3.7 GEOLOGY AND SOILS

This section describes the existing geology, soils, and paleontological and mineral resources at and in the vicinity of the LRDP area and analyzes the potential environmental effects of the 2021 LRDP related to these topics. For information on soil quality related to agricultural use, refer to Section 3.2, "Agriculture and Forestry Resources." For information related to flooding, drainage, and groundwater quality at the LRDP area, refer to Section 3.10, "Hydrology and Water Quality," of this EIR.

Public comments on the NOP (Appendix B) included concerns regarding erosion. These impacts are described and addressed, where appropriate, within this section.

3.7.1 Regulatory Setting

FEDERAL

National Earthquake Hazards Reduction Act

The National Earthquake Hazards Reduction Act was passed to reduce the risks to life and property resulting from earthquakes. The act established the National Earthquake Hazards Reduction Program (NEHRP). The mission of NEHRP includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. NEHRP designates the Federal Emergency Management Agency as the lead agency of the program and assigns several planning, coordinating, and reporting responsibilities. Other NEHRP agencies include the National Institute of Standards and Technology, National Science Foundation, and the U.S. Geological Survey (USGS).

STATE

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code [PRC] Sections 2621-2630) (Alquist-Priolo Act or A-P Act) was originally named the "Alquist-Priolo Special Studies Zones Act" and was created in 1972 to reduce the risk to life and property from surface fault rupture during earthquakes by regulating construction in active fault corridors and prohibiting the location of most types of structures intended for human occupancy across the traces of active faults. The law addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. Amended in 1994, the Alquist-Priolo Act now includes a disclosure obligation for real estate licensees.

The LRDP area, including the Westside Research Park, is not located within an Alquist-Priolo active fault zone (Bryant and Hart 2007). The LRDP area does not lie within any State-mapped zones containing Holocene active faults (a fault that has moved in the last 10,000 years) or active faults, nor have any Holocene-active faults been mapped on the main residential campus or the Westside Research Park by any jurisdiction.

Seismic Hazards Mapping Act

The intent of the Seismic Hazards Mapping Act (PRC Section 2690‑2699.6) is to reduce damage resulting from earthquakes. While the Alquist-Priolo Act addresses surface fault rupture, the Seismic Hazards Mapping Act addresses other earthquake-related hazards, including ground shaking, liquefaction, seismically induced landslides and amplified ground shaking. The Seismic Hazards Mapping Act's provisions are similar in concept to those of the Alquist-Priolo Act: the State is charged with identifying and mapping areas at risk of strong ground shaking, liquefaction, landslides, and other corollary hazards, and cities and counties are required to regulate development within mapped Seismic Hazard Zones. Under the Seismic Hazards Mapping Act, permit review is the primary mechanism for local regulation of development. Specifically, cities and counties are prohibited from issuing development permits for projects in Seismic Hazard Zones until appropriate site- specific geologic or geotechnical investigations have been carried out and measures to reduce potential damage have been incorporated into the development plans.

Programmatic mapping for the Seismic Hazards Mapping Act by the California Geological Survey is completed and published on USGS 7½-minute quadrangles. The LRDP area does not lie within any of the quadrangles thus far published by the State, so this statute and the resulting maps have no direct effect on the 2021 LRDP.

California Building Standards Code

The State of California provides minimum standards for building design through the California Building Standards Code (CBC) (California Code of Regulations, Title 24). Where no other building codes apply, Chapter 29 regulates excavation, foundations, and retaining walls.

The CBC has been modified from the International Building Code for California conditions with prescriptive code tailored to California conditions. The seismic shaking sections of the CBC ostensibly utilize guidance from publication ASCE/SEI 7, jointly published by the American Society of Civil Engineering and the Structural Engineering Institute (ASCE 2016). ASCE/SEI 7 identifies minimum prescriptive seismic factors that must be considered in structural design. These factors and the procedures outlined for deriving them are listed referenced in Chapters 16, 16a, 18 and 18a of the CBC, all of which provide minimum prescriptive minimum design guidance for the geotechnical design of excavations, foundations, and retaining walls. (The primary difference between the "a" and "non-a" chapters is that the "a" chapters are primarily intended for structures regulated by the State of California Division of the State Architect.) Appendix J of the CBC provides further guidance for grading activities, including drainage and erosion control. CBC Section 1803A.3 also requires the completion of a geotechnical investigation report with the following basis of investigation:

> *Soil classification shall be based on observation and any necessary tests of the materials disclosed by borings, test pits or other subsurface exploration made in appropriate locations. Additional studies shall be made as necessary to evaluate slope stability, soil strength, position and adequacy of load-bearing soils, the effect of moisture variation on soil-bearing capacity, compressibility, liquefaction and expansiveness.*

It is important to note that there is no specific guidance or mention in the CBC of the hazards and risks related to the unique geological features underlying the main residential campus, primarily karst topography and marble bedrock. Karst topography is characterized by irregular surfaces resulting from subsidence or collapse of the bedrock and sediment into those subterranean cavities that have developed within the marble bedrock. Past development on the main residential campus has been supported by robust geotechnical and geological investigations that provide focused evaluation of the risks related to design and construction in geological terrane with karst-related risks.

Surface Mining and Reclamation Act of 1975

The Surface Mining and Reclamation Act of 1975 (PRC Sections 2710-2796.5) (SMARA) regulates surface mining operations and assures that adverse environmental impacts are minimized and mined lands are reclaimed to a usable condition via a comprehensive policy for surface mining and reclamation.

SMARA also encourages the production, conservation, and protection of the state's mineral resources through annual mining reporting requirements for mines and by tying it to the development of statewide standards by the State Water Resources Control Board (SWRCB) for permitting and operation of Onsite Wastewater Treatment Systems (otherwise known as septic systems).

UNIVERSITY OF CALIFORNIA

University of California Seismic Safety Policy

The UC Seismic Safety Policy was crafted to provide an acceptable level of earthquake safety for students, employees, and the public who occupy UC facilities and leased facilities, to the extent feasible by present earthquake engineering practice. Feasibility is determined by balancing the practicality and the cost of protective measures, depending on the forecasted severity and probability of injury resulting from seismic activity.

UC Santa Cruz Campus Standards Handbook

The UC Santa Cruz Campus Standards Handbook outlines required products and mandatory design constraints for all construction on the campus (UC Santa Cruz 2017). The standards are meant to ensure that UC Santa Cruz constructs functional and durable buildings, based on experience with existing campus buildings. The standards are complementary to project-specific requirements and can be modified, as necessary, at the discretion of the UC Santa Cruz project manager based on site-specific geotechnical investigations. UC Santa Cruz requires:

- review of schematic, design development, 50 percent, 100 percent construction documents, and 100 percent backcheck submittals;
- compliance with federal, State, and regional codes or acts; in the case of conflict between codes, the more stringent code conditions apply;
- soil investigation reports, as necessary, for projects;
- site survey information;
- consultation with the Design Advisory Board, normally at the beginning of schematic design, midway through schematic design, and midway through design development;
- review by the Campus Physical Planning Advisory Committee after the end of schematic design;
- design review approval for applicable projects by the UC Regents;
- review and approval by the State Fire Marshal and Division of the State Architect at construction document completion;
- approval of completed design development documents by the State Public Works Board for major State-funded projects;
- independent reviews are required by the UC Regents for cost, design, and seismic safety; and
- design compliance with current LRDP EIR mitigation measures and any project-specific mitigation measures.

The UC Santa Cruz Campus Standards Handbook also includes Section 01 57 23-Storm Water Pollution Control which requires projects greater than 1 acre to comply with the Construction General Permit (CGP) and for projects under 1 acre to comply with UC Santa Cruz Erosion and Sediment Control Standards and Best Management Practices for construction projects less than 1 acre in area involving soil disturbance greater than 50 cubic yards (UC Santa Cruz 2014). Best Management Practices are outlined in Appendix D of the UC Santa Cruz Campus Standards Handbook and include runoff controls, sediment capture, spill prevention, and tracking control (UC Santa Cruz 2017). UC Santa Cruz reviews all permit registration documents before submitting for coverage under the CGP.

LOCAL

As noted in Section 3.0.1, "University of California Autonomy," UC Santa Cruz, a constitutionally created State entity, is not subject to municipal regulations of surrounding local governments for uses on property owned or controlled by UC Santa Cruz that are in furtherance of its education purposes. However, UC Santa Cruz may consider, for coordination purposes, aspects of local plans and policies for the communities surrounding the campus when it is appropriate and feasible, but it is not bound by those plans and policies in its planning efforts. No local plans or policies are considered relevant to the 2021 LRDP with respect to geology and soils.

3.7.2 Environmental Setting

REGIONAL GEOLOGY

The LRDP area is situated on the western flank of the Santa Cruz Mountains, in the central portion of the Coast Ranges Physiographic Province of California (Coast Ranges Province). The Coast Ranges Province consists of a series of coastal mountain chains paralleling the pronounced northwest-southeast structural grain of central California geology. The structural grain is controlled by a complex of active faults and faults with pre-Holocene activity, that form the San Andreas Fault system. Southwest of the San Andreas Fault, the Coast Ranges including the Santa Cruz Mountains are underlain by a large, northwest-trending, fault-bounded, elongate prism of granitic and metamorphic basement rocks, collectively known as the Salinian Block. The Salinian Block is separated from contrasting basement rock types to the northeast and the southwest by the San Andreas and the Sur-Nacimiento Fault systems, respectively, as shown in Figure 3.7-1. Overlying the granitic and metamorphic basement rocks is a sequence of dominantly marine sediments of Tertiary age and non-marine sediments of Pliocene to Pleistocene age. As shown in Figure 3.7-1, the Tertiary and younger rocks within the LRDP area occur only as thin, scattered patches of deposits that overlie the exposed metamorphic and granitic basement complex.

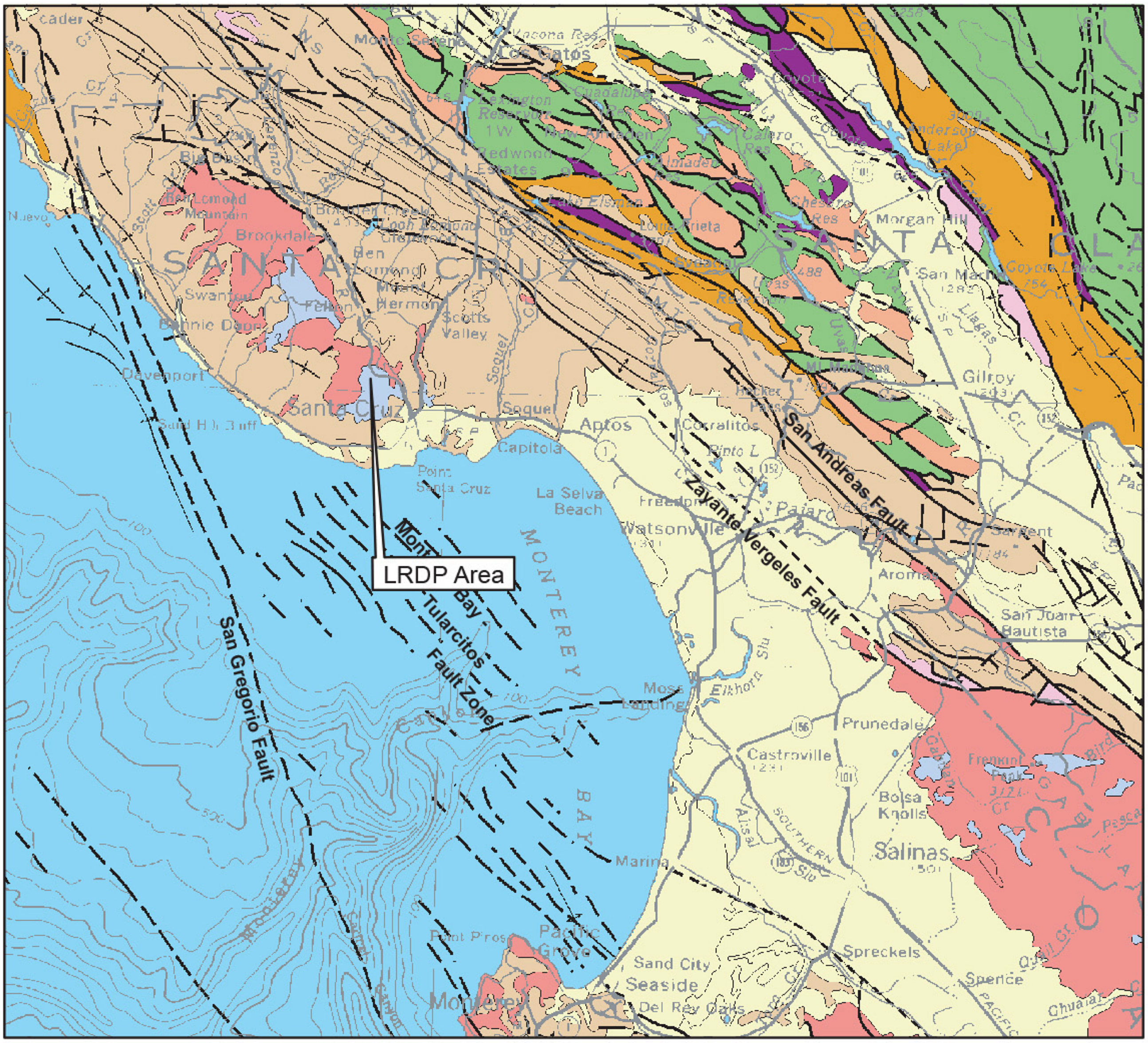
LOCAL GEOLOGY

The main residential campus is located at the southeast end of the crest of Ben Lomond Mountain, in Santa Cruz County, California (Figure 3.7-2). Ben Lomond Mountain is a large granitic massif that has been uplifted and tilted toward the southwest along the Ben Lomond Fault, which bounds the mountain to the northeast. The northeastern edge of the block drops steeply into the valley of the San Lorenzo River. The south- to southwest-facing flank of Ben Lomond Mountain is broad with a relatively gentle to moderate slope. This slope is notched by a series of Pleistocene marine terraces that give the mountain a stair-step like appearance. The developed portion of the main residential campus lies on this gently sloping, south facing hillside. The southern half of the main residential campus, including most of the developed portion of campus, is largely underlain by marble bedrock. Dissolution of the marble by percolating ground water has dimpled the terrain with closed depressions due to sinkhole formation, a process which is illustrated in Figure 3.7-3. The main residential campus is cut by several steep walled, north-south flowing streams, but an integrated drainage system has not formed due to sporadic stream flow capture by sinkholes. Elevations on the main residential campus vary from about 300 feet at the southern edge of campus, to almost 1,200 feet at the northwestern boundary. Relief is typically low to moderate, except along the steep east-facing escarpment on the eastern side of campus and along the sides of some campus drainages.

The Westside Research Park is located within the Coast Ranges Geomorphic Province, which extend about 600 miles from the Oregon border to central coastal California. The area of the site is generally underlain by Holocene deposits of alluvial origin. These materials consist of well sorted silt, sand and gravel. Underlying these alluvial deposits is Pleistocene alluvium and bedrock. Elevation on the Westside Research Park is approximately 60 feet above mean sea level. The site is generally flat with the exception of a 3-foot rise from Delaware Avenue on the southern perimeter of the site rising to approximately 5-feet on the northern boundaries of the site.

Soils

There are a large variety of soil types with variable composition, texture and thicknesses, which are directly correlative from the highly variable bedrock from which they are weathered and developed. The last time Soil Conservation Service (SCS) soil map, which is now known as the Natural Resources Conservation Service (NRCS), were published for Santa Cruz County 1980 (SCS 1980). The Santa Cruz County soil map includes the LRDP area. The Santa Cruz County soils map identified 12 different soil types in the LRDP area, as shown in Figure 3.7-4 (SCS 1980). Seven of the soil types are dominant, with the greatest areal extent on the main residential campus, as well as additional soil types of relatively minor aerial extent. The major soil types are discussed below by the geographic areas of the 2021 LRDP.

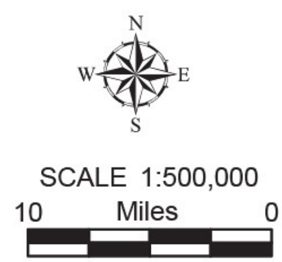


Reference: Jennings, C.W., 1977, Geologic Map of California: California Department of Conservation, Division of Mines and Geology, scale 1:750,000.
Digital Data: Saucedo, G.J., Bedford, D.R., Raines, G.L., Miller, R.J., and Wentworth, C.M., 2000, GIS Data for the Geologic Map of California: California Department of Conservation, Division of Mines and Geology, CD-ROM 2000-007, ver. 2.0.

EXPLANATION

Geologic Units
- Quaternary Deposits
- Quaternary Volcanics
- Tertiary Sedimentary Rocks
- Tertiary Volcanic Rocks
- Pre-Tertiary Sedimentary Rocks
- Pre-Tertiary Volcanic Rocks
- Grantic Intrusive Rocks
- Franciscan Complex
- Ultramafic Rocks
- Pre-Tertiary Metamorphic Rock
- Pre-Cambrian Metamorphic and Igneous Rocks

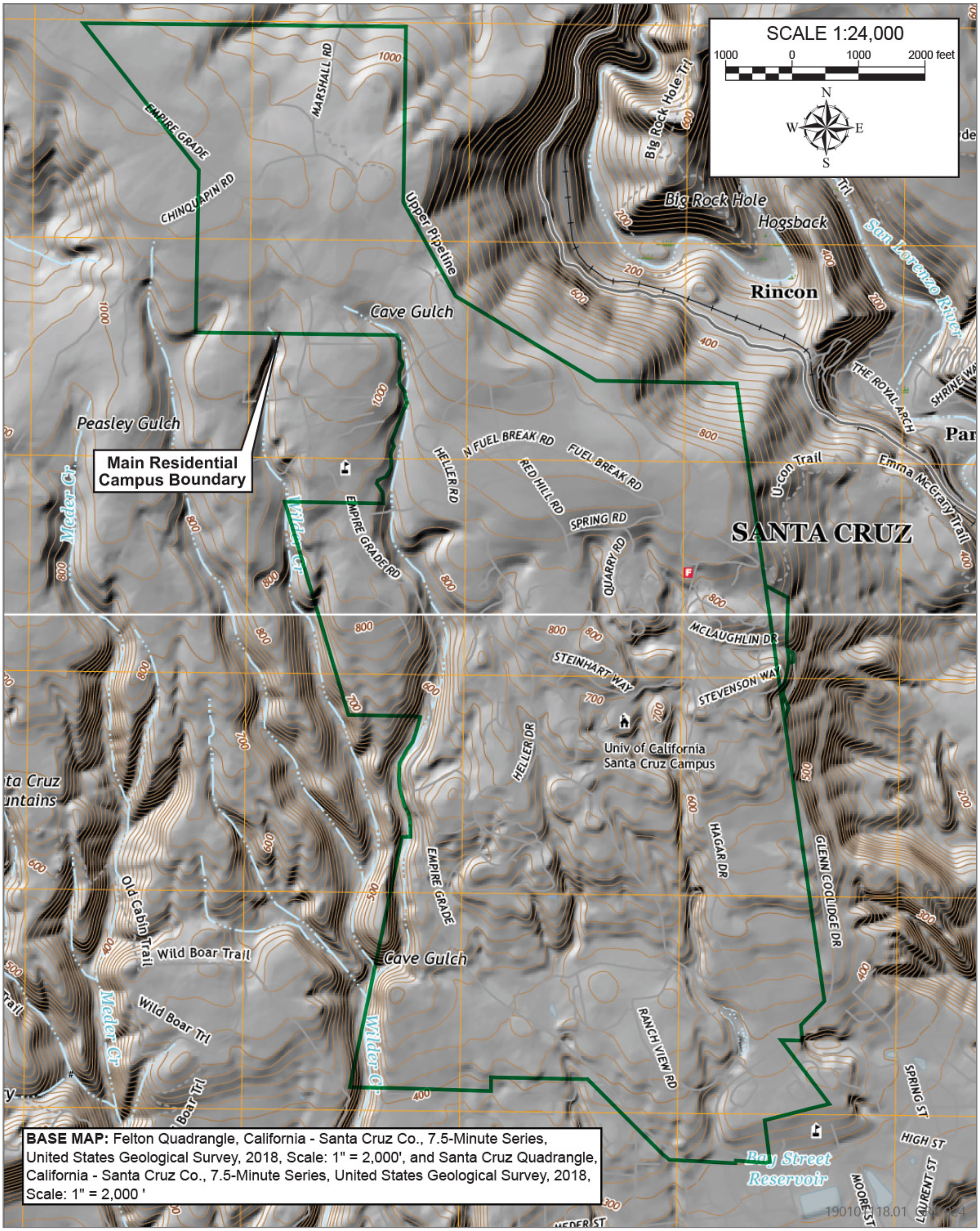
Symbols
- contact
- fault, certain
- fault,approx. located
- fault, concealed or inferred
- anticline
- monocline
- syncline



190101118.01 GRX 025

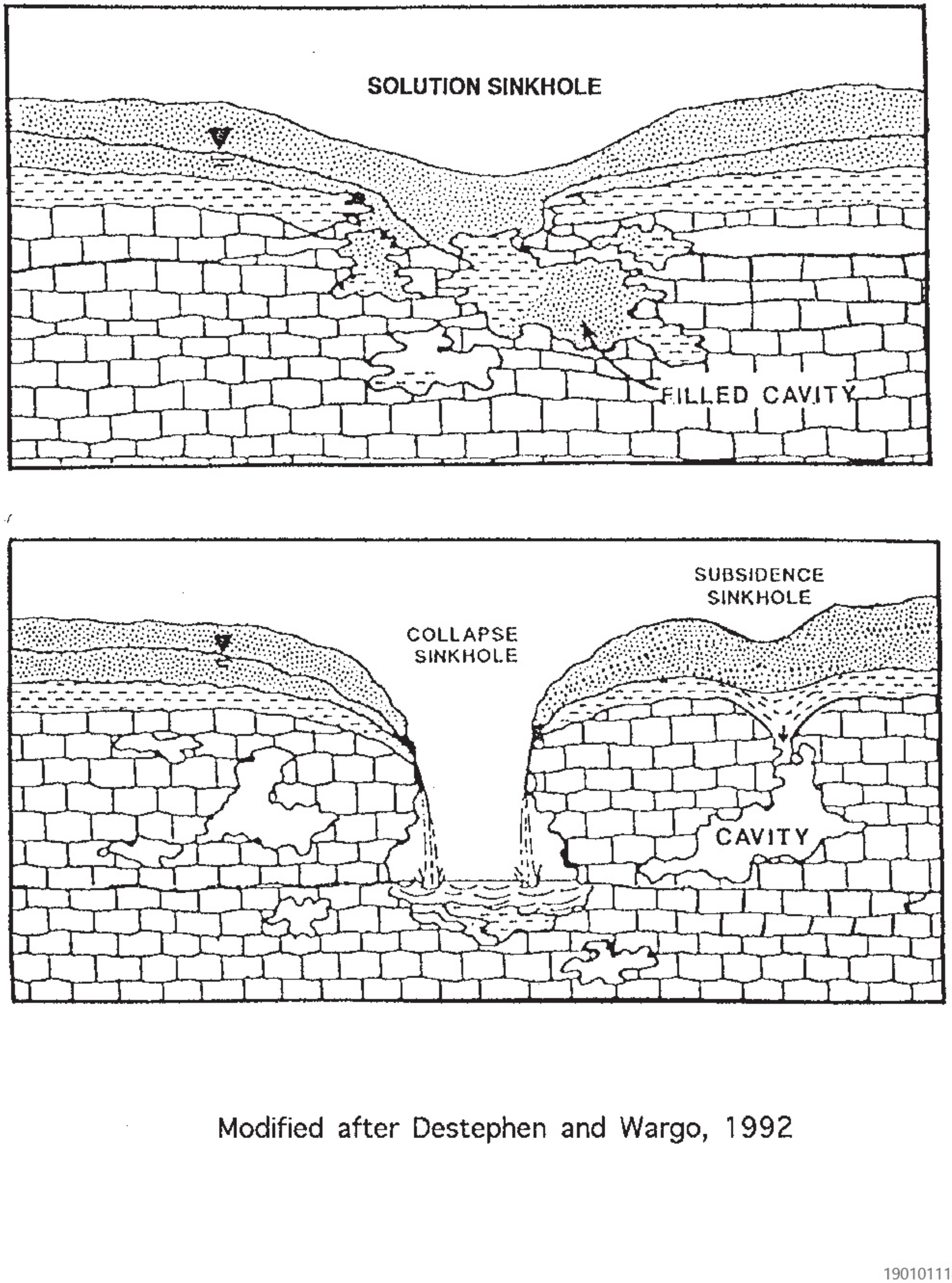
Source: Figure produced and provided by Zinn Geology in 2020

Figure 3.7-1 Regional Geologic Map



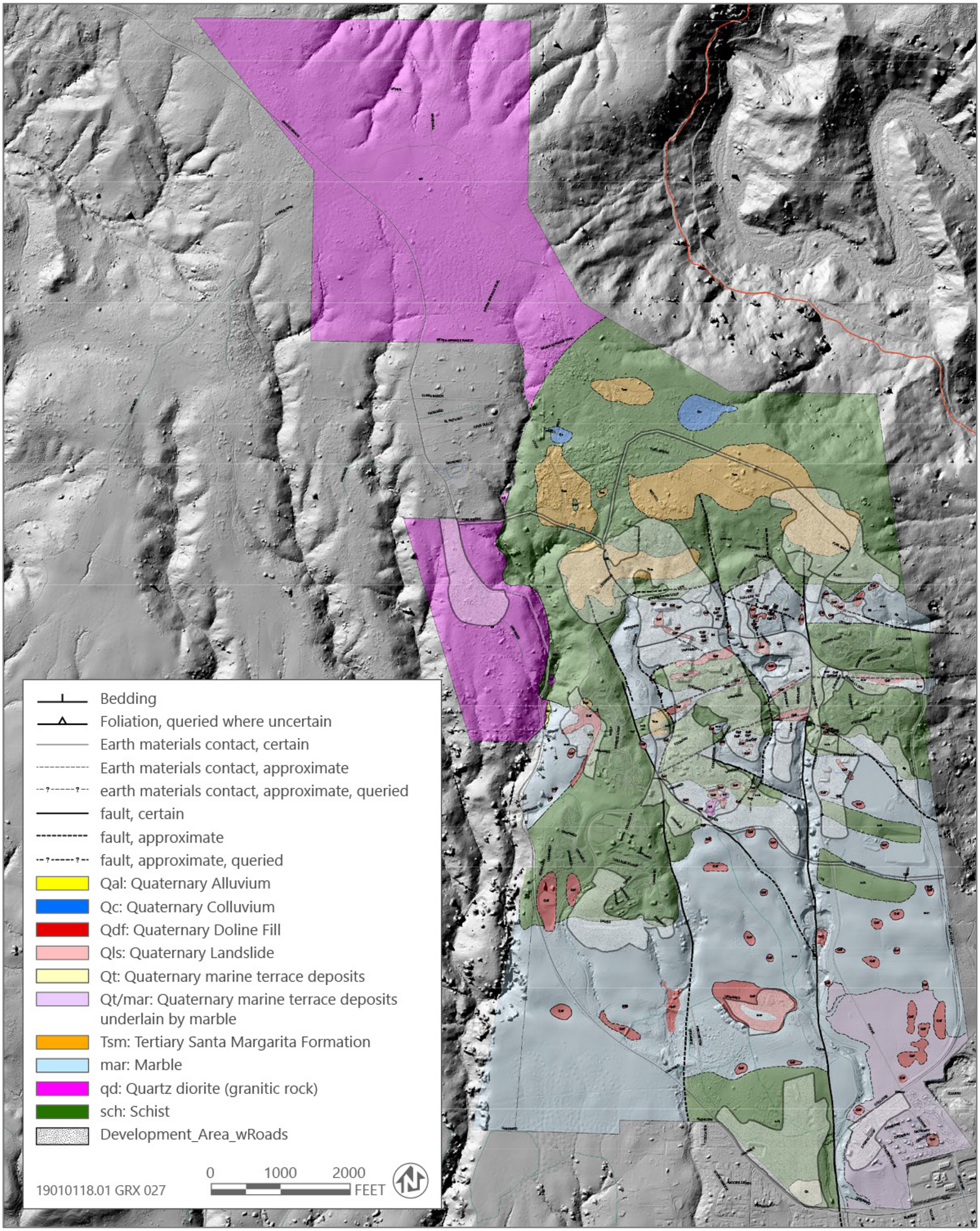
Source: Figure produced and provided by Zinn Geology in 2020

Figure 3.7-2 Topographic Map for the Main Residential Campus



Source: Figure adapted from Destephen, R.A., and Wargo R.H. 1992

Figure 3.7-3 Sinkhole Formation Process



Source: Figure produced and provided by Zinn Geology in 2020

Figure 3.7-4 Main Residential Campus Geologic Map

It is important to note that the distribution of soils depicted on the NRCS soil maps that cover the main residential campus are inaccurate and imprecise from the geological and geotechnical engineering perspective. This is because the NRCS maps do not present a level of detail that can reflect the complex structure and composition of the bedrock that underlies the UC Santa Cruz campus. Since soil is derived from the underlying bedrock, soil composition and distribution are predominantly controlled by the composition and distribution of the underlying bedrock. It is considered acceptable to use the maps for regional planning purposes and initial reconnaissance design level work, but due to the complexity of the soils on the main residential campus, UC Santa Cruz requires site-specific investigations with robust subsurface work by geologists, geotechnical engineers, and civil engineers for development and related activities.

<u>Main Residential Campus</u>

Upper/North Campus Soils

The predominant soil types on the upper/north portion of the main residential campus are Watsonville loam, Lompico-Felton complex, and Aptos loam. Watsonville loam is found on coastal terraces and formed in alluvium. The thickness of this unit is about 4 to 5 feet. Watsonville loam has very low permeability and the erosion hazard is slight to moderate. The Lompico-Felton complex is found at the base of slopes and near ridge tops and is composed of material weathered from sandstone, shale, siltstone, mudstone or schist. It is typically 3 feet thick. Permeability of the Lompico-Felton complex soil is moderate, and the erosion hazard is very high. Aptos loam is found on hills and mountains and is composed of material weathered from sandstone, siltstone, or shale. It is typically about 3 feet thick and found overlying a weathered fractured shale. Aptos loam has moderate permeability and erosion potential.

Central/Lower Campus Soils

The predominant soil type in the central campus is the Nisene-Aptos complex and the distributed soil types in the lower campus are predominantly Elkhorn sandy loam, Los Osos loam, Ben Lomond-Felton complex, and Watsonville loam. The Nisene-Aptos complex is mainly found on the lower slopes of the Santa Cruz Mountains and is composed of material derived from sandstone, siltstone, or shale. It is typically about 5 to 9 feet thick. Permeability of Nisene-Aptos soil is moderate, and the erosion hazard is high. Elkhorn sandy loam is found on old alluvial fans and marine terraces and is typically about 2 to 5 feet thick. Elkhorn sandy loam has moderately low permeability and slight to moderate erosion hazard. Los Osos loam is found on wide ridges on hills and mountains and is composed of material weathered from sandstone or shale. Typically, it is about 8 to 17 inches thick. Los Osos loam generally has low permeability and moderate erosion potential. The Ben Lomond-Felton complex is typically found in valleys and low areas near drainage ways and is composed of material eroded from sandstone, shale, siltstone, schist, or granite. It is typically about 4 feet thick. The permeability of the Ben Lomond-Felton complex is moderately low and the erosion potential varies from slight to very high. As stated above, Watsonville loam is found on coastal terraces and formed in alluvium. The thickness of this unit is about 4 to 5 feet. Watsonville loam has very low permeability and the erosion hazard is slight to moderate.

Westside Research Park

The predominant soil types on the Westside Research Park campus are Watsonville loam, which are found on coastal terraces and formed in alluvium. The thickness of this unit is about 4 to 5 feet. Watsonville loam has very low permeability and the erosion hazard is slight to moderate (Stanford Libraries 2020).

Expansive Soils

Expansive soils (soils that shrink and swell depending on moisture level) are present in scattered sections of the LRDP area. The distribution of expansive soils can be highly variable across building sites due to the derivation of the soils from the weathering of the highly faulted and folded layers of metamorphic rock. Expansive soils can damage building foundations if they are inadequately designed for a soil's expansive properties. Table 3.7-1, below, presents the shrink-swell potential of the soils in the LRDP area.

Table 3.7-1 Shrink-Swell Potential for Soils in the UC Santa Cruz LDRP Plan Area

Soil Type	Depth (Inches)	Shrink-Swell Potential
Aptos	0-23 >23	Low Moderate
Ben Lomond	All depths	Low
Bonnvdoon	All depths	Moderate
Catelli	All depths	Low
Danville	0-17 17-29 >29	Moderate High Moderate
Elkhorn	0-21 >21	Low Moderate
Felton	0-11 11-43 >43	Low Moderate Low
Lompico	0-5 >5	Low Moderate
Los Osos	0-19 19-36	Moderate High
Nisene	0-10 10-58	Low Moderate
Sur	All depths	Low
Tierra	0-14 >14	Low High
Watsonville	0-18 18-39 >39	Low High Moderate

Source: SCS 1980

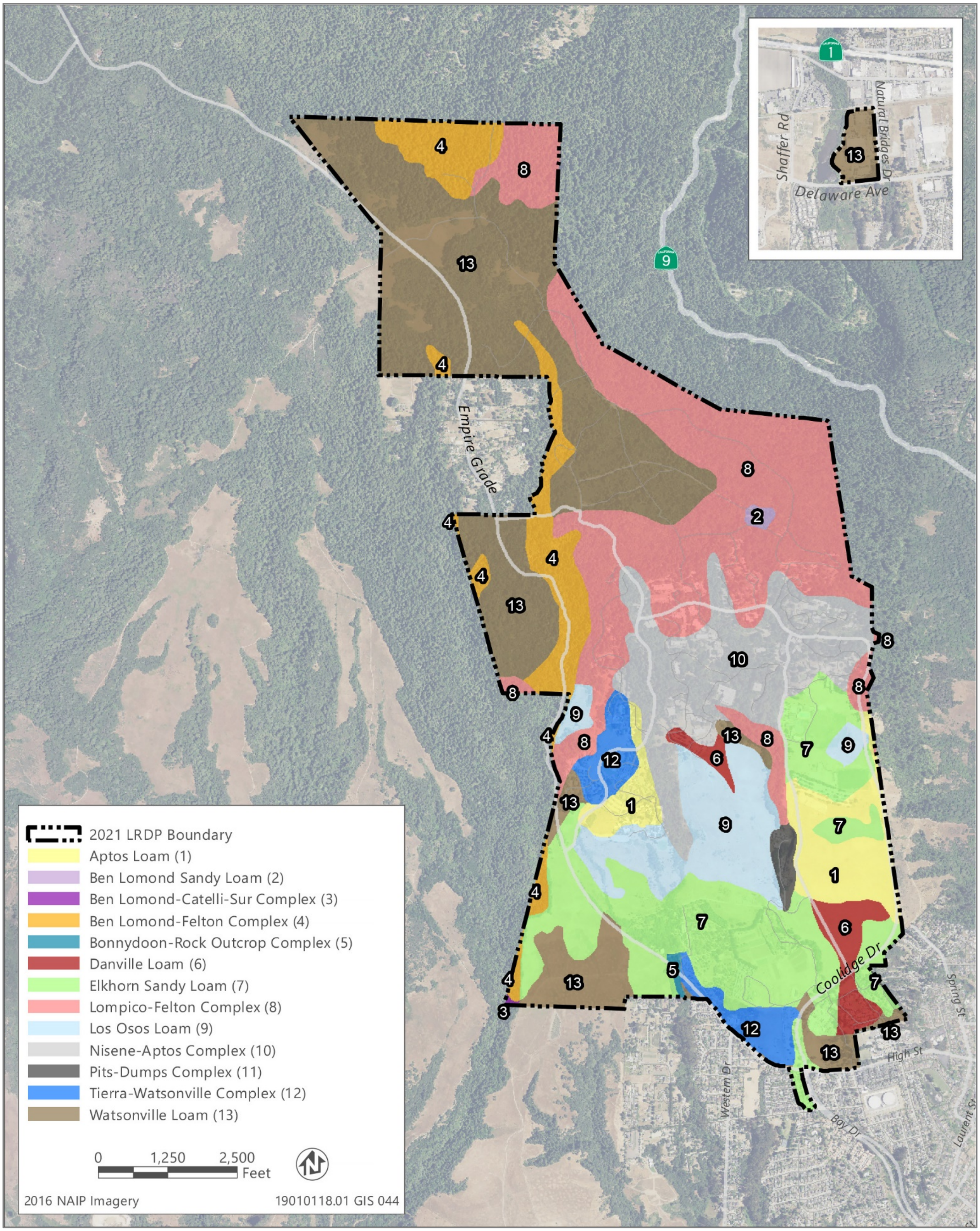
Erosion

As noted in the "Soils" section, above, the soils have been classified for susceptibility to erosion, based on soil characteristics and site slope (SCS 1980). As indicated in Table 3.7-2, cross-referenced with Figure 3.7-5, large portions of the north campus contain soils with a slight to moderate erosion potential, and significant pockets of soils with a high to very high erosion potential are present in the upper, central, and lower areas of the main residential campus. The Westside Research Park contains soils with a slight to moderate erosion potential.

Table 3.7-2 Erosion Potential for Soils in the UC Santa Cruz LRDP Plan Area

Soil Type	Erosion Potential
Nisene-Aptos Complex	Moderate
Lompico-Felton Complex	Very High
Watsonville Loam	Slight to Moderate
Danville Loam	Slight to Moderate
Elkhorn Sandy Loam	Slight to Moderate
Tierra-Watsonville Complex	High
Los Osos Loam	Moderate
Ben Lomond Sandy Loam	Very High
Ben Lomond-Felton Complex	Slight to Very High
Aptos Loam	Slight to Moderate

Source: SCS 1980.



Source: data downloaded from NRCS in 2020

Figure 3.7-5 Soils at the Main Residential Campus

The portion of the main residential campus underlain by karst is pockmarked with dolines (or sinkhole), with some of the sinkholes present in the drainages (i.e., swallow holes). Erosion, sedimentation, and infiltration, both natural and man-made, can have complex interactions. Some sinkholes have been filled by infiltration of fine-grained sediments or by wall collapse, which can exacerbate erosion problems. In other locations, the sinkholes have enlarged and capture a majority of the sediment and a portion or all of the drainage water, resulting in very little erosion downstream. These issues are discussed in more detail in Section 3.10, "Hydrology and Water Quality," along with evaluation of 2021 LRDP effects on stormwater runoff patterns, flooding, and drainage.

UC Santa Cruz has developed standards to comply with both the Statewide Construction General Permit and the Statewide Phase II MS4 Permit. These standards are included in the Campus Standards Handbook and incorporated by reference in the specifications for campus development projects.

Seismicity

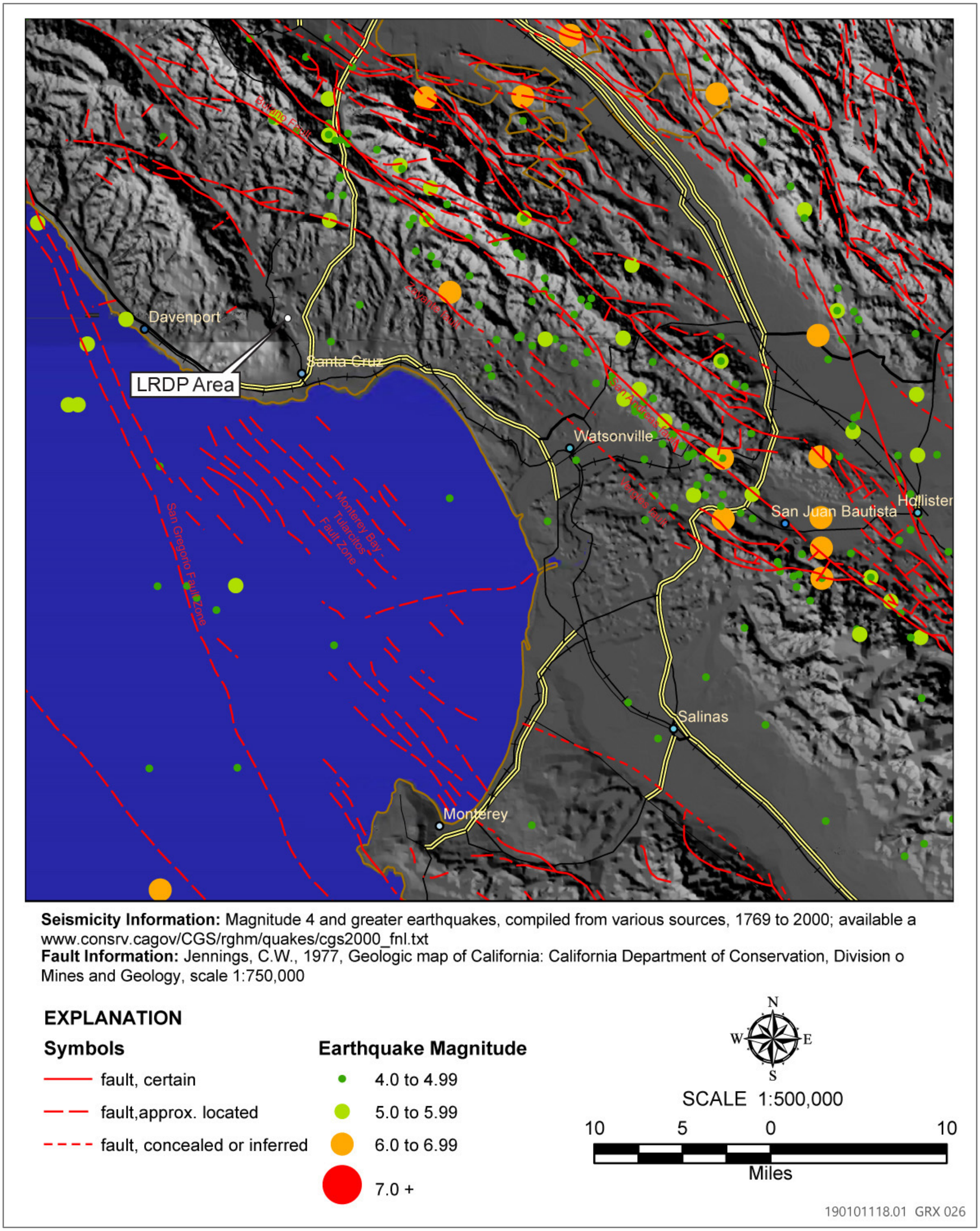
Throughout the late Cenozoic Era (approximately the past 25 million years), central California has been dominated by tectonic forces associated with lateral or "transform" motion between the North American and Pacific crustal plates, producing a complex system of northwest-trending faults (e.g., the San Andreas Fault system). These faults show horizontal displacements measured in tens to hundreds of miles. Uplift, deformation, erosion, and subsequent re-deposition of sedimentary rocks have been driven primarily by the northwest-directed, horizontal (strike-slip) movement of the plates and the associated southwest to northeast-oriented compressive stress. The region continues to be characterized by moderate to high rates of tectonic and seismic activity (Figure 3.7-6).

The State of California has addressed these hazards to public safety and property through identifying areas presenting geologic risk and imposing regulations. More specifically, the California Geological Survey is responsible for the preparation and maintenance of programmatic mapping of these areas, as required by the Seismic Hazards Mapping Act. Zones of required investigation for possible earthquake faulting, landslides, and liquefaction are delineated and distributed to cities, counties, and State construction agencies to help identify where higher building standards may be necessary for safe development. Seismic hazards resulting from earthquakes include ground rupture along a fault line (also called surface rupture) ground shaking, liquefaction, subsidence, and mass wasting. Each of these potential hazards is discussed below.

<u>Faults</u>

Most earthquakes originate along fault lines. A fault is a fracture in the Earth's crust along which rocks on one side are displaced relative to those on the other side due to plate tectonics. Most faults are the result of repeated displacement that may have taken place suddenly and/or by slow creep (California Geological Survey 2018). The State of California has developed a classification system that defines an active fault as one that have had surface displacement in in Holocene time. The following passage from CGS SP42 Section 5.2 explains the rationale as follows:

> *For the purposes of the A-P Act, an active fault is defined as one which has "had surface displacement within Holocene time" (the last 11,700 years). This definition does not mean that faults lacking evidence for surface displacement within Holocene time are necessarily inactive. A fault may only be presumed to be inactive based on satisfactory geologic evidence; however, the evidence necessary to prove inactivity sometimes is difficult to obtain and locally may not exist. By virtue that fault investigations are required by the A-P Act to assess the recency of fault movement implies that faults within an EFZ are presumed to be active until determined otherwise.*
>
> *Terms such as "potentially active" and "inactive" have been commonly used in the past to describe faults that do not meet the SMGB definition of "active fault." However, these terms have the potential to cause confusion from a regulatory perspective, as they are not defined in the A-P Act, and may have other non-regulatory meanings in the scientific literature or in other regulatory environments. In order to avoid these issues, introduced below are terms that provide added precision when used in classifying faults regulated by the A-P Act. Faults are classified into three categories on the basis of the absolute age of their most recent movement…on a hypothetical trench log:*



Source: Figure produced and provided by Zinn Geology in 2020

Figure 3.7-6 Area Faults and Historic Seismic Activity

1) Holocene-active faults: Faults that have moved during the past 11,700 years. This age boundary is an absolute age (number of years before present) and is not a radiocarbon (14C) age determination, which requires calibration in order to derive an absolute age.

2) Pre-Holocene faults: Faults that have not moved in the past 11,700 years, thus do not meet the criteria of "Holocene-active fault" as defined in the A-P Act and SMGB regulations. This class of fault may be still capable of surface rupture, but is not regulated under the A-P Act. Depending on available site-specific and regional data such as proximity to other active faults, average recurrence, variability in recurrence, the timing of the most recent surface rupturing earthquake, and case studies from other surface rupturing earthquakes, the project geologist may, but is not required to, recommend setbacks. Engineered solutions can also be considered by a licensed engineer operating within his or her field of practice.

3) Age-undetermined faults: Faults where the recency of fault movement has not been determined. Faults can be "age-undetermined" if the fault in question has simply not been studied in order to determine its recency of movement. Faults can also be age-undetermined due to limitations in the ability to constrain the timing of the recency of faulting. Examples of such faults are instances where datable materials are not present in the geologic record, or where evidence of recency of movement does not exist due to stripping (either by natural or anthropogenic processes) of Holocene-age deposits. Within the framework of the A-P Act, age-undetermined faults within regulatory Earthquake Fault Zones are considered Holocene-active until proved otherwise.

It is worth reiterating that a project located outside of an Earthquake Fault Zone is still regulated by the A-P Act if a Holocene-active fault is found at that site. This can happen if a lead agency has established its own regulatory zone requiring an assessment of surface fault rupture hazard or in a situation where a Holocene-active fault is discovered during a geologic investigation for that project. If located outside of an Earthquake Fault Zone, age-undetermined faults are not regulated by the A-P Act. However, the project geologist may want to consider all available data and provide recommendations regarding whether setbacks or other engineered solutions should be considered in the placement or design of a structure crossing these faults.

Regional Faults

The following sections present information on the active and potentially active faults in the region. The descriptions are taken primarily from Nolan, Zinn and Associates (2005) and from the USGS Quaternary Faults database. The faults are shown on Figure 3.7-6.

Ben Lomond Fault

The Ben Lomond Fault is the nearest mapped large fault to the main residential campus and Westside Research Park. In the immediate vicinity of the campus, this fault is inferred to trend approximately north/south along the eastern boundary of the campus. It is a bedrock fault, which had significant vertical movement in the Tertiary Period. Twelve miles of the fault trace have been mapped along the San Lorenzo River Valley. The Ben Lomond Fault is not mapped as active by either the State or Santa Cruz County, although it appears to join the active Zayante Fault at its northwest end (Nolan, Zinn and Associates 2005).

San Andreas Fault System

The San Andreas Fault, located approximately 11 miles northeast of the main residential campus in the Santa Cruz Mountains, is an active fault and is a major seismic hazard in northern California (Working Group on Northern California Earthquake Potential [NCEP] 1996). The main trace of the fault trends northwest-southeast, extending over 700 miles from the Gulf of California through the Coast Ranges to Point Arena, where the fault extends offshore.

Geologic evidence suggests that the San Andreas Fault has experienced right-lateral, strike-slip movement throughout the latter portion of Cenozoic time (the past 20 to 30 million years), with cumulative offset of hundreds of miles. Surface rupture during historical earthquakes, fault creep, and historical seismicity confirm that the San Andreas Fault and its branches, the Hayward, Calaveras, and San Gregorio Faults, are all active today.

Historical earthquakes along the San Andreas Fault and its branches have caused significant seismic shaking in the Monterey Bay area. The two largest historical earthquakes on the San Andreas Fault to affect the area were the moment magnitude (Mw) 7.9 San Francisco earthquake of April 18, 1906 (centered near Olema to the north of San Francisco) and the Mw 6.9 Loma Prieta earthquake of October 17, 1989. The San Francisco earthquake caused severe seismic shaking and structural damage to many buildings in the Monterey Bay area. The Loma Prieta earthquake appears to have caused more intense seismic shaking than the 1906 event in localized areas of the Santa Cruz Mountains, even though its regional effects were not as extensive. Based on records from the 1906 San Francisco earthquake, it is estimated that the maximum credible earthquake likely to occur along the San Andreas Fault would equal 8.3 Mw, which represents more than 30 times the energy released by the 1989 Loma Prieta Earthquake. There were also significant earthquakes in northern California along or near the San Andreas Fault in 1838, 1865 and possibly 1890 (Sykes and Nishenko 1984; NCEP 1996).

Geologists have recognized that the San Andreas Fault system can be divided into segments with "characteristic" earthquakes of different magnitudes and recurrence intervals (Working Group on California Earthquake Probabilities [WG], 1988 and 1990). A study by NCEP in 1996 has redefined the segments and the characteristic earthquakes for the San Andreas Fault system in northern and central California. Two "locked" overlapping segments of the San Andreas Fault system represent the greatest potential hazard to the campus.

The first segment is defined by the rupture that occurred from Cape Mendocino to San Juan Bautista along the San Andreas Fault during the great Mw 7.9 earthquake of 1906. The NCEP (1996) has hypothesized that this "1906 rupture" segment experiences earthquakes with comparable magnitudes at intervals of about two hundred years.

The second segment is defined by the rupture zone of the Mw 6.9 Loma Prieta earthquake. Although it is uncertain whether this "Santa Cruz Mountains" segment has a characteristic earthquake independent of great San Andreas Fault earthquakes, the NCEP (1996) has assumed an "idealized" earthquake of Mw 7.0 with the same right-lateral slip as the 1989 Loma Prieta earthquake, but having an independent segment recurrence interval of 138 years and a multi-segment recurrence interval of 400 years.

The USGS Working Group on California Earthquake Probabilities 2002 (2002 WG) re-evaluated the geologic data and characterized the earthquake sources for the San Francisco Bay Region, which includes Santa Cruz, in the *Earthquake Probabilities in the San Francisco Bay Region: 2002-2031*. The segmentation model utilized in this study is largely similar to that adopted by NCEP in 1996, although the 2002 WG added far more complexity to the model, and reduced the forecasted magnitudes for the different segments (USGS 2003). The study is appropriate for use in estimating seismic hazard in Santa Cruz and estimating the intensity of ground shaking expected for specified scenario earthquakes. The study determined that there is a 62 percent probability of at least one magnitude 6.7 or greater (M≥6.7) earthquake in the 3-decade interval 2002-2031 in the San Francisco Bay Region. For the San Andreas Fault there is a 21 percent probability of a M≥6.7 in the 2002-2031 period. Furthermore, the San Andreas Fault system has one of the highest probabilities of generating a M≥6.7 earthquake before 2032, and this fault has sufficient length to generate a large earthquake of M7.5 or larger (USGS 2003). The 2002 California probabilistic seismic hazard maps issued by the California Geological Survey (Cao et al. 2003) appear to have largely adopted the earthquake magnitudes issued by the 2002 WG. The most significant change in modeling the San Andreas Fault Zone by Cao et al. (2003) is the elimination of a singular listing of the penultimate event, the 1906 Mw 7.9 earthquake (although such an event can be derived by looking at the aggregate probability of the individual segments rupturing together, as they did in 1906).

In spite of the increasing complexity of the models addressing different size earthquakes with different recurrence intervals on the sundry segments of this fault, it is undeniable that the 1906 Mw 7.9 earthquake still eclipses all other events which have occurred on the San Andreas Fault in this region.

Zayante-Vergeles Fault

The Zayante-Vergeles Fault is west of the San Andreas Fault, located approximately 8 miles northeast of the main residential campus. It lies west of the San Andreas Fault and trends about 50 miles northwest from the Watsonville lowlands into the Santa Cruz Mountains. The southern extension of the Zayante Fault, known as the Vergeles Fault, merges with the San Andreas Fault south of San Juan Bautista.

The Zayante-Vergeles Fault has undergone late Pleistocene and Holocene movement (1.8 million years ago to present) and is potentially active. Movement has been vertical and probably accompanied by right-lateral, strike-slip movement (Nolan, Zinn and Associates 2005).

The Zayante Fault may have undergone sympathetic (secondary) fault movement during the 1906 earthquake centered on the San Andreas Fault, although this evidence is equivocal. Seismic records strongly suggest that a section of the Zayante Fault, approximately 3 miles long, underwent sympathetic movement in the 1989 earthquake. The earthquakes tentatively correlated to the Zayante Fault were centered at a depth of 5 miles; no instances of surface rupture on the fault have been reported. The fault, which is considered potentially active, is capable of generating a Mw 6.8 earthquake with an effective recurrence interval of 10,000 years, or a Mw earthquake of 7.0 with no stated recurrence (Nolan, Zinn and Associates 2005).

San Gregorio Fault

The San Gregorio Fault runs mostly offshore in the vicinity of the Santa Cruz County coastline, cutting across the land for a short distance at Point Año Nuevo and then heads offshore and northwest where it intersects with the San Andreas Fault near Bolinas. The portion of the fault nearest the main residential campus is approximately 8.5 miles to the southwest. The Point Año Nuevo portion of the fault displays evidence of predominantly right-lateral strike slip displacement throughout the late Pleistocene and Holocene. The most recent earthquake along the San Gregorio Fault zone occurred after 1270 AD to 1400 AD, but prior to the arrival of Spanish missionaries in 1775 AD (USGS Quaternary Fault and Fold Database of the United States).

Monterey Bay-Tularcitos Fault Zone

The northwest-trending Monterey Bay-Tularcitos Fault zone, located approximately 5 miles south of the campus, is approximately 25 miles long and 6 to 9 miles wide and consists of numerous small offset (en echelon) faults.

The fault zone intersects the coast in the vicinity of Seaside and Ford Ord, where several onshore fault traces have been tentatively correlated with offshore traces. Movement in the fault zone appears to be predominantly right-lateral, and strike-slip. Fault traces show evidence of Quaternary (less than 1.8 million years ago) movement both onshore and offshore and, therefore, they are considered potentially active (Rosenberg and Clark 1994).

Historical earthquakes have been tentatively located in the Monterey Bay-Tularcitos Fault zone including two events, estimated at 6.2 on the Richter Scale in October 1926. Because of possible inaccuracies in locating the epicenters of these earthquakes, it is possible that they actually occurred on the nearby San Gregorio Fault zone. Another earthquake in April 1890 might be attributed to the Monterey Bay-Tularcitos Fault zone.

On-Campus Faults

There are no faults that underly the Westside Research Park. On the main residential campus, the older metamorphic bedrock is cut by a series of north-south and east-west trending faults. Some have located in the field by geologists as part of mapping programs or grading observation, but many are inferred by the secondary development of erosional valleys, depressions and sinkholes or because the faults juxtapose dissimilar rock types across narrow zones. Jordan Gulch and Moore Creek are underlain by the two north-south trending faults and define the three structural blocks that underlie central and lower campus. These faults are not apparent on the north and upper campus and do not appear to cut the Tertiary age Santa Margarita Formation located on the north campus. The faults on the main residential campus are clearly not Holocene-active, given that the faults do not appear to cut bedrock that is 1.8 million years old, along with the geometry of the faults with respect to the neotectonics setting in this region. There is no need to consider setbacks or investigations of the faults, at least with respect to surface fault ground rupture hazard.

The old east-west trending faults on the main residential campus appear to be offset or truncated by the north-south faults indicating that they are even older than the north-south faults and are therefore are not Holocene-active (Nolan, Zinn and Associates 2005).

Primary Seismic Hazards

The current CBC requirements for seismic shaking analysis for buildings and infrastructure now rely upon incredibly complex time dependent and time independent models issued by the USGS that are a hybrid of deterministic and probabilistic hazards analyses of faults, both real and artificial. The previous method of assigning moment magnitude earthquake values to discretized segments of faults along with “characteristic” earthquakes has been discarded in favor of much more robust statistical analyses that are appropriate for use in risk-based analyses. The protocols for developing minimum prescriptive seismic structure dependent shaking values are given in the ASCE/SEI 7 manual and those protocols are referenced in the current CBC, as described above. The regional faults located in the region of UC Santa Cruz are shown on Figure 3.7-6.

Surface Fault Rupture

Surface rupture is the surface expression of movement along a fault. Structures built over an active fault can be torn apart if the ground ruptures. The potential for surface rupture is based on the concepts of recency and recurrence. Surface rupture along faults is generally limited to a linear zone a few meters wide. The Alquist-Priolo Act (see the Regulatory Setting discussion, above) was created to prohibit the location of structures designed for human occupancy across, or within 50 feet of, an active fault, thereby reducing the loss of life and property from an earthquake. The LRDP area is not located within an Alquist-Priolo active fault zone (Bryant and Hart 2007).

Ground Shaking

The LRDP area lies within one of the most seismically active areas in the western United States. Strong seismic shaking has occurred and will occur again on campus within the next 100 years (which is the CBC design life of campus structures). The intensity of seismic shaking, or strong ground motion, during an earthquake is dependent on the distance and direction from the epicenter of the earthquake, the magnitude of the earthquake, and the geologic conditions of the surrounding area. Ground shaking could potentially result in the damage or collapse of buildings and other structures.

As noted above, current CBC requirements for seismic shaking analysis for buildings and infrastructure now rely upon incredibly complex models and protocols for developing minimum prescriptive seismic structure dependent shaking values given in the ASCE/SEI 7 manual and those protocols are referenced in the current CBC. It should be noted that there is a campus-specific dilemma encountered when using the ASCE/SEI 7 seismic design criteria in determining site class, which is based on the site soil properties when designing structures in the karst where marble bedrock underlies the site. Most relationships are based on average shear wave velocities for the upper 100 feet of earth materials. The difficulty in deciding which relationship to choose arises when the planned foundation of the building will simultaneously rest upon pinnacles of crystalline marble as well as extremely deep pockets of soft soil filling old dolines. Research literature that addresses this topic is unavailable, so it is important for geologists and other design professionals to collaborate on construction issues.

Karst Hazard and Subsidence

In areas that are underlain by water soluble rocks such as the marble bedrock found at the main residential campus, dissolution over hundreds of thousands of years from surface water and groundwater often produces a complex network of interconnected underground channels and caverns as well as karst topography. Such topography is characterized by irregular surfaces resulting from subsidence or collapse of the bedrock and sediment into those subterranean cavities that have developed within the marble bedrock.

Depressions in the land surface resulting from the intersection with a zone of collapse of overlying sediments into a void, are called "sinkholes" or "dolines." There are three types of dolines. Solution dolines are formed by gradual settling of surficial sediments into a solution cavity while solution is occurring. These dolines are characterized by gently sloping sides and an absence of rock outcrops along the walls. Such dolines do not have extensive caverns or experience rapid large-scale collapse. Collapse dolines are formed by the sudden collapse of the roof of an underground void. They have steep sides and rocky, irregular walls. Subsidence dolines are similar to solution dolines but are formed when surface sediments are washed into existing subsurface cavities. The overlying soils subside since some of their volume has been washed into the adjacent void.

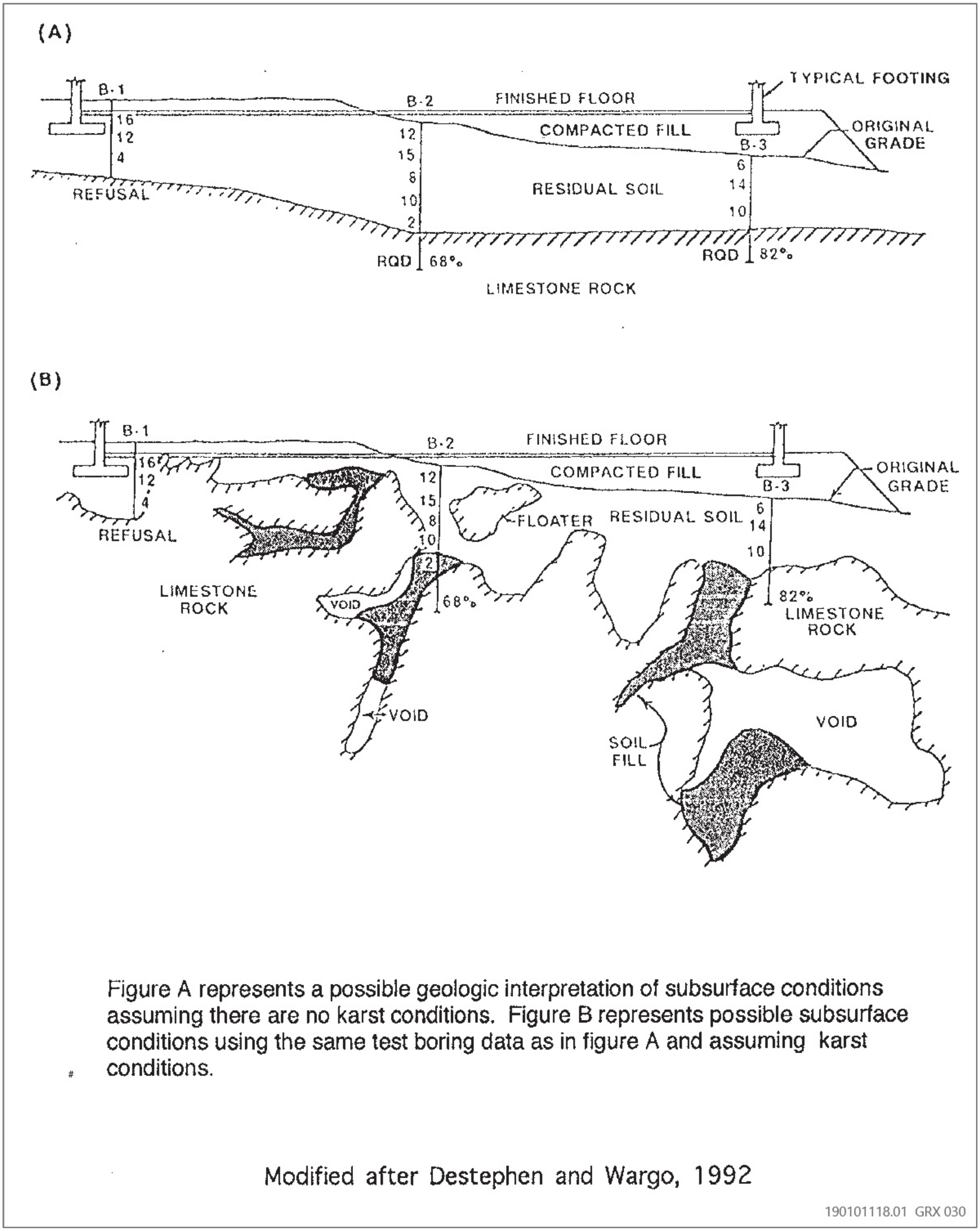
The karst topography on the main residential campus has not been subject historically to catastrophic collapse of large underground voids, as is occasionally seen in karst regions in the eastern United States. Neither is there geologic evidence for prehistoric large-scale cavern collapse on campus. Most dolines present on the campus appear to be solution dolines. The relative absence of large-scale collapse features is most likely a result of the limited lateral extent and thickness of the marble section on campus. However, the weathering processes associated with marble bedrock create special problems for the siting and founding of buildings, with or without sudden doline collapse. These potential problems must be recognized in the site investigation and design programs. Therefore, the hazards discussed below deal with problems encountered in investigating building sites and designing foundations, rather than immediate threats to life or potential structural collapse of buildings.

One of the principal problems of developing areas underlain by karst is the extreme irregularity of the karst features, and consequently the lack of predictability of subsurface conditions. Because of this unpredictability, some level of risk is inherent in developing in karst regions, as no amount of site investigation can reveal every detail of the subsurface. The surface of the marble bedrock can be highly irregular. Boring data from prior investigations on the campus for the last decade show a variation in the elevation of the marble surface of more than 100 feet over a horizontal distance of 10 feet or less. This variability can easily be missed in an otherwise competent geotechnical site investigation. A building can be sited with a portion of the foundation resting on a solid marble pillar while the adjacent portion of the structure is resting on over 100 feet of poorly consolidated doline fill. Depending upon the loads placed on a foundation, such conditions could lead to structural failure. Similarly, caverns and small underground voids can easily be missed even with an aggressive drilling and exploration program. Loading of the ceiling of a cavern could lead to partial collapse or subsidence of the cavern ceiling and the foundation into the void.

In addition to cavern collapse and subsidence of soils into voids, there is widespread dissolution of the marble surface below the overlying deposits. This dissolution creates areas of weak or soft soils in a thick zone that directly overlies the marble surface. These zones are composed of marble fragments in a matrix of silt, sand, and clay. The marble fragments may or may not be in point-to-point contact and the soil matrix is generally soft and poorly consolidated. Caverns or large voids are always present in these soft zones, and the zones are usually not associated with evidence for doline formation or collapse. Such zones may have inadequate bearing strength and may present hazards to construction unless recognized. Figure 3.7-7 shows the type of subsurface conditions that can be encountered in an area of solution cavities, and two types of interpretations derived from the data; one interpretation incorrectly assumes "layer cake" stratigraphic conditions while the second interpretation assumes a much more complicated karst terrain stratigraphy.

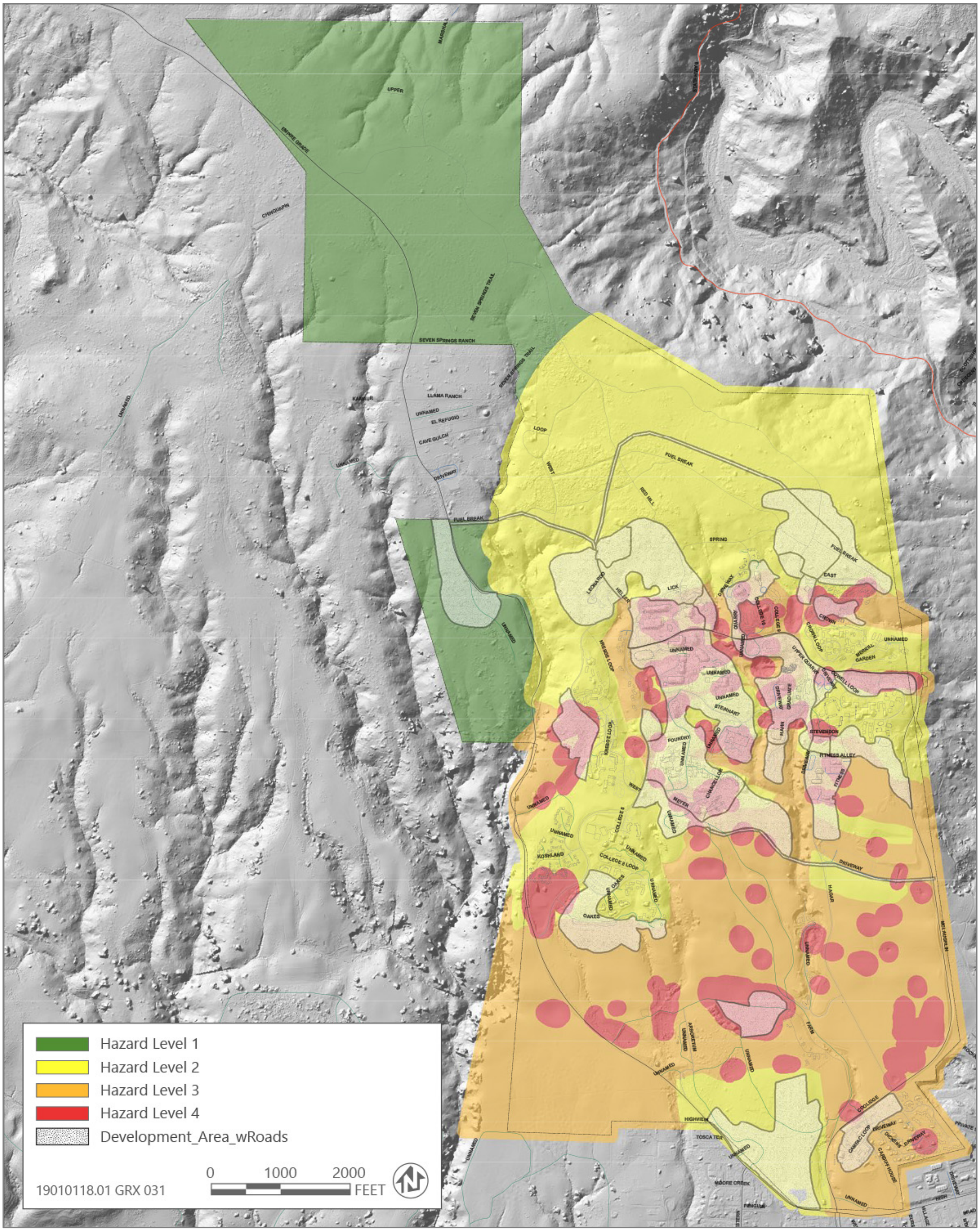
The karst hazard zone map (Figure 3.7-8) separates the main residential campus into four hazard level zones based on the character of bedrock and the results of previous geotechnical investigations. The zones are defined as:

- Zone 1 - Areas underlain by granitic rocks with no karst-related hazards. No special precautions or recommendations specific to karst processes are necessary. This zone encompasses areas underlain by granitic rocks.
- Zone 2 - Areas with low potential for karst-related hazards. These are underlain by schist, where no marble or evidence for sinkhole activity has been observed, either in boreholes or at the surface. This zone was created by applying a 100-foot buffer beyond the contacts for the applicable earth material units as shown on the current campus geologic map. The buffers were included to account for the inherent uncertainty in locating borings and earth materials contacts portrayed by consultants in the many previous reports on which the compilation map is based. Zone 2 represents areas with a higher hazard level than Zone 1, because marble can occur as isolated lenses or pods, or may occur at depth.
- Zone 3 - Zone 3 includes areas underlain directly or at shallow depth by marble, but that lack any direct indication of doline formation or other solution collapse of site soils in either surface or surface data. Site investigations in this zone should include subsurface investigations appropriate for this geologic setting. A 100-foot buffer has been applied to the margins of the zone as described above.
- Zone 4 - Areas with a high potential for hazards due to karst conditions. This includes areas underlain by marble with evidence of doline formation. A 100-foot buffer has been applied to the margins of the zone as described above (Nolan, Zinn and Associates (2005) and Zinn Geology [in press]).



Source: Figure adapted from Destephen, R.A., and Wargo R.H. 1992

Figure 3.7-7 Geologic Interpretation In Karst Terrain



Source: Figure produced and provided by Zinn Geology in 2020

Figure 3.7-8 Karst Hazards

Most of the existing main residential campus core buildings are located in Karst Hazard Zones 3 and 4. To address the karst hazard, most existing construction on the UC Santa Cruz campus includes conventional spread footing foundations, which are adequate where building pressures are light and low-density zones or solution cavities are relatively deep. Other foundation construction techniques that have been used in karst areas include spread footings with grade beams to span low-density zones, structural mats and post-tensioned slabs, pier and grade beam foundations with either end-bearing or side-wall friction for support, driven piles, geotextile-reinforced compacted fill, pressure or compaction grouting of underlying sediments combined with the aforementioned footings, and deep dynamic compaction (Nolan, Zinn and Associates 2005).

Liquefaction and Lateral Spreading

The soils on the main residential campus and Westside Research Park have been characterized by Dupré (1975) as having a low susceptibility to liquefaction. There are no reports of liquefaction and its attendant effects on the campus as a result of the 1989 Loma Prieta Earthquake or the 1906 Earthquake (Youd and Hoose 1978; Lawson 1908), but the population and anecdotal reports were so sparse in this region in 1906, it is possible that any damage sustained on what is now the campus area during the 1906 earthquake could have gone unnoticed.

Only one past geotechnical engineering investigation on the main residential campus, for the north campus (Steven Raas and Associates 2000), identified potentially liquefiable deposits. Liquefiable deposits were identified in two of the 34 borings advanced as part of that investigation. The liquefiable deposits were found between depths of 4 and 16 feet below the ground surface, with a corresponding calculated liquefaction-induced settlement of up to 2.5 inches. The liquefiable deposits appear to be within weathered schist bedrock, near the contact with Santa Margarita Formation sand.

Mass Wasting and Landslides

Mass wasting refers to the collective group of processes that characterize down slope movement of rock and unconsolidated sediment overlying bedrock. These processes include landslides, slumps, rockfalls, flows, and creeps. Many factors contribute to the potential for mass wasting, including geologic conditions as well as the drainage, slope, and vegetation of the site. Landslide deposits on the main residential campus are located along Cave Gulch near the western boundary. The lack of landslides is likely due to the presence of hard, stable, granitic and metamorphic rocks that underlie the main residential campus and Westside Research Park. Potential hazards from landslides are present in limited areas where steep slopes are overlain by substantial thicknesses of colluvium and soil, generally along the larger stream drainages and in the old marble quarries.

Mineral Resources

Marble quarrying of the main residential campus was historically extensive and tied to production of cement. However, UC Santa Cruz does not actively mine or quarry the primary mineral resource in the LRDP area, marble bedrock, nor is there any plan to do so in the future. The marble bedrock is extensive across the main residential campus.

Paleontological Setting

Significant nonrenewable vertebrate and invertebrate fossils and unique geologic units have been documented throughout California. The fossil yielding potential of a particular area is highly dependent on the geologic age and origin of the underlying rocks. Paleontological potential refers to the likelihood that a rock unit will yield a unique or significant paleontological resource. All sedimentary rocks, some volcanic rocks, and some low-grade metamorphic rocks have potential to yield significant paleontological resources. Depending on location, the paleontological potential of subsurface materials generally increases with depth beneath the surface, as well as with proximity to known fossiliferous deposits.

Marine formations in Santa Cruz County have yielded significant invertebrate and vertebrate fossils, including several taxa of marine mammals. Potential fossil-bearing formations in the LRDP area include marine formations (Santa Margarita sandstones, Santa Cruz mudstone, and Quaternary marine terrace deposits) and sedimentary formations (Quaternary non-marine terrace deposits and doline deposits).

Santa Margarita sandstones in the Santa Cruz region have yielded significant marine vertebrate fossils. Outcrops of the Santa Margarita formation, late Miocene age through early Pliocene age marine sediments, primarily sandstone, occur in small patches in the northern portion of the main residential campus. The Santa Margarita formation evidences a range of marine environments. The lower strata often contain abraded vertebrate fossils of primarily Clarendonian age marine mammals (13 to 9 million years ago) with some terrestrial mammal remains, including horses and gomphotheres. Complete skeletons of large marine mammals such as sea cows, whales, and sea lion- and walrus-like pinnipeds have been recovered in some localities. Deposits of the Santa Margarita formation in the central Santa Cruz Mountains have yielded invertebrate fossils that occur only in Pliocene age deposits (Clark 1981), which suggests a depositional history that spans Late Miocene through early Pliocene time (13 to 2 million years ago). Although no finds have been made in the Santa Margarita sandstones on the UC Santa Cruz campus, this may be because there has been no development in the Santa Margarita formation. The Santa Margarita sandstone formations in the LRDP area are considered to have high potential to include significant fossils.

Quaternary marine terrace deposits, which are remnants of high marine terraces, have been mapped in the southeastern portion of the main residential campus, where they overlie marble and schist. The marine terrace deposits are sediments deposited on wave-cut platforms, with a wedge of non-marine deposits backed against an ancient sea cliff. These consist of unconsolidated deposits of silt, sand, clay, and gravel, around 900,000 years old. Although deposits of this kind may preserve fossils, no fossil finds have been documented in doline fill deposits and Quaternary marine terrace sediments in the region, nor have any fossil finds been made on campus, despite extensive development in areas underlain by Quaternary marine and on-marine terrace deposits. While these deposits may have some potential to yield fossils, the potential to encounter fossils in these formations in the LRDP area is considered low.

Dolines, which developed in the main residential campus area during the Pleistocene and Holocene as the result of dissolution of marble, which is water soluble. Dolines, once formed, act as surface drains and tend to collect sediment and decomposed rock. Although there have been no finds to date in the coastal California region, some of the best preserved late Pleistocene vertebrate fossils recovered from regions of high precipitation or dense vegetation elsewhere in California have been from caves developed in limestone and marble. Remains of animals trapped in or washed into a sinkhole or transported into an underground cavern by flowing water or as a result of collapse, may be mineralized and preserved. Mineralized remains would not be expected to occur in recent near-surface fill deposits in dolines. However, fossil remains may occur in interstices and caverns in the karst material, or in the older levels of sinkhole deposits. Dolines occur in numerous locations on the central and lower portions of the main residential campus and there has been extensive development in these areas. This suggests that this setting is not paleontologically sensitive on campus, or that fossils in this setting are rare. Therefore, the potential to encounter fossils in dolines in the LRDP area is considered low.

The immediate surface formations at 2300 Delaware Avenue, the site of the Westside Research Park, are relatively recent emergent coastal terrace deposits, which generally are not paleontologically sensitive because of their recent age. Locally, these deposits are underlain by Santa Cruz mudstone, a Plio-Pleistocene marine deposit formation that has yielded marine vertebrate fossils, including sea mammals, fish, and birds, in the Santa Cruz region (UCMP 2010). This formation, which could be exposed by excavation at this site, is considered to have high paleontological potential.

3.7.3 Environmental Impacts and Mitigation Measures

ANALYSIS METHODOLOGY

To evaluate project impacts, resource conditions that could pose a risk to the 2021 LRDP were identified through review of documents pertaining to these topics within the LRDP area. Sources consulted include USGS and CGS technical maps and guides; the NRCS Soil Survey (available through the Soil Survey Geographic Database [SSURGO]); the Santa Cruz County Soils Survey (Stanford Libraries 2020); previous environmental impact reports; background reports prepared for nearby plans and projects; and published geologic literature. The information obtained from these sources was reviewed and summarized to establish the existing conditions (described above) and identify potential environmental hazards. In determining level of significance, the analysis assumes that the project alternatives would comply with relevant laws, regulations, guidelines, and project-specific geotechnical studies.

SIGNIFICANCE CRITERIA

Thresholds of significance are based on Appendix G of the State CEQA Guidelines. 2021 LRDP implementation would result in a significant impact on geology, soils, paleontological, or mineral resources if it would:

- directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:
  1. 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,
  2. strong seismic ground shaking,
  3. seismic-related ground failure, including liquefaction, or
  4. landslides;
- result in substantial soil erosion or the loss of topsoil;
- 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 landslides, lateral spreading, subsidence, liquefaction or collapse;
- be located on expansive soil creating substantial risks to life or property;
- have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the purposes of the disposal of wastewater;
- directly or indirectly destroy a unique paleontological resource or site or unique geologic feature;
- result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state; or
- result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

ISSUES NOT EVALUATED FURTHER

Surface Fault Rupture

Although UC Santa Cruz is located in a seismically active region that includes several active earthquake faults of local and regional significance, the LRDP area is not located within a designated Alquist-Priolo Earthquake Fault Zone. The faults mapped on campus do not appear to cut bedrock that is 1.8 million years old and their geometry with respect to the regional neotectonics setting makes it unlikely that they will rupture the ground surface within the design life of any buildings or infrastructure on the camps. There is no need to consider setbacks or investigations of the faults with respect to surface fault ground rupture hazard. Compliance with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook would minimize any potential impacts related to fault rupture. Thus, implementation of the 2021 LRDP would not expose people or structures to potential substantial adverse effects related to the rupture of a known earthquake fault; and this issue is not evaluated further.

Septic Systems

There are no septic systems or alternative wastewater systems within the LRDP area and future development associated with the 2021 LRDP would not include the construction or use of septic facilities; therefore, no impact would occur and this issue is not evaluated further. This issue would only be important if wastewater processing that relied on soils for effluent treatment was proposed, and it is not.

Mineral Resources

The LRDP area is within an area designated as a Mineral Resource Zone (MRZ) due to the presence of subsurface limestone marble. The area is classified as MRZ-3a, defined as an area where mineral resources are known to exist, but where insufficient information is available to determine the value of those resources (Santa Cruz County 2020). Although the marble quarrying history of the campus was historically extensive and tied to the production of cement in the past, UC Santa Cruz does not actively mine or quarry its primary mineral resource, marble bedrock, nor is there any plan to do so in the future. The marble bedrock is extensive across the main residential campus. Therefore, existing and proposed 2021 LRDP development does not preclude potential quarry activities in the future if the campus were to choose to do so. Implementation of the 2021 LRDP would not result in the loss of availability of mineral resources and this issue is not evaluated further.

IMPACTS AND MITIGATION MEASURES

Impact 3.7-1: Increase the Risk of Exposure of People or Buildings to Seismic Ground Shaking

The LRDP area is in a seismically active region that includes several active earthquake faults of local and regional significance. All structures proposed to be constructed or redeveloped would be required to comply with regulatory mandates in the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook to ensure that new and modified buildings and infrastructure would be capable of withstanding anticipated levels of ground shaking. For this reason, the potential impact related to ground shaking would be **less than significant**.

As discussed in Section 3.7.2, the LRDP area is located in a seismically active region that includes several active earthquake faults of local and regional significance, including the San Andreas Fault. As stated above, the E*arthquake Probabilities in the San Francisco Bay Region: 2002-2031* determined that there is a 62 percent probability of at least one magnitude 6.7 or greater (M≥6.7) earthquake in the 3-decade interval 2002-2031 in the San Francisco Bay Region. For the San Andreas Fault there is a 21 percent probability of a M≥6.7 in the 2002-2031 period. Furthermore, the San Andreas Fault system has one of the highest probabilities of generating a M≥6.7 earthquake before 2032 and this fault has sufficient length to generate a large earthquake of M7.5 or larger (USGS 2003). High accelerations generated from large magnitude earthquakes on any of the nearby active faults in the region could lead to structural damage of buildings and infrastructure if they are not designed to withstand the forces generated from those accelerations, which in turn would result in exposure of the occupants to those hazards.

As noted above, current CBC requirements for seismic shaking analysis for buildings and infrastructure now rely upon incredibly complex models and protocols for developing minimum prescriptive seismic structure dependent shaking values given in the ASCE/SEI 7 manual and those protocols are referenced in the current CBC. Design professionals generating site specific seismic shaking data for building designs would consult the latest guidelines and protocols outlined in the CBC and the ASCE/SEI 7.

The UC Seismic Safety Policy was crafted to provide an acceptable level of earthquake safety for students, employees, and the public who occupy UC facilities and leased facilities, to the extent feasible by present earthquake engineering practice. Feasibility is determined by balancing the practicality and the cost of protective measures, depending on the forecasted severity and probability of injury resulting from seismic activity. The Campus Standards Handbook outlines required products and mandatory design constraints for all construction on the UC Santa Cruz campus (UC Santa Cruz 2017). The Handbook contains a set of standards that are provided to UC Santa Cruz consultants for guidance in the preparation of construction documents. The Handbook includes building and site requirements, and standards for soil treatment, earthwork, and erosion control.

The UC Seismic Safety Policy, to which the campus adheres, requires anchorage for seismic resistance of nonstructural building elements such as furnishings, fixtures, material storage facilities, and utilities that could create a hazard if dislodged during an earthquake. Campus Environmental Health and Safety provides guidance for preparing department-level Illness and Injury Prevention Plans that emphasizes methods for minimizing seismic hazards in laboratories, for example, by properly securing chemical containers and gas cylinders. Each department has a Safety Coordinator who develops and maintains a departmental emergency response plan. The departmental emergency response plans must be submitted to the Emergency Preparedness Policy Group for annual review to ensure consistency with the campus Emergency Operations Plan, which includes seismic safety and building evacuation procedures. The emergency procedures incorporated into the departmental emergency response plans further reduce the hazards from seismic shaking by preparing faculty, staff, and students for emergencies. In addition, and consistent with changes to the UC Seismic Safety Policy in 2017, UC Santa Cruz has an ongoing program to upgrade or replace existing buildings not adequately prepared to withstand currently assessed seismic hazards, which includes an evaluation of each structure located within the LRDP area and a determination as to the need for further structural improvements. All of these procedures would continue to be implemented as new facilities are developed on campus under the 2021 LRDP.

Compliance with CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook mandates would reduce the potential impact related to seismic ground shaking through the identification of site-specific seismic hazards and implementation of responsive structural design in accordance with peer-reviewed earthquake loads and seismic performance requirements. Therefore, the potential risk of loss, injury, or death related to seismic ground shaking would be **less than significant**.

Mitigation Measures

No mitigation is required for this impact.

Impact 3.7-2: Increase the Risk of Exposure of People or Buildings to Seismic-Related Ground Failure, Including Liquefaction

Development and redevelopment per the 2021 LRDP could occur on a geologic unit or soil that could become unstable. In addition, ground failure could be triggered by seismic shaking and could result in on- or off-site landslides, lateral spreading, or liquefaction, creating potential risks to life or property. All structures proposed to be constructed or redeveloped would be required to comply with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook, to ensure that all new and modified structures would be capable of withstanding anticipated levels of ground shaking. For this reason, the potential impact related to ground failure and liquefaction would be **less than significant**.

Construction on unstable soil or bedrock can pose risk to life and property. Unstable earth materials include landslides and areas with soils that are susceptible to liquefaction or lateral spreading. Landslide potential is limited to a few areas of the campus, which generally are located along the larger stream drainages and in old quarries. Development under the 2021 LRDP is not proposed in such areas.

Liquefaction and lateral spreading of soils can occur when loose saturated soils are subjected to long duration intense seismic shaking from large magnitude earthquake events. Although, there are very few locations on the campus that are underlain by loose, saturated soils, previous geotechnical investigation has identified potentially liquefiable deposits (Steven Raas and Associates 2000) within the LRDP area.

Because there are only a few areas on the campus that are underlain by unstable earth materials, new development on the campus under the 2021 LRDP would, for the most part, not be located on such units and the risk to life and property would not be significant. However, some of the proposed bridges could cross areas with landslide potential and there are some limited areas within the north campus development area where the surficial soils may be susceptible to liquefaction. New construction in these areas could expose people and property to the risk from unstable ground conditions, and thereby result in a potentially significant impact.

As discussed above, all structures proposed to be constructed or redeveloped would be required to comply with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook, to ensure that all new and modified buildings and infrastructure would be capable of withstanding anticipated levels of ground shaking. Site-specific geotechnical studies and soil engineering reports would be required before consideration of approval for all development pursuant to the 2021 LRDP. These site-specific geotechnical studies and soil engineering reports would evaluate potential risk associated with seismic ground failure and liquefaction for individual projects pursuant to the 2021 LRDP and incorporate project-specific design requirements and conditions of approval for all development pursuant to the 2021 LRDP. Therefore, the potential risk of ground failure and liquefaction would be **less than significant**.

Mitigation Measures

No mitigation is required for this impact.

Impact 3.7-3: Result in Substantial Erosion or Loss of Topsoil during Construction, Operations, or Maintenance

Development and redevelopment project construction, operations, and maintenance under the 2021 LRDP may involve vegetation removal, clearing, and grading of soils, all of which could result in erosion and loss of topsoil, particularly if soils are exposed to wind or stormwater during construction. However, through compliance with all required regulations, such as SWRCB General Permit for Discharges of Stormwater Associated with Construction Activity (Construction General Permit Order 2009-0009-DWQ) and the Statewide Phase II MS4 Permit, the impact related to substantial erosion or loss of topsoil during construction would be **less than significant**.

The LRDP area is underlain by soils that range from slightly to very highly erodible, based on U.S. Soil Conservation Service classification (see Table 3.7-2). Highly to very highly erodible soils are present in some areas of central and north campus and in small portions of the lower campus. These problems and the effects of alterations to predevelopment storm water runoff patterns are discussed in more detail in Section 3.10, "Hydrology and Water Quality."

Construction of facilities, operations of campus facilities, and maintenance activities would result in soil-disturbing activities that could lead to increased erosion including grading, trenching, boring, and removal of trees and other vegetation. For construction projects under 1 acre, UC Santa Cruz has developed a set of erosion control standards for construction projects that would apply. For construction projects over 1 acre, compliance with the SWRCB General Permit for Discharges of Stormwater Associated with Construction Activity (Construction General Permit Order 2009-0009-DWQ) would apply. For operations and maintenance activities, the Statewide Phase II MS4 Permit would apply. These standards are included in the Campus Standards Handbook and incorporated by reference into the specifications for campus development projects.

In addition, UC Santa Cruz continues to assess the health and functionality of the existing campus storm drain system, natural drainages and karst systems, as well as proposed improvements to those systems and development of non-potable water systems. Refer to Section 3.10, "Hydrology and Water Quality," for further information. This plan addresses existing drainage and erosion issues, current water infrastructure planning, campus projects currently under development, and presents goals for water sustainability and resilience.

2021 LRDP development areas do not encroach on steep slopes and drainages, and campus standards require that substantial development on slopes greater than 20 percent be avoided. Therefore, tree removal and other construction activities would not occur on steep slopes, with the exception of footings for the proposed bridges that cross the deep drainages on campus.

The regulatory and permitting requirements for building construction and stormwater control provide adequate protection against soil erosion during and as a result of construction, operations, and maintenance activities. Therefore, the impact associated with erosion and sedimentation from implementing the 2021 LRDP would be **less than significant**.

Mitigation Measures

No mitigation is required for this impact.

Impact 3.7-4: Increase the Risk of Exposure of People or Buildings to Expansive or Otherwise Unstable Soils

The LRDP area includes soils with high shrink-swell potential. Development and redevelopment projects within the LRDP area on these soils could result in shrinking and swelling of soils, which can cause damage to foundations. However, all structures constructed or redeveloped would be required to comply with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook, which require site-specific geotechnical studies and soil engineering reports to address potential risk associated with expansive or unstable soils. Because project-specific design requirements and conditions of approval would be incorporated for all development pursuant to the 2021 LRDP, the potential for structural damage due to shrinking and swelling of soils would be **less than significant**.

As discussed in Section 3.7.2 and shown in Table 3.7-1, soil types range in shrink-swell potential from low to high. Expansive soils (soils that shrink and swell depending on moisture level) are present in scattered sections of the main residential campus and their distribution can be highly variable even across building sites. This is due to the derivation of the soils from the weathering of the highly faulted and folded layers of metamorphic rock in those sections of the main residential campus. Expansive soils can damage building foundations if they are inadequately designed for their expansive properties. This can cause heaving and cracking of slabs-on-grade, pavements, and structures founded on shallow foundations if they are inadequately engineered for these conditions. Potential risk to life and property would result if buildings and other structures were constructed on expansive soils without appropriate design, and the impact would be potentially significant. Engineering solutions available include but are not limited to replacement of expansive soils with fill, treatment of soils, or deepening of foundations.

As discussed above, all structures proposed to be constructed or redeveloped would be required to comply with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook. Site-specific geotechnical studies and soil engineering reports would be required before consideration of approval of development pursuant to the 2021 LRDP. These site-specific geotechnical studies and soil engineering reports would evaluate potential risk associated with expansive or unstable soils and incorporate project-specific design requirements and conditions of approval for all development pursuant to the 2021 LRDP. Therefore, the potential for structural damage due to shrinking and swelling of soils would be **less than significant**.

Mitigation Measures

No mitigation is required for this impact.

Impact 3.7-5: Increase the Risk of Exposure of People or Buildings to Unstable Conditions Due to Karst Topography, Including Subsidence or Collapse

The LRDP area includes karst topography, which is characterized by irregular surfaces resulting from subsidence or collapse of the bedrock and sediment into subterranean cavities that have developed within the marble bedrock. Future development per the 2021 LRDP could result in construction of facilities on sites underlain by dolines or sinkholes, both of which are a characteristic of karst topography, that are filled with soft soil that lead to settling or collapse beneath facilities. However, all structures constructed or redeveloped would be required to comply with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook, which require site-specific geotechnical studies and soil engineering reports to address potential karst hazard risks. Because project-specific design requirements and conditions of approval would be incorporated for all development pursuant to the 2021 LRDP, the potential for structural damage due to karst topography would be **less than significant**.

As shown in Figure 3.7-8, Karst Hazards Map, the LRDP area includes karst topography, which is characterized by irregular surfaces resulting from subsidence or collapse of the bedrock and sediment into subterranean cavities that have developed within the marble bedrock. Construction in karst terrain is potentially hazardous because many karst features are not visible at the surface. Based on boring data from prior investigations on the main residential campus, the surface of the marble bedrock is highly irregular, varying in elevation by more than 100 feet over a horizontal distance of 10 feet or less (Nolan, Zinn and Associates 2005; Zinn Geology, in press). Underground cavities may be concealed by loose and soft soil and these soils may have inadequate bearing capacity for construction. Such soils may also contain marble rubble, overlain by more consolidated soils supported by soil arching. Settling and/or collapse can occur beneath a structure above an undetected cavity.

There is only one documented instance of doline collapse under a main residential campus building. In that instance, the collapse was triggered at the Earth and Marine Science Building during construction of the building because the contractor focused disposal of construction stormwater into an existing doline filled with soft soil (Zinn Geology, in press). There was also a reactivation of an infilled doline when a sinkhole collapse occurred under the campus emergency 911 line, possibly as a result of a recent installation of an underground stormwater treatment system leaking and triggering collapse of soft doline fill. There are no other documented instances of catastrophic collapse on the UC Santa Cruz campus, nor is there any geologic evidence of historical collapse (Nolan, Zinn and Associates 2005). However, the unpredictability of subsurface conditions taken in tandem with imposing heavy building loads or infrastructure systems poses risks to development.

As discussed above, all structures proposed to be constructed or redeveloped would be required to comply with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook. Site-specific geotechnical studies and soil engineering reports would be required before consideration of approval of development pursuant to the 2021 LRDP. These site-specific geotechnical studies and soil engineering reports conducted jointly by geotechnical engineers and geologists would evaluate, consistent with the requirements of Chapter 18 of the CBC, potential risk associated with karst hazards, including reviewing the most current version of the Karst Hazards Map (Figure 3.7-8) as part of site-specific project design to determine the level of hazard that could be presented to the proposed development and implementing the investigative protocols outlined on the map for the specific zone (see the "Karst Hazard and Subsidence" subsection in Section 3.7.2, "Environmental Setting," above, for description of the zones). Consistent with the aforementioned CBC requirements and taking into account location-specific information provided by geology studies conducted by UC Santa Cruz (e.g., UC Santa Cruz Campus Geology Report [UC Santa Cruz 2005]), full consideration of potential hazards from dolines would include collapse of cavern roofs, settlement of doline fill or low density soil zones on top of the marble, and failure or sliding of materials adjacent to the cavities. Foundations adjacent to the solution chambers, and not just those overlying the voids or chambers, are therefore potentially at risk and will be evaluated in the site-specific geotechnical studies and soil engineering reports.

To address the karst hazard, most existing construction on the UC Santa Cruz campus includes conventional spread footing foundations, which are adequate where building pressures are light and low-density zones or solution cavities are relatively deep. Other foundation construction techniques that have been used in karst areas include spread footings with grade beams to span low-density zones, structural mats and post-tensioned slabs, pier and grade beam foundations with either end-bearing or side-wall friction for support, driven piles, geotextile-reinforced compacted fill, pressure or compaction grouting of underlying sediments combined with the aforementioned footings, and deep dynamic compaction (Nolan, Zinn and Associates 2005).

Construction in karst terrain is potentially hazardous because many karst features are not visible at the surface, and settling or collapse can occur beneath a structure. However, all structures proposed to be constructed or redeveloped would be required to comply with the CBC, UC Seismic Safety Policy, and UC Santa Cruz Campus Standards Handbook. These regulations require site-specific geotechnical studies and soil engineering reports, which would be conducted by geotechnical engineers and geologist experienced in karst hazards before consideration of approval of development pursuant to the 2021 LRDP. Because project-specific design requirements and conditions of approval would be incorporated for development pursuant to the 2021 LRDP, the potential for structural damage due to karst topography would be **less than significant**.

Mitigation Measures

No mitigation is required for this impact.

Impact 3.7-6: Directly or Indirectly Destroy Unique Paleontological Resources

Development under the 2021 LRDP could result in the disturbance of paleontologically sensitive formations, which could result in the potential disturbance of paleontological resources. Potential fossil-bearing formations in the LRDP area include marine formations (Santa Margarita sandstones, Santa Cruz mudstone, and Quaternary marine terrace deposits) and sedimentary formations (Quaternary non-marine terrace deposits and doline deposits). A **potentially significant** impact on paleontological resources could result if an inadvertent discovery is made during ground-disturbing activities associated with development and redevelopment projects under the 2021 LRDP.

Development under the 2021 LRDP could result in the disturbance of paleontologically sensitive formations, which could result in the potential disturbance of paleontological resources. Paleontological potential refers to the likelihood that a rock unit will yield a unique or significant paleontological resource. All sedimentary rocks, some volcanic rocks, and some low-grade metamorphic rocks have potential to yield significant paleontological resources. Depending on location, the paleontological potential of subsurface materials generally increases with depth beneath the surface, as well as with proximity to known fossiliferous deposits.

As discussed in Section 3.7.2, above, marine formations in Santa Cruz County have yielded significant invertebrate and vertebrate fossils, including several taxa of marine mammals. Potential fossil-bearing formations in the LRDP area include marine formations (Santa Margarita sandstones, Santa Cruz mudstone, and Quaternary marine terrace deposits) and sedimentary formations (Quaternary non-marine terrace deposits and doline deposits).

Santa Margarita sandstones in the Santa Cruz region have yielded significant marine vertebrate fossils. Although no finds have been made in the Santa Margarita sandstones on the UC Santa Cruz campus, this may be because there has been no development in the Santa Margarita formation. The Santa Margarita sandstone formations in the LRDP area are considered to have high potential to include significant fossils.

No fossil finds have been documented in doline fill deposits and Quaternary marine terrace sediments in the region, nor have any fossil finds been made on campus, despite extensive development in areas underlain by Quaternary marine and non-marine terrace deposits. Therefore, while these deposits may have some potential to yield fossils, the potential to encounter fossils in these formations in the LRDP area is low.

Dolines, or sinkholes, are a characteristic of karst topography, which developed in the main residential campus area during the Pleistocene and Holocene as the result of dissolution of marble. Dolines occur in numerous locations on the central and lower portions of the main residential campus and there has been extensive development in these areas. This suggests that this setting is not paleontologically sensitive on campus, or that fossils in this setting are rare. Therefore, the potential to encounter fossils in dolines in the LRDP area is low.

The Westside Research Park site is underlain by relatively recent emergent coastal terrace deposits, which generally are not paleontologically sensitive because of their recent age. However, these deposits are underlain by Santa Cruz mudstone, a Plio-Pleistocene marine deposit formation that has yielded marine vertebrate fossils, including sea mammals, fish, and birds, in the Santa Cruz region (UCMP 2010). This formation, which could be exposed by excavation at this site, is considered to have high paleontological potential.

Although discovery is relatively unlikely, paleontological resources have been documented within geologic formations in the Santa Cruz Region and the LRDP area includes potential fossil-bearing formations. For this reason, a significant impact on paleontological resources could result if an inadvertent discovery is made during ground-disturbing activities associated with development and redevelopment projects under the 2021 LRDP. Therefore, the impact on paleontological resources would be **potentially significant**.

Mitigation Measures

Mitigation Measure 3.7-6: Treatment of Paleontological Resources

For development within the potential fossil-bearing formations in the LRDP area, namely marine formations of Santa Margarita sandstones, Santa Cruz mudstone, and Quaternary marine terrace deposits, and sedimentary formations of Quaternary non-marine terrace deposits and doline deposits, UC Santa Cruz shall require, as part of contract specifications, that the contractor provide a paleontological resources awareness training program to all construction personnel active on the project site during earth moving activities. The first training will be provided prior to the initiation of ground disturbing activities. The training will be developed and conducted in coordination with a qualified paleontologist. The program will include relevant information regarding fossils and fossil-bearing formations that may be encountered. The training will also describe appropriate avoidance and minimization measures for resources that have the potential to be located on the project site.

If any paleontological resources are encountered during ground-disturbing activities, the contractor shall ensure that activities in the immediate area of the find are halted and that UC Santa Cruz is informed. UC Santa Cruz shall retain a qualified paleontologist to evaluate the discovery and recommend appropriate treatment options pursuant to guidelines developed by the Society of Vertebrate Paleontology, including development and implementation of a paleontological resource impact mitigation program by a qualified paleontologist for treatment of the particular resource, if applicable. These measures may include, but not be limited to the following:

- salvage of unearthed fossil remains and/or traces (e.g., tracks, trails, burrows);
- screen washing to recover small specimens;
- preparation of salvaged fossils to a point of being ready for curation (e.g., removal of enclosing matrix, stabilization and repair of specimens, and construction of reinforced support cradles); and
- identification, cataloging, curation, and provision for repository storage of prepared fossil specimens.

<u>Significance after Mitigation</u>

Mitigation Measure 3.7-6 requires a paleontological awareness training for construction personnel on projects within potential fossil-bearing formations. If paleontological resources are discovered during ground-disturbing activities, Mitigation Measure 3.7-6 requires that a qualified paleontologist evaluate the discovery and notify UC Santa Cruz, and that appropriate treatments are implemented to document and protect the resources. Implementation of these measures would reduce the potential impacts to unique paleontological resources to a **less-than-significant** level.