Appendix G-a Geological Background Technical Report

Appendices

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May 2020

GEOLOGICAL BACKGROUND TECHNICAL REPORT FOR THE GENERAL PLAN UPDATE

City of Santa Ana

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PLACEWORKS

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1.1 INTRODUCTION

Ensuring public safety is a fundamental goal for any municipality, including Santa Ana. All the benefits and public goods that Santa Ana residents and businesses enjoy are difficult to achieve when health and safety could be compromised. Potential risks to health, life, and property involve man-made and natural hazards. Santa Ana, like much of southern California, is subject to many geologic hazards.

To provide a foundation for the goals, policies, and programs for the General Plan update and the environmental setting for the Environmental Impact Report, this report explores the various geologic hazards in Santa Ana. The key objective is to identify and evaluate geologic hazards that can impact the health, safety, and social well-being of a community.

This report includes an overview of the following hazards in Santa Ana:

» Seismic and geologic hazards, including surface or nonsurface rupture, shaking, liquefaction, landslides, soil hazards, and other similar hazards.

Data and information for this chapter were compiled from a wide variety of state and federal agencies. State agencies include the California Department of Conservation, California Geological Survey, Office of Emergency Services, Department of Water Resources, and others. Federal resources include the Federal Emergency Management Agency, among several others. The analysis contained herein relies on secondary research; no fieldwork was conducted.

1. Introduction

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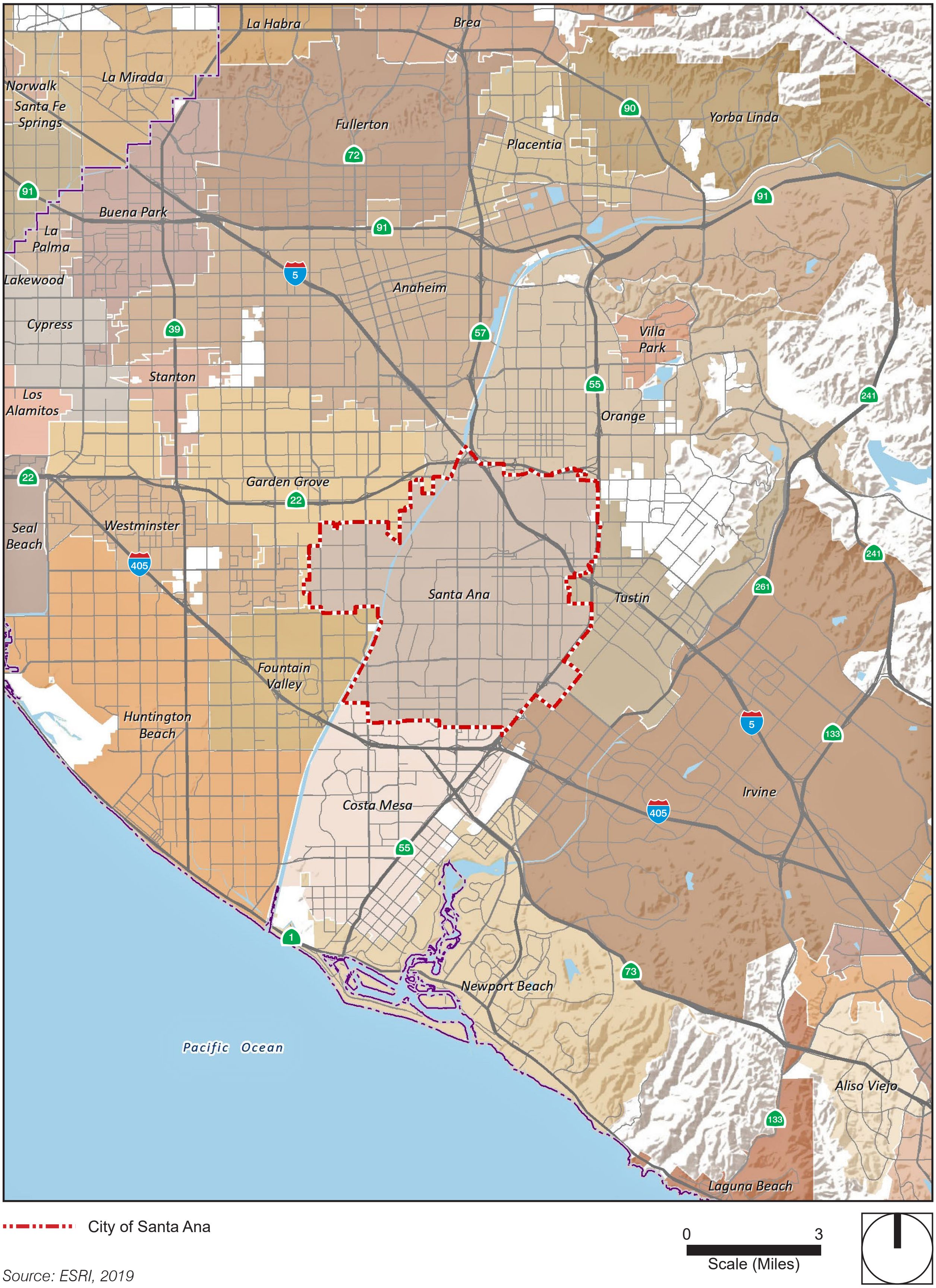
Figure 1 - Regional Location



Source: ESRI, 2019

1. Introduction

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2. Geologic and Seismic Hazards

This section describes the geologic and seismic hazards in Santa Ana, including the various state and local regulations affecting these hazards and then detailing specific geologic and seismic hazards present in Santa Ana.

2.1 REGULATORY FRAMEWORK

Santa Ana's regulatory framework for geologic and seismic hazards includes state law, the general plan, and municipal code requirements. These primary regulations are described as follows.

Alquist-Priolo Earthquake Fault Zone

The Alquist-Priolo (AP) Earthquake Fault Zoning Act of 1972 was intended to mitigate the hazard of surface fault rupture by prohibiting the location of structures for human occupancy across the trace of an active fault. The act delineates "Earthquake Fault Zones" along faults that are "sufficiently active" and "well defined." The act also requires that cities and counties withhold development permits for sites within an earthquake fault zone until geologic investigations demonstrate that the sites are not threatened by surface displacement from future faulting. Pursuant to this act, structures for human occupancy are not allowed within 50 feet of the trace of an active fault. As described later, no AP zones are delineated in Santa Ana.

Seismic Hazard Mapping Act

Earthquakes can cause significant damage even if surface ruptures do not occur. The Seismic Hazard Mapping Act (SHMA) of 1990 was intended to protect the public from the hazards of nonsurface fault rupture from earthquakes, including strong ground shaking, liquefaction, seismically induced landslides, or other ground failure. The California Geological Survey prepares and provides local governments with seismic hazard zone maps that identify areas susceptible to nonsurface fault hazards. SHMA requires responsible agencies to approve projects within seismic hazard zones only after a site-specific investigation to determine if the hazard is present, and the inclusion, if a hazard is found, of appropriate mitigation(s). Orange County has been issued maps showing nonsurface fault hazards, discussed later in this chapter.

California Building Code

Every public agency enforcing building regulations must adopt the provisions of the California Building Code (CBC), which is Title 24, Part 2 of the California Code of Regulations. The most recent version is the 2016 CBC (effective January 1, 2017). The CBC is updated every three years and provides minimum standards to protect property and public safety by regulating the design and construction of excavations, foundations, building frames, retaining walls, and other building elements to mitigate the effects of seismic shaking and adverse soil conditions. The CBC also contains provisions for earthquake safety based on factors including occupancy type, the types of soil and rock onsite, and the strength of ground shaking with specified probability of occurring at a site. A city may adopt more restrictive codes than state law based on conditions in their community.

Government Codes for Specific Building Types

While the CBC regulates the design and construction of most buildings and structures in a community, certain facilities have additional requirements from state and federal agencies. These include hospitals, schools, essential facilities, and lifeline infrastructure, listed below.

Acute care hospitals. These facilities are required to meet the standards of the Alquist Hospital Seismic Act.

Public schools. Public schools that are being constructed or rehabilitated are required to comply with standards under the Field Act, Division of State Architectural standards, and California Education Code § 17317.

Essential facilities. Essential facilities (police, fire, emergency community facilities, etc.) must comply with the additional standards and requirements of the Essential Services Building Seismic Safety Act.

Lifeline infrastructure. Bridges, utilities, dams/reservoirs, and other infrastructure must adhere to regulations of the Department of Water Resources, Department of Transportation, and Public Utilities Commission.

"Mobile Home Parks" and the "Special Occupancy Parks Act"

Mobile homes are prefabricated homes placed on piers, jackstands, or masonry block foundations. Floors and roofs are usually plywood, and outside surfaces are covered with sheet metal. Severe damage can occur when mobile homes fall off their supports, severing utility lines and piercing the floor with jack stands. The California Health and Safety Code governs mobile homes and special occupancy parks. In 2011, regulations were adopted that address park construction, maintenance, use, occupancy, and design. However, the amendments do not require earthquake-resistant bracing systems. Because the city has nearly 4,000 mobile homes (many of which are occupied by seniors), and mobile homes generally fare poorly in earthquakes, ensuring the safety of mobile home occupants is a concern.

California General Plan Law and OPR General Plan Guidelines

State law (Government Code § 65302) requires cities to adopt a comprehensive long-term general plan that includes a safety element. The safety element is intended to provide guidance for protecting 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 by the Public Resources Code §§ 2691 et. seq. and other geologic hazards known to the legislative body. The seismic safety element must also include mapping of known seismic and geologic hazards from the California Geological Survey and a series of responsive goals, policies, and implementation programs to improve public safety.

Santa Ana General Plan

The 1982 Santa Ana General Plan has two goals that address seismic hazards. Goal 1 is established to "provide a safe environment for all Santa Ana residents and workers." Goal 2 is established to "minimize the effects of natural disasters." These goals are supported by three specific policies addressing seismic hazards. Specific measures in the General Plan include, but are not limited to, the following:

- Enforce seismic design provisions of the Uniform Building Code.
- Identify all unreinforced masonry buildings.
- Develop seismic standards specifically addressed to architecturally or culturally significant older buildings.
- Develop a risk assessment and strategy for location and seismic protection of key communication, command/control and emergency medical facilities.

Santa Ana Municipal Code

The Santa Ana Municipal Code and other City development policies and procedures provide guidance on addressing specific geologic and seismic hazards in Santa Ana. Among others, these include the following:

Chapter 8, Buildings and Structures. These codes address grading standards, excavation, and fills. This also includes compliance with regulations for unreinforced masonry structures in accordance with "Unreinforced Masonry Law," found in California Government Code §§ 8875 et seq.

The City of Santa Ana Building Official may place additional requirements upon the construction of infrastructure, buildings, and other improvements based on the findings from plan check, soils testing, and geotechnical investigations.

2.2 EXISTING CONDITIONS

This section describes the local geologic setting and associated seismic and geologic hazards associated with the City's location, topography, soils, and faulting.

Geologic Setting

The City of Santa Ana is located on the southern portion of the Downey Plain, which is a broad alluvial plain that covers the northwestern portion of Orange County (Yerkes et al. 1965). Santa Ana is situated within the Peninsular Ranges Geomorphic Province. This geomorphic province encompasses an area that extends approximately 900 miles from the Transverse Ranges and the Los Angeles Basin to the southern tip of Baja California. The province varies in width from approximately 30 to 100 miles depending on location. In general, the province consists of a northwest-southeast oriented complex of blocks separated by similarly trending faults.

Santa Ana is underlain by Holocene and Pleistocene alluvial deposits and early Pleistocene marine deposits (Morton 2004). Below these deposits lies Miocene and late Cretaceous sedimentary rocks. The Santa Ana Mountains rising to 5,700 feet above sea level are located to the northeast and east of the City, and the San

2. Geologic and Seismic Hazards

Joaquin Hills are located to the southeast (Google Earth Pro 2019). The Santa Ana River flows through the western portion of the City on its way to the Pacific Ocean, to the southwest. Santa Ana is generally flat with a gentle slope toward the southwest (USGS 2015a; 2015b; 2015c; 2015d).

The Peninsular Ranges Geomorphic Province is traversed by a group of subparallel and fault zones trending roughly northwest. Major active fault systems—San Andreas, San Jacinto, Whittier-Elsinore, and Newport-Inglewood fault zones—form a regional tectonic framework consisting primarily of right-lateral, strike-slip movement (Jennings & Bryant 2010). Santa Ana is situated between two major active fault zones—the Whittier-Elsinore Fault Zone to the northeast and the Newport-Inglewood Fault to the southwest. Other potentially active faults located near the City of Santa Ana include the Elysian Park blind thrust, Chino-Central Avenue, San Joaquin Hills blind thrust, San Jose, Cucamonga, Sierra Madre, and Palos Verdes faults (CGS 2019; Cao et al 2003).

The Richter Scale is used to describe the magnitude (M) of an earthquake. Each one-point increase in magnitude (M) represents a 10-fold increase in earthquake wave size and a 30-fold increase in energy release (strength). For example, an M8 earthquake produces 10 times the ground motion amplitude of an M7 earthquake, 100 times that of an M6 quake, and 1,000 times the motion of a magnitude 5. However, the M8 earthquake is 27,000 times stronger than an M5 quake. Typically, earthquakes of M5 or greater are considered strong earthquakes capable of producing damage.

Table 1 provides a summary of the key faults that could produce significant earthquakes (exceeding M5) that would most impact Santa Ana. The table also includes the maximum associated magnitudes of earthquakes along each fault. Figure 1 follows, showing the location of fault hazards and their proximity to Santa Ana.

Table 1 Earthquake Faults near Santa Ana

Fault	Description of Earthquake Fault Zone	Maximum Hazard
Newport-Inglewood	The Newport-Inglewood Fault Zone consists of a series of disconnected, northwest-trending fault segments which extend from Los Angeles, through Long Beach and Torrance, to Newport Beach and offshore south past Oceanside. Although no major rupture has occurred since the 1933 Long Beach quake (6.4 M), the fault is considered active and is zoned under the Alquist-Priolo Earthquake Fault Zone Act. The fault is located about four miles from the City.	M 7.1
Whittier Fault Zone	The Whittier Fault Zone extends from Whittier Narrows in Los Angeles County, southeasterly to Santa Ana Canyon where it merges with the Elsinore Fault Zone. The Whittier Fault Zone is located about nine miles from the northern edge of the City. The Whittier Fault is active and is zoned under the Alquist-Priolo Earthquake Fault Zone Act.	M 6.8

2. Geologic and Seismic Hazards

Table 1 Earthquake Faults near Santa Ana

Fault	**Description of Earthquake Fault Zone**	**Maximum Hazard**
Elsinore Glen Ivy Segment	The Glen Ivy segment of the Elsinore Fault Zone is located about twelve miles from the City. Dominant movement along this fault is right-lateral strike-slip. The Glen Ivy segment is zoned under the Alquist-Priolo Earthquake Fault Zone Act.	M 6.8
San Joaquin Hills Blind Thrust	Located at depth about a mile southeast of the City, the San Joaquin Hills Blind Thrust Fault is approximately 17 miles long and is characterized by reverse dip-slip movement. This fault is responsible for the uplift of the San Joaquin Hills. The San Joaquin Hills Blind Thrust Fault is considered active and is not zoned under the Alquist-Priolo Earthquake Zone Act.	M 6.6
Chino-Central Avenue	The Chino-Central Avenue Fault branches away from the Elsinore (Glen Ivy) Fault and extends northwest 13 miles through the Prado Basin and into the Puente Hills. Dominant movement along the fault is right-lateral reverse oblique slip. The Chino Fault is about 14 miles northeast of the City and is zoned under the Alquist-Priolo Earthquake Zone Act.	M 6.7
Puente Hills Blind Thrust	Located at depth about ten miles northwest of the City, the Puente Hills Blind Thrust Fault is approximately 27 miles long and is characterized by reverse dip-slip movement. The Puente Hills Blind Thrust Fault is considered active and is no zoned under the Alquist-Priolo Earthquake Fault Zone Act.	M 7.1
Upper Elysian Park Blind Thrust	The Upper Elysian Park Blind Thrust Fault is located at depth about ten miles north of the City. The fault is approximately 12 miles long and is characterized by reverse dip-slip movement. The Upper Elysian Park Blind Thrust Fault is considered active and is not zoned under the Alquist-Priolo Earthquake Fault Zone Act.	M 6.4
San Jose	The San Jose Fault is 12 miles long, extending southwest and west from near the mouth of San Antonio Canyon on the southern front of the San Gabriel Mountains about 21 miles north of the City. The fault is characterized by left-lateral reverse oblique-slip movement, and was responsible for the 1990 M 5.4 Upland earthquake.	M 6.9
Cucamonga	The Cucamonga Fault is the eastward extension of the Sierra Madre Fault Zone and is located 26 miles northeast of the City, extending 17 miles long, from Duncan Canyon to San Antonio Heights along the San Gabriel Mountains. The fault is characterized by reverse dip-slip movement. The Fault is active and within an Alquist-Priolo Earthquake Fault Zone.	M 6.9

2. Geologic and Seismic Hazards

Table 1 Earthquake Faults near Santa Ana

Fault	Description of Earthquake Fault Zone	Maximum Hazard
San Jacinto	The San Jacinto Fault, located about 36 miles northeast of the City, is considered to be the most active fault in southern California. The fault zone extends 130 miles and is characterized by right-lateral strike-slip movement. The San Jacinto Fault is considered active and is capable of a maximum moment magnitude 6.9 earthquake. The fault is zoned under the Alquist-Priolo Earthquake Fault Zone Act.	M 6.9
Sierra Madre Fault Zone	Located 24 miles north of the City, this fault zone extends 35 miles long, from Claremont and following the southern front of the San Gabriel Mountains to San Fernando. This fault zone is characterized by reverse dip-slip movement. The western portion of the Sierra Madre Fault is zoned under the Alquist-Priolo Earthquake Fault Zone Act.	M 7.2
Palos Verdes	The Palos Verdes Fault is located offshore about 16 miles southwest of the City. The fault zone extends for about 50 miles southeast from the northern front of the Palos Verdes Peninsula. The fault zone is characterized by reverse right-lateral oblique-slip movement. The fault is not zoned under the Alquist-Priolo Earthquake Fault Zone Act.	M 7.3
San Andreas	The San Bernardino and Southern segments of the San Andreas Fault are located about 40 miles northeast of the City. Past work estimates that the recurrence interval for a M 8.0 earthquake along the entire fault zone is 50–200 years, and a 140–200 year recurrence interval for a M 7.0 earthquakes along the southern fault zone segment.	M 7.5+

Source: Cao et al., 2003.

Seismic Hazards

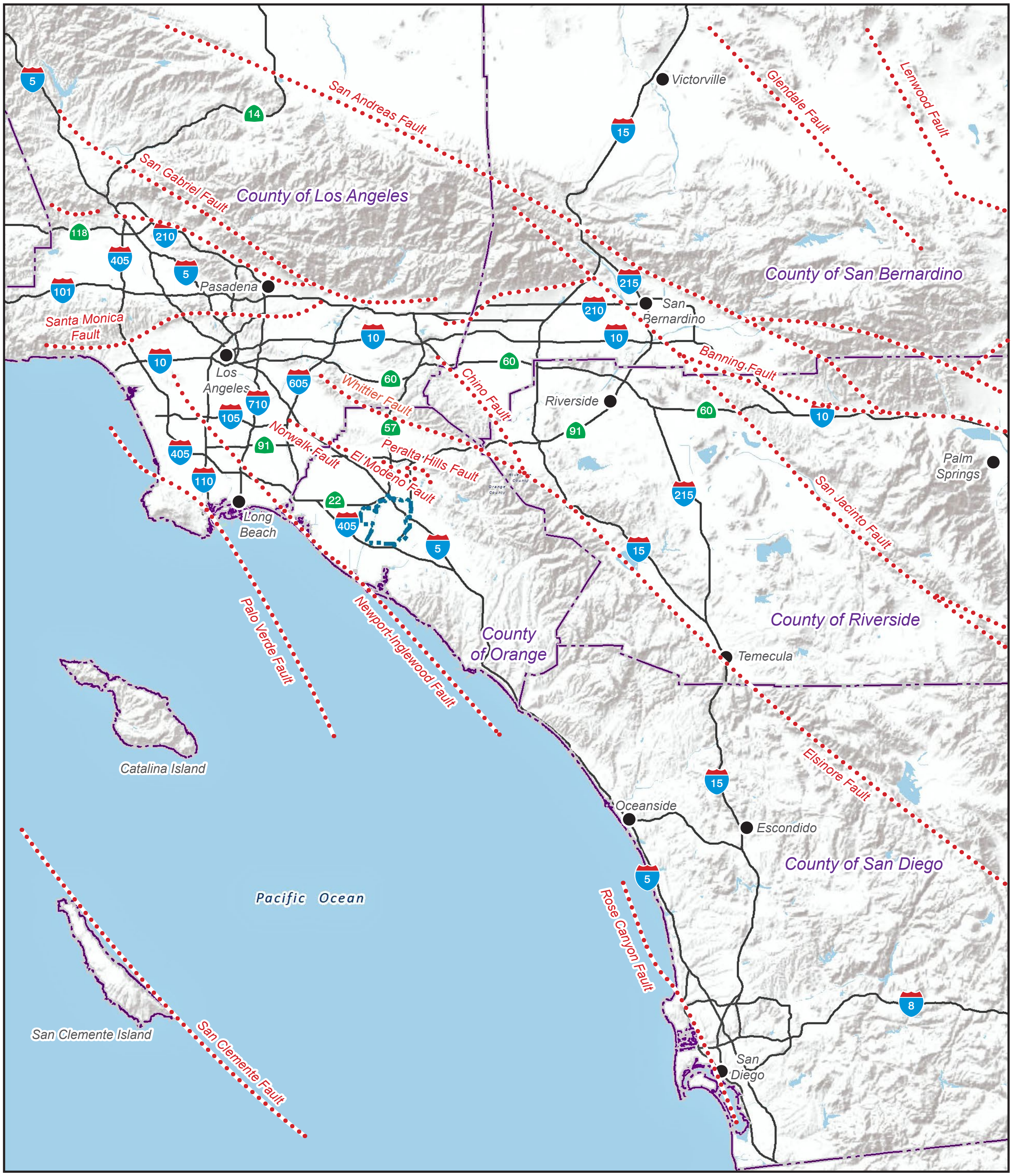
Historically, the City of Santa Ana has not experienced a major destructive earthquake. However, based on a search of earthquake databases of the United States Geological Survey (USGS) National Earthquake Information Center (NEIC), several major earthquakes (magnitude 5.8 or more) have been recorded within approximately 60 miles of the City since 1769 (USGS 2019). The latest of these were the Northridge earthquake and Granada Hills aftershock in 1994, about 60 miles from the City.

The primary seismic hazards related to earthquakes are summarized below:

SURFACE (FAULT) RUPTURE

Seismic activity has been known to cause surface rupture, or ground displacement, along a fault or within the general vicinity of a fault zone. In accordance with the Alquist-Priolo Earthquake Fault Zoning Act (AP

Figure 2 - Regional Fault Location Map



City of Santa Ana

Fault Line

Note: All fault locations and dimensions are approximate and not all faults are shown.
Source: California Department of Mines and Geology. Preliminary fault activity map of California, 1994.

0 20
Scale (Miles)

2. Geologic and Seismic Hazards

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Zoning Act), the State Geologist has established fault zones along known active faults in California. No active surface faults are mapped and zoned under the AP Zoning Act in Santa Ana (CGS 2019).

Primary ground rupture usually results in a relatively small percentage of the damage caused by an earthquake. Primary fault rupture is rarely confined to one fault; it often spreads out into complex patterns of secondary faulting and ground deformation. Secondary faulting involves a web of interconnected faults that rupture in response to a primary rupture. Secondary ground deformation can include fracturing, shattering, warping, tilting, uplift, and/or subsidence. Such deformation may be relatively confined along the rupturing fault or spread over a large region. Deformation and secondary faulting can also occur without primary ground rupture, as in the case of ground deformation above a blind (buried) thrust fault.

STRONG SEISMIC GROUND SHAKING

Ground shaking refers to vibration of the ground from an earthquake. Shaking above Magnitude 5 on the Richter Scale is known to damage structures. Earthquakes are common to southern California, and geologic evidence is used to determine the likelihood and magnitude of ruptures along a fault. Peak horizontal ground acceleration (PHGA) values that could be expected in Santa Ana are based on types and characteristics of fault sources, distances and estimated maximum earthquake magnitude, and subsurface site geology. The PHGA estimate depends on the method of determination. The maximum magnitude (Mmax) is considered the largest earthquake expected to occur along a fault and is based in part on fault characteristics (length, style of faulting and historic seismicity). The Newport-Inglewood Fault is the dominant active fault that could significantly impact the City.

Ground motion will generally amplify as it passes from the bedrock and through the softer, deep alluvial deposits. The PHGA at the surface of a site depends substantially on the thickness of sedimentary deposits beneath the site. Based on USGS estimates for the Santa Ana area and a 1.0-second spectral acceleration, site effects from the geologic units underlying the City may be three times the effect of crystalline bedrock at the same location.

LIQUEFACTION AND RELATED GROUND FAILURE

Liquefaction happens when strong earthquake shaking causes sediment layers that are saturated with groundwater to lose strength and behave as a fluid. This subsurface process can lead to near-surface or surface ground failure. Surface ground failure is usually expressed as lateral spreading, flow failures, ground oscillation, buoyancy forces on underground structures, increased lateral earth pressure on retaining walls, post-liquefaction settlement and/or general loss of bearing strength. Sand boils (injections of fluidized sediment) commonly accompany these different types of failure. Liquefaction can damage building foundations, structures, and infrastructure, leading to collapse.

Susceptibility to liquefaction typically depends on: 1) the intensity and duration of ground shaking; 2) the age and textural characteristic of the alluvial sediments; and 3) the depth to the groundwater. Loose, granular materials at depths of less than 50 feet, with silt and clay contents of less than 30 percent, and saturated by relatively shallow groundwater table are most susceptible to liquefaction. These geological conditions are typical in parts of southern California, in valley regions and alluvial floodplains. In Santa Ana, most of the city is within areas that are susceptible to liquefaction, including the southern half of the city and along the margins of Santiago Creek and the Santa Ana River (CGS 2019) (see Figure 3, *Liquefaction Zones*).

SLOPE FAILURE (LANDSLIDES)

Landslides are perceptible downward movements of soil, debris, rock, or a combination of these under the influence of gravity. Landslide materials are commonly porous and very weathered in the upper portions and margins of the slide. They may also have open fractures or joints. Slope failures can occur during or after periods of intense rainfall or in response to strong seismic shaking. Landslides are distinguished from minor debris flows because in a landslide, the majority of material moved is bedrock materials, and a minor debris flow is the surface slippage of soil. Fire events in areas of high topographic relief can lead to conditions conducive to debris flows.

Landslides, debris flows, or any movement of earth or rock are most common in areas of high topographic relief, such as steep canyon walls or steep hillsides. As the entire City is nearly flat, landslides are not a major hazard in Santa Ana (USGS 2015a; 2015b; 2015c; 2015d).

Geologic Hazards

Based on available studies, the geologic hazards most likely to occur in the City of Santa Ana include expansive soils, corrosive soils, and settlement/collapsible soils (to a lesser degree). Each of these potential hazards is discussed below, followed by maps showing vulnerable locations.

EXPANSIVE SOILS

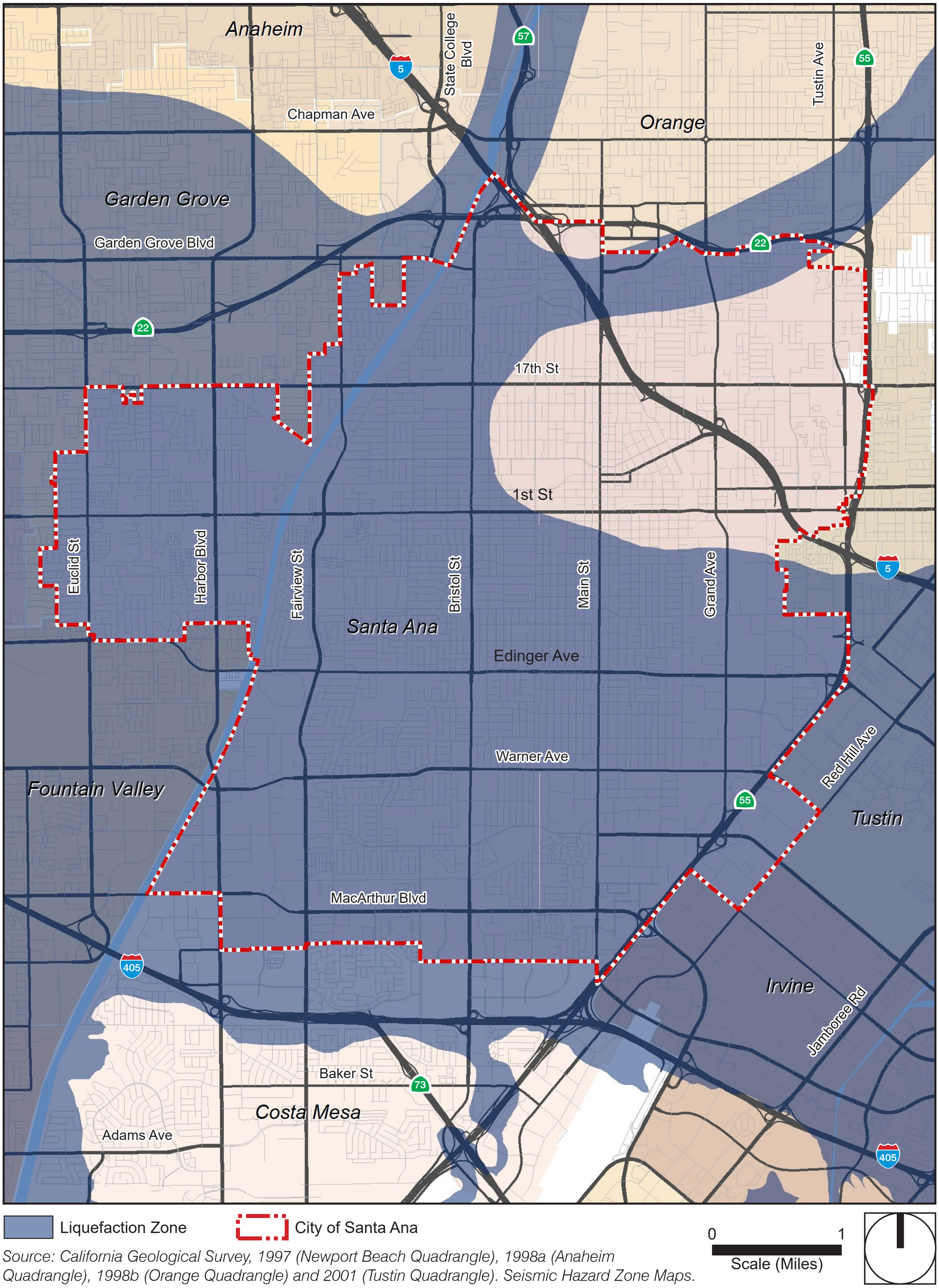
Expansive and collapsible soils are two of the most widely distributed and costly of geologic hazards. Expansive soils will shrink or swell as the moisture content decreases or increases. Expansive soil and rock are typically characterized by clayey material that shrinks as it dries and swells as it becomes wet. Homes, infrastructure, and other structures built on these soils may experience shifting, cracking, and breaking damage as soils shrink and subside or expand. Expansive soils are also known to cause damage to the foundation of structures.

Based on the presence of alluvial materials within the City, there is some potential for expansive soils throughout Santa Ana (Morton 2004; USDA 1978). Expansive soils are possible wherever clays and elastic silts may be present, including alluvial soils and weathered granitic and fine-grained sedimentary rocks. Expansive soils are tested prior to grading as part of a soil engineering report—as required by the CBC and the City of Santa Ana—and are mitigated as necessary.

CORROSIVE SOILS

Corrosive soils contain chemical constituents that may cause damage to construction materials such as concrete and ferrous metals. One such constituent is water-soluble sulfate, which, if in high enough concentrations, can react with and damage concrete. Electrical resistivity, chloride content, and pH level are all indicators of a soil's tendency to corrode ferrous metals. High chloride concentrations from saline

Figure 3 - Liquefaction Zones



Source: California Geological Survey, 1997 (Newport Beach Quadrangle), 1998a (Anaheim Quadrangle), 1998b (Orange Quadrangle) and 2001 (Tustin Quadrangle). Seismic Hazard Zone Maps.

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minerals can corrode metals (carbon steel, zinc, aluminum, and copper). Low pH and/or low resistivity soils could corrode buried or partially buried metal structures.

Soils throughout the majority of Santa Ana have been found to be highly corrosive to metals and marginally to moderately corrosive to concrete (USDA 1978). Typical mitigation for corrosive soil includes corrosion-resistant coatings. Corrosive soils for concrete and/or metals are often addressed through techniques that include cathodic protection, use of specialty concrete overlays, and other techniques. The City's Engineering Standards require that proposed projects include soil investigations and cathodic protection for metal piping when corrosive soils are encountered.

LAND SUBSIDENCE

Land sinking or subsidence is generally related to substantial overdraft of groundwater reserves from underground reservoirs. Santa Ana has shown historical subsidence and is considered to be a potential hazard on the City (Riel et al 2018). Historically, subsidence in Santa Ana does not show a pattern of widespread irreversible permanent lowering of the ground surface. The probability of subsidence effects is generally low in the majority of Santa Ana, with the most susceptible areas along the margins of the Santa Ana River and Santiago Creek. Groundwater storage by Orange County Water District and statutory commitments to sustainable groundwater management practices reduce the potential for future land subsidence, and ongoing surveying of the ground surface by Orange County Water District provides a way to verify that their efforts in preventing subsidence are effective (OCWD 2015).

SETTLEMENT AND/OR COLLAPSE

The potential hazard posed by seismic settlement and/or collapse in the City is considered to be moderate based on the compressibility of the underlying alluvial soils and the presence of shallow groundwater (CGS 2019). Strong ground shaking can cause settlement of alluvial soils and artificial fills if they are not adequately compacted. Because unconsolidated soils and undocumented fill material are present in the City, seismically induced settlement and/or collapse are possible (Morton 2004). Site-specific mass grading and compaction, which would occur as part of future development, would mitigate any potential impacts from compressible soils within the City.

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3. Implications for the General Plan Update

Santa Ana has many environmental hazards that present potential risks to the safety of residents, commerce, and personal property. While the risks vary according to whether development is located near industrial and transportation land uses, or on the periphery, every neighborhood is subject to potential hazards. Since a fundamental mission of the City is to protect public health and safety, understanding the changing nature of seismic and geologic safety hazards is a key part of that effort.

3.1 ISSUES FOR CONSIDERATION

» **Seismic and Geologic Hazards.** Santa Ana is located between the Elsinore Fault Zone and the Newport-Inglewood Fault. These fault zones along with regional faults can produce earthquakes of Magnitude 7.0 or greater. As a result of earthquakes, the City is subject to liquefaction and seismic ground shaking. Geologic hazards, such as corrosive soils, are more of an everyday concern with large swaths of Santa Ana underlain by soils corrosive to steel. The City has adopted state-mandated safety codes to address these concerns, which are acknowledged as some of the most stringent codes and regulations in the nation.

However, concern remains. Of particular concern is vulnerable structures—hospitals, health care facilities, schools, and mobile homes—built decades ago in accordance with standards at that time. Not all of these land uses have been upgraded to meet current building codes or are required to be retrofitted to withstand high-magnitude earthquakes or geologic hazards. For instance, mobile home units typically perform poorly in natural hazards, but they are not required to have bracing to permanent foundations. Similarly, hospitals statewide have been slow to complete upgrades mandated by the Alquist Hospital Facilities Seismic Safety Act.

3.2 OPPORTUNITIES

Santa Ana faces a wide range of natural hazards—like most cities in the state. Many of these hazards cannot be completely mitigated or prevented. They remain part of the fabric of Santa Ana. The best defense for keeping Santa Ana safe from hazards is to focus on prevention, preparedness, risk reduction, and control measures while maintaining the capability to respond in an effective manner during a disaster. The general plan update can further these objectives.

» **General Plan Vision.** Seismic safety is a principal theme of the general plan's vision. Given the change in general plan safety legislation, the principle could be broadened to address geologic and seismic safety concerns beyond the normal purview of safety related to seismic events. This would provide the framework for an enhanced discussion of seismic safety in the general plan.

» **General Plan Implementation.** The general plan could also contain new programs for addressing seismic safety issues in the community. These programs should be coordinated with the recently adopted hazard mitigation plan. Specific programs could be proposed or designed to:

3. Implications for the General Plan Update

- Encourage the retrofit of mobile homes with bracing and other devices to protect seniors and lower income families living in those units.
- Encourage compliance with new safety requirements for health care facilities promulgated by the Office of Statewide Health Planning and Development.
- Study measures to improve safety for soft-story construction, concrete tilt-up construction, and other vulnerable structures.
- Develop and publish evacuation routes that can be incorporated into the hazard mitigation plan and general plan update.

4. Environmental Impacts

This chapter describes the impacts of the project on geotechnical, geologic and seismic conditions within the city. The analysis of impacts addresses direct and indirect impacts and cumulative impacts.

4.1 IMPACTS

This section describes the long-term impacts of the General Plan Update. The City is subject to a number of geotechnical, geologic and seismic risk hazards. Compliance with building and design codes would include design measures to minimize impacts so that they are less than adverse for strong ground shaking, liquefaction, slope stability, and compressible, corrosive and expansive soils.

4.1.1 Surface (Fault) Rupture

The city is not within a recognized area of active faulting, and no active faults have been observed within the city. The absence of active faults within the city means that there would be no impact from surface fault rupture hazards.

4.1.2 Strong Seismic Ground Shaking

Strong seismic shaking from a local event on the Newport-Inglewood Fault or another regional fault is considered a hazard for this project. The proximity of active faults that are capable of generating large magnitude earthquakes means that structures within the city could be affected by strong seismic ground shaking. Structures could be damaged or destroyed and people could be harmed during a major seismic event.

All structures that would be constructed in accordance with the General Plan Update would be designed to meet or exceed current design standards as found in the latest California Building Code (CBC). Therefore, new structures are expected to remain standing, but may suffer damage requiring closure and replacement. These project design measures would reduce the exposure of people and structures to harm from strong ground shaking hazards such that there would not be a significant impact.

4.1.3 Liquefaction and Related Ground Failure

Liquefaction and related ground failure hazards exist within most of the city, including the southern half of the city and along the margins of Santiago Creek and the Santa Ana River (CGS 2019). This subsurface process can lead to near-surface or surface ground failure. Surface ground failure is usually expressed as lateral spreading, flow failures, ground oscillation, buoyancy forces on underground structures, increased lateral earth pressure on retaining walls, post-liquefaction settlement and/or general loss of bearing strength. Sand boils (injections of fluidized sediment) commonly accompany these different types of failure. Liquefaction can damage or destroy building foundations, structures, and infrastructure, that could lead to the harm of people.

All structures constructed following the General Plan Update would be designed in accordance with current seismic design standards as found in the California Building Code (CBC). Design measures would be implemented according to the most recent CBC that would reduce the impact of liquefaction and seismic settlement, including, but not limited to, ground improvement techniques such as in-situ densification, load transfer to underlying non-liquefiable bearing layers and over-excavation and recompaction with engineered fill method. These design measures would reduce the potential exposure of people and structures to the hazard from liquefaction and seismic settlement such that there would not be a significant impact.

4.1.4 Slope Failure (Landslides)

There are no substantial hazards with respect to slope stability, as the city is mostly flat. As such, there would not be a significant impact from slope stability.

4.1.5 Expansive Soils

Based on the presence of alluvial materials within the City, there is some potential for expansive soils throughout Santa Ana (Morton 2004; USDA 1978). Expansive soils are possible wherever clays and elastic silts may be present, including alluvial soils and weathered granitic and fine-grained sedimentary rocks. The presence of expansive soils in the City represents a hazard to structures and people.

CBC design code has been adopted within the City which requires that structures be designed to mitigate expansive soils. Methods that could be used to reduce the impact of expansive soils include drainage control devices to limit water infiltration near foundations, over-excavation and recompaction of engineered fill method, or support of the foundation with piles. These project design measures, or a combination of them, would reduce the impact of expansive soils to less than significant.

4.1.6 Corrosive Soils

Corrosive soils have been found throughout the majority of Santa Ana to be highly corrosive to metals and marginally to moderately corrosive to concrete (USDA 1978). The potential impacts of corrosive soils are corrosion of concrete, preventing complete curing, reducing concrete strength, and corroding buried or partially buried metal components and structures. The weakening of structures from corrosive soils could result in some structural damage or failure of underground utilities, which could expose people to harm. The presence of corrosive soils within the City represents a hazard to structures and people.

CBC design code has been adopted within the City which requires that structures be designed to mitigate corrosive soils. Typical mitigation for corrosive soil includes using a low water-to-cement ratio to decrease the permeability of concrete, using sulfate-resistant cement, and corrosion-resistant coatings. Corrosive soils for concrete and/or metals are often addressed through techniques that include cathodic protection, use of specialty concrete overlays, and other techniques. The City's Engineering Standards require that proposed projects include soil investigations and cathodic protection for metal piping when corrosive soils are encountered. These design measures, or a combination of them, would reduce the impact of corrosive soils to less than significant.

4.1.7 Land Subsidence

Santa Ana has shown historical subsidence and is considered to be a potential hazard on the City (Riel et al 2018). Historically, subsidence in Santa Ana does not show a pattern of widespread irreversible permanent lowering of the ground surface. The probability of subsidence impacts is generally low in the majority of Santa Ana, with the most susceptible areas along the margins of the Santa Ana River and Santiago Creek. Groundwater storage by Orange County Water District and statutory commitments to sustainable groundwater management practices reduce the potential for future land subsidence, and ongoing surveying of the ground surface by Orange County Water District provides a way to verify that their efforts in preventing subsidence are effective. The statutorily required sustainable groundwater management practices by Orange County Water District reduce the impact of subsidence to less than significant.

4.1.8 Settlement and/or Collapse

Settlement and collapse are likely to exist in areas with alluvial soils. Areas of large settlement can damage, or in extreme cases, destroy structures. The presence of compressible soils within the city represents a hazard to structures and people.

CBC design code has been adopted within the city which requires that structures be designed to mitigate compressible soils. Methods that could be used to reduce the impact of compressible soils include in-situ densification, transferring the load to underlying non-compressible layers with piles and overexcavation of compressible soil and recompaction with engineered fill. These design measures, or a combination of them, would reduce the impact of compressible soils to less than significant.

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