5.5 GEOLOGY AND SOILS

This section of the recirculated Draft Environmental Impact Report (DEIR) evaluates the potential for development pursuant to the IBC Vision Plan and Mixed Use Overlay Zoning Code to be impacted by geology and soils conditions in the project area. The analysis in this section is based in part on the following resources:

- *Due Diligence Geotechnical Assessment, Proposed 4-Story Residential/Commercial Building, 16901 Jamboree Road, City of Irvine, County of Orange, California,* Petra Geotechnical, Inc., April 25, 2005.
- *Feasibility-Level Geotechnical Evaluation, Proposed Jamboree Village Expansion, 16901 Jamboree Road, Irvine California,* Geotechnical Professionals, Inc., July 26, 2006.
- *Geotechnical Engineering Investigation, Proposed Residential Development, 16901Jamboree Road, Irvine, California,* NorCal Engineering, March 15, 2006.
- *Preliminary Geotechnical Investigation for Proposed Multi-Level Residential Development at the Intersection of Kelvin Avenue and Jamboree Road, Lot 9, City of Irvine, California*, NMG Geotechnical, Inc., September 12, 2006.
- *Geologic/Geotechnical Engineering Overview Report, Irvine Technology Center Redevelopment, Irvine, California*, Neblett & Associates, Inc., August 31, 2006.
- *Preliminary Geotechnical Investigation, Proposed Multi-Story Residential Complex, 16952 Millikan Avenue, City of Irvine*, Albus-Keefe & Associates, Inc., January 2006
- *Seismic Hazard Evaluation of the Tustin 7.5-Minute Quadrangle, Orange County, California*, California Department of Conservation, Division of Mines and Geology, January 2001.
- *State of California Seismic Hazard Zones, Tustin Quadrangle, Official Revised Map*, California Department of Conservation, Division of Mines and Geology, January 2001.
- *Environmental Impact Report, Irvine Business Center, Irvine, California*, Robert Bein, William Frost and Associates, August 1992.

Complete copies of these studies and technical information are available for review at the City of Irvine Community Development Department and on the City's website www.cityofirvine.org.

5.5.1 Environmental Setting

Regulatory Background

California Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was signed into state law in 1972, as amended, primarily to mitigate the hazard of fault rupture by prohibiting the location of structures for human occupancy across the tract of an active fault. The Act requires the State Geologist to delineate Earthquake Fault Zones along faults that are "sufficiently active" and "well defined." According to the State Geologist, an active fault is one that has had surface displacement within the Holocene Epoch (roughly the last 11,000 years). A potentially active fault is defined as any fault that has had surface displacement during Quaternary time (last 1,600,000 years) but not within the Holocene. An inactive fault is one that has been proven not to have moved in 1,600,000 years. 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 displacements from future faulting. Pursuant to this Act, structures for human occupancy are not allowed within 50 feet of the trace of an active fault.

Seismic Hazard Mapping Act

The Seismic Hazard Mapping Act was adopted by the state in 1990 to protect public safety from the effects of earthquake hazards apart from surface fault rupture, including strong ground shaking, liquefaction, seismically induced landslides, or other ground failure caused by earthquakes. The goal of the act is to minimize loss of life and property by identifying and mitigating seismic hazards. The California Geological Survey (CGS) prepares and provides local governments with seismic hazard zone maps that identify areas susceptible to amplified shaking, liquefaction, earthquake-induced landslides, and other ground failures. The seismic hazard zones delineated by the CGS are called "zones of required investigation" because site-specific geological investigations are required for construction projects within these areas.

California Building Code and Uniform Building Code

Development in the City of Irvine is required to adhere to the building standards of the most recent California Building Code (CBC). Current law states that every local agency enforcing building regulations, such as cities and counties, must adopt the provisions of the CBC within 180 days of its publication. The publication date of the CBC is established by the California Building Standards Commission and the code is also known as Title 24 of the California Code of Regulations. The most recent building standard adopted by the legislature and used throughout the state is the January 2008 version of the CBC, often with local, more restrictive amendments that are based upon local geographic, topographic, or climatic conditions. The 2008 CBC is based on the 2006 International Building Code. These codes provide minimum standards to protect property and the public welfare 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 procedures and limitations for the design of structures are based on site characteristics, occupancy type, configuration, structural system height, and seismic zoning for Seismic Zone 4. Seismic ratings are derived from Uniform Building Code specifications, which divide the US into five geographical zones. Zone 4 comprises most of central and coastal California, and is the most prone to earthquake activity.

City of Irvine Municipal Code

The City of Irvine's Building Regulations are included in the City's Municipal Code as Section 5-9-301, Building Code. The City has adopted by reference the most recent version of the CBC.

The City of Irvine's Grading Code is Chapter 1 of the City's Municipal Code. The Grading Code establishes rules and regulations to control excavation, grading, and earthwork construction (including fills and embankments), and establishes administrative requirements for issuance of permits, approval of plans, and inspection of grading construction in accordance with the requirements for grading and excavation contained in the UBC as adopted and modified by City ordinance. The Grading Code also contains water quality requirements.

Regional Setting

Geologic Setting

The proposed project site lies at the southern end of the broad Coastal Plain of Orange County, mostly in the Tustin Plain, although a large portion of the project site southwest of the I-405 is considered to be on the easternmost margin of Newport Mesa. The Tustin Plain is part of the coastal section of the Peninsular Range Province, a geomorphic province that extends 900 miles south from the Los Angeles basin to the tip of Baja California. The Peninsular Ranges Province is characterized by elongated northwest-trending mountain ridges separated by sediment-floored valleys. The Tustin Plain separates the Santa Ana Mountains, to the north and east, from the San Joaquin Hills to the south. The northwest-trending Santa Ana Mountains have uplifted on their eastern side along the Whittier-Elsinore Fault Zone, producing a tilted, irregular, and complex highland that slopes westward toward the sea. Regional tectonic activity has uplifted the San Joaquin Hills and Newport Mesa between the Santa Ana River and San Juan Capistrano. This folding has occurred as this entire section of the coast has been uplifted by the San Joaquin Hills blind thrust fault.

Sediments eroded from the Santa Ana Mountain and the San Joaquin Hills have been deposited by streams emanating from these highlands (Santiago Creek, Peters Canyon Wash, Rattlesnake Canyon Wash, San Diego Creek, El Modena Canyon, etc.) and the lower reach of the Santa Ana River to produce the broad, complex, alluvial fan of the Tustin Plain, which consists of relatively flat-lying unconsolidated to semiconsolidated sediments that are approximately 30 to over 1,200 feet thick beneath the site, generally thickening to the northwest. These deposits include strata of the upper member of the Pliocene Fernando Formation (approximately 2 to 3 million years old) and Pleistocene (10,000 to 2 million years old) older alluvium. The near-surface, unconsolidated Holocene sediments beneath the site are between 10 and 20 feet thick and predominately consist of young alluvial fan deposits. Soil development at the site includes well-drained soils of the Alo, Balcom, and Myford Series, which are characteristic of upland and marine terrace deposits, and poorly drained soils of the Chino and Omni Series and Thapto-Histic Fluvaquents, which are characteristic of alluvial fan, floodplain, and coastal basin deposits.

Faulting and Seismicity

Earthquakes are common to southern California, and geologic evidence is used to determine the likelihood of future ruptures along a fault. Faults are described as active, potentially active, or inactive, based on their potential for activity. Those faults that have evidence of surface displacement within the Holocene epoch (the last 11,000 years) have the highest potential of generating earthquakes and are described as active. Distinct land forms suggesting movement within the last 11,000 years include scarps, sag ponds, drainages, linear valleys, and springs. Earthquake Fault Zones (formerly known as special study zones) have been established along known active faults in California in accordance with the Alquist-Priolo Earthquake Fault Zoning Act. No active surface faults are mapped or known to cross the site, and the site is not in an Alquist-Priolo Earthquake Fault Zone.

The amplitudes of earthquake waves are measured on the Richter Scale. Each one-point increase in magnitude represents a ten-fold increase in wave amplitude and a 32-fold increase in energy. That is, a Magnitude (M) 7 earthquake produces 100 times (10 x 10) the ground motion amplitude of an M 5 earthquake, and releases approximately 1,000 times (32 x 32) more energy.

The known regional active and potentially active faults that could produce the most significant ground shaking at the site are the San Joaquin Hills, Newport-Inglewood (Offshore), Newport-Inglewood (LA Basin), and Whittier-Elsinore Faults.

The Newport-Inglewood Fault zone extends northwest from offshore Newport Beach to Inglewood, as close as approximately 3.5 miles to the southwest of the project site, with the offshore portion as close as approximately 7.5 miles south. The 1933 Long Beach earthquake originated along this fault. Because the Newport-Inglewood fault zone is broad, up to 3.5 miles wide in Costa Mesa and Newport Beach, it is known as the Newport-Inglewood Structural Zone. This zone consists of discrete faulting, deformation, en-echelon faults, and northwest-trending fold belts and hills. This zone is considered seismically active with numerous recorded earthquakes of generally small size. The best-known earthquake on the Newport-Inglewood was the 1933 M 6.3 Long Beach Earthquake.

It is thought that a blind thrust fault, that is, a fault that does not extend to the surface, may exist beneath the San Joaquin Hills, based on indirect evidence. This supposed San Joaquin Hills blind thrust is recognized by the California Geological Survey to be active, although is not in an Alquist-Priolo Earthquake Fault Zone due to its blind nature.

The Whittier fault zone extends along the southwestern base of the Puente Hills and merges into the Elsinore Fault Zone, which trends along the eastern base of the Santa Ana Mountains. The Elsinore and Whittier Fault Zones have been grouped together by some scientists into the Whittier-Elsinore Fault Zone, which is as close as approximately 18 to 20 miles to the north and northeast of the site. The Whittier fault zone is considered active; however, no moderate or major historic earthquakes have occurred along the fault. The October 1 and 4, 1987, and February 19, 1988, earthquakes of M

5.9, 5.3, and 5.0, respectively, were centered in the Whittier area, but did not occur on the Whittier Fault. The Elsinore Earthquake of 1910, which was of M 6, occurred on the Elsinore Fault (SCEDC 2007).

Other faults in the region on which major earthquakes have occurred include the Sierra Madre Fault, approximately 32 miles north of the site with a maximum probable earthquake of M 7.0; the San Jacinto Fault, approximately 42 miles northeast of the project site and with a maximum probable earthquake of M 6.9; and the San Andreas Fault, approximately 48 miles northeast of the site, which has a maximum probable earthquake of M 7.8.

As with all of Orange County, the project site is in the Uniform Building Code Seismic Zone 4. This is the highest classification of the four zones in the United States, with the most stringent requirements for building design. The project site is also mostly in the City of Irvine Seismic Response Area (SRA) 1, although portions of the project site southwest of Michelson Drive are mostly in SRA 2 (according to Figure D-3 in the City of Irvine General Plan). SRAs describe the different types and magnitudes of potential seismic hazards, making it possible to evaluate the risks of property damage, personal injury, and loss of vital services that may result from an earthquake. In SRA 1 the predominant characteristics are soft soils and high groundwater, and the predominant characteristics in SRA 2 are denser soils and deeper groundwater. In SRA 1, liquefaction is the primary potential seismic hazard. In SRA 2, ground motion is the primary potential seismic hazard.

Peak horizontal ground acceleration (PHGA) is generally used to measure the amplitude of a particular ground motion. The PHGA values for the site were estimated using probabilistic seismic hazard analyses, based on currently available earthquake and fault information.

A probabilistic seismic hazard analysis was performed using the United States Geological Survey Earthquake Hazards website to estimate the PHGA for the site. Various probabilistic density functions were used in the analysis to assess the uncertainty inherent in the calculation with respect to magnitude, distance, and ground motion. The results of the analysis suggest that the PHGA in alluvial conditions, such as those on the site, with a 10 percent probability of exceedance in 50 years (that is, a recurrence interval of 475 years) is approximately 0.34g, or 34 percent of the acceleration of gravity. This level of ground motion is considered the Design Basis Earthquake.

Geologic Hazards

Expansive Soils

Expansive soils shrink or swell as the moisture content decreases or increases. Structures built on these soils may experience shifting, cracking, and breaking damage as soils shrink and subside or expand. Based on the presence of alluvial materials within the IBC, there is a potential for expansive soils. This is supported in that expansive soils have been encountered in numerous geotechnical investigations within the IBC.

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 the soil's tendency to corrode ferrous metals. Numerous geotechnical investigations within the IBC have encountered severely corrosive soils, as classified by Uniform Building Code Table 19-A-3.

Subsidence

The phenomenon of widespread land sinking, or subsidence, is generally related to substantial overdraft of groundwater or petroleum reserves from underground reservoirs. The project does not have an oil field or drinking water production wells on-site and has not been used for the extraction of either resource. Subsidence is therefore not considered a potential hazard on the project site.

Seismic Hazards

The southern California region is known to be seismically active. The project site is in Seismic Zone 4. Earthquakes occurring within approximately 60 kilometers of the site are generally capable of generating ground shaking of engineering significance to the proposed construction, as evidenced by the 1987 Whittier and 1994 Northridge earthquakes.

Earthquake Faults and Historic Earthquakes

Historic earthquakes in the project area include the 1857 Fort Tejon earthquake (magnitude 7.9) on the San Andreas fault, the 1933 Long Beach earthquake (magnitude 6.3) along the Newport-Inglewood Fault Zone, the 1987 Whittier Narrows earthquake (magnitude 5.9) on the Elysian Thrust Fault, the 1992 Landers earthquake (magnitude 7.4), and the 1994 Northridge earthquake (magnitude 6.6).

Surface (Fault) Rupture

Primary fault rupture is fissuring and offset of the ground surface along a rupturing fault during an earthquake. Primary ground rupture due to fault movement typically results in a relatively small percentage of the total damage in an earthquake, but being too close to a rupturing fault can result in extensive damage. Secondary fault rupture is ground surface displacement along faults other than the main traces of active regional faults. Movement along these faults generally occurs in response to movement on a nearby regional fault. Secondary ground deformation includes fracturing, shattering, warping, tilting, uplift, and/or subsidence. Deformation and secondary faulting can also occur without primary ground rupture, as in the case of ground deformation of a blind (buried) thrust fault.

Earthquake Fault Zones (known as Special Studies Zones prior to 1994) have been established in accordance with the Alquist-Priolo Special Studies Zone Act of 1972. The act directs the State Geologist to delineate the regulatory zones that encompass surface traces of active faults that have a potential for future surface rupture. The purpose of the Alquist-Priolo Act is to regulate development near active faults in order to mitigate the hazard of surface rupture. The site is not in an Alquist-Priolo Earthquake Fault Zone. The surface traces of any active or potentially active faults are not known to pass directly through or project toward the site. Therefore, the potential for surface fault rupture at the site during the design life of the proposed development is considered low.

Strong Earthquakes

The closest mapped active fault to the site is the San Joaquin Hills blind thrust fault, at least 2 kilometers beneath the project site. Because the fault is blind, it does not reach the surface, thus it does not pose a significant rupture hazard. During the past decade, researchers have speculated that low-angle thrust faults, like the San Joaquin Hills blind thrust fault, may be present beneath the Los Angeles basin and are capable of producing moderate to large earthquakes. Table 5.5-1 provides a list of the faults and fault systems within an approximately 60-kilometer radius that are considered to contribute to the seismic exposure of the site.

Due to the location of the project site within a region known to be seismically active, the project is required to adhere to design criteria as presented in the most recent CBC, including criteria for structures within Seismic Zone 4. Compliance with seismic design criteria is a standard condition of all project approvals and would minimize seismic hazards to the extent feasible.

Table 5.5-1
Earthquake Faults

Fault Name	Distance from Project Site (miles)
San Joaquin Hills	0.0
Newport-Inglewood – LA Basin	7.4
Newport-Inglewood – Offshore	7.8

Chino-Central Avenue	13.9
Whittier	15.2
Elsinore – Glen Ivy	16.4
Puente Hills Thrust	16.9
Palos Verdes	19.0
San Jose	24.7
Elsinore – Temecula	28.1
Coronado Bank	29.2
Upper Elysian Park	30.6
Sierra Madre	30.8
Cucamonga	31.1
Raymond	33.9
Clamshell-Sawpit	35.5
Verdugo	35.9
Hollywood	37.7

Source: NMG Geotechnical 2006

Slope Failure (Landslides)

Landslides are perceptible downward movements of a mass of earth (soil and/or debris), rock or a combination of the two under the influence of gravity. Landslide materials are commonly porous and very weathered in the upper portions and along the 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. Areas of high topographic relief, such as steep canyon walls, are most likely to be impacted by slope failure. As shown in the State of California Seismic Hazard Zones, Tustin Quadrangle map, the project site is not in an area likely to have earthquake-induced landslides (CGS 2001).

Liquefaction and Related Ground Failure

Liquefaction is a process whereby 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 that can result in property damage and structural failure. If surface ground failure does occur, it is usually expressed as lateral spreading, flow failures, ground oscillation, and/or general loss of bearing strength. Sand boils (injections of fluidized sediment) can commonly accompany these different types of failure.

In order to determine a region's susceptibility to liquefaction, three major factors must be analyzed:

- The intensity and duration of ground shaking.
- The age and textural characteristics of the alluvial sediments. Generally, the younger, less compacted sediments tend to have a higher susceptibility to liquefaction. Textural characteristics also play a dominant role in determining liquefaction susceptibility. Sands and silts with, at most, low plasticity tend to be more susceptible to liquefaction than clayey soils and silts with relatively high plasticity.
- The depth to the groundwater. Groundwater saturation of sediments is required in order for earthquake-induced liquefaction. In general, groundwater depths shallower than 10 feet to the surface can cause the highest liquefaction susceptibility.

Research and historical data indicate that loose, granular materials at depths of less than 50 feet with silt and clay contents of less than 30 percent saturated by relatively shallow groundwater table are most susceptible to liquefaction. These geological conditions are typical in parts of southern California, including the City of Irvine (City of Irvine GP

2003), and in valley regions and alluviated floodplains. Most of the project site is in SRA-1, which is susceptible to liquefaction.

Much of the project area (mostly northeast of Interstate 405 but also near San Diego Creek) is in a Zone of Required Investigation for Liquefaction, as shown on the State of California Seismic Hazard Zones, Tustin Quadrangle map, reissued in January 2001. Maps of seismic hazard zones are issued by CGS in accordance with the Seismic Hazards Mapping Act, ratified on April 1, 1991.

Hazardous Buildings

The principal threat in an earthquake is not ground shaking, fault rupture, or liquefaction, but the damage that these cause to buildings. Continuing advances in engineering design and building code standards over the past decade have greatly reduced the potential for collapse in an earthquake of most of our new buildings. However, many buildings were built, before some of the earthquake design standards were incorporated into the building code. Several specific building types are a particular concern in this regard.

- **Unreinforced Masonry Buildings:** In the late 1800s and early 1900s, unreinforced masonry was the most common type of construction for larger downtown commercial structures and for multi-story apartment and hotel buildings. These were recognized as a collapse hazard following the San Francisco earthquake of 1906 and continue to be the most hazardous buildings in an earthquake.

  Per Senate Bill 547, local jurisdictions are required to enact structural hazard reduction programs by inventorying pre-1943 unreinforced masonry buildings and developing mitigation programs to correct the structural hazards.

- **Precast Concrete Tilt-Up Buildings:** This building type was introduced following World War II and gained popularity in light industrial buildings during the late 1950s and 1960s. Extensive damage to concrete tilt-up buildings in the 1971 San Fernando earthquake revealed the need for better anchoring of walls to the roof, floor, and foundation elements of the building and for stronger roof diaphragms.[1] In the typical damage to these buildings, the concrete wall panels would fall outward and the roof would collapse.

- **Soft-Story Buildings:** Soft-story buildings are those in which at least one story, commonly the ground floor, has significantly less rigidity and/or strength than the rest of the structure. This can form a weak link in the structure unless special design features are incorporated to give the building adequate structural integrity. Typical examples of soft-story construction are buildings with glass curtain walls on the first floor only, or buildings placed on stilts or columns, leaving the first story open for landscaping, street-friendly building entry, parking, or other purposes. In the early 1950s to early 1970s, soft-story buildings were a popular construction style for low- and mid-rise concrete frame structures.

- **Nonductile Concrete Frame Buildings:** The brittleness of nonductile concrete frame buildings can create major damage and even collapse under strong ground shaking. This type of construction, which generally lacks masonry shear walls, was common in the very early days of reinforced concrete buildings, and they continued to be built until the codes were changed to require ductility in the moment-resisting frame in 1973.

  There were large numbers of these buildings built for commercial and light industrial use in California's older, densely populated cities. Although many of these buildings have four to eight stories, there are many in the lower height range. This category also includes one-story parking garages with heavy concrete roof systems supported by non-ductile concrete columns.

[1] A roof diaphragm is a structural roof deck that is capable of resisting shear that is produced by lateral forces, such as wind or seismic loads.

5.5.2 Thresholds of Significance

According to Appendix G of the CEQA Guidelines, a project would normally have a significant effect on the environment if the project would:

G-1 Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. (Refer to Division of Mines and Geology Special Publication 42.)

ii) Strong seismic ground shaking.

iii) Seismic-related ground failure, including liquefaction.

iv) Landslides.

G-2 Result in substantial soil erosion or the loss of topsoil.

G-3 Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

G-4 Be located on expansive soil, as defined in Table 18-1B of the Uniform building Code (1994), creating substantial risks to life or property.

G-5 Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Both Initial Studies, included as Appendices A and B, substantiate that impacts associated with the following thresholds would be less than significant:

- Threshold G-1i
- Threshold G-5

These impacts will not be addressed in the following analysis.

5.5.3 Environmental Impacts

Existing Plans, Programs, and Policies

The following measures are existing plans, programs, or policies (PPPs) that apply to the proposed project and will help to reduce and avoid potential impacts related to geology and soils:

PPP 5-1 Revegetation of cut and fill slopes shall be required in accordance with the City of Irvine Grading Code (Municipal Code Title 5, Division 10) and Grading Manual.

PPP 5-2 All grading operations and construction will be conducted in conformance with the applicable City of Irvine Grading Code (Municipal Code Title 5, Division 10) and Grading Manual, the most recent version of the California Building Code, and consistent with the recommendations included in the most current geotechnical reports for the project area prepared by the engineer of record.

PPP 5-3 In accordance with the City of Irvine Grading Code (Municipal Code Title 5, Division 10) and Grading Manual, detailed geotechnical investigation reports for each Rough Grading Plan shall be submitted to further evaluate faults, subsidence, slope stability, settlement, foundations, grading constraints, liquefaction potential, issues related to shallow groundwater, and other soil engineering design conditions and provide site-specific recommendations to mitigate these issues/hazards. The geotechnical reports shall be prepared and signed/stamped by a Registered Civil Engineer specializing in geotechnical engineering and a Certified Engineering Geologist. The City of Irvine Geotechnical Engineer/Engineering Geologist shall review the rough grading plan to ensure conformance with recommendations contained in the reports.

PPP 5-4 In accordance with the City of Irvine Grading Code (Municipal Code Title 5, Division 10) and Grading Manual, grading and earthwork shall be performed under the observation of a Registered Civil Engineer specializing in Geotechnical Engineering in order to achieve proper subgrade preparation, selection of satisfactory fill materials, placement and compaction of structural fill, stability of finished slopes, design of buttress fills, subdrain installation, and incorporation of data supplied by the engineering geologist.

PPP 5-5 In accordance with the City of Irvine Grading Code (Municipal Code Title 5, Division 10) and Grading Manual, grading and earthwork shall also be performed under the observation of a Certified Engineering Geologist to provide professional review and written approval of the adequacy of natural ground for receiving fills, the stability of cut slopes with respect to geological matters, and the need for subdrains or other groundwater drainage devices. The geologist shall geologically map the exposed earth units during grading to verify the anticipated conditions, and if necessary, provide findings to the geotechnical engineer for possible design modifications.

PPP 5-6 Future buildings and structures (e.g., houses, retaining walls) shall be designed in accordance with the City of Irvine Building Code and the most recent Uniform Building Code and/or California Building Code. The concrete utilized shall take into account the corrosion and soluble sulfate soil conditions at the site. The structures shall be designed in accordance with the seismic parameters included in the UBC/CBC.

Project Design Features

There are no specific Project Design Features that relate to potential geology and soils impacts.

The following impact analysis addresses thresholds of significance for which the Initial Study disclosed potentially significant impacts. The applicable thresholds are identified in brackets after the impact statement.

IMPACT 5.5-1: FUTURE RESIDENTS AND EMPLOYEES COULD BE SUBJECTED TO STRONG EARTHQUAKES. [THRESHOLD G-1ii]

Impact Analysis: The intensity of ground shaking at a given location depends on several factors, but primarily on the earthquake magnitude, the distance from the epicenter to the site of interest, and the response characteristics of the soils or bedrock units underlying the site. The San Joaquin Hills and Newport-Inglewood faults are potentially capable of producing the most intense ground accelerations at the site, given that they are over 1.2 miles beneath the site and 7.4 miles west of the site, respectively. An earthquake on the San Joaquin Hills fault is anticipated to affect the site similarly with respect to ground motions as that of an earthquake on the Newport-Inglewood fault zone (Neblett 2006). The estimated moment magnitude on the Newport-Inglewood fault zone is 7.1. An earthquake of this size on the Newport-Inglewood fault zone could produce seismic shaking with peak horizontal ground accelerations at about 0.38g. Smaller events on the Chino-Central Avenue or Whittier faults, and earthquakes on other faults further away from the site, could be expected to produce smaller peak horizontal ground accelerations at the project site than that of the Newport-Inglewood fault zone.

The proposed project area is in Seismic Zone 4 of the Uniform Building Code, meaning in the site vicinity the hazard posed by earthquakes is considered high, due to the proximity of known active faults. In southern California, there is no way to avoid earthquake hazards. Appropriate measures to mitigate and minimize the effects of earthquakes are included in the 2007 CBC, with specific provisions for seismic design. The CBC has been accepted as the basic design standard in the City of Irvine and Orange County. The design of structures in accordance with the CBC is expected to minimize the effects of ground shaking to the greatest degree feasible and to less than significant levels except for a catastrophic seismic event.

Subsequent Development Pursuant to the Proposed Project

The proposed project also includes 2,250 pending units identified in Section 3, *Project Description*, for which applications are on file with the City. Impacts associated with the individual development projects—Martin Street Condos, 2851 Alton, Avalon Jamboree II, Irvine Technology Center, Kilroy, Alton/Millikan Apartments, and 2852 Kelvin—would not differ significantly from the IBC Vision Plan. As described above, impacts are less than significant with incorporation of the PPPs and PDFs.

IMPACT 5.5-2: FUTURE DEVELOPMENT COULD POTENTIALLY BE SUBJECTED TO SEISMIC-RELATED GROUND FAILURE, INCLUDING LANDSLIDES, LATERAL SPREADING, SUBSIDENCE, LIQUEFACTION, OR COLLAPSE, RESULTING IN RISKS TO LIFE AND PROPERTY. [THRESHOLDS G-1iii, G-1iv AND G-3]

Impact Analysis: Secondary effects of earthquakes are nontectonic processes such as ground deformation, including fissures, settlement, displacement, and loss of bearing strength, and are the leading causes of damage to structures during a moderate to large earthquake. Secondary effects leading to ground deformation include liquefaction, lateral spreading, seismically induced landslides, and ground lurching.

Impacts Related to Liquefaction

Research and historical data indicate that loose, granular materials at depths of less than 50 feet with silt and clay contents of less than 30 percent saturated by relatively shallow groundwater table are most susceptible to liquefaction. These geological conditions are typical in parts of southern California, including the City of Irvine (City of Irvine GP 2003), and in valley regions and alluviated floodplains. Most of the project site is in SRA-1, which is susceptible to liquefaction.

Much of the project area (mostly northeast of Interstate 405 but also near San Diego Creek) is in a Zone of Required Investigation for Liquefaction, as shown on the State of California Seismic Hazard Zones, Tustin Quadrangle map, reissued in January 2001.

Impacts Related to Seismically Induced Landslides

Marginally stable slopes (including existing landslides) may be subject to landslides caused by earthquakes. The landslide hazard depends on many factors, including existing slope stability, shaking potential, and presence of existing landslides. The terrain of the project site is relatively flat. Therefore, landslides are not expected to impact the project site.

Impacts Related to Seismically Induced Lateral Spreading

Lateral spreading is a phenomenon where large blocks of intact, nonliquefied soil move downslope on a large liquefied substratum. The mass moves toward an unconfined area, such as a descending slope or stream-cut bluff, and has been known to move on slope gradients as little as one degree. Although a liquefaction-induced lateral spread landslide is unlikely because there does not appear to be a "free-face" adjacent to the site, this should be evaluated on a site-specific basis. Site-specific mass grading and compaction that would occur as part of development in the project area would mitigate any potential impacts from seismically induced lateral spreading within the project site.

Impacts Related to Seismically Induced Settlement, Subsidence, and/or Collapse

The potential hazard posed by seismic settlement and/or collapse within the project area is considered to be low in the area underlain by Newport Mesa, but may be moderate for the remainder of the project area, based on the compressibility of the underlying soils and the presence of shallow groundwater. Strong ground shaking can cause settlement of alluvial soils underlying the site by allowing sediment particles to become more tightly packed. Alluvial deposits are especially susceptible to this phenomenon. Artificial fills, if not adequately compacted, may also experience seismically induced settlement. Because unconsolidated soils and undocumented fill material are present within the project area, seismically induced settlement and/or collapse are potential impacts.

Subsidence of basins attributed to overdraft of groundwater aquifers or overpumping of petroleum reserves has been reported in various parts of southern California. There are no oil or gas fields in the project area. Although groundwater withdrawal in the project area has lead to lowered groundwater levels, it has not been excessive. Dewatering may be necessary during grading and construction of new developments in the project area, although this would not result in overpumping of the groundwater system. Therefore, subsidence due to overpumping of groundwater or petroleum reserves is not considered to be a potentially significant impact for the project, and no mitigation is required.

Site-specific mass grading and compaction that would occur as part of future development within the project area would serve to mitigate any potential impacts to seismically induced settlement and/or collapse within the project site. Please refer to PPPs 5-1 through 5-5.

Impacts Related to Ground Lurching

Seismically induced ground lurching occurs when soil or rock masses move at right angles to a cliff or steep slope in response to seismic waves. Structures built on these masses can experience significant lateral and vertical deformations if ground lurching occurs. The project area is on relatively flat terrain, and the potential for ground lurching is considered low. Therefore, no significant adverse impact related to ground lurching is anticipated.

Impacts Related to Dewatering

Excavations extending deeper than about two feet are expected to encounter wet soil conditions and groundwater may be encountered at depths greater than 5 to 10 feet during construction. For projects involving subterranean parking garages, it is likely that a dewatering system will have to be designed and constructed. Construction dewatering systems are constructed for the purpose of temporarily lowering the groundwater table beneath the site for the duration of basement construction. Compliance with existing regulations, including the Uniform Building Code and City of Irvine Grading and Excavation Regulation and Grading Manual, would reduce this impact to less than significant.

For projects where the existing groundwater level is above the subterranean floor level, the floor slabs may be subject to hydrostatic uplift. In addition, there is potential for water seepage through floor slabs and walls which may result in water accumulation and ponding in the basement. Therefore, it will be necessary to incorporate adequate water-proofing and drainage measures for subterranean walls and floor slabs. Also, an active dewatering system consisting of well-points and pumps (with automatic or manual controls) around the buildings may be necessary to control groundwater level and to mitigate water flow into basements during an emergency. The well-points installed for construction dewatering may be incorporated into the de-watering system.

In addition, there is a possibility that some minor settlement and lateral movement of soil in off-site areas adjacent to the site may result from dewatering. However, given the limited size of site's available for redevelopment and the temporary nature of the dewatering activities, subsidence and lateral movement due to construction dewatering is not expected. Compliance with existing regulations, including City of Irvine Grading and Excavation Regulation and Grading Manual, would reduce these hazards to less than significant.

The water quality impacts of dewatering activities are addressed in detail in Section 5.7, *Hydrology and Water Quality*, of this Recirculated DEIR. It should be noted that before water collected by a dewatering system could be discharged into municipal storm drains, the project would be required to obtain a permit pursuant to Order Number 98-67, adopted on July 10, 1998 by the Santa Ana Regional Water Quality Control Board.

Subsequent Development Pursuant to the Proposed Project

The proposed project also includes 2,250 pending units identified in Section 3, *Project Description*, for which applications are on file with the City. Impacts associated with the individual development projects—Martin Street Condos, 2851 Alton, Avalon Jamboree II, Irvine Technology Center, Kilroy, Alton/Millikan Apartments, and 2852 Kelvin—would not differ significantly from the IBC Vision Plan, as identified above. Dewatering will be required for Avalon Jamboree II, Irvine Technology Center, and Kilroy. However, as described above, impacts are less than significant with incorporation of the PPPs and PDFs.

IMPACT 5.5-3: THE PROJECT WOULD NOT RESULT IN SUBSTANTIAL SOIL EROSION OR THE LOSS OF TOPSOIL. [THRESHOLD G-2]

Impact Analysis: Soils in the project area have already been disturbed by development in the IBC. Therefore, the loss of topsoil is not a potential impact. Soils in the project area are particularly prone to erosion during the grading phase of development, especially during heavy rains. Reduction of the erosion potential can be accomplished through a Storm Water Pollution Prevention Plan, which specifies best management practices for temporary erosion controls. Such measures typically include temporary catchment basins and/or sandbagging to control runoff and contain sediment transport within the project site. A comprehensive discussion of erosion can be found in Section 5.7, *Hydrology and Water Quality*.

Subsequent Development Pursuant to the Proposed Project

The proposed project also includes 2,250 pending units identified in Section 3, *Project Description*, for which applications are on file with the City. Impacts associated with the individual development projects—Martin Street Condos, 2851 Alton, Avalon Jamboree II, Irvine Technology Center, Kilroy, Alton/Millikan Apartments, and 2852 Kelvin—would not differ significantly from the IBC Vision Plan. As described above, impacts are less than significant with incorporation of the PPPs and PDFs.

IMPACT 5.5-4: THE PROJECT COULD HAVE CORROSIVE OR EXPANSIVE SOIL. [THRESHOLD G-4]

Impact Analysis: Highly expansive soils swell when they absorb water and shrink as they dry and can cause structural damage to building foundations and roads. Thus, they are less suitable for development than nonexpansive soils. The project area is known to have a very high potential for expansive soils. The presence of expansive soils in areas proposed for construction would be considered a potentially significant impact. Construction techniques that address expansive soils include deepened foundations, post-tension foundations, and moisture conditioning. Compliance with the PPPs 5-1 through 5-5, which require site-specific geotechnical investigations for new construction, would reduce potential impacts associated with expansive soils to a less than significant level.

Subsequent Development Pursuant to the Proposed Project

The proposed project also includes 2,250 pending units identified in Section 3, *Project Description*, for which applications are on file with the City. Impacts associated with the individual development projects—Martin Street Condos, 2851 Alton, Avalon Jamboree II, Irvine Technology Center, Kilroy, Alton/Millikan Apartments, and 2852 Kelvin—would not differ significantly from the IBC Vision Plan. As described above, impacts are less than significant with incorporation of the PPPs and PDFs.

5.5.4 Cumulative Impacts

The geographic scope for geology and seismicity includes growth projections for Orange County within the framework of the regional geologic setting. Past projects in surrounding Orange County cities and unincorporated areas have converted undeveloped and agricultural land to urban uses resulting in residential and employment increases and exposure of a greater number of persons to geologic and seismic hazards. The contribution of these past projects to area growth is also reflected in the Orange County Projections, OCP-2006. Most of the soils on the site are well suited for urban development, including construction. On-site impacts related to soils, such as erosion, loss of topsoil, expansive soils, and corrosion, are proposed to be controlled through various Plans, Programs, and Policies identified in PPPs 5-1 through 5-6.

The level of seismic activity expected in the project area is similar to the county and other regions of southern California. All development at the project site and new development in the region in general will be required to be constructed to withstand probable seismic forces, including seismic-related ground failure like liquefaction. As cumulative projects are constructed, more people and structures will be exposed to seismic hazards. Other geotechnical constraints, such as expansive soils and landslides, may present hazards to cumulative development. Adherence to site-specific geotechnical recommendations and applicable building codes and grading ordinances will reduce potential cumulative geotechnical impacts to a level less than significant.

5.5.5 Level of Significance Before Mitigation

Upon implementation of the PPPs listed above, the following impacts would be less than significant: 5.5-1, 5.5-2, 5.5-3 and 5.5-4.

Impact 5.5.-1

Adherence to PPP 5-6 would ensure that all structures are designing in accordance with the CBC. Design of structure in accordance with the CBC would minimize the effects of ground shaking to the greatest degree feasible and to less than significant levels except for a catastrophic seismic event. Therefore, impacts are less than significant.

Impact 5.5-2

PPP 5-1 through PPP 5-6 would ensure that geologic conditions affecting a project site would be mitigated. PPP 5-3 would require a detailed geotechnical investigation for each Rough Grading Plan. In addition, PPP 5-4 and PPP 5-5 would require that all earthwork be performed in accordance with the City of Irvine Grading Code and Grading Manual. With adherence to the PPPs, geotechnical hazards would be less than significant.

Impact 5.5-3

Soils in the project area are particularly prone to erosion during the grading phase of development, especially during heavy rains. However, adherence to best management practices for temporary erosion controls, including temporary catchment basins and/or sandbagging to control runoff and contain sediment transport within the project site, within the Stormwater Pollution Prevention Plan would ensure no significant impact occur.

Impact 5.5-4

Adherence to PPP 5-2 through PPP 5-6, which include requirements for site-specific geotechnical investigations for new construction, would reduce potential impacts associated with expansive soils to a less than significant level.

5.5.6 Mitigation Measures

No mitigation measures are required.

5.5.7 Level of Significance After Mitigation

No significant impacts have been identified and no mitigation measures are required.

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