4.5 GEOLOGY, SOILS, AND SEISMICITY

The following chapter summarizes information concerning current geologic conditions in the Specific Plan Area. It also evaluates the potential environmental consequences of future development that could arise from adopting and implementing the proposed Specific Plan Update, and approval and development of the proposed Transit-Oriented Developments (TOD) #1 and #2 (together referred to as the "proposed Project"). Such consequences could include potentially significant direct and indirect environmental impacts related to geology, soils, and seismicity.

The analysis in this chapter is based on the following reports:

- BAGG Engineers, Inc., 2013, Draft Report Geotechnical Engineering Investigation, Proposed Development, Millbrae Station West Side Properties, Millbrae, California, dated June 21, 2013.
- Cornerstone Earth Group, 2014, Geotechnical Investigation – Millbrae BART Transit Oriented Development, dated June 13, 2014.

The above-referenced geotechnical resources reports are included in this Draft EIR as Appendix D, Geotechnical Data.

4.5.1 ENVIRONMENTAL SETTING

4.5.1.1 REGULATORY FRAMEWORK

Federal Regulations

There are no federal regulations regarding geology, soils and seismicity that are applicable to the proposed Project.

State Regulations

The most relevant State laws that regulate geology, soils, and seismicity in the Specific Plan Area are the Alquist-Priolo Earthquake Fault Zoning Act, the Seismic Hazards Mapping Act, and the California Building Code (CBC), each of which is described below.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface fault rupture to structures used for human occupancy.[1] The main purpose of the Act is to prevent the construction of

[1] Originally titled the *Alquist-Priolo Special Studies Zones Act* until renamed in 1993, Public Resources Code Division 2, Chapter 7.5, Section 2621.

buildings used for human occupancy on top of the traces of active faults. Although the Act addresses the hazards associated with surface fault rupture, it does not address other earthquake-related hazards, such as seismically induced ground shaking, landslides, or liquefaction.[2]

The law requires the State Geologist to establish regulatory zones (originally known as Special Study Zones and now referred to as Earthquake Fault Zones ["EFZs"]) around the surface traces of active faults, and to publish maps that depict these zones.[3] The published maps are distributed to the affected cities, counties, and State agencies for their use in planning and controlling new or renewed construction. In general, construction within 50 feet of the trace of an active fault is prohibited.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act, enacted in 1990, addresses earthquake hazards other than surface fault rupture, such as liquefaction and seismically induced landslides.[4] Under this Act, seismic hazard zones (i.e. areas where seismically induced landslide and liquefaction hazards are known to be present) are mapped by the State Geologist to assist local governments in land use planning. The Act states that "it is necessary to identify and map seismic hazard zones in order for cities and counties to adequately prepare the safety element of their General Plans and to encourage land use management policies and regulations to reduce and mitigate those hazards to protect public health and safety."[5] Section 2697(a) of the Act states that "cities and counties shall require, prior to the approval of a project located in a seismic hazard zone, a geotechnical report defining and delineating any seismic hazard."[6]

California Building Code

The State of California provides a minimum standard for building design through the CBC, which is found in Part 2, Title 24, Part 2, Volumes 1 and 2 of the California Code of Regulations (CCR). The most current issuance of the CBC, the CBC, is based on the 2012 International Building Code (IBC) modified to account for California conditions. It is generally adopted on a jurisdiction-by-jurisdiction basis, often subject to further modifications based on local conditions. Through the CBC, the State provides a minimum standard for building design and construction. The CBC contains specific requirements for seismic safety, excavation, foundations, retaining walls, and site demolition. It also regulates grading activities, including drainage and erosion control.[7]

[2] California Geological Survey (CGS), Alquist-Priolo Earthquake Fault Zones, http://www.conservation.ca.gov/cgs/rghm/ap/Pages/main.aspx, accessed on February 3, 2015.

[3] Earthquake Fault Zones are regulatory zones around active faults. Although they vary in width, most zones are approximately 0.25 mile wide, http://www.conservation.ca.gov/cgs/rghm/ap/Pages/main.aspx, accessed on February 24, 2015.

[4] California Geological Survey (CGS), Seismic Hazards Zonation Program, http://www.conservation.ca.gov/cgs/shzp/Pages/prc_shmact.aspx , accessed on February 24, 2015.

[5] California Public Resources Code, Division 2, Chapter 7.8, Section 2691(c).

[6] California Public Resources Code, Division 2, Chapter 7.8, Section 2697(a)

[7] California Building Standards Commission , 2015. California Building Code, California Code of Regulations,Title 24, Part 2, Volumes 1 and 2, http://www.bsc.ca.gov/Home/Current2013Codes.aspx, accessed on February 23, 2015.

Local Regulations

Millbrae 1998-2015 General Plan

The Safety Element of the City of Millbrae General Plan, adopted November 24, 1998, outlines various goals, policies, and implementing programs that are relevant to geology, soils, and seismic hazards. The policies relevant to the Specific Plan Area are listed in Table 4.5-1.

TABLE 4.5-1 GENERAL PLAN POLICIES RELEVANT TO GEOLOGY, SOILS AND SEISMICITY

Number	Policy
Safety (S) Element	
S1.3	Minimize Geological Hazards. Require all geologic hazards be adequately addressed and mitigated through project development. Development proposed within areas of potential geological hazards shall not be endangered by, nor contribute to, the hazardous conditions on the site or on adjoining properties.
S1.4	Seismic Safety. Assure existing and new structures are designed to protect people and property from seismic hazards.
S1.5	Geologic/Geotechnical Studies. Require geotechnical studies for development proposals; such studies should determine the actual extent of geologic/ geotechnical hazards, optimum location for structures, the advisability of special structural requirements, and the feasibility and desirability of a proposed facility in a specified location. In particular, the land generally west of the Spur property as potentially hazardous to development. Require detailed geologic/ geotechnical site studies for all new development and site alterations in this part of the City. Studies should evaluate development risk and determine the engineering precautions necessary to satisfactorily mitigate any risk.
S1.6	Geotechnical and Geologic Review. Require geotechnical and geologic review of development proposals in accordance with City procedures to assess potential seismic hazards, liquefaction, landsliding, mudsliding, erosion, sedimentation and settlement in order to determine if these hazards can be adequately mitigated. Once identified, all areas having unstable soil conditions and/ or potential seismic hazards should be inventoried and monitored.
S1.7	Bay Fill. Ensure the safety of new development on Bay fill against the effects of liquefaction and/ or subsidence through proper construction techniques.
S1.9	Serra Fault. Buildings for human occupancy should not be constructed on or across the main surface lineaments of the Serra Fault, unless such buildings can safely accommodate anticipated fault displacements. [N.B. Mapped traces of the Serra Fault appear to be well set-back from the Specific Plan Area, lying roughly 0.65 miles to the southwest.]
S1.10	Active Faults. The City will minimize, to the extent possible, major streets or public utility lines for gas, water, electricity, flood control, and sanitary sewers being constructed across any active faults.
S1.11	Capital Improvements to Improve Safety. The City shall continue to give priority to capital improvements required to maintain an acceptable level of safety throughout the community, and will take measures to prevent damage to the City's infrastructure and emergency facilities resulting from seismic, geologic and geotechnical hazards.
S1.16	Erosion/Sediment Control. Provide appropriate erosion and sediment control measures in conjunction with proposed development in areas susceptible to erosion and regularly maintain all creekbeds and conduits to minimize problems stemming from their erosion.
S2.1	High Occupancy Structures. High-occupancy structures (such as schools, hospitals, office buildings and apartments) or critical emergency facilities (such as fire and police stations, emergency relief storage facilities, and water storage tanks) should not be located within an active fault's "zone of potential surface deformation". In addition, high-occupancy structures should be designed or redesigned to protect human life to the highest degree possible during the "maximum probable event" of seismic activity. High occupancy structures should also have emergency plans approved by the City.

Source: City of Millbrae General Plan 1998-2015, adopted November 24, 1998.

Millbrae Municipal Code

The City of Millbrae Municipal Code contains all ordinances for the city. The Municipal Code is organized by Title, Chapter, and Section. The current Municipal Code is up to date through Ordinance 747, passed on May 27, 2014. The following provisions of Title 9, Building Regulations, of the Municipal Code are relevant to geologic, soils, and seismic hazards:

- **Chapter 9.05 Building Code.** Per Section 9.05.010 the City has adopted the 2013 California Building Code including modifications relevant to Millbrae. The Building Code contains specific requirements for seismic safety, excavation, foundations, retaining walls, and site demolition.
- **Chapter 9.45 Grading.** This chapter contains grading-related requirements such as issuance of permits prior to development, erosion control measures and plans, periodic inspections during grading, stability of cut slopes, and weather limitations during grading.
- **Chapter 9.65 Seismic Hazard Identification Program for Unreinforced Masonry Buildings.** This Chapter contains provisions for the identification of buildings in the city, which exhibit structural deficiencies in their capacities for seismic resistance, and determination of the magnitude of those deficiencies in the context of public safety.

4.5.1.2 EXISTING CONDITIONS

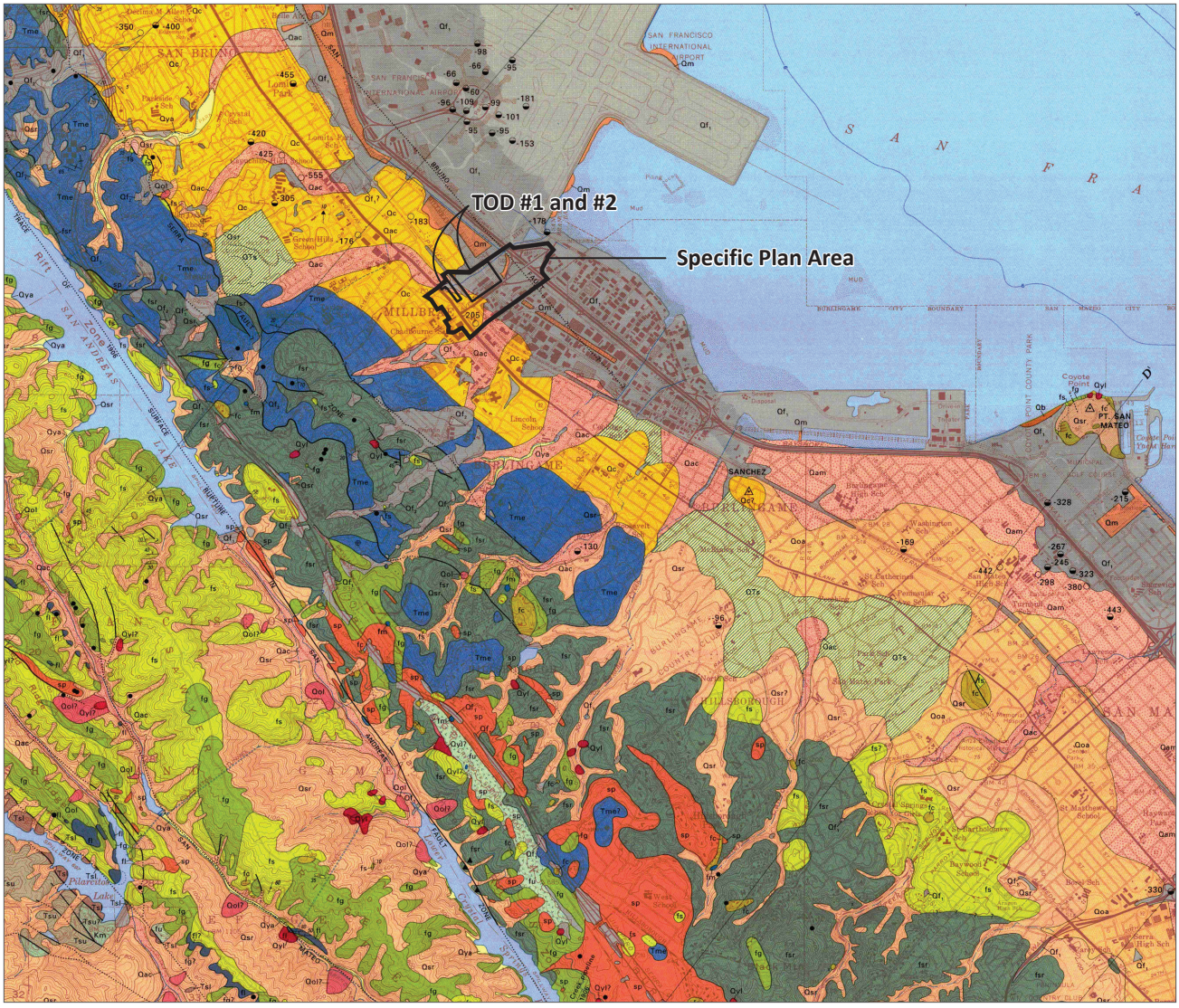
This section includes a discussion of the existing geological and seismic conditions and soil resources in and around the Specific Plan Area.

Soils and Geology

The Specific Plan Area is located within the United States Geological Survey's (USGS's) Montara Mountain, California 7.5-minute topographic quadrangle map[8] (see Figure 4.5-1). From a geomorphology perspective, the Specific Plan Area and the surrounding city of Millbrae lie in the San Francisco Peninsula, which, in turn, is set within the Coast Ranges Geomorphic Province.[9] The San Francisco Peninsula lies north of the Santa Cruz Mountains where it is flanked by the Pacific Ocean and San Francisco Bay to the west and east, respectively. The Coast Ranges geomorphic province is typified by a chain of northwest-southeast trending mountains that stretch from the Oregon border on the north to Point Conception on the south. In the San Francisco Bay area, most of the Coast Ranges are underlain by tectonically complex, Jurassic- to Cretaceous-age bedrock of the Franciscan Complex.

[8] United States Geological Survey (USGS), 2012. Montara Mountain, California Quadrangle, 7.5-Minute Series, scale 1:24,000, digital download available at: http://nationalmap.gov/ustopo/index.html, accessed on February 17, 2015.

[9] Norris, R.M. and R.W. Webb, 1990. *Geology of California,* Second Edition.



Source: USGS, 1994, Geologic Map of the Montara Mountain and San Mateo 7 ½ Minute Quadrangles, San Mateo County, California, compiled by Earl Pampeyan.

0 1
Scale (Mile)

DESCRIPTION OF MAP UNITS

- Qya — Younger alluvium (Holocene)
- QTs — Sedimentary deposits, undivided (Holocene to Pliocene)
- Qaf — Fine-grained alluvium (Holocene)
- Qam — Medium-grained alluvium (Holocene)
- Qac — Coarse-grained alluvium (Holocene)
- Qsr — Slope wash, ravine fill, and colluvium (Holocene)
- Qm — Bay mud (Holocene)
- Qb — Beach deposits (Holocene)
- Qd — Dune sand (Holocene)
- Qyl — Younger landslide deposits (Holocene)
- Qf_1 — Artificial fill (Holocene) Unit 1
- Qf_2 — Unit 2
- Qol — Older landslide deposits (Holocene and Pleistocene?)
- Qoa — Older alluvium (Pleistocene)

PIGEON POINT AND LA HONDA BLOCKS

- Qmt — Marine terrace deposits (upper Pleistocene)
- Tp — Purisima Formation (Pliocene)
- Tmi — Mindego Basalt (Miocene and (or) Oligocene)

Sandstone, shale, and conglomerate (Paleocene)

- Tsu — Upper part
- Tsl — Lower part
- Km — Granitic rock of Montara Mountain (Cretaceous)
- pKm — Metasedimentary rock (pre-Cretaceous)

PILARCITOS AND SAN FRANCISCO BAY BLOCKS

- Qs — Santa Clara Formation (Pleistocene)
- Qc — Colma Formation (Pleistocene)
- Tme — Merced Formation (upper Pliocene)
- Ta — Arenite (Eocene?)

Franciscan Complex and associated rocks (Cretaceous and Jurassic)

- fu — Meta-igneous and metasedimentary rocks, undivided
- fs — Sandstone
- fcg — Conglomerate
- fg — Greenstone
- fc — Chert
- fl — Limestone
- fm — Metamorphic rock
- fsr — Sheared rock
- sp — Serpentinite
- sc — Silica-carbonate rock

Figure 4.5-1
Geologic Map

The topography in the immediate vicinity of the Specific Plan Area is relatively flat, with a gentle prevailing slope toward the northeast. Ground surface elevations at the Specific Plan Area generally range from 15 to 60 feet above mean sea level (msl), whereas the neighboring hills to the southwest locally attain elevations in excess of 450 feet above msl. Much of the runoff in the Specific Plan Area flows northeast in Laurel Creek, eventually discharging to nearby San Francisco Bay.

Based on the geologic mapping conducted by the USGS, the California Geological Survey, and others, the Specific Plan Area is immediately underlain by Holocene artificial fill and Bay Mud in the northeast part, and sediments of the Pleistocene Colma Formation and Quaternary alluvium in the southwest part.[10] The artificial fill was described as poorly consolidated to well-consolidated gravel, sand, silt, and local rock fragments. The Bay Mud, which consists of fine-grained, estuarine sediments such as soft to medium stiff clay and fine sand, underlies the artificial fill at many locations in the northeast part of the Specific Plan Area. The Colma Formation is composed of poorly consolidated silty sand and sandy clay of a shallow marine origin, with lesser amounts of poorly to well-sorted sand and gravel. The Quaternary alluvium was described as unconsolidated, moderately sorted sand and gravel that often forms stream levees, fans, and floodplains. In contrast to these (geologically) young sediments, the aforementioned hills southwest of the Specific Plan Area appear to be underlain by a combination of the marine sedimentary bedrock of the Upper Pliocene Merced Formation and the sheared, Jurassic to Cretaceous sedimentary bedrock (i.e. altered volcanic sediments and chert) of the Franciscan Complex. This bedrock is often referred to as the "Franciscan Mélange," especially where it is heavily sheared and tectonic inclusions are present.

Soil mapping data available through the U.S. Department of Agriculture's (USDA's) *Web Soil Survey*, a nationwide cooperative soil database, indicates that most of the Specific Plan Area is underlain by so-called Urban Land Orthent or Urban Land soil types.[11] The Urban Land Orthents reportedly consist of soils that have been cut and filled for urban development, such as the construction of roads and buildings. These soils are nearly level to gently sloping, and they reportedly consist of deep, well-drained silty clay loam. In most areas, the texture of the upper part of the soil varies greatly because it has been graded and moved or fill material has been added. Their characteristics are highly variable due to differences in the type and amount of fill material used. Runoff is reportedly slow, and the hazard of water erosion is slight.[12]

Two recent geotechnical investigations within the Specific Plan Area provide more definitive information about the nature of soils in the area.[13,14] The investigations were conducted at two different but proximal TOD #1 and TOD #2 project sites (see Appendix D, Geotechnical Data, of this Draft EIR). Together, they used a variety of exploratory techniques to better define the shallow geology underlying these areas, and to document and quantify the geotechnical properties of subsurface earth materials. The exploratory techniques included soil borings drilled

[10] USGS, 1994. Geologic Map of the Montara Mountain and San Mateo 7 ½ Minute Quadrangles, San Mateo County, California, compiled by Earl Pampeyan.

[11] U.S. Department of Agriculture (USDA), Natural Resources Conservation Service, 2015. Web Soil Survey, http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, accessed on February 4, 2015.

[12] USDA, Soil Conservation Service, 1991, Soil Survey of San Mateo County, Eastern Part, and San Francisco County, California.

[13] BAGG Engineers, Inc., 2013, Draft Report Geotechnical Engineering Investigation, Proposed Development Millbrae Station West Side Properties, Millbrae, California, dated June 21, 2013.

[14] Cornerstone Earth Group, 2014, Geotechnical Investigation, Millbrae BART Transit Oriented Development, dated June 13, 2014.

with hollow-stem auger drill rigs, cone-penetrometer test borings, and a broad array of field and laboratory tests and evaluations. In general, the geotechnical studies found that shallow soils often consisted of shallow artificial fill of widely varying thickness ranging up to 9 feet thick, underlain by native soils composed of stiff, medium dense sandy clay to clayey sand with local occurrences of soft, compressible Bay Mud. The thickness of the Bay Mud appeared to be greatest at sample locations further northeast. The TOD #1 project site varied from 6 to 11 feet thick near the northeast corner of that project site, whereas the thicknesses at the TOD #2 project site were considerably greater, ranging from 8.5 to a maximum of 28 feet that was documented in the northeast part of that site.

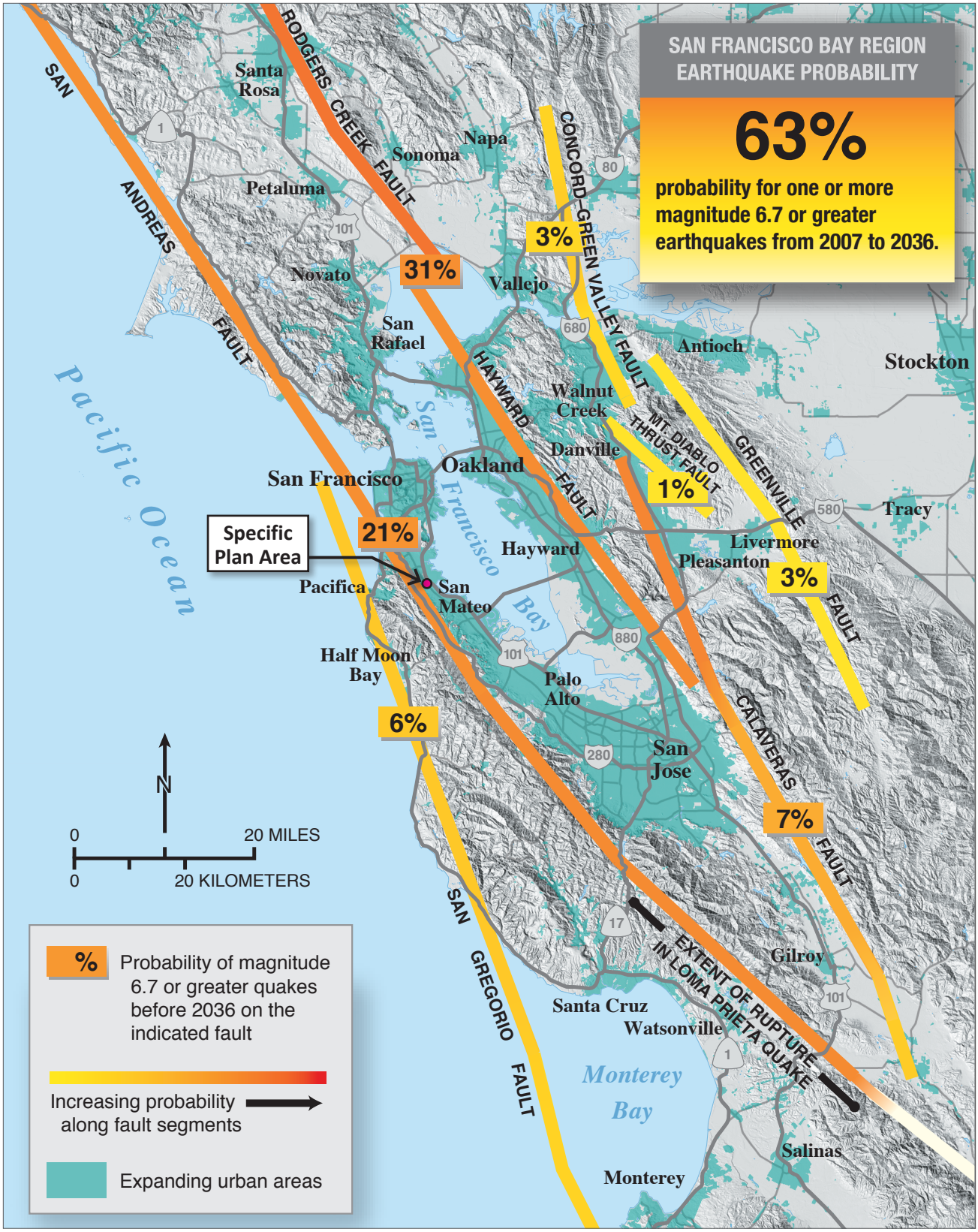
The geotechnical investigations also documented the presence of silty sand and sandy clay of the Pleistocene Colma Formation beneath the native soils and Bay Mud sequence described above. The depth to this formation varied considerably, and its upper contact typically lay 6 to 18 feet below ground surface (bgs) at the TOD #1 project site. Although the contact was not expressly identified in the boring logs for the TOD #2 project site, the depth to this contact appears to be greater based on the observed base of the Bay Mud beneath that Project site. Finally, certain deeper borings beneath the TOD #1 project site encountered well-indurated sedimentary and low-grade metamorphic bedrock (tentatively assigned to the Franciscan Formation) at depths between 30 and 40 feet bgs. Borings beneath the TOD #2 project site were drilled and sampled to depths of 80 feet bgs. The absence of such well-indurated bedrock in these borings suggests that the upper contact of the Franciscan Formation may approach depths of 100 feet bgs or more beneath the TOD #2 project site.

Regional Faulting, Seismicity, and Related Seismic Hazards

The Working Group on California Earthquake Probabilities, a collaborative effort involving the USGS, the California Geological Survey, and the Southern California Earthquake Center, estimates that the 30-year probability of a magnitude 6.7 or greater earthquake striking the San Francisco Bay area is 63 percent[15] (see Figure 4.5-2). An earthquake of moderate to high magnitude generated within the San Francisco Bay area could cause significant ground shaking in the Specific Plan Area. The degree of shaking would depend on a number of variables including the magnitude of the event, the duration of the event, the distance to the zone of rupture (i.e. hypocenter), and local geologic conditions.

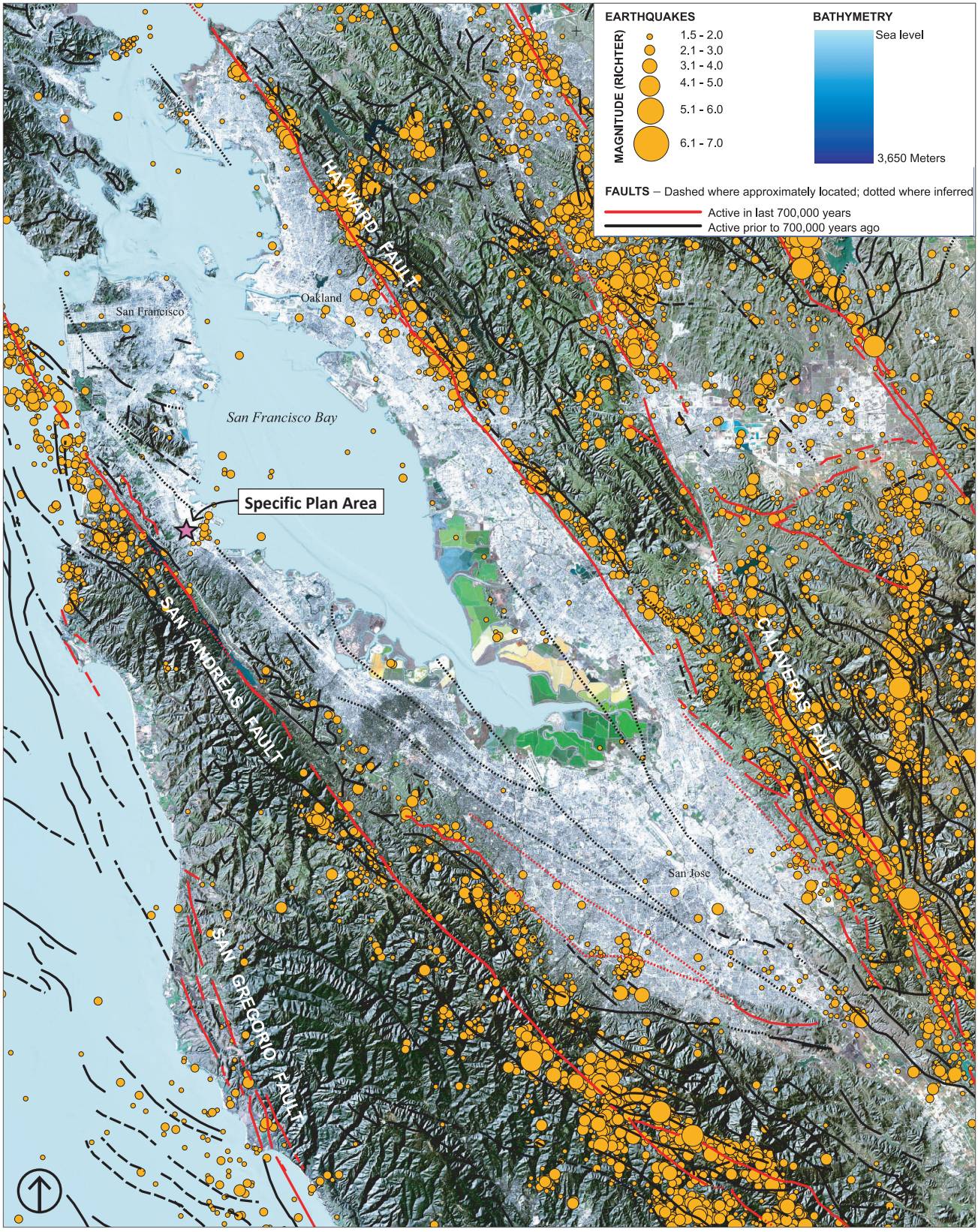
The Specific Plan Area lies roughly 1.5 miles northeast of the northwest-southeast trending San Andreas Fault Zone, a prominent regional tectonic feature that demarks the margin between the North American and Pacific Tectonic Plates. Movement along this fault system has produced the present-day northwest trending topographic and structural grain that dominates the region. The entire San Andreas Fault system, which includes not only the main San Andreas Fault, but its associated fault splays, is about 40 miles wide, extending from the San Gregorio fault that runs parallel to the Pacific coast, east to the Coast Ranges-Central Valley blind thrust at the edge of the Central Valley. The San Andreas Fault itself is the dominant fault in this region and is capable of producing the largest earthquakes, but many other faults in the system such as the Calaveras, Hayward, and Rodgers Creek Faults, are also active and capable of producing significant earthquakes. Although right-lateral, strike-slip movement dominates the fault system, thrust faulting has been locally documented (see Figure 4.5-3).

[15] 2007 Working Group on California Earthquake Probabilities, 2008, The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2), page 6.



Source: 2007 Working Group CA Earthquake Probabilities, 2008, The Uniform CA Earthquake Rupture Forecast, Ver.2 (UCERF 2).

Figure 4.5-2
Earthquake Probabilities



Source: USGS, 2004, Earthquakes and Faults in the San Francisco Bay Area (1970-2003), Scientific Investigations Map 2848.

Figure 4.5-3
Map of Earthquake Faults

As noted above, the San Andreas Fault, which lies approximately 1.5 miles southwest of the Specific Plan Area, is the closest State-designated "active" fault that has been mapped near the Specific Plan Area. By definition, active faults are ones that have ruptured in the last 11,000 years (some San Andreas examples: 1906 San Francisco Earthquake and 1989 Loma Prieta Earthquake). Accordingly, an Alquist-Priolo Zone (i.e. APZ) has been mapped about its trace.[16] In addition to the San Andreas Fault, the Serra Fault has been considered a "potentially active" fault that traverses the west part of the City of Millbrae. This fault runs roughly parallel to the San Andreas, passing through the west part of the City of Millbrae. Its closest mapped trace lies approximately 0.65 miles southwest of the Specific Plan Area. Although it was originally mapped as an Alquist Priolo SSZ in the mid-1970s, it was later re-classified as "potentially active" based on a re-evaluation by the California Geological Survey.[17] Its status notwithstanding, no active or potentially active faults have been mapped within the Specific Plan Area, nor is the area located within a State-designated APZ.

Landslides

As previously discussed in this section, the topography in the Specific Plan Area and in its immediate vicinity is comparatively flat, with gentle prevailing slopes toward the northeast, in the direction of San Francisco Bay. Given this topographic setting, the potential for landslides is considered negligible. The State of California, pursuant to the Seismic Hazard Zonation Program, has not identified any landslide hazard zones that lie within the Specific Plan Area. In a related county-wide investigation, the USGS determined that the probability of debris flows (a common form of landslide) at the Project site was near-zero.[18]

Liquefaction

Liquefaction is a phenomenon where unconsolidated, moisture-laden granular soils rapidly lose cohesion and are temporarily transformed to a fluid state due to shaking and vibration. Such shaking and vibration can occur during major seismic events, and the resulting loss of soil strength can produce ground failure, resulting in damage to buildings, roads, bridges, pipelines, and other man-made structures. Liquefaction is most likely to occur in areas typified by unconsolidated, fine-grained, granular sediments and high soil moisture content, such as areas with shallow groundwater.

The CGS has not mapped the Specific Plan Area or its vicinity for potential seismically-induced liquefaction hazards. Nevertheless, the USGS has mapped much of the San Francisco Bay region to better understand the comparative risk for seismically-induced liquefaction.[19] This mapping effort generally shows that the Specific Plan Area has been designated as an area of "moderate" to "very high" liquefaction hazard.

[16] California Geological Survey (CGS), 2013. Search for Regulatory Maps (including Earthquake Fault Zones), http://www.quake.ca.gov/gmaps/WH/regulatorymaps.htm, accessed on July 8, 2013.

[17] California Division of Mines and Geology, 1981, Fault Evaluation Report FER-H9, Serra Fault, dated March 31, 1981.

[18] USGS, 1992. Map of Debris-Flow Probability, San Mateo County, California. Compiled by Robert K. Mark. Miscellaneous Investigation Series, Map 1-1257-M.

[19] USGS, 1997. Quaternary Geology and Liquefaction Susceptibility Maps, San Francisco 1:100,000, Open-File Report 97-715, compilers: Keith L. Knudsen, Jay Stratton Noller, Janet M. Sowers, and William R. Lettis of William Lettis & Associates, Inc.

In their assessment, the USGS evaluated liquefaction susceptibility based on: 1) the presence of loose, cohesionless, sandy, or silty deposits no deeper than 50 feet bgs; 2) the presence of groundwater that can produce saturated conditions in these sediments; 3) historical evidence of liquefaction during previous seismic events; and 4) various borehole test data and logs. Liquefaction susceptibility units were then established using a criteria matrix that assigned a susceptibility value to different combinations of geologic units (i.e. type and age of the deposit) and groundwater levels.

The recent geotechnical investigations at the TOD #1 and TOD #2 project sites provided a more conclusive evaluation of liquefaction potential within the Specific Plan Area. For the more easterly TOD #2 project site, shallow groundwater was encountered between the approximately depths of 5.5 and nearly 20 feet bgs. Quantitative analysis of the liquefaction potential concluded that post-liquefaction differential settlement could be as great as 1.5 inches in the west-central part of the TOD #2 project site (i.e. Area 5A). For the TOD #1 project site, similar liquefaction modeling indicated levels of post-liquefaction total settlement up to one inch and differential settlement in the range of once inch in 100 feet.

Unstable Geologic Units

Geologic units and soils beneath the Specific Plan Area could present risks where they are considered unstable, that is, prone to subsidence, differential settlement, and/or shrink-swell behavior (i.e. expansive soils). Much like liquefaction, soil stability often depends on a variety of site-specific factors, such as soil texture, moisture content, mineralogical composition (i.e. certain clay minerals, notably clays of the smectite group, are more prone to shrink-swell behavior), cohesiveness, and organic content.

Shrink-swell is the repeated change in volume (expansion and contraction) that occurs in fine-grained, clay-rich sediments as they undergo alternating wetting and drying cycles. Structural damage to overlying buildings, roads, or other man-made infrastructure can occur over a long period of time, usually as a result of inadequate soil and/or foundation engineering or the construction of structures directly on expansive soils.

Previous USDA soil surveys of the Specific Plan Area and its surroundings revealed that the predominant soils in the shallow subsurface consist of loam and clayey loam. Although the USDA survey concluded that this soil "has few limitations" for urban development, they nevertheless acknowledged that the Urban Land Orthent soils are extremely variable, consisting of loamy material in areas that have been mechanically altered for residential and other urban uses.

Recent, site-specific geotechnical investigations provided a more definitive evaluation of the stability of soils within the Specific Plan Area. During the investigations, representative soil samples were subjected to laboratory tests to quantify a variety of characteristics, including Plasticity Index (PI). For the TOD #1 project site, 11 soil samples were tested. The resultant PI values ranged from 0 to 35, suggesting that the swelling potential of soil in this part of the Specific Plan Area is low to moderate. The two most plastic samples were sandy clays encountered at 2 feet bgs in boring B-1 and 14 feet bgs in boring B-7. A review of the boring logs suggests these samples correlate with occurrences of loose native soil and Bay Mud, respectively. The results of plasticity tests on samples from the TOD #2 project site yielded comparable results with PI values ranging from 12 to 20, also suggesting a low to moderate swelling potential.

The Bay Mud, a well-known fine-grained sedimentary unit that flanks much of south San Francisco Bay is known to be present in the Specific Plan Area. These deposits often consist of highly compressible, plastic clay with minor layers of lean to sandy clay, silt to clayey silt, and clayey sand, with local peat interbeds and lenses. Bay Mud is normally moderately to highly compressible, and often poses a geological hazard due to consolidated settlement. Consolidation settlement occurs when a fine-grained soil is loaded with the weight of new fill or of improvements such as structures or roads. The new loads cause increases in soil pore water pressure, and as the pore pressures wane, the soil volume decreases. Settlement rates are also influenced by the permeability and thickness of the soil layers.

4.5.2 STANDARDS OF SIGNIFICANCE

The proposed Project would have a significant impact with regard to geology, soils and seismicity if it would:

1. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
   - Surface rupture along a known active fault, including those faults identified on recent Alquist-Priolo Earthquake Fault Zoning Maps issued by the State Geologist, or active faults identified through other means (i.e. site-specific geotechnical studies, etc.).
   - Strong seismic ground shaking.
   - Seismic-related ground failure, including liquefaction.
   - Landslides.
2. Result in substantial soil erosion or the loss of topsoil.
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 landsliding, lateral spreading, subsidence, liquefaction, or collapse.
4. Be located on expansive soil, as defined in Section 1803.5.3 of the California Building Code, creating substantial risks to life or property.
5. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

With regards to Standard of Significance 5, as discussed in Chapter 3, Project Description, the Specific Plan Area is in a highly urbanized area within the City of Millbrae. Development of the Specific Plan Area will not require the use of septic tanks or alternative waste water disposal systems. Wastewater will be discharged into the existing public sanitary sewer system, which is serviced by the City of Millbrae's Public Works Department. Accordingly, there would be no impact related to soils in this respect and no further discussion on this topic is warranted in this Draft EIR.

4.5.3 IMPACT DISCUSSION

GEO-1	The proposed Project would expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving surface rupture along a known active fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction and landslides.

Specific Plan Update

Development of the Specific Plan Area would have a significant environmental impact if it would expose people or structures to potentially substantial adverse effects including the risk of loss, injury, or death involving surface rupture along a known active fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction; and landslides. As previously discussed, no Alquist-Priolo Earthquake Fault Zones or seismically-induced landslide hazard zones have been established by the CGS within the Specific Plan Area boundaries, nor have any such zones been mapped in the immediate vicinity. Furthermore, no potentially active faults have been mapped within the Specific Plan Area. The Serra Fault, the closest mapped potentially active fault, appears to be well set-back, located roughly 0.65 miles west of the Specific Plan Area. Thus, the risk of surface fault rupture or earthquake-induced landslides associated with the development of the Specific Plan Area is considered low and the impacts from implementation of the Specific Plan Update as they relate to surface fault rupture or seismic-related landslides are considered *less than significant* and no mitigation measures are required.

The hazards posed by strong seismic ground shaking during a major earthquake, while variable, are nearly omnipresent across the Specific Plan Area and its surroundings. Adherence to applicable building code and building permit requirements would ensure that the impacts associated with such ground shaking are minimized to the maximum extent practicable. Impacts related to strong seismic ground shaking due to implementation of the Specific Plan Update are considered *less than significant* and no mitigation measures are required.

The topography in the Specific Plan Area and in its immediate vicinity is comparatively flat, the CGS has not identified any landslide hazard zones within its boundaries, and the USGS determined that the probability of debris flows is near-zero. Therefore, the impacts from development of the Specific Plan Area as they relate to seismic-related landslides are considered *less than significant* and no mitigation measures are required.

Although the Specific Plan Area has not been mapped by the CGS for potential liquefaction hazards, a regional liquefaction assessment conducted by the USGS assigned a "moderate" to "very high" liquefaction susceptibility to the area, with the greatest susceptibility corresponding to the northeastern-most part of the plan area. Recent, site-specific geotechnical investigations at the TOD #1 and TOD #2 project sites, which are situated in the southwest and central part of the Specific Plan Area, yielded projected liquefaction settlement values that are generally consistent with the USGS's "moderate" susceptibility rating. Nevertheless, significant liquefaction impacts arising from development in the Specific Plan Area cannot be ruled out, and such development could expose people or buildings to substantial adverse effects due to seismic-related liquefaction. Accordingly, the impacts from development of the Specific Plan Area as they relate to seismic-related liquefaction are considered *significant*.

Impact GEO-SP-1: Implementation of the Specific Plan Update could expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving surface rupture along a known active fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction and landslides.

Mitigation Measure GEO-SP-1: Prior to approval of grading permits for a future construction project within the Specific Plan Area, a detailed final geotechnical investigation shall be performed to identify significant geotechnical constraints on the proposed development. The report shall develop formal recommendations for project design and construction, including site grading/soil preparation and foundation design. Among other components, the report shall include a quantitative evaluation of liquefaction susceptibility including projected levels of post-liquefaction settlement; an evaluation of soil shrink-swell potential; and an investigation of compressible soils that may be prone to settlement/subsidence. The report shall be provided by the applicant to the City of Millbrae for review and approval and to ensure that foundations designed for all proposed structures are appropriate and meet code requirements. The geotechnical engineer of record shall also review the final grading, drainage, and foundation plans to confirm incorporation of the report recommendations and field monitoring during project construction shall be performed to verify that the work is performed as recommended.

Significance With Mitigation: Less than significant.

TOD #1 Project

The recent detailed geotechnical investigation of the TOD #1 project site included evaluations of potential geologic and geotechnical hazards, such as surface rupture along a known active fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction and landslides.[20] Much like the rest of the Specific Plan Area, no active or potentially active faults have been mapped at the TOD #1 project site or in its immediate vicinity. Similarly, the CGS has not established any Alquist-Priolo EFZs within its boundaries. Thus, the impacts of the TOD #1 project's development as they relate to surface rupture along a known fault are considered *less than significant* and no mitigation measures are required.

The hazards posed by strong seismic ground shaking during a major earthquake are nearly omnipresent across the Specific Plan Area, including the TOD #1 project site. Adherence to applicable building code and building permit requirements would ensure that the impacts associated with such ground shaking are minimized to the maximum extent practicable. The impacts of development of the TOD #1 project site as they relate to strong seismic ground shaking are considered *less than significant* and no mitigation measures are required.

Although the recent geotechnical investigation of the TOD #1 project site indicated projected total post-liquefaction settlements of less than one inch and projected differential settlements in the range of less than one inch in 100 feet, the report identified "variable liquefaction settlement" as one of the two most significant constraints on the proposed TOD #1 project. Thus, the potential impacts of development of the TOD #1 project site as they relate to seismically induced liquefaction are considered *significant*.

[20] BAGG Engineers, Inc., 2013, Draft Report, Geotechnical Engineering Investigation, Proposed Development Millbrae Station West Side Properties, Millbrae, California, dated June 21, 2013.

The topography in the TOD #1 project site is comparatively flat, the CGS has not identified any landslide hazard zones within its boundaries, and the USGS determined that the probability of debris flows is near-zero. Therefore, the potential impacts from development of the TOD #1 project site as they relate to seismic-related landslides are considered *less than significant* and no mitigation measures are required.

Impact GEO-TOD#1-1: The proposed TOD #1 project could expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving surface rupture along a known active fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction and landslides.

Mitigation Measure GEO-TOD#1-1: The recent geotechnical investigation of the TOD #1 project site concluded that "variable liquefaction settlement" was one of the two most significant geotechnical constraints on the project site. The report presented formal recommendations for project design and construction, including site grading/soil preparation and foundation design, some goals of which were to mitigate the potential for liquefaction-related settlement, expansive soils, and highly compressible soils prone to settlement/subsidence. The final geotechnical report shall be provided to the City of Millbrae for review and approval. The geotechnical engineer of record should also review the final grading, drainage, and foundation plans to confirm incorporation of the report recommendations. Lastly, field monitoring during project construction is warranted to verify that the work is performed as recommended and in accordance with the approved plans and specifications.

Significance With Mitigation: Less than significant.

TOD #2 Project

The recent detailed geotechnical investigation of the TOD #2 project site included evaluations of potential geologic and geotechnical hazards, such as surface rupture along a known active fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction and landslides. Much like the rest of the Specific Plan Area, no active or potentially active faults have been mapped at the TOD #2 project site or in its immediate vicinity. Similarly, the CGS has not established any Alquist-Priolo EFZs within its boundaries. Thus, the impacts of the proposed TOD #2 project's development as they relate to surface rupture along a known fault are considered *less than significant* and no mitigation measures are required.

The hazards posed by strong seismic ground shaking during a major earthquake are nearly omnipresent across the Specific Plan Area, including the TOD #2 project site. Adherence to applicable building code and building permit requirements would ensure that the impacts associated with such ground shaking are minimized to the maximum extent practicable. The impacts of development of the TOD #2 project site as they relate to strong seismic ground shaking are considered *less than significant* and no mitigation measures are required.

The recent geotechnical investigation of the TOD #2 project site forecasted post-liquefaction settlement in excess of two inches in certain parts of this project site and differential settlement as much as 1.5 inch over 30 feet. For references, these forecasted levels are greater than estimated at the TOD #1 project site. The report identified settlement, including liquefaction-related settlement, as a significant geotechnical concern. Thus, the potential impacts of development of the TOD #2 project site as they relate to seismically induced liquefaction are considered *significant*.

The topography in the TOD #2 project site is comparatively flat, the CGS has not identified any landslide hazard zones within its boundaries, and the USGS determined that the probability of debris flows is near-zero. Therefore, the potential impacts from development of the TOD #2 project site as they relate to seismic-related landslides are considered *less than significant* and no mitigation measures are required.

Impact GEO-TOD#2-1: The proposed TOD #2 project could expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving surface rupture along a known active fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction and landslides.

Mitigation Measure GEO-TOD#2-1: The recent geotechnical investigation of the proposed TOD #2 project site identified settlement, including liquefaction-related settlement, as a significant geotechnical concern. The report presented formal recommendations for project design and construction, including site grading/soil preparation and foundation design, some goals of which were to mitigate the potential for liquefaction-related settlement, expansive soils, and highly compressible soils prone to settlement/subsidence. The final geotechnical report shall be provided to the City of Millbrae for review and approval. The geotechnical engineer of record should also review the final grading, drainage, and foundation plans to confirm incorporation of the report recommendations. Lastly, field monitoring during project construction is warranted to verify that the work is performed as recommended and in accordance with the approved plans and specifications.

Significance With Mitigation: Less than significant.

GEO-2	The proposed Project would not result in substantial soil erosion or the loss of topsoil.

Specific Plan Update

Substantial soil erosion or loss of topsoil during construction could, in principle, undermine structures and slopes during development in the Specific Plan Area. Compliance with existing regulatory requirements such as the CBC and the Millbrae Municipal Code would reduce impacts associated with soil erosion or the loss of topsoil. Specifically, Title 9, Building Regulations, Chapter 9.45, Grading, contains grading-related requirements such as permitting, erosion control measures and plans, periodic inspections during grading, stability of cut slopes, and weather limitations during grading. Erosion control Best Management Practices during construction frequently include hydroseeding and short-term biodegradable erosion control blankets; linear sediment barriers such as silt fences, sandbag barriers, or straw bale barriers; fiber rolls, gravel bag berms, and check dams to break up slope length or flow; silt fences or other means of inlet protection at storm drain inlets; post-construction inspection of all drainage infrastructure for accumulated sediment; and clearing of accumulated sediment in such drainage structures. Additionally, General Plan Policy S1.6, Erosion/Sediment Control, sets forth appropriate erosion and sediment controls at development sites. Provide appropriate erosion and sediment control measures in conjunction with proposed development in areas. In light of the above, adherence to existing regulatory requirements would ensure that the impacts associated with substantial erosion or the loss of topsoil resulting from development of the Specific Plan Area would be *less than significant* and no mitigation measures are required.

Significance Without Mitigation: Less than significant.

TOD #1 Project

Substantial soil erosion or loss of topsoil during construction could, in principle, undermine structures and slopes during development in the TOD #1 project site. Compliance with existing regulatory requirements such as the CBC, grading requirements contained in the City of Millbrae Municipal Code, and General Plan Policy S1.6, Erosion/Sediment Control, would reduce impacts associated with soil erosion or the loss of topsoil. Consequently, adherence to existing regulatory requirements would ensure that the impacts associated with substantial erosion or the loss of topsoil resulting from development of the TOD #1 project site would be *less than significant* and no mitigation measures are required.

Significance Without Mitigation: Less than significant.

TOD #2 Project

Substantial soil erosion or loss of topsoil during construction could, in principle, undermine structures and slopes during development in the TOD #2 project site. Compliance with existing regulatory requirements such as the CBC, grading requirements contained in the City of Millbrae Municipal Code, and General Plan Policy S1.6, Erosion/Sediment Control, would reduce impacts associated with soil erosion or the loss of topsoil. Consequently, adherence to existing regulatory requirements would ensure that the impacts associated with substantial erosion or the loss of topsoil resulting from development of the TOD #2 project site would be *less than significant* and no mitigation measures are required.

Significance Without Mitigation: Less than significant.

GEO-3	The proposed Project would result in a significant impact related to development on unstable geologic units and soils or result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

Specific Plan Update

The Bay Mud, a well-known fine-grained sedimentary unit that flanks much of south San Francisco Bay, is known to be present in the Specific Plan Area based on mapping by the USGS. In addition, detailed geotechnical investigations at the TOD #1 and TOD #2 project sites revealed the presence of as much as 30+ feet of Bay Mud in those areas. These deposits often consist of highly compressible, plastic clay that is moderately to highly compressible, and often poses a geological hazard due to consolidated settlement or subsidence. Consolidation settlement occurs when a fine-grained soil is loaded with the weight of new fill or of improvements such as structures or roads. The loads cause increases in soil pore water pressure, and as the pore pressures wane, the soil volume decreases. Settlement rates are also influenced by the permeability and thickness of the soil layers. Considering the presence of highly compressible Bay Mud sediments, and City of Millbrae General Plan policy S1.7 (i.e. "Bay Fill") notwithstanding, the impacts associated with development of the Specific Plan Area as they relate to subsidence (i.e. settlement-prone compressible soils) are considered *significant*.

Impact GEO-SP-3: Implementation of the Specific Plan Update could result in a significant impact related to development on unstable geologic units and soils or result in lateral spreading, subsidence, liquefaction, or collapse.

Mitigation Measure GEO-SP-3: Implement Mitigation Measure GEO-SP-1.

Significance With Mitigation: Less than significant.

TOD #1 Project

A recent detailed geotechnical investigation at the TOD #1 project site revealed the presence of significant thicknesses of Bay Mud, especially in the northeast part of that site, where its presence was documented at depths up to 17 feet bgs. These deposits often consist of highly compressible, plastic clay that is moderately to highly compressible. Bay Mud often poses a geological hazard due to consolidated settlement or subsidence, and the geotechnical report considered its presence one of the two most significant geotechnical constraints at the site. Considering the presence of highly compressible Bay Mud sediments, and City of Millbrae General Plan policy S1.7 (i.e. "Bay Fill") notwithstanding, the impacts associated with development of the TOD #1 project site as they relate to subsidence (i.e. settlement-prone compressible soils) are considered *significant*.

Impact GEO-TOD#1-3: The proposed TOD #1 project could result in a significant impact related to development on unstable geologic units and soils or result in lateral spreading, subsidence, liquefaction, or collapse.

Mitigation Measure GEO-TOD#1-3: Implement Mitigation Measure GEO-TOD#1-1.

Significance With Mitigation: Less than significant.

TOD #2 Project

A recent detailed geotechnical investigation at the TOD #2 project site revealed the presence of significant thicknesses of Bay Mud, extending to depths as great as 27 feet bgs. These deposits often consist of highly compressible, plastic clay that is moderately to highly compressible. Bay Mud poses a geological hazard due to consolidated settlement or subsidence, and the geotechnical report considered its presence one of the most significant geotechnical concerns at the site. Considering the presence of highly compressible Bay Mud sediments, and City of Millbrae General Plan policy S1.7 (i.e. "Bay Fill") notwithstanding, the impacts associated with development of the TOD #2 project site as they relate to subsidence (i.e. settlement-prone compressible soils) are considered *significant*.

Impact GEO-TOD#2-3: The proposed TOD #2 project could result in a significant impact related to development on unstable geologic units and soils or result in lateral spreading, subsidence, liquefaction, or collapse.

Mitigation Measure GEO-TOD#2-3: Implement Mitigation Measure GEO-TOD#2-1.

Significance With Mitigation: Less than significant.

GEO-4	The proposed Project would create substantial risks to life or property as a result of its location on expansive soil, as defined in Section 1803.5.3 of the California Building Code (CBC).

Specific Plan Update

As previously discussed, soil surveys of San Mateo County, including the Specific Plan Area, classified the dominant soils in that part of the City of Millbrae as Urban Land Orthent-type soils that predominantly consist of loam or clay loam. A USDA survey concluded that this soil "has few limitations" for urban development, although they acknowledged that the Urban Land Orthent soils are extremely variable. Recent detailed geotechnical investigations at the TOD #1 and TOD #2 project sites provided more detailed evaluations of expansive soil. Representative soil samples were subjected to laboratory tests to quantify soil properties including Plasticity Index (PI), a measure of soil shrink-swell potential. For the TOD #1 project site, the soils exhibited PI values ranging from 0 to 35, suggesting low to moderate swelling potential. The results of plasticity tests on samples from the TOD #2 project site yielded comparable results, also suggesting a low to moderate swelling potential. Because certain soils have been classified as having "moderate" shrink-swell potential, the impacts associated with development of the Specific Plan Area as they relate to expansive soils are considered *significant*.

Impact GEO-SP-4: Implementation of the Specific Plan Update could create substantial risks to property as a result of its location on expansive soil, as defined by Section 1803.5.3 of the California Building Code.

Mitigation Measure GEO-SP-4: Implement Mitigation Measure GEO-SP-1.

Significance With Mitigation: Less than significant.

TOD #1 Project

A recent detailed geotechnical investigation at the TOD #1 project site included a detailed evaluation of expansive soil. A total of 11 soil samples were tested and the resultant PI values ranged from 0 to 35, suggesting that the soil swelling potential is low to moderate. The two most plastic samples were sandy clays encountered at 2 feet bgs in boring B-1 and 14 feet bgs in boring B-7. A review of the boring logs suggests these samples correlate with occurrences of loose native soil and Bay Mud. Because some soils exhibited moderate expansion potential, the report explicitly considered shrink-swell potential in its recommendations for project design and construction, including site grading/soil preparation and foundation design. Consequently, the impacts associated with development of the TOD #1 project site as they relate to expansive soils are considered *significant*.

Impact GEO-TOD#1-4: The proposed TOD #1 project could create substantial risks to property as a result of its location on expansive soil, as defined by Section 1803.5.3 of the California Building Code.

Mitigation Measure GEO-TOD#1-4: Implement Mitigation Measure GEO-TOD#1-1.

Significance With Mitigation: Less than significant.

TOD #2 Project

A recent detailed geotechnical investigation at the TOD #2 Project site included a detailed evaluation of expansive soil. Representative soil samples were laboratory tested and the resultant PI values ranged from 12 to 20, suggesting that the soil swelling potential is low to moderate. Because some soils exhibited moderate expansion potential, the impacts associated with development of the TOD #2 project site as they relate to expansive soils are considered *significant*.

Impact GEO-TOD#2-4: The proposed TOD #2 project could create substantial risks to property as a result of its location on expansive soil, as defined by Section 1803.5.3 of the California Building Code.

Mitigation Measure GEO-TOD#2-4: Implement Mitigation Measure GEO-TOD#2-1.

Significance With Mitigation: Less than significant.

4.5.4 CUMULATIVE IMPACTS

GEO-5	The proposed Project, in combination with past, present, and reasonably foreseeable projects, would result in less than significant cumulative impacts with respect to geology and soils.

Active or potentially active earthquake faults have not been mapped in the Specific Plan Area, including the TOD #1 and TOD #2 project sites and new development would be subject to CBC and Municipal Code requirements as well as certain City General Plan policies. Compliance with these requirements and adherence to relevant policies would, to the maximum extent practicable, reduce cumulative, development-related impacts that relate to seismic shaking, soil erosion and loss of topsoil, and seismically induced landslides. Potentially significant impacts related to liquefaction and settlement (i.e. subsidence) have been identified in the Specific Plan Area, although the potential impacts are site-specific and are generally limited to onsite conditions. Thus, these conditions would not affect offsite locations or projects. Such impacts would not be considered cumulatively considerable, and the cumulative impacts would be less than significant.

Development of the proposed Project would not significantly contribute to cumulative impacts with respect to geology, soils, and seismicity. Accordingly, these potential cumulative impacts are considered less than significant with implementation of Mitigation Measure GEO-SP-1, GEO-TOD#1-1 and GEO-TOD#2-1.

Significance With Mitigation: Less than significant.