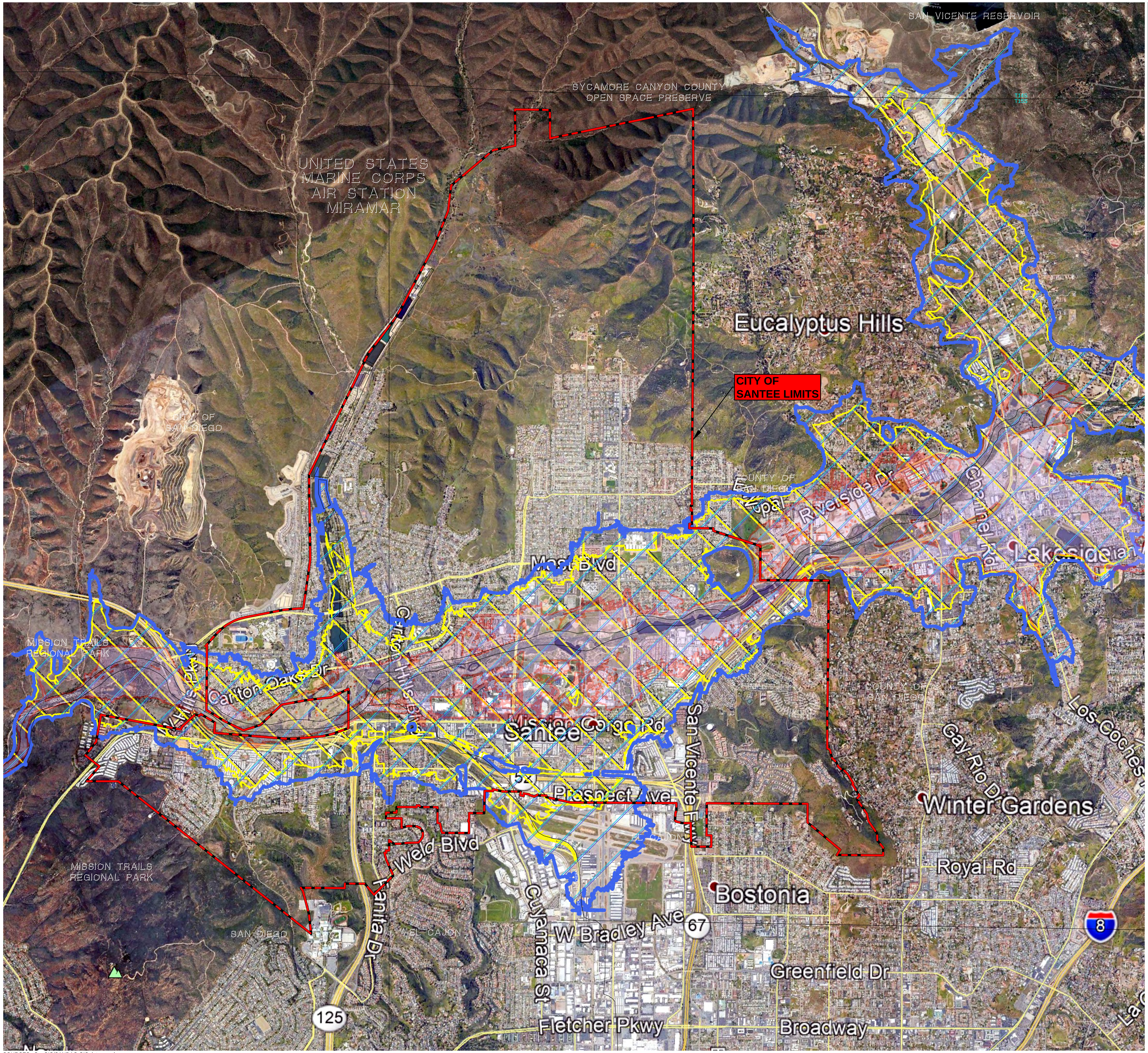

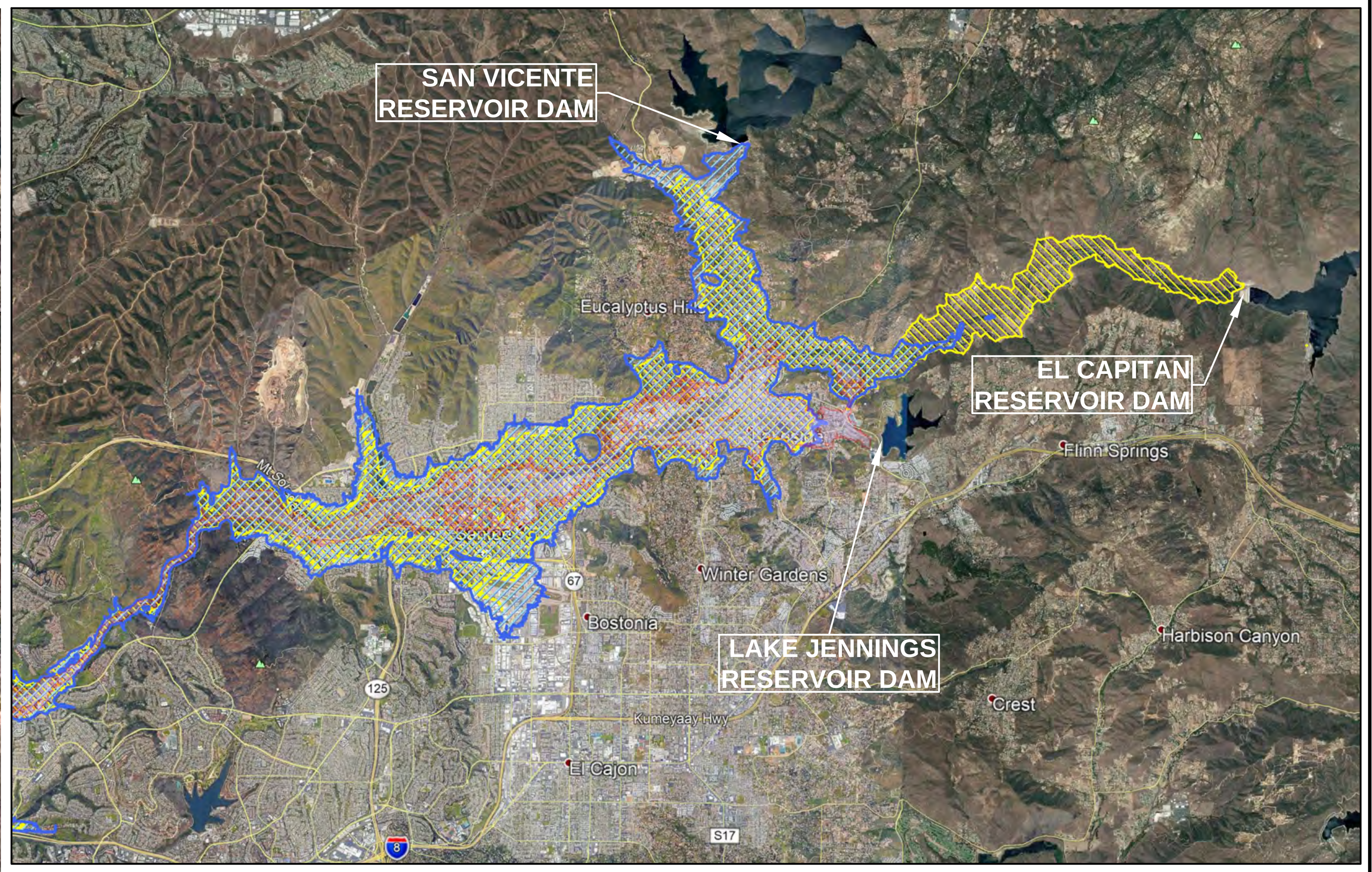

INUNDATION ZONE VICINITY MAP

NOT TO SCALE

0' 1,500' 3,000' 4,500' 6,000'

SCALE 1"=1,500' (On 42x30)

LEGEND

........LAKE JENNINGS (CHET HARRITT) INUNDATION ZONE

........SAN VICENTE INUNDATION ZONE

........EL CAPITAN INUNDATION ZONE

SOURCES: SanGIS/SANDAG GIS data warehouse.

DAM/RESERVOIR INUNDATION MAP

CITY OF SANTEE SEISMIC SAFETY STUDY

SANTEE, CALIFORNIA

GEOCON INCORPORATED
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS
6960 FLANDERS DRIVE - SAN DIEGO, CALIFORNIA 92121 - 2974
PHONE 858 558-6900 - FAX 858 558-6159

SCALE 1" = 1,500'	DATE 03 - 29 - 2021		FIGURE 3
PROJECT NO. G2647 - 52 - 01			
SHEET 1 OF 1			

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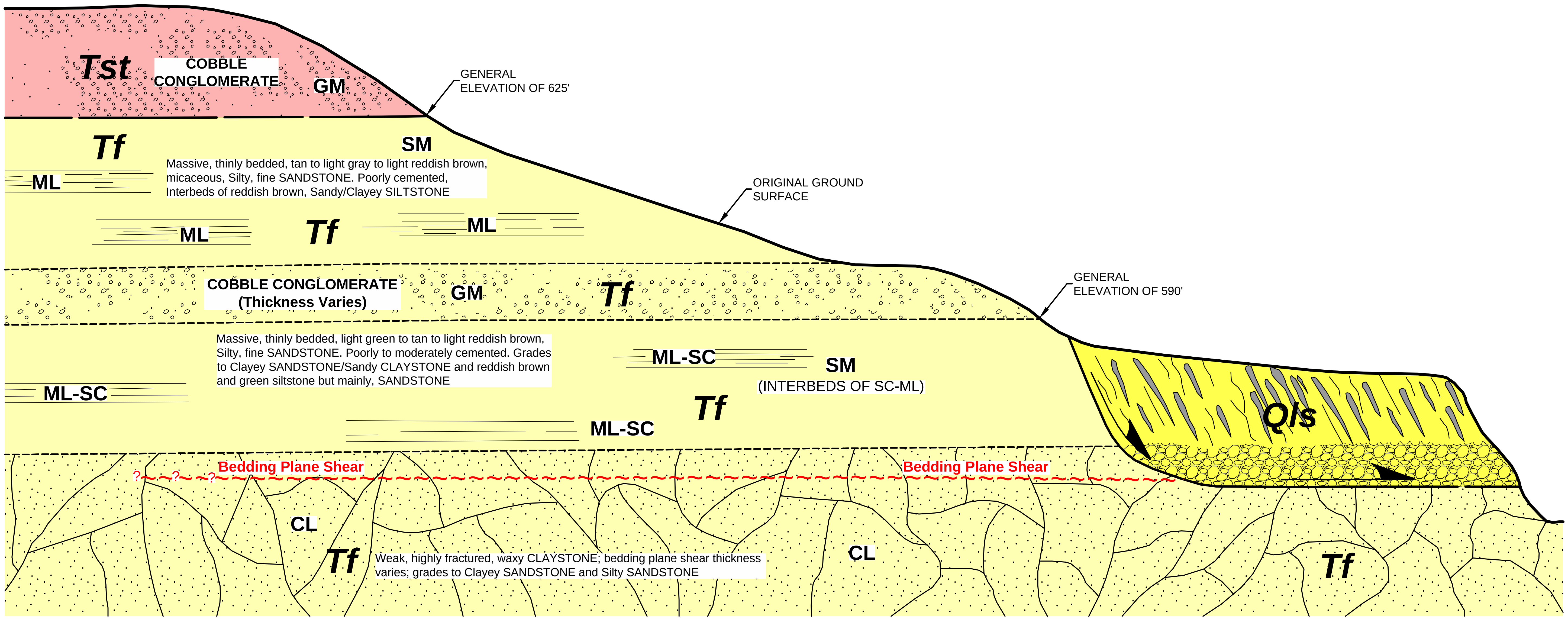

CHARACTERISTIC GEOLOGY OF SANTEE AREA

NO SCALE, CONCEPTUAL ONLY

GEOCON LEGEND

- **Qls** ....LANDSLIDE DEPOSITS
- **Tst** ....STADIUM CONGLOMERATE
- **Tf** ....FRIARS FORMATION

CHARACTERISTIC GEOLOGY OF SANTEE AREA

CITY OF SANTEE SEISMIC SAFETY STUDY

SANTEE, CALIFORNIA

GEOCON INCORPORATED
GEOTECHNICAL CONSULTANTS
6960 FLANDERS DRIVE - SAN DIEGO, CALIFORNIA 92121 - 2974
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SCALE NOT TO SCALE	DATE 03 - 29 - 2021
PROJECT NO. G2647 - 52 - 01	FIGURE 4
SHEET 1 OF 1	

APPENDIX A

APPENDIX A

TECHNICAL TABLES FROM SEISMIC SAFETY REPORT DISCUSSIONS

TABLE A-1
DETERMINATION OF GEOTECHNICAL STUDIES REQUIRED

Group/Risk Category (Examples) **Stability Category**	**Group I** (Parks, Open Spaces, Golf Courses, Agricultural Land, Landfills, Barns, Storage Shelters)	**Group II** (Residential, Commercial and Industrial Buildings, Warehouses, Apartment Buildings, Motels, Secondary Roadways)	**Group III** (Theatres, Lecture Halls, Dining Halls, Schools, Churches, Prisons, Small Healthcare Facilities, Infrastructure Plants, Storage for Explosives/Toxins, Main Roads, Mid to High-Rise Buildings, Large Structures Intended for Human Occupancy)	**Group IV** (Hazardous Material Facilities, Hospitals, Fire and Rescue, Emergency Facilities and Shelters, Police Stations, Power Stations, Aviation Control Facilities, National Defense, Water Storage)
Generally Stable Areas. Underlain by Granitic Rock or Gentle Slopes.	Geologic Reconnaissance	Geotechnical Investigation Geologic Reconnaissance	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study
Moderately Stable Areas. Underlain by Stadium Conglomerate.	Geologic Reconnaissance	Geotechnical Investigation Geologic Investigation	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study
Generally Unstable Areas. Underlain by Friars Formation, Landslides or Debris Flows.	Geologic Reconnaissance	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study
Potentially Liquefiable Areas. Possibly Underlain by Alluvium and a High Water Table.	Geologic Reconnaissance	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study

TABLE A-2
TYPES OF GEOTECHNICAL STUDIES

Report Type	Description
Geologic Reconnaissance	• Performed under the supervision of, and signed by a Certified Engineering Geologist (CEG) in the State of California. • Conducted during the initial planning stages. • Includes a literature search (available reports, published geologic maps, stereo aerial photographs), research on existing problems in the areas, a site description, and a field inspection to identify/assess potential geologic hazards requiring further study. • Recommends the scope for additional geotechnical studies. • Engineering design recommendations are not included in a Geologic Reconnaissance.
Geologic Investigation	• Performed under the supervision of, and signed by a Certified Engineering Geologist (CEG) in the State of California. • Can be conducted during the environmental review process, but usually occurs at the tentative map stage. • Considers the conditions of preliminary grading plans, i.e., hazardous building sites, stabilization, excavations, and/or avoidance of hazardous soil types. • Includes literature review, field investigation, subsurface testing, laboratory analysis, and special design criteria. • Includes preparation of a Geologic Map and a description of geologic conditions. • Recommends the scope for additional geotechnical studies.
Geotechnical Investigation	• Performed under the supervision of, and signed by a Certified Engineering Geologist (CEG) and licensed Registered Civil Engineering (RCE) practicing in the field of soil engineering or a Geotechnical Engineer (GE) registered in the State of California. • Normally conducted in conjunction with Geologic Investigations. • Considers final grading plans and tentative maps. • Includes literature review, field investigation, subsurface testing, laboratory analysis, and special design criteria. Conclusions and recommendations include foundation design and recommended grading specifications. • Includes preparation of a Geologic Map and a description of geologic conditions.
Seismic Hazard Study	• Performed under the supervision of, and signed by a Certified Engineering Geologist (CEG) and licensed Registered Civil Engineering (RCE) practicing in the field of soil engineering or a Geotechnical Engineer (GE) registered in the State of California. • Conducted in accordance with the guidelines set forth by the California Geological Survey.

TABLE A-3
GEOTECHNICAL/SEISMIC HAZARD MAP LEGEND

Legend	Soil Type	Location	Relative Landslide Susceptibility	Liquefaction Hazard	Expansion Condition
A	Granitic Rock	Hard Rock Outcrops and Decomposed Granitics, Northern Slopes (Fanita Ranch), Central Area (Ramsgate Way), Southwestern Area (Rancho Fanita Drive, Cowles Mountain)	Least Susceptible	Nominal	Very Low
B	Stadium Conglomerate	Northwestern and Northern Slopes (Fanita Ranch), Southern Undeveloped Area	Marginally Susceptible (Generally Susceptible to Debris Flow)	Nominal	Low
C1	Alluvium	Main Drainage Channels, Possible Shallow Groundwater, San Diego River	Marginally Susceptible	Moderate to High	Variable
C2	Alluvium/Debris Flow	Secondary Drainage and Tributary Channels, Fluctuating Groundwater	Variable	Nominal to Low	Moderate
C3	Older Alluvium	Gentle Slopes Western Area, Flanks of the San Diego River (Carlton Oaks Drive), Central Area (Woodpark Drive)	Generally to Marginally Susceptible (Where underlain by Friars Formation)	Low to Moderate	Variable
D1	Landslides Confirmed	Sloping Southern Area (Route 125 and Fanita Drive), Fanita Ranch, Carlton Hills, Castlerock	Most Susceptible	Nominal	Moderate to High
D2	Landslides Possible	Various Areas Throughout Friars Formation	Most Susceptible	Nominal	Moderate to High
D3	Friars Formation	Northern Slopes (Cuyamaca Street, Lake Canyon Road, Fanita Ranch) and Southern Slopes (Mesa Heights Road, Route 125)	Most Susceptible	Nominal	Moderate to High
--	Unmapped Surficial Deposits: Undocumented Fill, Topsoil, Colluvium	Undeveloped Areas	Variable	Variable	Variable
--	Unmapped Surficial Deposits: Previously Placed Fill	Developed Areas	Variable	Variable	Variable

TABLE A-4
MODIFIED MERCALLI INTENSITY (DAMAGE) SCALE OF 1931 (ABRIDGED)

Intensity Value	Quantitative Description [Average Peak Velocity (cm/s), Average Peak Acceleration (m/s2), Rossi-Forel Scale]
I	Not felt except by a very few under especially favorable circumstances. [--, --, I]
II	Felt only by a few persons at rest, especially on upper floors of buildings; delicately suspended objects may swing. [--, --, I to II]
III	Felt quite noticeable indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake; standing motor cars may rock slightly; vibration like passing truck; duration estimated. [--, --, III]
IV	During the day felt indoors by many, outdoors by few; at night some awakened; dishes, windows and doors disturbed; walls making creaking sound; sensation like heavy truck striking building; standing motor cars rocked noticeably. [1-2 cm/s, 0.015g-0.02g, IV to V]
V	Felt by nearly everyone; many awakened; some dishes, windows etc., broken; a few instances of cracked plaster; unstable objects overturned; disturbances of trees, piles and other tall objects sometimes noticed; pendulum clocks may stop. [2-5 cm/s, 0.03g-0.04g, V to VI]
VI	Felt by all; many frightened and run outdoors; some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; damage slight. [5-8 cm/s, 0.06g-0.07g, VI to VII]
VII	Everybody runs outdoors; damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken; noticed by persons driving motor cars. [8-12 cm/s, 0.10g-0.15g, VIII]
VIII	Damage slight in specially designed structures, considerable in ordinary substantial buildings, with partial collapse, great in poorly built structures; panel walls thrown out of frame structures; fall of chimneys, factory stacks, columns, monuments, walls; heavy furniture overturned; sand and mud ejected in small amounts; changes in well water; persons driving motor cars disturbed. [20-30 cm/s, 0.25g-0.30g, VIII+ to IX]
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse; buildings shifted off foundations; ground cracked conspicuously; underground pipes broken. [45-55 cm/s, 0.50g-0.55g, IX+]
X	Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked; rails bent; landslides considerable from river banks and steep slopes; shifted sand and mud; water splashed (slopped) over banks. [> 60 cm/s, > 0.60g, X]
XI	Few, if any (masonry) structures remain standing; bridges destroyed; broad fissures in ground; underground pipelines completely out of service, earth slumps and land slips in soft ground; rails bent greatly. [--, --, --]
XII	Damage total. Waves seen on ground surfaces. Line of sight and level distorted. Objects thrown upward into the air. [--, --, --]

(g = gravity = 9.80 m/s^2)

TABLE A-5
GEOLOGIC TIME

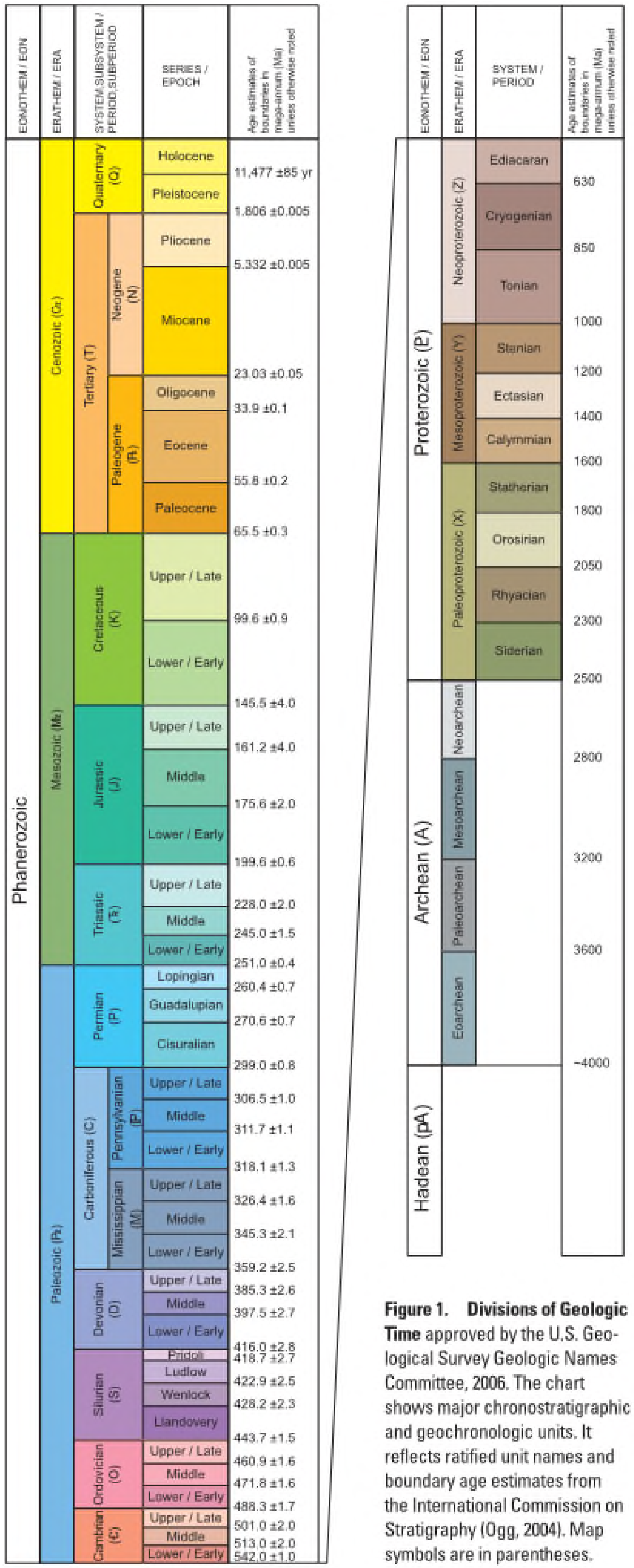

Figure 1. Divisions of Geologic Time approved by the U.S. Geological Survey Geologic Names Committee, 2006. The chart shows major chronostratigraphic and geochronologic units. It reflects ratified unit names and boundary age estimates from the International Commission on Stratigraphy (Ogg, 2004). Map symbols are in parentheses.

APPENDIX B

APPENDIX B

DEFINITION OF TECHNICAL TERMS

Active Fault	An Active Fault is one that exhibits separation in historic time or along which separation of Holocene deposits can be demonstrated. If Holocene deposits are not offset, but numerous epicenters have been recorded on or in close proximity to the fault, a classification of active may be used.
Alluvium	Surficial, stream deposited materials that have undergone no significant cementation or consolidation; typically, loose sands, gravels, or clays deposits in valleys and other drainage areas in the last 11,000 years.
Bed	A layer or tabular body of sedimentary rock greater than one centimeter thick, that lies essentially parallel to the surface or surfaces on or against which it was formed.
Bedding	The arrangement of sedimentary rocks in layers than are more than one centimeter thick.
Bedding Plane	The surface that separates each successive layer of a sedimentary rock from its proceeding layer.
Bedding Plane Shear	A shear that parallels a bedding plane. Also known as bedding parallel shear.
Boulder	A detached rounded rock that is larger than 12 inches.
Cementation	The process by which loose sediments become cohesive sedimentary rock through the addition of natural cementing agents such as calcium carbonate, iron oxide, or silica.
Cobble	Particles of rock that possess a size of 3 inches to 12 inches.
Clast	An individual constituent, grain, or fragment of rock, produced by weathering of a larger rock mass.
Expansive	Refers to a clayey soil that will expand and contract with changes in moisture content.

Fault	A fracture in rock along which there has been displacement.
Formation	A general term used in describing soil or rock masses that have been mapped as distinct units.
Fracture	A general term for any break in a rock mass.
Friars Formation	The Friars Formation is composed of beds of brown, red, and green mudstones and claystones alternating with loosely to moderately well cemented, fine to medium grained, light gray to brown sandstones. The thickness of these beds ranges from 2 to 40 feet or more. Studies by various geotechnical firms have confirmed that the Friars Formation contain a significant cobble conglomerate bed 25 to 50 feet thick and lying at an elevation of approximately 450 feet.
Gravel	Particle of rock that will pass a 3-inchg sieve but be retained on a No. 4 sieve.
Inactive Fault	A fault is classified Inactive when a fault trace exhibits no separation of Holocene deposits or if the fault is overlain by unfaulted Pleistocene deposits.
Intensity	Intensity refers to the degree or strength of shaking at a specified place. It is not based on the energy released by an earthquake but is a rating assigned by an experienced observer using a descriptive scale with grade indicated by Roman numerals from I to XII. Intensity is a rating of the severity of damage producing properties of the ground motion at a specific location. The scale of measurement is based upon the sensation of persons and upon physical damage to structural and man-made objects. The most widely used and accepted intensity scale is the Modified Mercalli Intensity Scale (Appendix A)
Interbedded	A term used to describe soil or rock material lying between beds, or lying in a bed parallel to other beds of a different material.
Joint	A surface of actual or potential fracture or parting in a rock.
Landslide	Any mass movement that occurs below the soil mantle that is caused by shear failure along one or several surfaces.

Liquefaction	Liquefaction is a process or condition in which a soil mass below the water table suddenly loses its strength during shaking, such as an earthquake, and behaves like a fluid. The primary factor affecting the potential of a soil to liquefy are proximity of the water table to the ground surface; soil type; relative density or void ratio; initial confining pressure; intensity of ground shaking; and, duration of ground shaking. In general, poorly graded materials are more susceptible to liquefaction than are well graded material and of the poorly grade materials, fine sand and silts tend to "liquefy" more readily than do coarse sands, gravelly soils or clay. Typically, soil containing more than about 30 to 40 percent (by weight) clay particles have a very low potential for liquefaction. In general, Modified Mercalli Intensities on the order of VII may create sufficient ground shaking to cause liquefaction of very susceptible deposits. As the intensity of seismic event increases, the range of susceptible deposits also increases.
Magnitude	Magnitude is related to that energy which is radiated from the earthquake source in the form of elastic waves. Basically, magnitude is the rating of a given earthquake related to the earthquake energy released in the hypocentral area and is independent of the base of observation since it is calculated from measurement on seismograms. It is expressed in ordinary numbers and decimals. Magnitude was originally defined by C. F. Richter as a logarithm (base 10) of the maximum amplitude of a Wood-Anderson seismogram at a distance of 100 kilometers (62 miles) from the focus. For other distances or for instruments of other types, conversion to the standard is accomplished.
Massive	A general term used to describe homogeneous sedimentary rock that is free of joints and bedding planes.
Matrix	The natural material in which a rock clast is embedded. In a rock in which certain constituents are much larger than the others, the smaller sized constituents compose the matrix.
Medium-Grained	A general term used to describe grains larger than 1 millimeter and smaller than 2 millimeters.
Mudstone	A rock composed of indefinite and varying proportions of clay, silt, and sand.

Outcrop	Rock that is exposed at the surface of the earth.
Pebble	A rounded rock fragment between 4 millimeters and 64 millimeters in size.
Poorly Sorted	A general term used to describe materials composed of nonuniform sized constituents.
Sand	Applies to unconsolidated minerals or rock particles that are less than 4 millimeters and more than 0.05 millimeters in size.
Sandstone	A consolidated sedimentary rock composed of cemented sand grains.
Sedimentary Rock	A term used to describe rock formed from a sediment. Generally composed of sand to clay-sized particles.
Silt	Applies to unconsolidated rock particles that are greater than 0.005 millimeters and less than 0.05 millimeters in size.
Siltstone	A consolidated rock composed predominantly of silt.
Slopewash	Soil and rock material that is or has been transported down a slope by running water not confined to channels.
Soil Creep	An imperceptibly slow and continuous downward and outward movement of soil on a slope.
Stadium Conglomerate	The cobble-sized clasts of the conglomerate are chiefly volcanic in origin with some quartzite and granitic cobbles and boulders which attain diameters of two to three feet. These clasts (rounded cobbles and boulders) are set in a matrix of red-brown to light brown, poorly to well sorted, and medium to coarse-grained sands. Cementation is highly variable, from strongly cemented to poorly cemented. Thick lenses of well-sorted sandstones are common.
Weathered	The physical disintegration and chemical decomposition of rock due to effects of the atmosphere.
Well-Sorted	Applies to materials composed of particles of approximately uniform size.

APPENDIX C

APPENDIX C

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