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

CITY OF SANTEE
COUNTY OF SAN DIEGO, CALIFORNIA

GEOCON
INCORPORATED

GEOTECHNICAL
CONSULTANTS

PREPARED FOR

CITY OF SANTEE
SANTEE, CALIFORNIA

OCTOBER 31, 2002
FINAL REPORT

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FINAL REPORT

City of Santee
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Attention: Mr. Cary P. Stewart

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

Gentlemen:

In accordance with your authorization of our proposal No. LG-00377, revised October 17, 2001, we have performed a 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.

If you have any 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. We have identified four 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, disruption of essential services, bodily injury, and loss of life. The four main seismically induced hazards specific to the City of Santee include the potential for landsliding and slope instability caused by the presence of ancient landslides, bedding plane shears, and weak claystone beds within the Friars Formation; ground shaking; the potential for liquefaction within the alluvial deposits of the San Diego River; and failure of any of the three major dams located upstream of the City. No areas of potential surface fault rupture were identified within the city limits. 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 D, List of References. The name of the California Division of Mines and Geology (CDMG) has recently been changed to the California Geological Survey. Documents published by the CDMG will be referenced as such.

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 the Public Resources Code, and other geologic hazards known to the legislative body; flooding; and wild land and urban fires. The safety element shall include mapping of known seismic and other geologic hazards. It shall also address evacuation routes, peakload water supply requirement, and minimum road widths and clearances around structures, as those items relative to identified fire and geologic hazards.

This Geotechnical/Seismic Hazard Study includes only geologic and seismic hazards. It 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 does contain an inundation map depicting areas that could be affected by rupture of several local reservoirs.

The scope of our services includes an inventory and review of available literature, development of a new hazard map, and preparation of this report. The literature reviewed included a report prepared by Geocon Incorporated, entitled *Geotechnical/Seismic Study for the Santee General Plan*, dated May 25, 1982.

3. RECOMMENDED GENERAL PLAN GOALS

The 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 in the last section. 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.

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 these hazards. 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 could include the following:

- **Objective 1.** To 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, 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 which are particularly susceptible to damage from seismic and other geologic phenomena.
- **Objective 2.** To assure that the project review process allows for consideration of seismic and geologic hazards as early as possible.
- **Policy 2.** For projects proposed in areas identified herein as being located in seismically and/or geologically hazardous areas, the geologic and 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.** To 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, *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 and hospitals to be reviewed by the State Architect.

An analysis of each of the three policies is delineated in the following sections.

4.1 Policy 1 - Awareness

The enclosed *Geotechnical/Seismic Hazard Map, Santee, California* (Figure 2), was compiled from various published maps for the La Mesa, El Cajon, Poway, and San Vicente Reservoir 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 all potential geotechnical and soil hazards be fully investigated at the environmental review stage prior to project approval. Such investigations shall include those identified in Table A-1, *Determination of Geotechnical Studies Required*, as may be warranted by results of the Initial Environmental Study.

4.2.1 Application of Data to 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 in 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 gives a description of each type of study including Geologic Reconnaissance, Geologic Investigation, Geotechnical Investigation, and Seismic Hazard Study. Critical structures, as shown under Group I in the table, are primarily emergency facilities that must remain in service in the event of a disaster. Typical structures would be hospitals, police and fire department structures, power generating stations and transmission lines, communication facilities, and municipal government centers. Hazardous facilities that house toxic or explosive chemical substances are also including under Group I. Nuclear power plant site considerations are not included in this category but would be covered under Federal regulations.

Group II are special occupancy structures which include schools, churches, main roads, high-rise buildings, and any large structures intended for high occupancy.

Structures with relatively low occupancy and subsequent high level of risk acceptance would require relatively less consideration or study. These structures or developments, shown as Group III structures include single-family residences, small apartments or motels, smaller commercial or industrial structures, warehouses, secondary roadways, and small government facilities.

The land uses shown in Group IV are those which are relatively insensitive to risk and would include such developments as parks, open spaces, golf courses, agricultural land, and sanitary landfill sites.

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 studies required or the information to be included in the Geologic Reconnaissance, Geologic Investigation, and Geotechnical Investigation, studies can range from very preliminary, such as feasibility analyses, to very detailed studies including extensive subsurface investigation, laboratory data testing generation, and engineering-geologic analysis. Consideration should be given to developing *Guidelines for Geotechnical Reports* which would set technical standards for all reports submitted to the City of Santee. References for developing *Guidelines for Geotechnical Reports* include the following:

1. California Department of Conservation, Division of Mines and Geology, *DMG Note 44 Recommended Guidelines For Preparing Engineering Geologic Reports,* 1986.

2. City of San Diego, *Technical Guidelines for Geotechnical Reports,* October 1988.

3. Association of Engineering Geologists, by Glenn A. Brown and Richard J. Proctor, Edited by Seena N. Hoose, *Professional Practice Handbook, Special Publication No. 5,* Third Edition, 1993.

4. State of California, State and Consumer Services Agency, Board for Geologists and Geophysicists, *Guidelines for Engineering Geologic Reports,* April 18, 1998.

In regard to 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* (Formerly DMG Note 37*), Guidelines to Geologic/Seismic Reports,* 1986.

2. California Department of Conservation, Division of Mines and Geology, *DMG Note 43, Recommended Guidelines for Determining the Maximum Credible and the Maximum Probable Earthquakes,* 1986.

3. State of California, State and Consumer Services Agency, Board for Geologists and Geophysicists, *Geologic Guidelines for Earthquake and/or Fault Hazard Reports,* April 18, 1998.

In addition, recommendations to mitigate seismic hazards should be provided in accordance with the following reports:

1. California Department of Conservation, Division of Mines and Geology, *Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California,* Adopted March 13, 1997.

2. Southern California Earthquake Center, University of Southern California, and the ASCE Los Angeles Section Geotechnical Group, *Recommended Procedures For Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California,* February 2002.

4.2.2 Review Procedures

Consideration should be given to establishing a review procedure for 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 preferably, one or more 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

Group I includes Occupancy Category 1 and Occupancy Category 2 structures. These are comprised of 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 II includes Occupancy Category 3 structures. These are comprised of special occupancy structures including schools; churches; main roads; large commercial and industrial structures; high-rises; and other high occupancy structures.

Group I and II 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. 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. This updating should be performed at least on an annual basis. In addition, we recommend that the City or the City's consultant maintain a master geotechnical map on which new information concerning the location of landslides, faults and potentially liquefiable areas could be added as new information is gained from geotechnical reports submitted for review.

In addition, review and update of the Zoning Ordinance should be 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 bounded 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 (see Figure 1, Vicinity Map).

5.2 Soil and Geologic Conditions

5.2.1 General

The following section describes the geologic and seismic setting of the Santee area. It includes 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 a relatively narrow coastal plain and the Peninsular Mountain Ranges of southwestern California and Baja California. The coastal plain is made up of a series of marine terraces which are deeply incised by canyons and tributaries, including the channel of the San Diego River. 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 Valley in the City of San Diego and drains into the Pacific Ocean. Much of Santee is located within the San Diego River Valley; however, the northern part of the City, most of which is undeveloped, is located on the highest of these old marine terraces at an elevation of approximately 1,000 feet. In the southeastern part of the City, the marine terrace and valley province end abruptly in the foothills of the Peninsular Ranges.

The geologic stratigraphy of Santee consists of several surficial soil types and three geologic formations. The surficial soil deposits consist of undocumented fill, previously placed fill, topsoil, colluvium, alluvium/debris flows, landslide deposits, and terrace deposits. In general, surficial soils consisting of alluvium and colluvium are found in drainage areas, such as the San Diego River channel, and near the base of slopes.

Formational units include the Eocene-age Stadium Conglomerate and Friars Formation, and Cretaceous granitic rock associated with the Peninsular Ranges. Both the Stadium Conglomerate and Friars Formation are sedimentary units. The clay portions of the Friars Formation are typically weak and prone to landsliding, whereas the overlying Stadium Conglomerate, although itself resistant to instability, may be "carried" with landslides in the underlying Friars Formation. Each of the surficial soil types and geologic units encountered is described below in order of increasing age. A discussion of the relationships between the units is presented in the Geologic Structure section of this report. A generalized depiction of the geology characteristic of the northern portion of the city is presented on Figure 4.

5.2.2 Undocumented Fill

In undeveloped and developed areas of the City of Santee, fill soils presumed to be undocumented were encountered and have been mapped in numerous geotechnical reports. An example of a larger 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 they require special evaluation and recommendations.

5.2.3 Previously Placed Fill

The majority of the central and southern portions of the City of Santee have been developed. The largest developments include the following: Black Horse Estates, Cajon Park, Carlton Country Club, Carlton Hills, Carlton Oaks, 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, Woodglen, and Woodside Industrial Park.

The fill materials placed during development of these projects generally consist of silty and clayey sands and sandy clays with gravel and cobble mixtures. Prior to grading or constructing additional improvements in previously graded areas, specific geotechnical evaluations or update reports should be performed to address the potential impacts to existing or proposed improvements underlain by these deposits.

5.2.4 Topsoil

In the undeveloped areas, topsoils blanket the majority of the formational units and range in thickness from approximately 1 to 3 feet. The topsoils are generally characterized as brown to dark brown, silty/clayey, fine to medium sands and sandy clays. Topsoils that overlie the Stadium Conglomerate are generally thinner, and have a greater percentage of gravel and cobble clasts. Topsoil deposits typically are considered compressible in their natural state, and ordinarily require remedial grading in areas planned to receive structural fill and/or settlement sensitive structures. The clayey topsoils characteristically have a medium to high expansion potential, and when present at the ground surface, commonly require specialized foundations to mitigate their impacts.

5.2.5 Colluvium

Colluvial soils are deep deposits of soils that have accumulated near the base of slopes through erosion of upslope materials and soil-creep processes. Colluvial deposits are encountered in the gentle, low-lying, slope areas near alluvial drainages primarily overlying the Friars Formation. Typically, these materials are deepest in areas underlain by the Friars Formation; however, they also occur in areas underlain by Stadium Conglomerate and granitic rocks. Colluvial materials were also found to overlie landslide deposits, particularly in graben zones near the head of the slides. The thickness of the colluvium is typically on the order of 10 feet or more. These deposits generally possess medium to high expansion potential, are poorly consolidated, and often require remedial grading in areas of planned development.

5.2.6 Alluvium/Debris Flows

Surficial deposits consisting of Holocene to late Pleistocene age alluvium occur in the drainage areas, such as the San Diego River channel, the valley bottoms, and lower portions of the valley slopes. The San Diego River alluvium is relatively deep and, in the near surface, typically consists of clean, medium-grained sands that are locally mined as a source of concrete sand.

Alluvial soils and debris flow materials cover a relatively large portion of the City and are found within drainages and tributary channels. For the purpose of this study, the alluvium and debris flow materials have not been differentiated. These deposits consist of relatively loose/soft, silty/clayey sands and sandy clays, with varying amounts of gravel and cobble derived from the bedrock units. It appears that many of the debris flow deposits originated from higher elevations of the northern portion of the City along steep slopes within the Stadium Conglomerate, and followed pre-existing alluvial channels. The majority of these deposits consists of silty/clayey, sandy gravel and cobble deposits. Conversely, alluvium within the lower elevations is derived from both Stadium Conglomerate and Friars Formation and typically possesses a higher clay content and lower cobble percentage with the exception of the main drainages where greater energy enabled transport of larger particle sizes.

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 alluvium is usually removed and replaced as properly compacted fill.

5.2.7 Landslide Deposits

Numerous ancient landslides and several possible landslide features have been identified during this study and previous investigations. The presence of the inferred deposits is based on topographic evaluation during field reconnaissance, interpretation of aerial photographs and topographic maps, and reports by the California Geological Survey.

Nearly all of the landslides encountered at the northern, undeveloped portion of the City occur along relatively gentle slopes within the Friars Formation and below an elevation of approximately 590 feet above MSL. On the southern portion of the City, landslides occur approximately between elevations of 400 to 600 feet above MSL. Characteristic morphology of steep back-scarp areas and bulging, hummocky, distorted topography, as well as deflected drainages are typical of landslide areas. Some landslide areas express a more subdued topography suggestive of incipient or older landslide deposits.

The landslide deposits observed are characterized as deep-seated, relatively intact, block-glide type movements or shallow to deep-seated bedrock slides with a varying degree of slip plane development and slide mass disturbance. In the undeveloped northern part of the City, the maximum thickness of landslide material encountered was approximately 44 feet. However, these deposits typically thicken toward their "head" which would yield a greater thickness, perhaps as thick 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 cobbly clay mixtures resembling debris flow materials were also encountered.

The majority of the landslides appear to have occurred along inherently weak, sheared, low-angle bedding planes (bedding plane shears), or weak, thinly laminated claystones within the Friars Formation. This is suggested by the relatively uniform, near-horizontal slip surfaces typically observed at the base of the slides, and because of a general correlation within exploratory borings between the elevations at which bedding plane shears occur in bedrock material. Further discussion of this correlation and an apparent regional zone of bedding plane weakness 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 landslide materials are present below proposed fill embankments, or in cut building pad areas, some remedial grading is often required. Some landslides will require complete removal, while other landslides will only require partial removals to compact the compressible portions of the deposits. Localized areas of deeper removals may be required in 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.

Cut slopes exposing landslide materials or 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, or other means. A discussion of slope stability issues is presented in the Geologic Hazard section of this report.

5.2.8 Terrace Deposits/Older Alluvium

Terrace deposits/older alluvium were encountered within a limited area between the alluvial deposits and either the Friars Formation or granitic rock. These deposits are relatively limited in extent and consist of locally cemented gravely sands and/or clayey gravel/cobble conglomerate.

5.2.9 Stadium Conglomerate

The Stadium Conglomerate of middle to late Eocene age occurs throughout the southwestern and northern parts of the City underlying the previously discussed high terrace and overlying both the granitic rocks and the Friars Formation.

Landslides occurring entirely within the Stadium Conglomerate are uncommon; however, this unit is often involved in sliding where it overlies the Friars Formation. Debris flows or mud flows are relatively common and are discussed in more detail under Geologic Hazards.

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 varies from approximately 40 feet to an estimated 375 feet. 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. This deposit generally consists of dense sandy to clayey, gravel and cobble conglomerate with interbedded silty sands. The Stadium Conglomerate is part of the upper Eocene Poway Group which includes the Mission Valley Formation and the Pomerado Conglomerate.

Moderately heavy to heavy excavation effort should be anticipated during grading within the Stadium Conglomerate due to randomly occurring highly-cemented zones. Cut or fill slopes composed of the Stadium Conglomerate generally possess good slope stability.

5.2.10 Friars Formation

The Eocene-age 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 the 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. The age of the Friars Formation is considered to be middle to late Eocene 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 foot of Cowles Mountain and throughout the northern part of the City except the extreme 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 northern, 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 occurrence of bedding plane shear zones has resulted in the landsliding and landslide-prone hillsides.

With the exception of the sandstone, and portions of the conglomeratic facies, soils derived from the Friars Formation typically posses a medium to high expansion potential and low shear strength. 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. 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 or buttresses are necessary.

5.2.11 Granitic Rock

The high marine terrace which forms the surface of Fletcher Hills and the northern parts of the City above Carlton Hills is underlain by Eocene age sediments of the Friars Formation and Stadium Conglomerate. Both formations overlie mid-Cretaceous granitic rocks composed primarily of quartz-diorite and granodiorite with their finer-grained equivalents occurring is some areas. The granitic rocks are deeply weathered in some areas to form extensive deposits of residuum or decomposed granitic rock. 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.

Gabbroic rocks and undifferentiated Santiago Peak Volcanics from the Cretaceous, and metavolcanic and metasedimentary rocks from the Jurassic Period may be found in limited areas designated as Granitic Rock.

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 between the sedimentary formations and underlying granitic rocks.

An evaluation of the structural elements measured during a geotechnical study of the northern portion of the City suggests that a prominent zone of weakness occurs within the Friars Formation between an elevation of approximately 495 and 540 MSL (see Figure 5). 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 occurs.

The marine terrace or coastal plain bordering 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 Pleistocene faults. In Santee however, there are no known faults which cut Pleistocene-aged materials nor are there any known major faults which cut Eocene or Cretaceous rocks.

The Lyons Valley Lineament (line of topographic expression) was identified as a fault on older published geologic maps, most notably the State of California Preliminary Fault and Geologic Map and the Geology Map of San Diego County (Weber, 1958). The Lyons Valley Lineament is shown trending toward the central portion of Santee but does not extend within the city limits. The northern end of this lineament occurs just west of Gillespie Field in El Cajon.

Bedding plane 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

6.1 General

This section presents a discussion of the 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. Lesser hazards within the area are mud flows or debris flows and colluvial soils. A discussion of groundwater and seepage related problems is also presented.

6.2 Ancient Landslides

The landslide areas within the City can usually be mitigated using generally accepted remedial grading techniques. 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.

Reactivated ancient landslides have been responsible for either partial or complete loss of 20 to 30 homes in the Santee area. The potential for additional loss in areas already developed on landslides is being studied by several geotechnical firms.

A landslide is defined as any mass movement of earth occurring below the limits of the soil mantle caused by shear failure along one or several surfaces (see Figure 4, Characteristic Geology of the Northern Santee Area). 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 to intense rainfall and 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 Geotechnical/Seismic Hazard Map, Figure 2 (map pocket). 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.

The reactivation of ancient landslides and the creation of new landslides have been most commonly caused by grading activities or a rise in groundwater level in a slide area or area containing bedding plane shears. 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 to reduce the potential for buildup of excessive hydrostatic pressures.

6.3 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 within city limits 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 an accumulation of topsoil, colluvium and debris derived from formational "parent material" near the base of moderate to steep slopes which have resulted from 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. While the causes of debris flows are generally well understood, specific details concerning these events make them difficult to predict. 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 impact development.

6.4 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, but may also be found in shallower drainages as a result of storm water infiltration. Because of fluctuating water levels in a given area, as a result of seasonal variation 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 at the ground surface. Seepage conditions in slopes, either graded or natural, are usually the result of groundwater flowing at the contact between materials of widely different permeabilities with the water perched on an underlying, less permeable material. 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 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 all geotechnical reports submitted to the City for new developments. The seepage and groundwater statement, as required by the City of San Diego for geotechnical reports, could be used as a guideline. Procedures for mitigation for the groundwater 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 and hillside areas. 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 effect remedial grading.

7. SEISMIC HAZARDS

7.1 General

This section presents a discussion of the seismic hazards anticipated in the study area. Seismic hazards are those hazards caused by earthquake-induced ground shaking, specifically, liquefaction potential, 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.

7.2 Local and Regional Faulting and Associated Ground Shaking

7.2.1 General

Seismic hazards pertain to threats to life and property caused by earthquake-induced ground shaking. Santee is fortunate, in that no active or potentially active faults are known to occur within or adjacent to the City, 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 (see Figure B-1, Epicenters of $M \geq 5$ California Earthquakes, 1800-1999). The purpose of this section is to summarize the various potential sources of seismic shaking, and to describe the resulting potential ground effects (see Figure B-2, Areas Damaged by $M \geq 5$ California Earthquakes, 1800-1999).

A review of geologic literature indicates that there are no known active or potentially active faults crossing the city. The Rose Canyon Fault Zone, located approximately 10¼ miles west of the City of

Santee, is the closest known active fault. An active fault is defined by the California Geological Survey as a fault showing evidence for activity within the last 11,000 years. The CDMG has included portions of the Rose Canyon Fault Zone within an Alquist-Priolo Earthquake Fault Zone. Since no Alquist-Priolo Earthquake Fault Zones exist within the City of Santee, there are no restrictions on development related to the Alquist-Priolo requirements.

For seismic design requirements, development within Santee should follow the latest adopted Uniform Building Code (UBC).

General regional seismic hazard references include the following:

1. Southern California Earthquake Preparedness Project, University of California, Irvine, and Leighton and Associates, *Proceedings, Workshop on The Seismic Risk in the San Diego Region: Special Focus on the Rose Canyon Fault System,* June 29-30, 1989.

2. California Department of Conservation, Division of Mines and Geology, *Special Publication 100, Planning Scenario for a Major Earthquake, San Diego-Tijuana Metropolitan Area,* 1990.

The CDMG's *Special Publication 100* includes earthquake planning scenario maps. These maps include seismic intensity distributions, location of schools, fire and law enforcement stations, major electrical power transmission routes, major natural gas transmission pipe lines and distribution mains, and water supply and waste-water facilities and transmission pipe lines that are located within the City of Santee and San Diego County in general.

7.2.2 Deterministic Seismic Hazard Analysis

Earthquakes that might occur on the Rose Canyon Fault Zone or other faults within the southern California and northern Baja California area are potential generators of significant ground motion in the City. In order to determine the distance of known faults to the City, the computer program EQFAULT, (Blake, 1996, revised 2000), was utilized. Principal references used within EQFAULT in selecting faults to be included are Jennings (1975), Anderson (1984), and Wesnousky (1986).

Within a search radius of 100 miles from the site, 39 known active faults were identified. The results of the deterministic seismicity analyses indicate that the Rose Canyon Fault Zone is the dominant source of potential ground motion in the city. Seismic parameters for the Rose Canyon Fault Zone include an estimated maximum earthquake magnitude (Mw) of 6.9, a peak site acceleration of 0.226 g, and an estimated site intensity of IX of the Modified Mercalli scale. Presented on Table B-3 in Appendix B are the earthquake events and site accelerations based on attenuation relationships of Sadigh *et al.* (1997) for the faults considered most likely to subject the city to ground shaking. The seismic risk within the

City is not considered significantly greater than that of the surrounding municipalities and the San Diego County area in general.

While listing of peak accelerations is useful for comparison of potential effects of fault activity in a region, other considerations are important in seismic design, including the frequency and duration of motion and the soil conditions underlying the site. We recommended that seismic design be performed in accordance with the Uniform Building Code or other applicable code.

In order to determine the historical earthquakes within 50 miles of Santee from 1800 to 2000, the computer program EQSEARCH, (Blake, 1996, revised 2000), was utilized. The closest historical earthquake to the City of Santee occurred on May 25, 1803. This earthquake was approximately 4½ miles away and had an estimated site acceleration of 0.16g. The location and magnitude of this earthquake are highly speculative. Presented on Table B-4 in Appendix B is the results of the estimation of peak accelerations within the City from California earthquake catalogs.

7.2.3 Probabilistic Seismic Hazard Analysis

The computer program FRISKSP (Blake, 1995, updated 1998) was used to perform a site-specific probabilistic seismic hazard analysis for the City of Santee. The program is a modified version of FRISK (McGuire, 1978) that models faults as lines to evaluate site-specific probabilities of exceedance of given horizontal accelerations for each line source. Geologic parameters not included in the deterministic analysis are included in this analysis. The program operates under the assumption that the occurrence rate of earthquakes on each mappable Quaternary fault is proportional to the fault's slip rate. Fault rupture length as a function of earthquake magnitude is considered, and estimates of site acceleration are made using the earthquake magnitude and closest distance from the site to the rupture zone. The program accounts for each of the following parameters: (1) earthquake magnitude, (2) rupture length for a given magnitude, (3) location of the rupture zone, (4) maximum possible magnitude of a given earthquake, and (5) acceleration at the site from a given earthquake along each fault. By calculating the expected accelerations from all identified earthquake sources, the program calculates the total average annual expected number of occurrences of site acceleration greater than a specified value.

Anticipated site acceleration due to a seismic event on any of the referenced faults was evaluated using a peak ground acceleration (PGA) that has a 10 percent probability of exceedance in 50 years, as suggested by CDMG Special Publication 117 (1997). The computer program (FRISKSP) and attenuation relationships suggested by Sadigh, *et al,*. (1997) were used to determine a site acceleration (PGA) of 0.25g. This value corresponds to a return period of approximately 475 years (Return Period = $T/[r(1+0.5r)] = 50/[0.1(1+0.5*0.1)] = 475$ years). For a 100-year exposure period and a 10 percent probability of occurrence, a site acceleration of 0.27g may be generated. This value corresponds to a return period of approximately 950 years. The FRISKSP computer program considers standard deviation in calculation of site acceleration. The values given above are representative of the central portion of the City. Site-specific seismic analyses should be performed for each new project in the City of Santee.

7.3 Soil Liquefaction

Within the City of Santee, the soil deposits that may be susceptible to liquefaction are the alluvial soils found in the San Diego River and its deeper tributary channels. The general extent of the liquefaction-susceptible materials is shown on Figure 2. Although all 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.

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 CDMG Special Publication 117.

7.4 Seismically-Induced Settlement

Seismically induced settlement is very closely related to liquefaction in that loose sands and silts below the water table may tend to settle or densify as a result of ground shaking. As the pore water pressure approaches a value equal to the confining pressure, the soil begins to undergo deformations. If the soil is loose, the deformations (settlement) can be quite large, as much as 20 percent of the affected thickness of the deposit.

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.

7.5 Seismically Induced Landslides and Rock Falls

Seismically induced landslides and rock falls are common in areas of high seismicity near the earthquake source. Over 1,000 such landslides occurred during the 1971 San Fernando earthquake in the foothills of the San Gabriel Mountains above the San Fernando Valley (Morton, 1971). Other areas of high seismicity, such as Japan, also suffer much damage from earthquake-induced landslides. Since Santee is located far from any major active faults, the potential for landsliding caused by earthquakes is considered to be low.

7.6 Flooding From Dam Hazards

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 Harrit Dam (Lake Jennings).

The San Vicente Dam is a concrete gravity structure located approximately 3½ miles northeast of the City. The dam has a capacity of 90,200 acre-feet and was built in 1943 (County of San Diego, 1991). Studies conducted in 1981 found the dam to be capable of resisting seismic damage under the regional seismic regime. There are plans currently under way to increase the capacity of the reservoir and the height of the dam.

The El Capitan Dam is a hydraulically filled earth structure located approximately 9 miles east of Santee. It has a capacity of 116,450 acre-feet and was built in 1934. A seismic stability analysis, reviewed by the California Division of Safety of Dams, establishes the operating requirements for the dam to properly and safely operate the dam. The California Division of Mines and Geology *Special Publication 100, Planning Scenario for a Major Earthquake, San Diego–Tijuana Metropolitan Area,* considers downstream impacts should a failure of the El Capitan Dam occur.

The Chet Harrit Dam (Lake Jennings) is located approximately 3 miles east of Santee. It is an earth-fill dam. Lake Jennings which is retained by the dam has approximately 10,700 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. Maps prepared in the 1970s showing areas of inundation for the three dams located upstream of the City of Santee are on file at the County of San Diego. The inundation limits have been reproduced on Figure 3 (map pocket). The inundation maps for the El Capitan Dam and the San Vicente Dam were prepared on November 19, 1974 and were evaluated by the City of San Diego Utilities Engineering Department for the City of San Diego. The inundation map for the Chet Harrit Dam was prepared in approximately 1975 by the Tudor Engineering Company for the Helix Water District. No hazardous conditions, to the best of our knowledge, exist at any of the structures. Information concerning the safety of these dams, which is reviewed annually by the California Department of Water Resources, Division of Dam Safety, may be obtained from that department. In addition, a report entitled "General Dam Evacuation Plan for San Diego County" has been prepared by the County of San Diego Office of Disaster Preparedness.

7.7 Tsunamis and Seiches

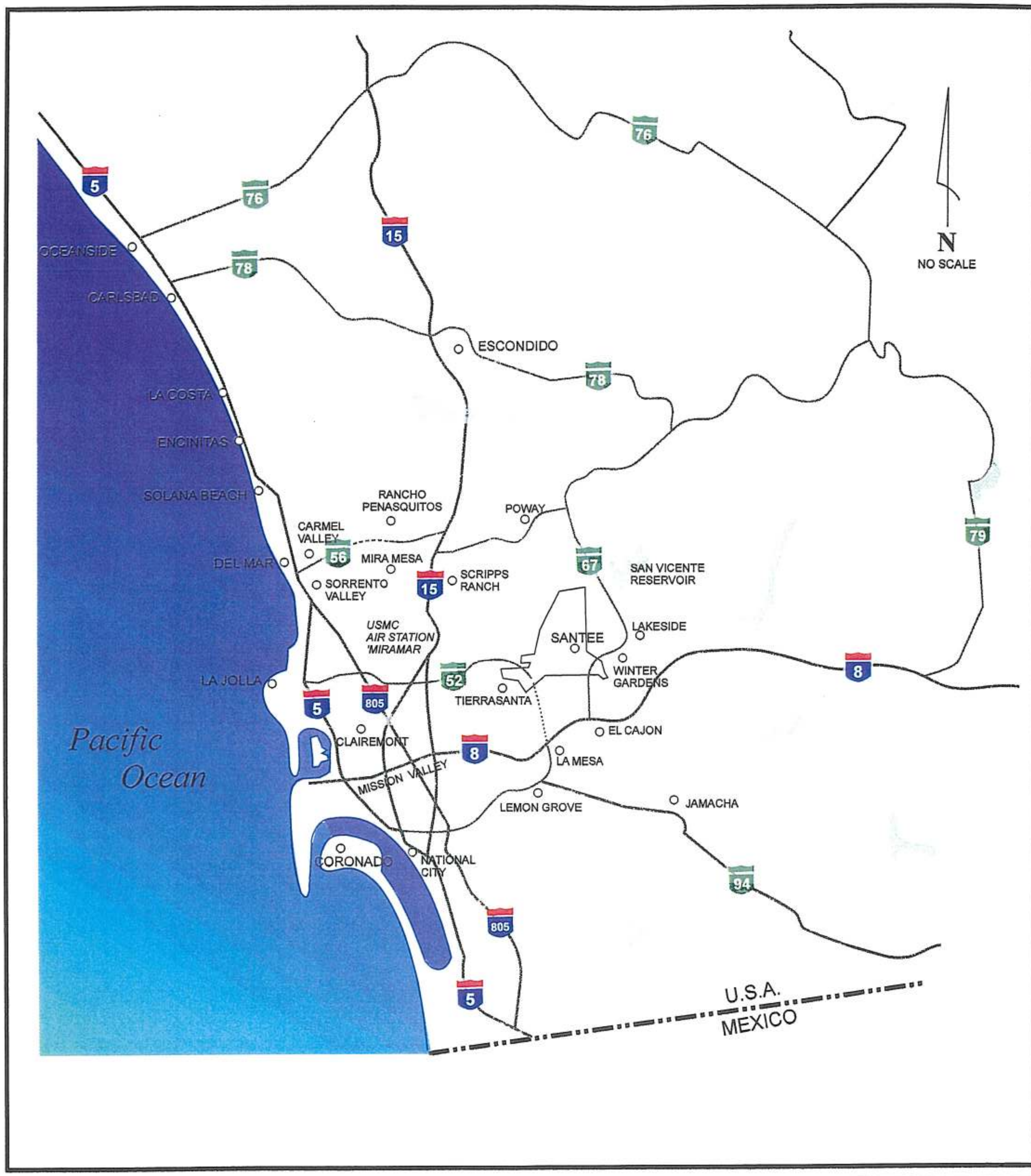
The site is not located near the ocean or adjacent to or downslope of any large bodies of water that could adversely affect the site in the event of earthquake-induced sea waves or seiches (wave oscillations in an enclosed or semi-enclosed body of water). The Santee Lakes are shallow detention ponds which do not pose a large hazard.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. The recommendations of this report pertain only to the site investigated and are based upon the assumption that the soil conditions do not deviate from those disclosed in the investigation. If any variations or undesirable conditions are encountered during construction, or if the proposed construction will differ from that anticipated herein, Geocon Incorporated should be notified so that supplemental recommendations can be given. 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 of his representative, to ensure that the information and recommendations contained herein are brought to the attention of the architect and engineer for the project and incorporated into the plans, and the necessary steps are taken to see that the contractor and subcontractors carry out such recommendations in the field.

3. The findings of this report are valid as of the present date. However, changes in the conditions of a property 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 three years.



GEOCON INCORPORATED
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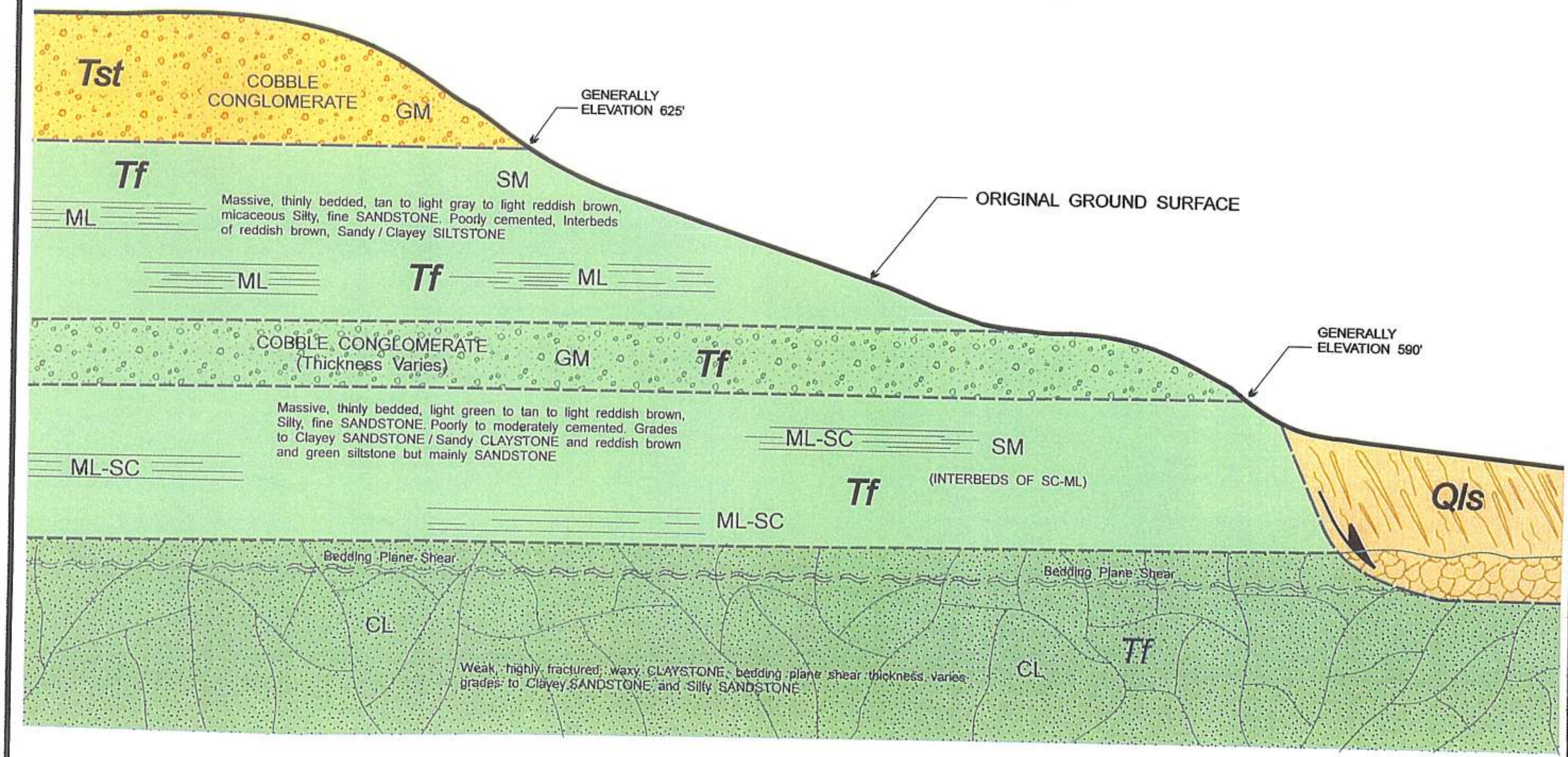
VICINITY MAP

GEOTECHNICAL / SEISMIC HAZARD STUDY
SANTEE, CALIFORNIA

MC / RSS		DSK / D000D	DATE 10 - 31 - 2002	PROJECT NO. 06828 - 32 - 01	FIG. 1

6828MC1

GEOTECHNICAL SEISMIC HAZARD STUDY



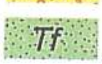
CHARACTERISTIC GEOLOGY OF NORTHERN SANTEE AREA

NO SCALE, CONCEPTUAL ONLY

LEGEND

......LANDSLIDE

......STADIUM CONGLOMERATE



......FRIARS FORMATION

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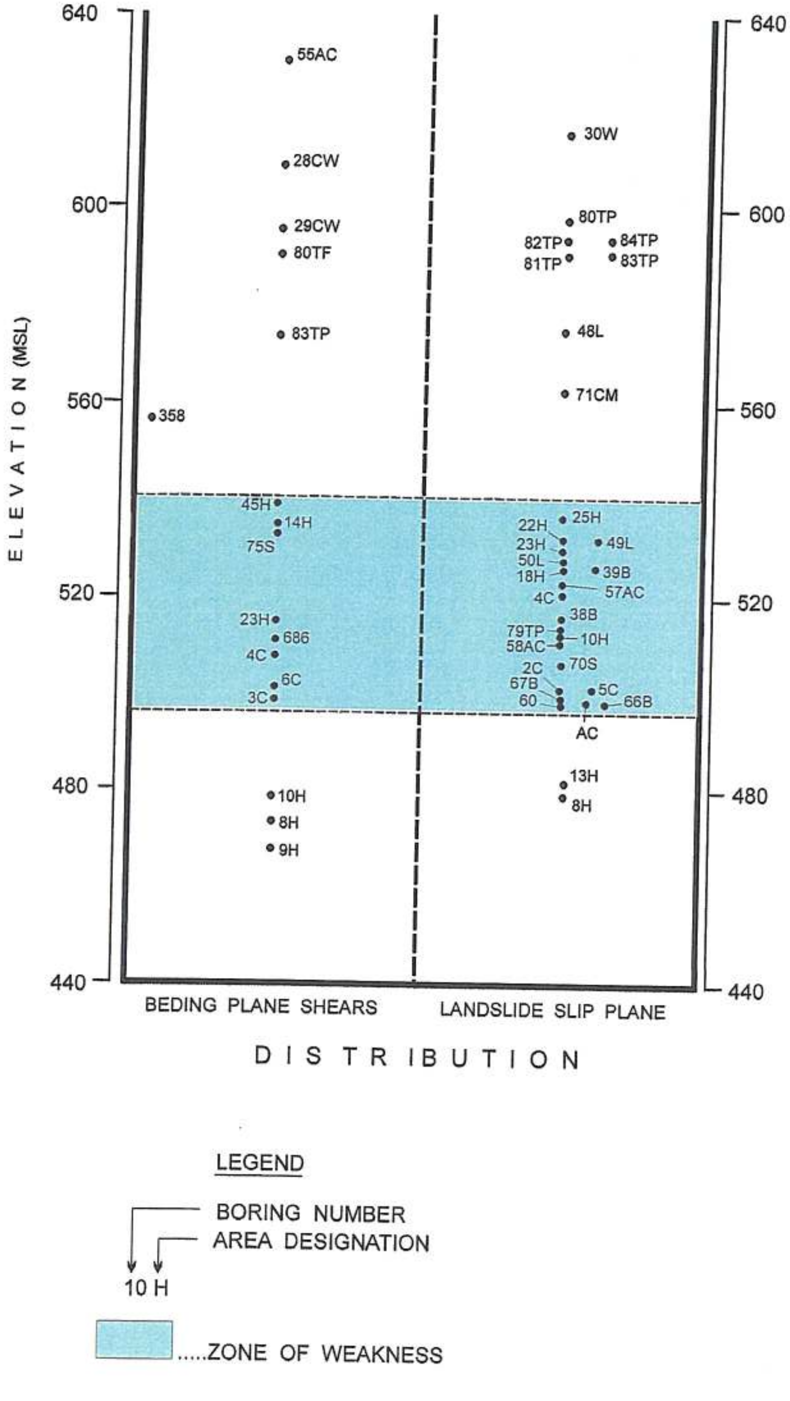
PROJECT NO. 06828 - 32 - 01
FIGURE 4
DATE 10 - 31 - 2002

6828MC / RSS



AREA DESIGNATION

AC.......AREA "C"
B.........BIRCHCREST BLVD.
CM......CUYAMACA STREET
C.........CHURCH SITE
CW......CECILWOOD DRIVE
G.........GANLEY ROAD
H.........HAIBERNS BLVD.
L.........LASO WAY
S.........STRATHMORE DRIVE
TP.......EAST SEWER TREATMENT PLANT

DISTRIBUTION OF BEDDING PLANE SHEARS AND LANDSLIDE SLIP PLANES IN FRIARS FORMATION

GEOCON INCORPORATED
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GEOTECHNICAL SEISMIC HAZARD STUDY
SANTEE, CALIFORNIA

KB / RSS		DSK / E0000	DATE 10 - 31 - 2002	PROJECT NO. 06828 - 32 - 01	FIG. 5

6828KB1B / RSS

APPENDIX A

APPENDIX A

TECHNICAL TABLES

TABLE A-1
DETERMINATION OF GEOTECHNICAL STUDIES REQUIRED

Stability Category	**Group I** Occupancy Category 1, Essential Facilities, Critical facilities including hospitals, fire and police facilities, power generating station, communication facilities, and dams. In addition, Occupancy Category 2, Hazardous Facilities including structures housing or supporting toxic or explosive chemicals or substances.	**Group II** Occupancy Category 3, Special Occupancy Structures including schools, churches, main road, large commercial and industrial structures, high-rises, and other high occupancy structures	**Group III** Occupancy Category 4, Residential, single-family homes, small apartments, motel, small commercial and industrial structures, and warehouses.	**Group IV** Relatively insensitive to geologic or seismic risk including golf courses, open spaces, parks, and landfill areas. Landfill areas may require detailed geologic study for environmental considerations.
Generally Stable Areas. Underlain by Granitic Rock or Gentle Slopes.	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Reconnaissance Seismic Hazard Study	Geotechnical Investigation Geologic Reconnaissance	Geologic Reconnaissance
Moderately Stable Areas. Underlain by Stadium Conglomerate.	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Reconnaissance	Geologic Reconnaissance
Generally Unstable Areas. Underlain by Friars Formation, Landslides or Debris Flows.	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geologic Reconnaissance
Potentially Liquefiable Areas. Possibly Underlain by Alluvium and a High Water Table.	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geotechnical Investigation Geologic Investigation Seismic Hazard Study	Geologic Reconnaissance

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, 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. • 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	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	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/s^2), 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

MAJOR DIVISIONS			AGE ESTIMATED IN MILLIONS OF YEARS	SOIL AND GEOLOGIC CONDITION
ERA	PERIOD	EPOCH		
CENOZOIC	QUATERNARY	HOLOCENE	0.01	**Surficial Deposits**
		PLEISTOCENE	**1.8**	**Terrace Deposits/Older Alluvium**
	TERTIARY	PLIOCENE	5.0	
		MIOCENE	22.5	
		OLIGOCENE	37.5	
		EOCENE	53.5	**Stadium Conglomerate Friars Formation**
		PALEOCENE	**65.0**	
MESOZOIC	CRETACEOUS	LATE/EARLY	136	**Granitic Rock**
	JURASSIC	LATE/MIDDLE/EARLY	195	**Santiago Peak Volcanics**
	TRIASSIC	LATE/MIDDLE/EARLY	**225**	
PALEOZOIC	PERMIAN	LATE/EARLY	280	
	PENNSYLVANIAN	LATE/MIDDLE/EARLY	320	
	MISSISSIPPIAN	LATE /EARLY	345	
	DEVONIAN	LATE/MIDDLE/EARLY	395	
	SILURIAN	LATE/MIDDLE/EARLY	435	
	ORDOVICIAN	LATE/MIDDLE/EARLY	500	
	CAMBRIAN	LATE/MIDDLE/EARLY	**570**	
PRECAMBRIAN Z			**800**	
PRECAMBRIAN Y			**1,600**	
PRECAMBRIAN X			**2,500**	
ARCHEAN				

APPENDIX B

APPENDIX B

LOCAL AND REGIONAL FAULTS

Four locations within the City of Santee were analyzed with the computer programs EQ FAULT and EQ SEARCH. These latitudes and longitude inputs are shown on Table B-1. Table B-2 shows the cumulative numbers of earthquakes with magnitude above 4.0 within a 50 miles radius of the City of Santee. Table B-3 shows the site parameters for the active faults within 100 miles of Santee. Table B-4 shows the estimated peak acceleration that the City of Santee experienced from 1800 to 2000. The following parameter and output for EQ FAULT and EQ SEARCH are shown below.

TABLE B-1
SITE COORDINATES

	West	East	North	South
Site Latitude	32.8370	32.8531	32.8996	32.8318
Site Longitude	117.0356	116.9460	116.9685	116.9884

EQ FAULT Version 3.00: DETERMINISTIC ESTIMATION OF PEAK ACCELERATION FROM DIGITIZED FAULTS
CALCULATION NAME: TEST RUN ANALYSIS FAULT-DATA-FILE NAME: CDMGGI.DAT
SEARCH RADIUS: 100 mi ATTENUATION RELATION: 20) Sadigh, *et al.*, (1997) Horizontal – Soil
UNCERTAINTY (M = Median, S = Sigma): M Number of Sigmas: 0.0
DISTANCE MEASURE: clodis SCOND: 0
BASEMENT DEPTH: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION
FAULT-DATA FILE USED: CDMGGI.DAT MINIMUM DEPTH VALUE (km): 0.0
END OF SEARCH- 39 FAULTS FOUND WITHIN THE SPECIFIED SEARCH RADIUS.
THE ROSE CANYON FAULT ZONE FAULT IS CLOSEST TO THE SITE.
IT IS ABOUT 10.3 MILES (16.6 km) AWAY.
LARGEST MAXIMUM–EARTHQUAKE SITE ACCELERATION: 0.2261 g.

EQ SEARCH VERSION 3.00: ESTIMATION OF PEAK ACCELERATION FROM CALIFORNIA EARTHQUAKE CATALOGS
EARTHQUAKE-CATALOG-FILE NAME: ALLQUAKE.DAT
SEARCH DATES: START DATE: 1800, END DATE: 2000, SEARCH RADIUS: 50.0 mi (80.5 km)
ATTENUATION RELATION: 20) Sadigh, *et al.,* (1997) Horizontal – Soil
UNCERTAINTY (M=Median, S=Sigma): M = Number of Sigmas: 0.0
ASSUMED SOURCE TYPE: DS (SS=Strike-slip, DS=Reverse-slip, BT=Blind-thrust)
SCOND: 0 Depth Source: A Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION MINIMUM DEPTH VALUE (km): 0.0
TIME PERIOD OF SEARCH: 1800 TO 2000 LENGTH OF SEARCH TIME: 201 years
THE EARTHQUAKE CLOSEST TO THE SITE IS ABOUT 4.5 MILES (7.3 km) AWAY.
LARGEST EARTHQUAKE MAGNITUDE FOUND IN THE SEARCH RADIUS: 6.7
LARGEST EARTHQUAKE SITE ACCELERATION FROM THIS SEARCH: 0.158 g
COEFFICIENTS FOR GUTENBERG & RICHTER RECURRENCE RELATION:
A-Value = 2.953 -3.249, B-Value= 0.809 – 0.888, Beta-Value= 1.863 – 2.044

TABLE B-2
TABLE OF MAGNITUDES AND EXCEEDANCES

Earthquake Magnitude	Number of Times Exceeded	Cumulative Number Per Year
4.0	159	0.79104
4.5	47	0.23383
5.0	18	0.08552
5.5	7	0.03483
6.0	3	0.01493
6.5	2	0.00995

TABLE B-3
DETERMINISTIC SITE PARAMETERS FOR SELECTED ACTIVE FAULTS

Fault Name	Distance From Site in Miles (km)	Estimated Maximum Magnitude (Mw)	Peak Site Acceleration (g)	Est. Site Intensity Modified Mercalli
Rose Canyon Fault Zone	10.3 (16.6)	6.9	0.226	IX
Coronado Bank	23.3 (37.5)	7.4	0.146	VIII
Elsinore–Julian	24.8 (39.9)	7.1	0.115	VII
Earthquake Valley	29.7 (47.8)	6.5	0.062	VI
Newport–Inglewood (Offshore)	31.8 (51.1)	6.9	0.077	VII
Elsinore–Temecula	33.1 (53.2)	6.8	0.068	VI
Elsinore–Coyote Mountain	34.8 (56.0)	6.8	0.064	VI
San Jacinto–Coyote Creek	46.2 (74.4)	6.8	0.044	VI
San Jacinto–Anza	47.1 (75.8)	7.2	0.059	VI
San Jacinto–Borrego	49.5 (79.7)	6.6	0.034	V
Elsinore–Glen Ivy	55.9 (89.9)	6.8	0.034	V
San Jacinto–San Jacinto Valley	58.2 (93.6)	6.9	0.035	V
Superstition Mtn. (San Jacinto)	60.2 (96.9)	6.6	0.026	V
Palos Verdes	60.8 (97.9)	7.1	0.039	V
Laguna Salada	62.4 (100.4)	7.0	0.035	V
Elmore Ranch	64.6 (103.9)	6.6	0.024	IV
Superstition Hills (San Jacinto)	65.2 (105.0)	6.6	0.023	IV
Chino-Central Ave. (Elsinore)	72.8 (117.2)	6.7	0.028	V
San Andreas–Coachella	73.2 (117.8)	7.1	0.030	V

TABLE B-3 (Continued)
DETERMINISTIC SITE PARAMETERS FOR SELECTED ACTIVE FAULTS

Fault Name	Distance From Site in Miles (km)	Estimated Maximum Magnitude (Mw)	Peak Site Acceleration (g)	Est. Site Intensity Modified Mercalli
San Andreas – Southern	73.2 (117.8)	7.4	0.038	V
Newport-Inglewood (L.A. Basin)	73.9 (118.9)	6.9	0.025	V
San Andreas–San Bernardino	75.4 (121.4)	7.3	0.034	V
Whittier	76.5 (123.1)	6.8	0.022	IV
San Jacinto-San Bernardino	78.8 (126.8)	6.7	0.019	IV
Brawley Seismic Zone	79.5 (127.9)	6.4	0.015	IV
Burnt Mtn.	80.0 (128.7)	6.4	0.014	IV
Pinto Mountain	81.3 (130.8)	7.0	0.024	IV
Imperial	80.2 (129.0)	7.0	0.024	V
Eureka Peak	82.4 (132.6)	6.4	0.014	IV
Compton Thrust	83.6 (134.6)	6.8	0.025	V
Elysian Park Thrust	85.7 (138.0)	6.7	0.022	IV
North Frontal Fault Zone (East)	92.2 (148.4)	6.7	0.020	IV
Cucamonga	92.8 (149.3)	7.0	0.025	V
Landers	93.0 (149.6)	7.3	0.025	V
San Jose	93.0 (149.7)	6.5	0.016	IV
North Frontal Fault Zone (West)	93.3 (150.2)	7.0	0.025	V
Sierra Madre	95.6 (153.9)	7.0	0.024	V
Cleghorn	96.4 (155.2)	6.5	0.012	III
Emerson So.–Copper Mtn.	98.2 (158.0)	6.9	0.017	IV

TABLE B-4
ESTIMATION OF PEAK ACCELERATION FROM CALIFORNIA EARTHQUAKE CATALOGS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
MGI	32.8000	117.1000	05/25/1803	0 0 0.0	0.0	5.00	0.158	VIII	4.5(7.3)
DMG	33.0000	117.0000	03/03/1906	2025 0.0	0.0	4.50	0.076	VII	7.2(11.5)
MGI	33.0000	117.0000	09/21/1856	730 0.0	0.0	5.00	0.111	VII	7.2(11.5)
MGI	33.0000	117.0000	12/29/1914	10 0 0.0	0.0	4.00	0.052	VI	7.2(11.5)
DMG	32.8000	116.8000	10/23/1894	23 3 0.0	0.0	5.70	0.148	VIII	9.2(14.8)
MGI	32.8000	116.8000	08/14/1927	1448 0.0	0.0	4.60	0.064	VI	9.2(14.8)
PAS	32.6790	117.1510	06/18/1985	32228.7	5.7	4.00	0.027	V	12.8(20.6)
DMG	32.7000	117.2000	05/27/1862	20 0 0.0	0.0	5.90	0.121	VII	13.4(21.6)
MGI	32.7000	117.2000	05/20/1920	1330 0.0	0.0	4.00	0.025	V	13.4(21.6)
MGI	32.7000	117.2000	04/19/1906	028 0.0	0.0	4.30	0.033	V	13.4(21.6)
MGI	32.7000	117.2000	09/08/1915	742 0.0	0.0	4.00	0.025	V	13.4(21.6)
T-A	32.6700	117.1700	12/00/1856	0 0 0.0	0.0	5.00	0.056	VI	13.9(22.4)
T-A	32.6700	117.1700	05/24/1865	0 0 0.0	0.0	5.00	0.056	VI	13.9(22.4)
T-A	32.6700	117.1700	01/25/1863	1020 0.0	0.0	4.30	0.031	V	13.9(22.4)
T-A	32.6700	117.1700	10/21/1862	0 0 0.0	0.0	5.00	0.056	VI	13.9(22.4)
T-A	32.6700	117.1700	04/15/1865	840 0.0	0.0	4.30	0.031	V	13.9(22.4)
GSP	33.0700	116.8000	12/04/1991	071057.5	15.0	4.20	0.026	V	15.3(24.6)
MGI	33.1000	116.8000	06/22/1918	557 0.0	0.0	4.00	0.019	IV	16.9(27.2)
PAS	32.6150	117.1520	10/29/1986	23815.3	14.6	4.10	0.021	IV	16.7(27.0)
MGI	32.7000	116.7000	03/21/1918	2325 0.0	0.0	4.00	0.018	IV	17.8(28.6)
DMG	33.0000	117.3000	11/22/1800	2130 0.0	0.0	6.50	0.135	VIII	19.0(30.6)
MGI	33.2000	117.0000	07/20/1923	7 0 0.0	0.0	4.00	0.014	IV	20.8(33.5)
MGI	33.0000	116.6000	06/11/1917	354 0.0	0.0	4.00	0.013	III	22.4(36.1)
DMG	33.1000	116.6330	02/08/1952	174028.0	0.0	4.00	0.012	III	23.8(38.4)
PAS	32.6270	117.3770	06/29/1983	8 836.4	5.0	4.60	0.019	IV	24.6(39.5)
DMG	33.2000	116.7200	05/12/1930	172548.5	0.0	4.20	0.013	III	25.2(40.6)
MGI	33.1000	116.6000	08/10/1921	2151 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	05/11/1915	1145 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	08/10/1921	19 6 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	02/05/1922	1915 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	02/09/1920	220 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	05/28/1917	1017 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	08/19/1917	710 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	03/04/1915	1250 0.0	0.0	4.00	0.011	III	25.4(40.9)
MGI	33.1000	116.6000	02/16/1915	1330 0.0	0.0	4.00	0.011	III	25.4(40.9)
DMG	33.2670	117.0170	06/07/1935	1633 0.0	0.0	4.00	0.011	III	25.5(41.1)
DMG	33.2000	116.7000	01/01/1920	235 0.0	0.0	5.00	0.026	V	25.9(41.7)
DMG	32.8500	117.4830	02/23/1943	92112.0	0.0	4.00	0.010	III	26.0(41.8)
DMG	33.1500	116.5830	12/02/1935	319 0.0	0.0	4.00	0.009	III	28.2(45.4)
DMG	33.1100	116.5230	01/24/1957	205449.9	3.9	4.60	0.015	IV	29.6(47.6)
MGI	33.2000	116.6000	10/12/1920	1748 0.0	0.0	5.30	0.028	V	29.7(47.9)
MGI	32.6000	116.5000	05/03/1918	425 0.0	0.0	4.00	0.008	III	31.2(50.3)
DMG	33.0020	116.4360	07/02/1957	65638.5	12.8	4.10	0.009	III	31.3(50.4)
DMG	33.0000	116.4330	06/04/1940	1035 8.3	0.0	5.10	0.022	IV	31.4(50.5)
PAS	33.1380	116.5010	10/10/1984	212258.9	11.6	4.50	0.012	III	31.7(51.0)
DMG	33.1670	116.5000	06/23/1932	23037.1	0.0	4.00	0.007	II	32.8(52.8)
DMG	33.1670	116.5000	06/23/1932	22552.7	0.0	4.00	0.007	II	32.8(52.8)
DMG	33.1000	116.4500	11/23/1953	1339 7.0	0.0	4.30	0.010	III	33.1(53.2)
DMG	33.0970	116.4440	08/18/1959	215221.3	17.3	4.30	0.010	III	33.3(53.6)
DMG	32.9670	116.3830	10/31/1942	15 758.0	0.0	4.00	0.007	II	33.6(54.0)
DMG	33.1670	116.4670	08/01/1960	193930.0	0.0	4.20	0.008	III	34.4(55.4)
DMG	33.1170	116.4170	06/04/1940	103656.0	0.0	4.00	0.007	II	35.3(56.8)
DMG	33.1170	116.4170	10/21/1940	64933.0	0.0	4.50	0.011	III	35.3(56.8)
GSP	33.1100	116.4000	04/01/1984	071702.3	11.0	4.00	0.006	II	36.0(57.9)
DMG	33.0380	116.3610	02/26/1957	211652.2	0.0	4.10	0.007	II	36.2(58.3)

TABLE B-4 (Continued)
ESTIMATION OF PEAK ACCELERATION FROM CALIFORNIA EARTHQUAKE CATALOGS

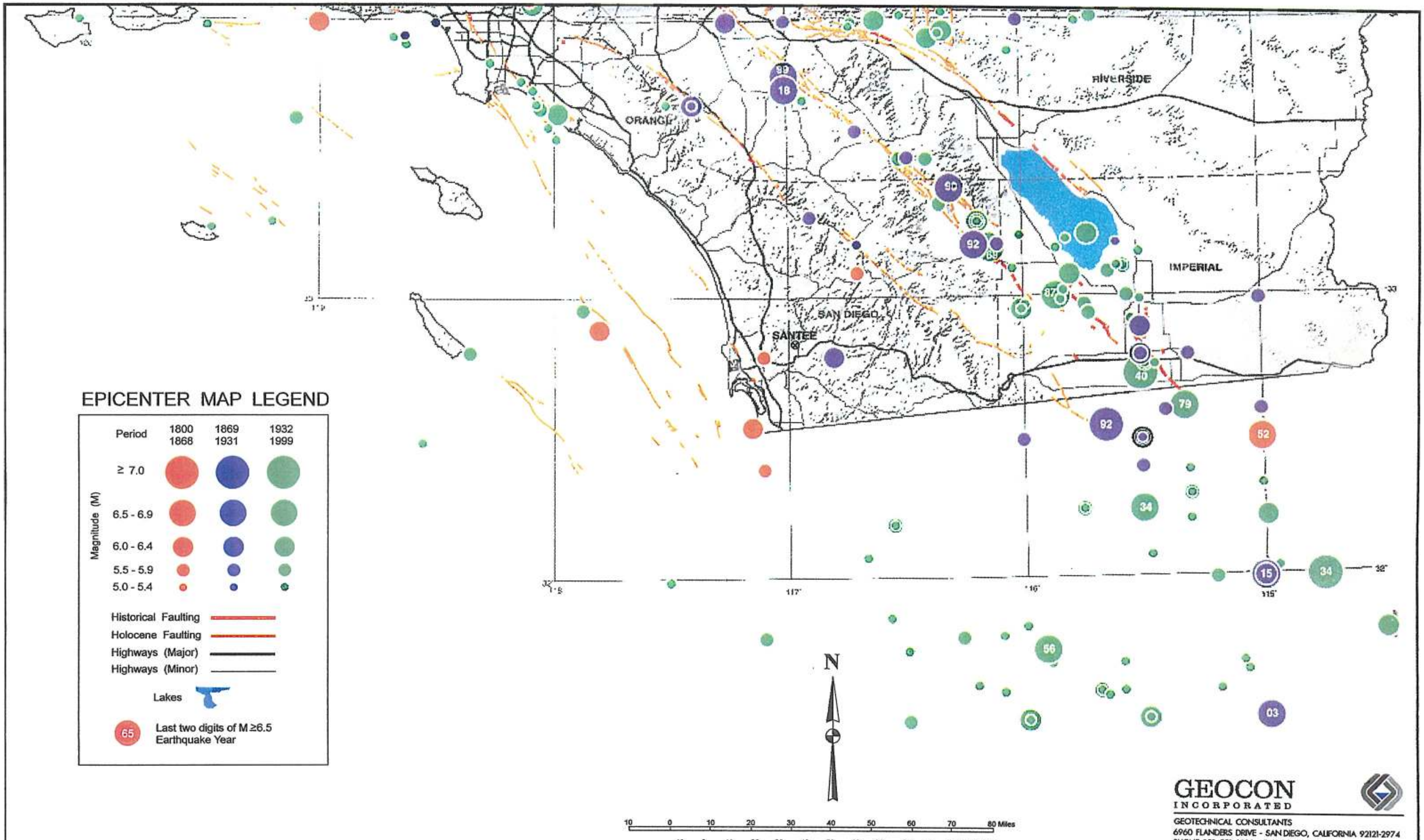
FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
DMG	33.1670	116.4170	10/14/1935	1550 0.0	0.0	4.00	0.006	II	36.9(59.3)
DMG	33.1670	116.4170	07/10/1938	18 6 0.0	0.0	4.00	0.006	II	36.9(59.3)
DMG	33.1670	116.4170	12/05/1939	173352.0	0.0	4.00	0.006	II	36.9(59.3)
DMG	33.4540	116.8980	07/29/1936	142252.8	10.0	4.00	0.006	II	38.5(61.9)
DMG	33.4560	116.8960	06/16/1938	55916.9	10.0	4.00	0.006	II	38.6(62.2)
DMG	32.6800	116.3540	01/21/1970	1124 0.4	8.0	4.10	0.007	II	36.4(58.6)
DMG	33.1210	116.3490	05/25/1971	10 252.9	8.0	4.10	0.006	II	39.0(62.7)
DMG	33.1830	116.3830	10/14/1949	02925.0	0.0	4.10	0.006	II	39.1(63.0)
PAS	33.4200	116.6980	06/05/1978	16 3 3.9	11.9	4.40	0.008	III	39.2(63.1)
DMG	32.9610	116.2900	08/25/1971	23 033.0	8.0	4.00	0.006	II	38.7(62.4)
DMG	33.0530	116.3060	04/02/1967	201538.6	1.0	4.30	0.007	II	39.6(63.7)
DMG	32.9520	116.2790	09/13/1973	173039.8	8.0	4.80	0.012	III	39.3(63.2)
DMG	32.9230	116.2720	10/14/1969	131842.7	10.0	4.50	0.009	III	39.4(63.4)
PAS	32.9050	116.2610	12/25/1975	71852.3	3.6	4.00	0.006	II	39.9(64.2)
DMG	32.9900	116.2680	11/08/1958	132044.1	2.4	4.10	0.006	II	40.4(65.0)
DMG	32.7000	116.3000	02/24/1892	720 0.0	0.0	6.70	0.066	VI	39.0(62.7)
DMG	33.4500	116.6830	04/25/1955	25515.0	0.0	4.00	0.005	II	41.4(66.7)
DMG	33.5000	117.0000	08/08/1925	1013 0.0	0.0	4.50	0.008	III	41.5(66.8)
DMG	33.2670	116.4000	06/06/1940	2321 4.0	0.0	4.00	0.005	II	41.5(66.8)
DMG	33.5000	116.9170	11/04/1935	355 0.0	0.0	4.50	0.008	III	41.6(66.9)
PAS	32.3020	116.8810	08/19/1978	931 5.7	19.8	4.10	0.007	II	37.1(59.7)
DMG	32.6000	116.3170	06/15/1946	194653.0	0.0	4.80	0.011	III	40.5(65.2)
DMG	32.9500	116.2500	11/14/1951	2355 3.0	0.0	4.10	0.006	II	40.9(65.8)
DMG	33.4000	116.5670	02/04/1953	43616.0	0.0	4.30	0.007	II	41.6(67.0)
T-A	33.5000	117.0700	12/29/1880	7 0 0.0	0.0	4.30	0.007	II	41.9(67.4)
DMG	33.4880	116.7770	06/12/1959	11 313.0	5.7	4.00	0.005	II	42.1(67.8)
DMG	33.0430	116.2600	08/22/1961	231933.6	12.1	4.40	0.008	II	41.8(67.3)
MGI	33.5000	116.8000	11/26/1916	17 5 0.0	0.0	4.00	0.005	II	42.6(68.5)
MGI	33.5000	116.8000	05/31/1917	435 0.0	0.0	4.00	0.005	II	42.6(68.5)
MGI	33.5000	116.8000	03/30/1918	16 5 0.0	0.0	4.60	0.009	III	42.6(68.5)
MGI	33.5000	116.8000	06/02/1917	435 0.0	0.0	4.00	0.005	II	42.6(68.5)
DMG	33.4170	116.5670	12/22/1950	2 536.0	0.0	4.00	0.005	II	42.6(68.5)
DMG	33.3330	116.4330	02/12/1954	94428.0	0.0	4.50	0.008	III	43.1(69.3)
DMG	33.4830	116.7000	12/28/1948	125341.0	0.0	4.00	0.005	II	43.2(69.5)
DMG	33.0500	116.2380	08/23/1961	1 047.8	11.9	4.70	0.010	III	43.2(69.5)
DMG	33.0330	116.2330	09/20/1961	5 410.0	0.0	4.00	0.005	II	43.1(69.4)
DMG	33.4670	116.6330	02/20/1934	1035 0.0	0.0	4.00	0.005	II	43.7(70.3)
DMG	33.0190	116.2250	08/20/1969	152957.2	0.6	4.00	0.005	II	43.3(69.7)
DMG	33.2000	116.3000	05/12/1930	414 0.0	0.0	4.00	0.005	II	43.9(70.6)
DMG	33.4000	116.5000	10/11/1918	4 0 0.0	0.0	4.00	0.005	II	43.9(70.6)
DMG	33.0210	116.2230	01/13/1963	23938.9	13.0	4.20	0.006	II	43.5(69.9)
DMG	33.3680	116.4440	03/25/1937	232026.7	10.0	4.00	0.005	II	44.3(71.3)
DMG	33.2830	116.3500	04/13/1949	75336.0	0.0	4.10	0.005	II	44.5(71.6)
PAS	32.9470	117.7360	01/15/1989	153955.2	6.0	4.20	0.006	II	41.3(66.5)
DMG	32.8170	116.2000	11/22/1953	81138.0	0.0	4.10	0.005	II	43.3(69.8)
DMG	33.4670	116.5830	03/26/1937	2124 0.0	0.0	4.00	0.005	II	45.1(72.5)
DMG	33.4670	116.5830	01/04/1938	029 0.0	0.0	4.50	0.007	II	45.1(72.5)
DMG	33.4670	116.5830	03/27/1937	528 0.0	0.0	4.00	0.005	II	45.1(72.5)
DMG	33.4670	116.5830	03/27/1937	742 0.0	0.0	4.50	0.007	II	45.1(72.5)
MGI	32.8000	116.2000	07/23/1929	1155 0.0	0.0	4.30	0.006	II	43.4(69.9)
PAS	33.0580	116.2110	03/22/1982	85328.6	4.6	4.50	0.007	II	44.9(72.2)
DMG	33.4200	116.4900	03/29/1937	17 316.8	10.0	4.00	0.005	II	45.3(73.0)
DMG	33.5080	116.6310	08/11/1967	05711.4	10.7	4.10	0.005	II	46.3(74.5)
GSP	32.8220	116.1750	05/24/1992	122225.8	12.0	4.10	0.005	II	44.8(72.1)
DMG	33.2910	116.3170	03/19/1966	142156.0	10.9	4.00	0.004	I	46.4(74.6)
DMG	33.2350	116.2660	04/09/1968	93833.0	5.2	4.00	0.004	I	46.8(75.3)
DMG	33.3430	116.3460	04/28/1969	232042.9	20.0	5.80	0.023	IV	47.3(76.0)

TABLE B-4 (Continued)
ESTIMATION OF PEAK ACCELERATION FROM CALIFORNIA EARTHQUAKE CATALOGS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
DMG	33.2000	116.2330	04/05/1942	92039.0	0.0	4.00	0.004	I	47.3(76.2)
DMG	33.5060	116.5850	05/21/1967	144234.4	19.4	4.70	0.008	III	47.4(76.2)
DMG	33.3000	116.3000	01/04/1940	8 711.0	0.0	4.00	0.004	I	47.5(76.5)
DMG	32.9500	116.1500	10/25/1942	185939.0	0.0	4.00	0.004	I	46.6(75.0)
DMG	33.5330	116.6330	09/21/1942	7 754.0	0.0	4.00	0.004	I	47.8(77.0)
DMG	33.4170	116.4170	01/02/1943	141118.0	0.0	4.50	0.007	II	47.9(77.0)
DMG	33.3150	116.3050	04/09/1968	1831 3.8	12.6	4.70	0.008	III	47.9(77.1)
PAS	33.4840	116.5130	08/11/1976	152455.5	15.4	4.30	0.006	II	48.2(77.5)
DMG	33.4260	116.4210	03/25/1937	20 4 8.3	10.0	4.00	0.004	I	48.2(77.5)
DMG	33.4830	116.5000	02/15/1951	104759.0	0.0	4.80	0.009	III	48.5(78.1)
DMG	33.4830	116.5000	02/15/1951	104957.0	0.0	4.80	0.009	III	48.5(78.1)
PAS	32.9700	117.8030	07/14/1986	03246.2	10.0	4.00	0.004	I	48.6(78.2)
PAS	32.9450	117.8060	09/07/1984	11 313.4	6.0	4.30	0.006	II	45.3(72.9)
DMG	32.3330	116.4670	01/13/1935	224 0.0	0.0	4.00	0.005	II	45.4(73.1)
GSP	32.9700	117.8100	04/04/1990	085439.3	6.0	4.00	0.005	I	45.8(73.7)
DMG	32.8000	117.8330	01/24/1942	214148.0	0.0	4.00	0.004	I	46.3(74.6)
PAS	32.9450	117.8310	07/29/1986	81741.8	10.0	4.10	0.005	II	46.7(75.2)
DMG	32.7170	117.8330	11/06/1950	205546.0	0.0	4.40	0.006	II	47.0(75.7)
PAS	32.9330	117.8410	07/29/1986	81741.6	10.0	4.30	0.006	II	47.2(75.9)
DMG	32.5830	117.8000	04/19/1939	741 0.0	0.0	4.50	0.007	II	47.7(76.8)
PAS	32.9860	117.8440	10/01/1986	201218.6	6.0	4.00	0.004	I	48.0(77.2)
DMG	32.8940	116.1190	09/16/1961	194939.4	18.5	4.40	0.006	II	48.0(77.3)
PAS	32.9900	117.8490	07/13/1986	14 133.0	12.0	4.60	0.007	II	48.3(77.7)
T-A	32.2500	117.5000	01/13/1877	20 0 0.0	0.0	5.00	0.011	III	48.7(78.4)
GSP	32.5880	116.1670	03/13/1999	133120.4	6.0	4.30	0.005	II	48.8(78.5)
GSP	32.5920	116.1650	02/19/1999	030832.2	3.0	4.20	0.005	II	48.8(78.6)
GSP	32.5930	116.1630	04/07/1999	062640.1	8.0	4.00	0.004	I	48.9(78.7)
PAS	33.5580	116.6670	06/15/1982	234921.3	12.2	4.80	0.009	III	48.7(78.3)
DMG	33.3330	116.3000	08/06/1933	332 0.0	0.0	4.70	0.008	II	48.9(78.7)
DMG	33.3330	116.3000	08/05/1933	2331 0.0	0.0	4.40	0.006	II	48.9(78.7)
PAS	33.5200	116.5580	08/02/1975	014 7.7	13.4	4.70	0.008	II	49.0(78.8)
DMG	33.2000	116.2000	05/28/1892	1115 0.0	0.0	6.30	0.034	V	49.1(79.0)
PAS	33.5010	116.5130	02/25/1980	104738.5	13.6	5.50	0.017	IV	49.2(79.1)
DMG	33.2790	116.2490	01/07/1966	191023.0	-1.7	4.00	0.004	I	49.2(79.1)
PAS	33.4580	116.4340	02/12/1979	44842.3	3.9	4.20	0.005	II	49.4(79.5)
GSP	33.3990	116.3540	07/26/1997	031456.0	11.0	4.80	0.009	III	49.5(79.7)
DMG	33.5000	116.5000	09/30/1916	211 0.0	0.0	5.00	0.010	III	49.5(79.7)
GSP	32.9850	117.8180	06/21/1995	211736.2	6.0	4.30	0.006	II	46.5(74.8)
DMG	33.5340	116.5610	09/23/1956	112441.9	12.2	4.30	0.005	II	49.7(80.0)
USG	33.0170	117.8170	07/16/1986	1247 3.7	10.0	4.11	0.004	I	49.7(80.0)
USG	33.0170	117.8170	07/14/1986	11112.6	10.0	4.12	0.005	II	47.0(75.6)
DMG	33.4670	116.4330	05/12/1939	1925 2.2	0.0	4.50	0.006	II	49.9(80.3)
DMG	33.1670	116.1670	11/16/1937	1057 0.0	0.0	4.00	0.004	I	49.9(80.3)
GSP	32.5870	116.1630	04/18/1999	155301.1	7.0	4.20	0.005	II	49.1(78.9)
PAS	32.9710	117.8700	07/13/1986	1347 8.2	6.0	5.30	0.014	III	49.2(79.2)
DMG	32.5330	116.1830	11/12/1939	1849 0.0	0.0	4.00	0.004	I	49.5(79.7)
DMG	32.5330	116.1830	02/22/1939	1030 0.0	0.0	4.00	0.004	I	49.5(79.7)

****

-END OF SEARCH- 159 EARTHQUAKES FOUND WITHIN THE SPECIFIED SEARCH AREA.



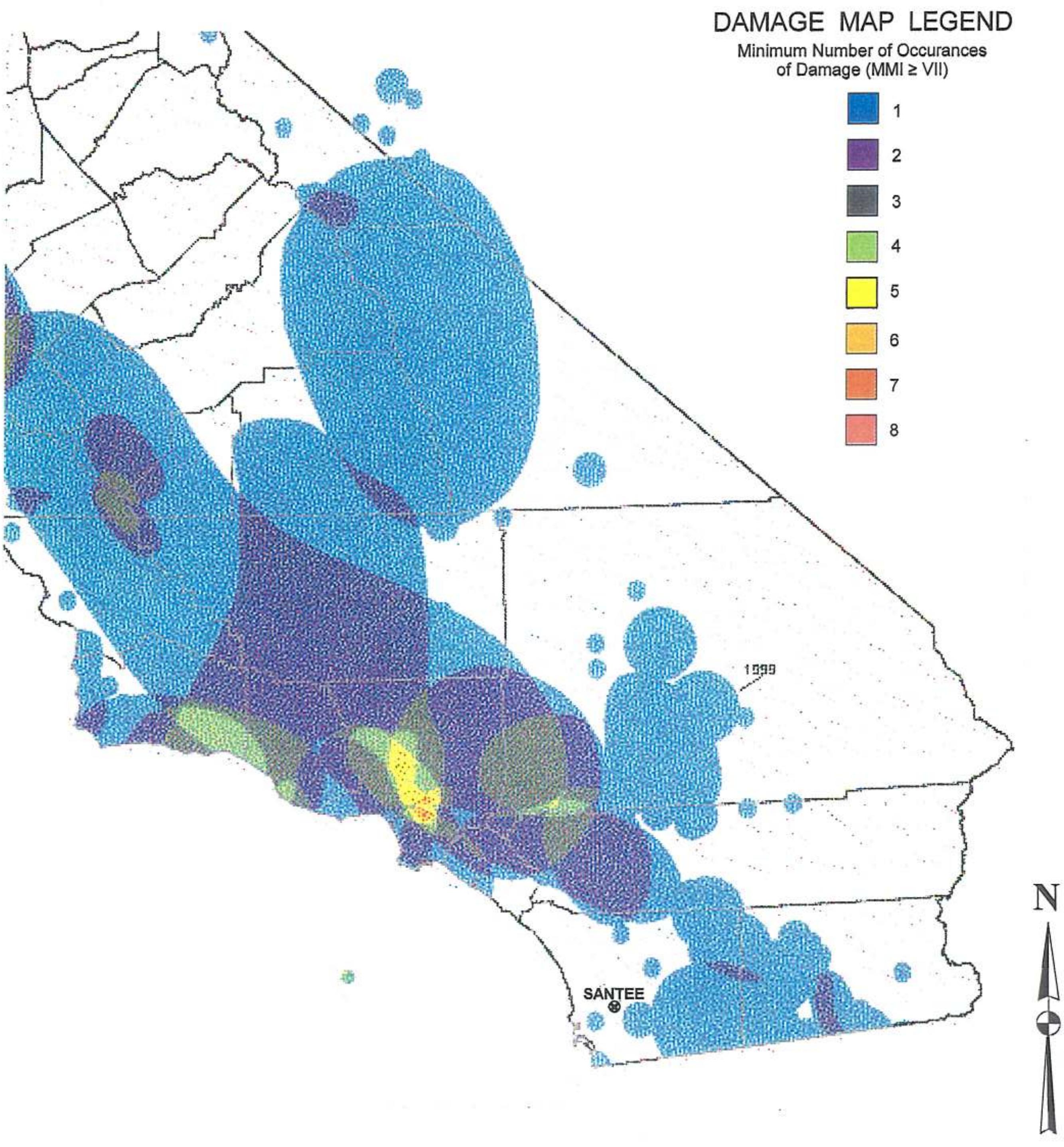
SOURCE : CDMG MAP SHEET 49, 2000

EPICENTERS OF M ≥ 5 CALIFORNIA EARTHQUAKES, 1800 - 1999

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

PROJECT NO. 06828 - 32 - 01
FIGURE B1
DATE 10 - 31 - 2002

6828KB1 / RSS



SOURCE : CDMG MAP SHEET 49, 2000

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AREAS DAMAGE BY M ≥ 5 CALIFORNIA EARTHQUAKES 1800 - 1999

KB / RSS		DSK / D000D	DATE 10 - 31 - 2002	PROJECT NO. 06828 - 32 - 01	FIG. B2

6828KB2 / RSS

APPENDIX C

APPENDIX C

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.
Boulder	A detached rounded rock that is larger than ten 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.
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	Uncemented pebbles.
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 B)
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 D

APPENDIX D

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