I. GEOLOGIC AND SEISMIC HAZARDS

P P P

This section discusses geologic and seismic hazards in the City of Berkeley. Knowledge of seismic hazards in the City of Berkeley has greatly increased since the adoption of the last Seismic Safety Element in 1977. The discussion in this section covers five types of geologic and seismic hazards, including: 1) active faulting and seismicity; 2) liquefaction potential; 3) ground failure and landslides; 4) tsunamis; and 5) risks related to unreinforced masonry buildings. The existing setting for seismic hazards has been concentrated to directly relate to the impacts discussed in Section 2 of this chapter, based on criteria of significance outlined in Section 2a, below.

1. Setting

a. Active Faulting and Seismicity. The Alquist-Priolo Earthquake Fault Zone Act of 1972 was established by the California Legislature to mitigate the potential hazards of surface rupture associated with seismic activity. The Act requires the California Division of Mines and Geology (CDMG) to evaluate and delineate active faults throughout the state. A fault or fault zone is considered active under the provisions of the Act if there is evidence of surface displacement within the last 11,000 years (Holocene time). If movement during historic or Holocene time cannot be demonstrated, but movement may have occurred during Quaternary time (the last 1.8 million years), the fault is classified as potentially active. Faults are not necessary inactive if movement during Quaternary time cannot be demonstrated. The geologic evidence necessary to prove inactivity is difficult to obtain and, in a given locality, may not exist.

Geologic reports of potential surface rupture hazards are required for development projects that include structures for human occupancy in Alquist-Priolo Earthquake Fault Zones. There is one Alquist-Priolo Earthquake Fault Zone within the City of Berkeley for the Hayward Fault, as shown in Figure IV.I-1. The Hayward Fault trace passes through the UC Berkeley campus and northeast to Tunnel Road. Because it is an active fault that runs directly beneath the City, the Hayward Fault represents a serious seismic hazard to people and property in the City.

Figure IV.I-1 Seismic Hazard Areas

Other significant regional faults that could generate seismic activity that could affect the City of Berkeley include (but are not limited to) the San Andreas Fault, located approximately 15 miles west of the City; the Calaveras Fault, located approximately 18 miles to the southeast, and the Rogers Creek Fault, located approximately 20 miles to the northwest. These faults and all other active faults in the Bay Area are shown in Figure IV.I-2. Earthquakes on active faults throughout the Bay Area could generate significant seismic hazards within the City of Berkeley, as evidenced in the 1989 Loma Prieta earthquake, which was centered over 50 miles from Berkeley.

The measure of an earthquake=s magnitude (M) is reported in moment magnitude (M_w), which is a measurement of the energy released by the earthquake. Moment magnitude is calculated based on the length and width of the fault plane that experienced movement. Moment magnitude has replaced the generally familiar Richter (or "local") magnitude (M_L) due, in part, to the difficulty in differentiating the size of large (larger than M_L 7-1/2) magnitude earthquakes.[1]

CDMG has developed parameters to estimate future activity for major faults in California based on length, width, and slip rate. The slip rate of a fault is estimated based on historic earthquake records and geologic evidence. Using these parameters, maximum moment magnitudes (M_{max}), or the estimated maximum magnitude earthquake for that fault segment, have been developed for each segment of major faults.[2,3] Although earthquakes cannot be predicted, return (or recurrence) intervals are calculated using the slip rate in relation to the displacement occurring during the M_{max} earthquake.[4] Major

[1] Perkins, J. and J. Boatwright, Association of Bay Area Governments, 1995. *The San Francisco Bay Area - On Shaky Ground*.

[2] California Department of Conservation, Division of Mines and Geology, 1996. California Fault Parameters, San Andreas Fault Zone.

[3] Ibid.

[4] Peterson, M., California Department of Conservation, Division of Mines and Geology, 1996. *Personal communication* with Baseline Environmental Consulting, 22 November.

faults proximate to the study area, their M_{max}, return interval, and distance from the City are presented in Table IV.I-1. Based on these parameters, the Working Group on California Earthquake Probabilities[5] has estimated that there is a 70 percent probability that one or more large earthquakes

[5] U.S. Geological Survey, 1990. Working Group on California Earthquake Probabilities, Probabilities of Large Earthquakes in the San Francisco Bay Region, California, U.S. Geological Survey Circular 1053.

Figure IV.I-2 Bay Area Fault Map 8x11

Table IV.I-1
MAJOR SAN FRANCISCO BAY AREA EARTHQUAKE FAULTS AND THEIR MAXIMUM MOMENT MAGNITUDE

Fault Name	Length (km)	Length (mi)	Slip Rate[a] (mm/year)	M_{max} [b]	Return Interval[c] (years)	Nearest Distance (from City of Berkeley) (mi)	Probability of Large Earthquake between 1990-2020
San Andreas-Peninsula Segment	88	55	17"3	7.1	400	8	0.23
San Andreas-North Coast Segment	322	200	24"3	7.6	B[d]	17	0.02
San Andreas-Santa Cruz Segment	37	23	14"3	7.0	400	48	<0.01
Northern Hayward	43	27	9"1	6.9	167	9	0.28
Southern Hayward	43	27	9"1	6.5	167	15	0.23
Entire Hayward	86	53	9"1	7.1	167	9	N/A[e]
Northern Calaveras	52	32	6"2	6.8	146	25	N/A[e]
Rogers Creek	63	39	9"2	7.0	222	25	0.22

[a] Slip rate based on historic earthquake records and geologic evidence.

[b] M_{max} = Maximum moment magnitude.

[c] Return interval calculated using slip rate in relation to the displacement occurring during the M_{max} earthquake.

[d] **C** = Not calculated by CDMG.

[e] N/A = Not available.

Sources: California Department of Conservation, Division of Mines and Geology, 1996, *California Fault Parameters, San Francisco Bay Area Faults*.
Wells, D.L. and Coppersmith, K.J., 1994, New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement. *Seismological Society of America Bulletin*, v. 84, no. 4, pp. 974-1002.
US Geological Survey, 1990, Probability of Large Earthquakes in the San Francisco Bay Region, California, USGS Circular 1053.

(M_L 6.7 or greater)[6] will occur in the San Andreas, Hayward, or Calaveras faults during the 30-year period of 1990 to 2020. However, this estimate does not include all known active seismic sources, including the Sea Cove-San Gregorio and Greenville Faults, and should be considered a minimum probability.

The faults with the greatest slip rates include the San Andreas Fault, Hayward Fault, Calaveras Fault, and San Gregorio Fault. Each of these faults has displayed evidence of historic earthquake activity and has potential to generate large-magnitude earthquakes. The 1989 Loma Prieta earthquake had a M_w of 6.9; while the 1906 San Francisco earthquake is estimated to have had an approximate M_w of 8.[7]

The occurrence of an earthquake produces seismic waves that emanate in all directions from the origin of the earthquake, or epicenter. The seismic waves cause ground shaking, which is typically strongest at the epicenter and diminishes (attenuates) as the waves move through the earth away from the source of the quake. The severity of ground shaking at any particular point is referred to as "intensity" and is a subjective measure of the effects of ground shaking on people, structures, and earth materials.[8] A critical factor affecting intensity at a site is the geologic material underneath that site. Deep, loose soils tend to amplify and prolong the shaking; soft clay and silty clay amplify the most. Igneous rock amplifies ground shaking the least.[9] The distribution of near-surface geologic materials in the City of Berkeley is shown on Figure IV.I-3, and the accompanying Table IV-I-2 summarizes the characteristics of these geologic materials. Where the underlying geologic material consists of unconsolidated sediments, artificial fills, and Bay Mud, ground shaking during an earthquake can be amplified, resulting in

[6] This publication on earthquake probabilities was completed in 1990, when M_L was still utilized to measure earthquake magnitude.

[7] Sydnor, R., California Department of Conservation, Division of Mines and Geology, November 21, 1996. *Personal communication* with Baseline Environmental Consulting.

[8] Perkins, J. and J. Boatwright, Association of Bay Area Governments, April 1995. *The San Francisco Bay Area - On Shaky Ground*.

[9] Ibid.

greater damage to structures,[10] although the effects of ground shaking on structures depends on building design, quality of construction, and foundation materials.

The Association of Bay Area Governments (ABAG) has developed maps intended to be used as a planning tool showing expected ground shaking intensities throughout the City for various earthquake scenarios. The City includes areas classified by

[10] Ibid.

Figure IV.1-3 Centralized Geologic Map 11 x 17 back of figure IV.1-3

Table IV.I-2
SUMMARY OF GEOLOGIC MATERIALS IN THE CITY OF BERKELEY[a]

Generalized Stratigraphic Section (i.e., geologic layers)	Geologic Age (Absolute Age)[b]	General Description
Bay mud (Qhbm)	Quaternary Holocene (less than 11,000 years old)	Water saturated estuarine mud; predominantly clay and silty clay with lenses of sand. Ranges from soft at top to increasingly consolidated with depth; plastic and highly expansive.
Alluvium (Qham, Qhaf, Qpa)	Holocene & Late Pleistocene (less than 70,000 years old)	Weakly to moderately consolidated, moderately sorted sand forming alluvial plains and stream levees. Locally contains well sorted clay, silt and gravel.
Colluvium (not shown on map)	Holocene & Late Pleistocene (less than 70,000 years old)	Composition varies from place to place. Colluvium on hillsides generally finer grained and darker in color than alluvium.
Leona (Northbrae) Rhyolite (Tr)	Tertiary (1.8 to 5 million years old)	Fresh rock is dense and presents good foundation conditions. Weathering can be as much as 30 feet deep. Weathered rock consists of loose fragments embedded in a clay matrix.
Contra Costa Group (Tps, Tbu)	Tertiary (1.8 to 5 million years old)	Consists of non-marine sedimentary rocks with associated basalt and andesite flows. Basalts and andesite generally stable; slope stability is poor in sedimentary rocks.
Great Valley Sequence (Ku)	Cretaceous (65 to 144 million years old)	Massive beds of sandstone alternating with siltstone and shale, minor conglomerate, limestone and lignite. Complexly folded and faulted. Slope stability conditions variable, but generally good.
Franciscan Assemblage (fs, fc, fm, sr)	Cretaceous-Jurassic (65 to 208 million years old)	Sandstones, shale, siltstones, chert, greenstone, and schist. Partially recrystallized and intruded by serpentine. Slope stability characteristics highly variable. Subject to sliding where highly sheared.
Serpentine (sp)	Cretaceous-Jurassic (65 to 208 million years old)	Generally soft and intensely sheared. The stability of sheared serpentine is poor.

[a] See Figure IV.I-3 for locations of geologic units.

[b] Modified after (1) Radbruch, D.H., 1969, *Aerial and Engineering Geology of the Oakland East Quadrangle*, USGS map GQ-769; and (2) Helley, E.J., K.R. Lajoie, W.E. Spangle, and M.L. Blair, 1979, *Flatland Deposits of the San Francisco Bay Region, California***B***Their Geology and Engineering Properties, and Their Importance to Comprehensive Planning*: U.S. Geological Survey Professional Paper 943.

Source: Radbruch, 1969 and Helley, 1979.

ABAG as having the potential for very strong to very violent shaking.[11] The areas of highest risk include the area along the trace of the Hayward Fault in the Berkeley Hills and the waterfront area, which is underlain by Bay Mud. The areas of lower amplification are those underlain by bedrock at the greatest distance from the fault. Expected ground shaking intensities resulting from magnitude (M_w) 7.3 earthquake on the Hayward Fault is presented in Figure IV.I-1. [12] A description of the Modified Mercalli ground shaking intensity descriptive system is presented in Table IV.I-3.

b0 Liquefaction. A secondary effect of amplified ground shaking in unconsolidated sediments, such as silts and sands, is liquefaction, which describes saturated, cohesionless soils becoming fluid-like during ground shaking. The loss of pore pressure in the material causes it to lose its shear strength, resulting in the soil losing its load-bearing capacity and spreading laterally or vertically. Liquefaction can result in a drop in the ground surface or cause buckling, rippling, and cracking of the ground surface, which can result in roads, rail lines, or buildings being displaced or severed. Areas of potential liquefaction within the study area are presented in Figure IV.I-1.

c0 Ground Failure and Landslides. The manifestations of ground failure are complex and highly variable; they include numerous varieties of landslides, sloughing, liquefaction, ground cracking, lurching, lateral spreading, subsidence and differential settlement. Ground failure occurrence and type depends on topographic, geological, and hydrologic characteristics of the ground, as well as potential triggering mechanisms (e.g., seismic ground shaking and saturation of the subsurface by intense storms). Landslides are the most prevalent form of ground failure in the City of Berkeley.

Landslides can occur during earthquakes, triggered by the strain induced in soil and rock by the ground shaking vibrations. During non-earthquake (static) conditions, slope failures occur most frequently during the rainy season when high groundwater conditions persist. Landslides are perhaps the most common form of ground failure that is not caused by earthquakes. Landslides occur most frequently in "wet years," but they can occur at any time. Landslides may also occur on slopes of 15 percent or less; however, the probability of a landslide is greater on steeper slopes with old landslide deposits.

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[11] Association of Bay Area Governments, 1998. Website <http://quake.cbag.ca.gov>

[12] Ibid.

Table IV.I-3
MODIFIED MERCALLI SCALE[a]

M[b]	Intensity	Effects
5	VI	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked.[c] Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle - CFR).
6	VII	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments - CFR). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
	VIII	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
7	IX	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations - CFR.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake foundations, sand craters.
8	X	Most masonry and frame structures destroyed with their foundations. some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
	XI	Rails bent greatly. Underground pipelines completely out of service.
	XII	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

[a] From Richter (1958).
[b] Richter magnitude correlation
[c] *Masonry A, B, C, D.* To avoid ambiguity of language, the quality of masonry, brick or otherwise, is specified by the following lettering (which has no connection with the conventional Class A, B, C construction).

- *Masonry A:* A Good workmanship, mortar, and design, reinforced, especially laterally, and bound together by using steel, concrete, etc; designed to resist lateral forces.
- *Masonry B:* Good workmanship and mortar, reinforced, but not designed to resist lateral forces.

$ *Masonry C:* Ordinary workmanship and mortar; no extreme weaknesses such as non-tied-in corners, but masonry is neither reinforced nor designed against horizontal forces.

$ *Masonry D:* Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Source: Richter, 1958.

These areas on steeper slopes and with old landslide deposits are also more sensitive to human-induced changes, such as grading, watering, removing and changing the type of vegetation, and changing drainage patterns.

On a City-wide basis, the two most important factors influencing the performance of slopes are the nature of the bedrock or surficial deposits and the slope angle. However, the presence or absence of several factors can exert a controlling effect on the stability of a particular hillside: deep-rooted vegetation; surface and subsurface drainage conditions; thickness and engineering characteristics of soils and underlying weathered, partially decomposed rock; orientation of bedding; or locally high rainfall.

Older, poorly constructed buildings in existing slide areas that were developed without an understanding of geologic conditions are most vulnerable to damage. Ground failure, including landslides, can be triggered by human-induced changes, such as building a structure (i.e., creating additional loads) on a slope or on unstable soils. Because of the location of Berkeley relative to the Hayward Fault, the City=s topography, and construction characteristics and location of the City=s buildings, properties in Berkeley are especially vulnerable to landslide damage. Figure IV.I-4 shows landslide hazard areas of the City, based on surface geologic observations, and interpretation of available subsurface data and photos.[13]

d0 <u>Tsunamis</u>. A tsunami is a sea wave produced by an offshore earthquake, volcanic eruption, or landslide.[14] Tsunamis can be very destructive when they reach coastlines and are capable of rising to 100 feet in height and moving at 30 miles per hour as they near the coast. Wave energy entering the mouth of the San Francisco Bay at the Golden Gate would be expected to attenuate as it moves into the open water of the Bay.[15] However, because the City of Berkeley is positioned directly across the open Bay from the mouth of the Golden Gate, wave run-up heights at the Berkeley waterfront would be expected to be among the highest of Bayfront locations along the Bay. The San Francisco Bay coastline is partially protected from inundation and damage associated with tsunamis because of the restricted hydraulic access at the Golden Gate. Wave run-

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[13] This map is intended to be used for General Plan purposes, not for site-specific safety determinations.

[14] Steinbrugge, K.V., 1982. *Earthquakes, Volcanoes and Tsunamis: An Anatomy of Hazards.*

[15] Ritter, J. and W. Dupre, 1972. *Maps Showing Areas of Potential Inundation of Tsunamis in the San Francisco Bay Region, California.* USGS, Misc. Field Studies MF480.

up heights for the 100-year tsunami event are predicted to range between 6.3 and 7.2 feet above the National Geodetic Vertical

Figure IV.I-4 Landslide Hazard Areas 8 x 11

Datum (NGVD) for the Berkeley coast.[16] Therefore, coastal areas below 7.2 feet NGVD could be subject to inundation during the 100-year or greater tsunami.

e0 Unreinforced Masonry Buildings. Historic data indicate that the greatest hazard to residents and employees posed by earthquake shaking is the collapse of poorly constructed, older buildings, especially unreinforced masonry (URM). The City has an inventory of URM buildings, as well as an ordinance that requires abatement of the hazard that they pose.

f0 Draft General Plan Policies. Policies included in the *Draft General Plan* that pertain to, could affect, or could be affected by geologic and seismic hazards include:

$ *Policy LU-7.* Preserve and protect the quality of life in Berkeley=s residential areas through careful land use decisions.

Action:

C. Carefully review and regulate proposals for additional residential development in the Fire Hazard Area and also the Seismic and Landslide Hazard Areas.

$ *Policy H-14: Seismic Reinforcement.* Maintain housing supply and reduce the loss of life and property caused by earthquakes by requiring structural strengthening and hazard mitigation in Berkeley housing.

$ *Policy H-15: Transit Oriented New Construction.* Encourage construction of new medium and high density housing on major transit corridors and in the Downtown consistent with the scale, character, and zoning of these areas.

$ *Policy H-18: High Density Zoning.* Maintain sufficient land zoned for high and medium density residential development to allow sufficient new construction to meet Berkeley's fair share of regional housing needs.

$ *Policy H-31: University of California.* Urge the University of California to provide housing for at least 25% of its students at affordable prices and expand housing opportunities for students and staff.

$ *Policy PD-9: Disaster Resistance and Post Disaster Preparation.* Encourage, and where appropriate require, owners of historically or architecturally valuable buildings to incorporate disaster-resistance measures to enable them to be feasibly repaired after a major earthquake or other disaster.

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[16] Garcia, A.W. and Houston, J.R., 1975. *Type 16 Flood Insurance Study: Tsunami Predictions for Monterey and San Francisco Bays and Puget Sound.* U.S. Army Corps of Engineers, Technical Report No. 11-75-17.

$ *Policy PD-16: Other New Incentives.* Consider potential new funding, tax-reduction, and technical-assistance incentives which the City and/or other entities could provide to facilitate preservation.

Action:

A. Consider providing new or expanded sources of financial assistance for unreinforced-masonry and other structures, including historically or culturally significant ones that need seismic retrofit.

$ *Policy S-1: Response Planning.* Ensure that the City=s emergency response plans are current and incorporate the latest information on hazards, vulnerability and resources.

$ *Policy S-2: Neighborhood Preparation and Education.* Continue to provide education, emergency preparedness training and supplies to the community at the neighborhood level to support neighborhood and community-based disaster response planning.

$ *Policy S-3: Public Information.* Publicize disaster preparedness efforts (such as CERT) and expand public awareness of specific hazards and risks by making available all relevant information including mapping and reports on various hazards, information on vulnerability and risk reduction techniques, evacuation routes, emergency services, and information on financial and technical assistance resources.

$ *Policy S-4: Special Needs Communities.* Continue to work with the social service community to ensure the safety of special needs populations.

$ *Policy S-5: The City=s Role in Leadership and Coordination.* Ensure that the City provides leadership and coordination of the private sector, public institutions and other public bodies in emergency preparedness.

$ *Policy S-6: Damage Assessment.* Establish and maintain a rapid damage assessment capability.

$ *Policy S-7: Emergency Water Supply.* Protect life and property in the event of an earthquake by evaluating alternate drinking water and fire-fighting water supply in the event of failure of the East Bay Municipal Utility District (EBMUD) water supply.

$ *Policy S-8: Continuity of Operations.* Provide for the continuation of City government and services following a major disaster.

$ *Policy S-9: Pre-Event Planning.* Establish pre-event planning for post-disaster recovery as an integral element of the emergency preparedness programs of the City Council and each of the City departments.

$ *Policy S-10: Sustaining Mitigation Initiatives.* Improve public awareness and establish new public/private partnerships to implement mitigation initiatives in the community and region through programs such as Project Impact.

$ *Policy S-11: Historic Structures.* Encourage and support the long-term protection of historic or architecturally significant structures to preserve neighborhood and community character.

$ *Policy S-12: Utility and Transportation Systems.* Improve the disaster-resistance of utility and transportation systems to increase public safety and to minimize damage and service disruption following a disaster.

$ *Policy S-13: Hazards Identification.* Identify, avoid and minimize natural and human-caused hazards in the development of property and the regulation of land use.

$ *Policy S-14: Land Use Regulation.* Require appropriate mitigation in new development, redevelopment/re-use or in other applications.

$ *Policy S-15: Construction Standards.* Maintain construction standards that minimize risks to human lives and property from environmental and human-caused hazards for both new and existing buildings.

$ *Policy S-17: Residential Seismic Retrofitting Incentive Program.* Maintain existing programs such as the Residential Seismic Retrofitting Incentive Program to facilitate retrofit of potentially hazardous structures.

$ *Policy S-18: Public Information.* Establish public information programs to inform the public about seismic hazards and the potential hazards from vulnerable buildings.

$ *Policy S-19: Risk Analysis.* Understand and track changes in seismic risk utilizing the best available information and tools.

$ *Policy S-20: Mitigation of Potentially Hazardous Buildings.* Pursue all feasible methods, programs and financing to mitigate potentially hazardous buildings.

2 Impacts and Mitigation Measures

a0 Criteria of Significance. A potentially significant environmental impact related to geologic and seismic hazards would result if implementation of any of the policies within the *Draft General Plan* would:

$ Expose significant numbers of people or structures to 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;

- $ Expose people or structures to major geologic hazards that could result in loss, injury or death related to strong seismic ground shaking, expansive soils, ground failure or seismic-related ground failure, including liquefaction, mudslides, or landslides;
- $ Result in substantial soil erosion or the loss of topsoil; or
- $ Alter landforms that would substantially change the topography or ground surface relief features.

For the purpose of this EIR, significant geologic hazards would pertain to soil and/or seismic conditions so unfavorable that they could not be overcome by reasonable design, construction, and maintenance practices.

b0 Impacts and Mitigation Measures. This section outlines potential geologic and seismic hazards impacts and suggests mitigation to address these impacts. Less-than-significant geologic and seismic impacts are discussed first, followed by significant impacts.

(1) Less-than-Significant Geologic and Seismic Impacts. Less-than-significant geologic and seismic hazards impacts are discussed below.

Implementation of *Policy H-14* relates to geologic and seismic hazards, but would not be expected to result in environmental impacts. Because there is no agricultural land in the City of Berkeley, development under the *Draft General Plan* would not result in substantial soil erosion or loss of topsoil. Because of the flat topography of all the developed areas of the City where redevelopment or intensification of uses under the *Draft General Plan* may occur (generally the Downtown and neighborhood commercial areas), no substantial alteration of topography would occur.

Improving the disaster-resistance of utility and transportation systems by repair and/or relocation projects would represent major undertakings and could potentially include numerous environmental impacts related to geologic conditions and seismicity. Such large-scale projects would be subject to project-specific CEQA review. Therefore, potential impacts associated with *Policy S-12* would be analyzed, and mitigated as feasible, under existing programs. This would be considered a less-than-significant impact.

(2) Potentially Significant Geologic and Seismic Impacts and Mitigation Measures. One potentially significant impact related to geologic and seismic hazards would result from implementation of the *Draft General Plan*.

Impact GEO-1: Construction of new medium- and high-density housing (*Policies H-1*5 and *H-18*) and additional student housing at UC Berkeley (*Policy H-31*) would result in an increase in the number of people potentially exposed to severe seismic ground shaking hazards. (PS)

Because the City of Berkeley is located in a seismically active area, all structures in the City could potentially be affected by ground shaking in the event of an earthquake. As noted in the setting section, very strong to very violent ground shaking is expected to occur in Berkeley during a major earthquake on the Hayward, Calaveras, or San Andreas faults. This level of seismic shaking could cause extensive non-structural (e.g., plaster, furnishings, lighting, etc.) and limited structural damage in buildings throughout the City. An increase in housing and commercial development would allow more people into the area, which could result in an increased number of injuries and fatalities during a major earthquake.

> Mitigation Measure GEO-1: The City shall prioritize and make implementation of the programs identified in *Policies LU-7, H-14, PD-9, PD-16* and *S-1* through *S-20* part of the Action Agenda to respond to the need to protect residents and development from seismic hazards. (LTS)