4.8 Geology and Soils

This section discusses the geologic, soil, and mineral resources conditions of the Planning Area and identifies the related potential environmental impacts and development constraints if the proposed General Plan Update were implemented. This analysis is based on a review of statutory law, local planning documents, and publications by the California Department of Conservation, California Geological Survey (formerly the Division of Mines and Geology), and the Division of Oil, Gas, and Geothermal Resources.

4.8.1 EXISTING SETTING

TOPOGRAPHY AND LOCAL GEOLOGY

Existing Setting

The City of Madera and the greater proposed General Plan Update Planning Area are located in the Great Valley Geomorphic Province of California, more commonly referred to as the San Joaquin Valley. The San Joaquin Valley is made up largely of alluvial fans sourced from the Sierra Nevada Range to the east, the Coastal Range to the west, and to some degree the Tehachapi Mountains to the south. Weathering of these mountain ranges combined with surface water flows and flooding have resulted in accumulation of alluvial (river), lacustrine (lake), and marine (ocean) deposits throughout the San Joaquin Valley at extreme depths of many thousands of feet (Madera County, 1995). Alluvium depths in the vicinity of the City of Madera average 500 feet, with depths generally increasing from east to west.

The Planning Area is generally flat with some areas of undulating slopes. The Planning Area contains the Fresno River and several smaller drainages, such as Schmidt and Cottonwood creeks, that have higher slopes in some locations along their length. Much of the topography along these banks has been heavily modified as a result of flood control and other efforts.

The Planning Area slopes generally downhill from northeast to southwest, with the highest elevations (about 315 feet above mean sea level (msl)) located in the vicinity of Madera Lake and the lowest elevations (about 210 feet above msl) located west of the wastewater treatment plant.

GEOTECHNICAL CONDITIONS

Structural Support

According to the U.S. Geologic Survey (USGS) and the U.S. Department of Agriculture, Natural Resources Conservation Service, the Planning Area contains 23 different soils, in addition to "gravel pits," "riverwash," and "towns," which are not classified beyond their descriptive names. The types of soils located in the Planning Area, the approximate acres of each type, and their general drainage and permeability characteristics are listed in **Table 4.8-1** below.

TABLE 4.8-1
SOIL TYPES AND ASSOCIATED ACREAGE – CITY OF MADERA GENERAL PLAN PLANNING AREA

Soil Class	Area (Acres)[1]	% of Total Area[2]	Slopes (Percent)	Drainage	Permeability	Shrink/Swell Potential
Alamo	806.2	1.2	0 to 1	Poor	Very Slow	High
Atwater	2,195.1	3.3	0 to 8	Good	Rapid	Low

Soil Class	Area (Acres)[1]	% of Total Area[2]	Slopes (Percent)	Drainage	Permeability	Shrink/Swell Potential
Borden	705.4	1.0	0 to 1	Moderate	Moderately Slow	Moderate
Cajon	0.2	Less than 0.1	0 to 1	Excessive	Rapid	Low
Chino	150.0	0.2	0 to 1	Poor	Moderately Slow	Moderate
Cometa	11,343.6	16.8	0 to 15	Moderate	Very Slow	High
Delhi	505.7	0.8	0 to 8	Excessive	Rapid	Low
Fresno	21.9	Less than 0.1	0 to 1	Moderate	Very Slow	Low
Grangeville	5,262.3	7.8	0 to 1	Poor	Moderately Rapid	Low
Greenfield	3,437.3	5.1	0 to 8	Good	Moderately Rapid	Low
Hanford	9,009.0	13.4	0 to 3	Good	Moderately Rapid	Low
Lewis	338.7	0.5	0 to 1	Good	Slow	High
Madera	1,963.1	2.9	0 to 3	Moderate to Good	Very Slow	High
Montpellier	88.6	0.1	3 to 15	Moderate to Good	Moderately Slow	Moderate
Pachappa	7,175.6	10.6	0 to 1	Good	Moderate	Moderate
Ramona	56.4	0.1	0 to 3	Good	Moderately Slow	Low
San Joaquin	11,978.2	17.8	0 to 8	Moderate to Good	Very Slow	High
Traver	2,680.8	4.0	0 to 1	Moderate to Poor	Moderate to Slow	Low
Trigo	119.5	0.2	0 to 15	Good	Moderately Rapid	Low
Tujunga	5,083.1	7.5	0 to 8	Excessive	Rapid	Low
Visalia	1,341.5	2.0	0 to 3	Good	Rapid	Low
Whitney	956.3	1.4	3 to 15	Good	Moderate to Moderately Rapid	Low to Moderate
Wunjey	5.5	Less than 0.1	0 to 1	Moderate to Good	Moderate to Moderately Rapid	Low

Source: U.S. Department of Agriculture, 2008a; U.S. Department of Agriculture, 2008b

Notes: [1]The sum of the acres listed does not equal the total of 67,408.8 acres due to the exclusion of non-soil and non-surveyed areas such as water, gravel pits, and towns. These are not strictly soil classes and are thus not included in this list. However, these acreages are included in the total acres.

[2]Percent of total area includes area assigned to water, gravel pits, and towns. As such, the sum of the percentages does not total 100.

GEOLOGIC HAZARDS FAULTS AND SEISMICITY

Faults

Earthquakes are generally expressed in terms of intensity and magnitude. Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. An earthquake's intensity varies from region to region, depending on the location of the observer with respect to the earthquake epicenter. **Table 4.8-2** provides a description and a comparison of intensity and magnitude.

TABLE 4.8-2
MAGNITUDE AND INTENSITY COMPARISON

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 to 3.0	I
3.0 to 3.9	II - III
4.0 to 4.9	IV – V
5.0 to 5.9	VI – VII
6.0 to 6.9	VII to IX
7.0 or higher	VIII or higher

Source: USGS, 2009

An earthquake's magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. Magnitude is based on the amplitude of the earthquake waves recorded on instruments which have a common calibration. The magnitude or strength of earth movement associated with seismic activity is typically quantified using the Richter scale. This scale is a measure of the strength of an earthquake or strain energy released by it, as determined by seismographic observations. This is a logarithmic value originally defined by Charles Richter (1935). An increase of one unit of magnitude (for example, from 4.6 to 5.6) represents a 10-fold increase in wave amplitude on a seismogram, or approximately a 30-fold increase in the energy released. In other words, a magnitude 6.7 earthquake releases over 900 times (30 times 30) the energy of a 4.7 earthquake.

The Modified Mercalli (MM) Intensity Scale is used in the United States to evaluate earthquake movements. The MM scale is composed of 12 increasing levels of intensity designated by Roman numerals. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and, finally, total destruction. The levels range from imperceptible shaking to catastrophic destruction. The MM scale does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects. The lower numbers of the intensity scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage. **Table 4.8-3** describes the typical effects observed at locations near the epicenter of earthquakes of different magnitudes.

TABLE 4.8-3
TYPICAL EFFECTS OF EARTHQUAKE ACTIVITY

Typical Maximum Modified Mercalli Intensity	Typical Effects of Earthquake Activity
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations are similar to the passing of a truck.

Typical Maximum Modified Mercalli Intensity	Typical Effects of Earthquake Activity
IV	Felt indoors by many, outdoors by few during the day. At night, some are awakened. Dishes, windows, and doors disturbed; walls make cracking sound. Sensation of a heavy truck striking building was felt. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage light.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures. Some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into air.

Source: USGS, 2009

Five major active and potentially active faults are close to the Planning Area: the San Andreas, San Joaquin, Ortigalita, Owens Valley, and Melones faults. Of these, the San Andreas and the Owens Valley faults are expected to be the sources of future major earthquakes. No active earthquake faults are located in the Planning Area—the closest active faults are 50 or more miles distant.

Ground Shaking

Ground shaking is the motion that occurs as energy is released during fault-related activity and is considered the most damaging of all seismic activities. The State of California Department of Conservation, California Geological Survey (CGS) calculates earthquake shaking hazards by projecting earthquake rates based on earthquake history and fault slip rates. As of 2007, CGS has used new fault parameters developed for probability calculations, further refining the national system of seismic zones. As part of a cooperative project between USGS and CGS, probabilistic seismic hazard maps and fault parameter maps have been developed for the entire state that provide an estimate of future earthquakes.

Probabilistic Seismic Hazards

The probabilistic seismic hazard models consider earthquakes on faults and in background sources (random earthquakes). The activity rates for any given fault includes consideration for the slip rate, or how quickly one side of the fault slides against the other, as well as the length and/or area of the fault rupture (if one occurs). The model itself contains data for all recorded earthquakes of magnitude 4.0 and greater. However, smaller earthquakes can have a measurable effect on future probability as they release less stored energy than larger quakes. To account for the effect of these smaller earthquakes, the probabilistic models incorporate background "random" earthquake factors that, in part, account for the effect of earthquakes smaller than magnitude 4.0.

According to the California Department of Conservation, Madera is in an area in which there is a 10 percent chance in the next 50 years for an earthquake that would result in "strong" ground shaking (as felt by people) and "light" damage to structures. (By comparison, portions of Los Angeles, an area of much higher seismic risk, are expected to experience "violent" ground shaking and "heavy" damage sometime within the next 50 years.) This shaking increases greatly in the northeastern portion of Madera County that lies within the Sierra Nevada range – which at its maximum could exceed 30 to 40 percent the acceleration of gravity. By comparison, portions of the Los Angeles basin, an area of much higher seismic risk, are expected to exceed 80 percent the acceleration of gravity within 50 years.

The Ground Motion Map further refines expected ground motion into three factors: peak ground acceleration (Pga), spectral acceleration at short periods (Sa 0.2 sec), and spectral acceleration at long periods (Sa 1.0 sec). Peak ground acceleration indicates the highest expected acceleration of a single point located on the ground. However, this is not truly indicative of shaking experienced by a building. For this purpose, spectral acceleration is calculated to simulate a particle mass on a massless vertical rod, thereby allowing for the exaggerated motion and associated acceleration effects of a vertical building. The expected Pga, Sa 0.2 sec, and Sa 1.0 sec for the three primary ground materials within the proposed General Plan Update Planning Area (firm rock, soft rock, and alluvium) are shown in **Table 4.8-4** below.

TABLE 4.8-4
PROBABILISTIC GROUND MOTION IN THE GENERAL PLAN PLANNING AREA
10 PERCENT EXCEEDANCE IN 50 YEARS

Motion Type	Transmission Material		
	Firm Rock	Soft Rock	Alluvium
Pga	0.126	0.137	0.180
Sa 0.2 Sec	0.291	0.317	0.042
Sa 1.0 Sec	0.137	0.175	0.246

Source: California Department of Conservation, 2008

The Fault Parameters Map indicates faults and fault zones considered at risk for generating significant seismic shaking. The County of Madera, and thus the entire proposed General Plan Update Planning Area, lies outside any identified faults or fault areas identified in the State Fault Parameters Map. The USGS Earthquake Hazards Program provides digital mapping of faults known to have been the source of magnitude 6.0 and greater earthquakes in recent geologic history. Those faults known to have significant activity within the last 15,000 years and within 100 miles of the proposed General Plan Update Planning Area are shown in **Table 4.8-5** below.

No earthquakes of magnitude 5.5 or greater have ever been recorded in the Madera area, nor have there been reports of damage in the area from earthquakes of such magnitude outside Madera County. The most recent notable earthquake affecting Madera occurred on May 30, 2003, with a magnitude of 3.1 and an epicenter located approximately 6 miles northwest of Madera.

TABLE 4.8-5
PRE-QUATERNARY FAULTS WITHIN 100 MILES OF THE CITY OF MADERA

Time of Last Activity	Fault/Zone Name	Section (if applicable)	Distance (miles)	Direction
0–150 years	San Andreas Fault Zone	Creeping	65	SW
		Santa Cruz	92	W
	Calaveras Fault Zone	Paicines	71	W
		Southern Calaveras	75	W
		Central Calaveras	79	W
	Hartley Springs Fault Zone	-	76	NE
	Hilton Creek Fault	-	80	NE
	Unnamed Faults in Volcanic Tablelands	-	95	NE
	Owens Valley Fault Zone	1822 Rupture	99	E
150–15,000 years	Ortigalita Fault Zone	Piedra Azul	47	W
		Little Panoche Valley	49	W
		Los Banos	56	W
		Cottonwood Arm	62	W
	San Andreas Fault Zone	Creeping	65	SW
		Parkfield	79	S
		Santa Cruz Mountains	98	W
	Quien Sabe Fault	-	70	W
	Calaveras Fault Zone	Paicines	71	W
		Southern Calaveras	75	W
		Central Calaveras	87	W
	Silver Lake Fault	-	77	NE
	Hilton Creek Fault	-	80	NE
	Hartley Springs Fault Zone	-	80	NE
	Round Valley Fault	-	84	E
	Mono Lake Fault	-	88	NE
	Zyante-Vergeles Fault Zone	-	89	W
	Greenville Fault Zone	Arroyo Mocho	90	NW
	Unnamed Faults in Volcanic Tablelands	-	94	E
	Owens Valley Fault Zone	Keough Hot Springs	96	E
		1822 Rupture	98	E
	Robinson Creek Fault Zone	-	97	NE
	Fish Slough Fault	-	97	E
	Sargent Fault Zone	Southeastern	98	W

Time of Last Activity	Fault/Zone Name	Section (if applicable)	Distance (miles)	Direction
		Northwestern	93	W
	Hayward Fault	Southeast Extension	98	W

Source: U.S. Geological Survey and California Geological Survey, 2006
Notes: All distances are approximate, measured from the geographic of the City of Madera proposed General Plan Update Planning Area to the approximate geographic center of the fault – not necessarily the location along the fault where the recorded event occurred. Differences in distance between historic events (0–150 years ago) and Holocene/Late Pleistocene events (150–15,000 years ago) on a particular fault/zone and section occur due to differences in plotting between the two databases.

Fault Rupture

The State of California passed the Alquist-Priolo Earthquake Fault Zoning Act in 1972 in order to reduce hazards from surface faulting to structures on the surface. The 1971 San Fernando earthquake resulted in extensive surface ruptures, which caused substantial damage to structures in the vicinity of those ruptures. As a response, the Alquist-Priolo Earthquake Fault Zoning Act was adopted to prevent the construction of buildings designed for human occupancy within the surface trace of active faults. As part of the act, the State Geologist is required to establish regulatory zones around fault surface traces. Local jurisdictions (counties, cities, etc.) are required to regulate development projects within those zones, preventing most structures. Single-family wood and steel frame buildings up to two stories in height are exempt from those regulations under the act. However, local jurisdictions are free to be more restrictive than what the state sets forth. As part of compliance with the Alquist-Priolo Act, the State Geologist published a list of counties, cities, and state agencies that are affected by Alquist-Priolo Fault Zones. The County and City of Madera do not appear on this list.

Secondary Hazards

Earthquake events can produce a variety of secondary hazards affecting structures and/or adversely affecting human safety. The most common secondary seismic hazards result from ground shaking, liquefaction, and the settlement of underlying soils.

Liquefaction Potential

Liquefaction is a process that occurs during earthquakes when the soils behave like quicksand. Significant damage to structures can result when buildings sink into the liquefied soil.

Liquefaction potential is determined from a variety of factors, including soil type, soil density, depth to the groundwater table, and the duration and intensity of ground shaking. Liquefaction is most likely to occur in deposits of water-saturated alluvium or areas of considerable artificial fill. Areas most prone to liquefaction are those which are water-saturated (specifically where the water table is less than 30 feet below the surface) and consist of relatively uniform sands that are of loose to medium density. According to the Madera County 1995 General Plan, although there are areas within the county where the water table is at 30 feet or less below the surface, soil types in the area are not conducive to liquefaction because they are either too coarse in texture or too high in clay content.

Subsidence

Subsidence is the gradual settling or sinking of surface soil deposits with little or no horizontal motion. Soils that are particularly subject to subsidence include those with high silt or clay content. Some areas of the San Joaquin Valley have experienced substantial amounts of subsidence, in excess of 20 feet over the past 50 years. However, according to the Madera County 1995 General Plan, the valley areas of Madera County have not experienced this problem. The nearest subsidence problems lie to the west of Madera County, in Fresno County. Because there is no high water table in Madera County, the risk of subsidence is considered to be very low.

SURFICIAL DEPOSITS AND SOIL TYPES

Characteristics and properties of geologic surficial deposits and soil types in the Planning Area are described below. Soil behavior properties for the area from the Natural Resources Conservation Service include engineering classification, erosion potential, erosion class, and excavation difficulty.

Soil Types

Descriptions of each of the 23 soil series evident in the proposed General Plan Update Planning Area and some general characteristics of each are described below.

Alamo

The Alamo series consists of moderately deep to hardpan, poorly drained soils that formed in alluvium from mixed sources. Alamo soils are in basins and drainage ways on floodplains and fan remnants. Slope ranges from 0 to 2 percent. These soils are used mainly for pasture land and some dry-farming of grains, rice, and irrigated pasture. Vegetation consists of annual grasses, forbs, and weeds.

Atwater

The Atwater series consists of very deep, well drained soils formed in granitic alluvium. Atwater soils occur on gently undulating to rolling dunes. These soils are used mainly for production of truck crops, grapes, fruit trees, nuts, grain, and alfalfa. Typical vegetation consists of annual grasses, weeds, and low-growing shrubs.

Borden

The Borden series has brown, slightly acid soils which are low in organic matter. Borden soils occur on gently sloping older alluvial fans and basin rims that may be hummocky under natural conditions. Borden soils are moderately well to well drained with slow surface runoff. They are often used for irrigated crops such as cotton, alfalfa, grain, and grapes with some areas used for dry grain and pasture.

Cajon

The Cajon series consists of very deep, somewhat excessively drained soils that formed in sandy alluvium from dominantly granitic rocks. Due to the rapid permeability of this soil class, flooding is often non-existent. These soils are used mostly for range, watershed, and recreational uses. Some areas within the county are used for growing alfalfa and other crops. Vegetation found in the Cajon series is mostly of the desert shrub variety, including creosote bushes, saltbush, Mormon-tea, Joshua trees, some Indian rice grasses, annual grasses, and forbs.

Chino Series

Chino soils are found in basins and floodplains at elevations of near sea level up to 3,100 feet. Poorly to somewhat poorly drained, these soils remain wet for much of the winter. However, this is commonly impacted by stream channel entrenchment or lowering of groundwater levels by nearby pumping. These soils are commonly used for grazing while drained areas are used for growing irrigated truck and row crops. Normal vegetation includes grass, weeds, and shrubs.

Cometa

The Cometa series consists of moderately deep, moderately well or well drained soils that formed in alluvium from granitic rock sources. These soils are generally found on gently sloping, slightly dissected older stream terraces. Moderately well or well drained, these soils are commonly used for rice, vineyards, orchards, dry-farmed grain, and livestock grazing. Typical vegetation includes annual grasses, forbs, and weeds.

Delhi

The Delhi series consists of very deep, somewhat excessively drained soils on slopes of 0 to 15 percent. These soils are typically used for growing grapes, peaches, truck crops, alfalfa, and for homesites. Principal native plants found on these soils are buckwheat and some shrubs and trees. Other vegetation commonly found on these soils include annual grasses and forbs.

Fresno

The Fresno series is made up of fine, sandy loams on flat or nearly flat slopes. Fresno soils typically occur in nearly level valley plains with irregular low hummocky topography. As these soils are very difficult to reclaim, they are not often used for agriculture. Vegetation is sparse in general with bare spots being very common. Those areas that do exhibit vegetation contain saline-alkali tolerant shrubs, weeds, and grasses.

Grangeville

The Grangeville series consists of very deep, somewhat poorly drained soils that formed in moderate coarse textured alluvium dominantly from granitic sources. This soil series is somewhat poorly drained and exhibits negligible to very low runoff. Natural formations of this soil indicated a high frequency of flooding historically; however much of the flooding potential of these soils has been eliminated by flood control features such as dams, pumping from the water table, and filling and leveling of sloughs in the vicinity. Grangeville soils are used intensively for growing alfalfa, grapes, cotton, and truck crops and as irrigated pasture. Vegetation in uncultivated areas includes annual grasses and forbs with some scattered oak and cottonwood trees.

Greenfield

The Greenfield series of soils consists of deep, well drained soils that formed from granitic sources as well as mixed rock. As this soil is well drained with moderately rapid permeability and slow to medium runoff, the Greenfield series is commonly used for the production of a wide variety of field, forage, and fruit crops as well as grains and pasture land. Vegetation on uncultivated areas includes annual grasses, forbs, some shrubs, and scattered oak trees.

Hanford

The Hanford series of soils consists of very deep, well drained soils that formed from typical granitic sources, similar to other series in the proposed General Plan Update Planning Area. As with Greenfield series soils, the good drainage and rapid permeability of Hanford soils have led to the use of these soils for the growing of a wide variety of fruits, vegetables, and general farm crops. Vegetation in undisturbed areas includes annual grasses with some herbaceous plants.

Lewis

The Lewis series consists of moderately deep, well drained soils formed in alluvial fans from mixed rock sources. Lewis soils are typically located on terraces, basins, and valley plains. These soils are moderately well drained and often wet due to the water table being located above the duripan for a time in wetter winters. Runoff is medium to high and permeability is slow – further exacerbating the potential for this soil to exhibit ponding or standing water during wetter weather. This series is used mainly for pasture land. Those areas that remain undisturbed commonly exhibit alkali-tolerant grasses and weeds. However, barren spots are common in some areas.

Madera

Commonly occurring in undulating low terraces, the Madera series consists of moderately deep to hardpan, well to moderately well drained soils that formed from granitic rock sources. Madera soils are hummocky, gently sloping, and often contain meandering drainageways and closed depressions, which fill with water to form vernal pools in the winter months. These soils exhibit medium to very slow runoff and very slow permeability. Cultivated areas of Madera soils are used mainly for irrigated cropland, growing alfalfa, almonds, grapes, oranges, rice, and tomatoes. Madera soils are also used for irrigated pasture, dry-farmed grain, and annual ranges. Vegetation consists of typical annual grasses for the vicinity as well as some forbs.

Montpellier

The Montpellier series consists of deep to very deep, well or moderately well drained soils formed alluvium from granitic sources. Occurring on a range of slopes, this series exhibits medium to slow runoff depending on the slope of the soil. Montpellier soils exhibit moderately slow permeability with decreasing permeability with lower depths. These soils are used primarily for farmed grains, vineyards, orchards, and rangeland. Typical vegetation includes annual grasses and forbs as well as some scattered oaks.

Pachappa

The Pachappa series consists of well drained soils developed from moderately coarse alluvium. While general drainage is good for these soils, surface runoff is slow and permeability is only moderate. As such, some evidence exists that these soils exhibited occasional overflow in the past. While little evidence points to such problems in recent history, these soils still exhibit excess salts and sodium, generally limiting agriculture on these soils to alfalfa, small grains, and some row crops. Uncultivated areas exhibit annual grasses, herbs, and shrubs.

Ramona

The Ramona series is a member of the fine-loamy, mixed soils. Ramona soils exhibit a wide range of slopes from nearly level to moderately steep, commonly occurring on terraces and fans.

Ramona soils are well drained and exhibit a range of runoff speeds. These soils are used primarily for the production of grain, grain-hay, pasture, irrigated citrus, olives, truck crops, and deciduous fruits. Uncultivated areas contain annual grasses, forbs, chamise, and chaparral.

San Joaquin

The San Joaquin series consists of moderately deep to duripan soils which are moderately well drained. San Joaquin soils are hummocky, nearly level to undulating terraces. Some areas have been leveled from their original topography. These soils exhibit medium to very high runoff and very slow permeability. They are commonly used for cropland and livestock grazing, with crops generally limited to small grains and rice. Some vineyards and fruit and nut orchards are located on San Joaquin soils as well.

Traver

Traver series soils are coarse, loamy, mixed soils that occur on level to depressional hummocky areas. These soils are moderately well to somewhat poorly drained, with moderately slow permeability and slow runoff. In their natural state, these soils are commonly used for early spring pasture alone. However, reclamation of some Traver soils has led to their use in growing cotton, sugar beets, and alfalfa. Uncultivated areas of Traver soils contain saltgrass and other salt-tolerant weeds with some bare spots.

Trigo

The Trigo series of soils consists of shallow, well drained soils formed in consolidated alluvium from mixed sources. These soils exhibit moderately rapid permeability and medium to rapid runoff. They commonly contain annual grasses, red brome, wild oats, ripgut brome, filaree, foxtail fescue, and mouse barley.

Tujunga

The Tujunga series consists of very deep, somewhat excessively drained soils formed in granitic-sourced granitic rock. Tujunga soils exhibit very low to negligible runoff and rapid permeability. Depending on location and condition, Tujunga soils can exhibit a wide range of flooding potential. These soils are used primarily for grazing, though some citrus, grapes, and other fruits are grown on Tujunga soils.

Whitney

The Whitney series consists of well drained soils on undulating hilly topography. Drainage is generally good with Whitney soils, with slow to medium surface runoff and moderate permeability. Whitney soils are used extensively for dry-farmed grains and, where irrigation is available, some fruits and vegetables. Uncultivated land contains annual grasses and associated herbaceous plants.

Wunjey

Wunjey soils consist of coarse-silty soils on nearly level to channeled floodplains and geologically recent alluvial fans. These soils are moderately well to well drained and exhibit slow runoff and moderately rapid permeability. Developed areas of Wunjey soils are used for growing cotton, alfalfa, and potatoes and for irrigated pasture. Uncultivated areas contain saltgrass and some annual grasses and forbs.

4.8.2 REGULATORY FRAMEWORK

FEDERAL

Uniform Building Code

The purpose of the Uniform Building Code (UBC) is to provide minimum standards to preserve the public peace, health, and safety by regulating the design, construction, quality of materials, certain equipment, location, grading, use, occupancy, and maintenance of all buildings and structures. UBC standards address foundation design, shear wall strength, and other structurally related conditions.

STATE

California Geological Survey

The Alquist-Priolo Earthquake Fault Zoning Act of 1972 (prior to January 1, 1994, known as the Alquist-Priolo Special Studies Zones Act – CCR, Title 14, Section 3600) sets forth the policies and criteria of the State of California in regard to building within active fault zones. The Alquist-Priolo Earthquake Fault Zoning Act outlines cities' and counties' responsibilities in prohibiting the location of developments and structures for human occupancy across the trace of active faults. The policies and criteria are limited to potential hazards resulting from surface faulting or fault creep within Earthquake Fault Zones delineated on maps officially issued by the State Geologist.

California Building Code

In addition to the requirements of the Uniform Building Code (see Federal, above), California Code of Regulations, Title 24, also known as the California Building Standard Code or the California Building Code (CBC), establishes further guidance for foundation design, shear wall strength, and other structurally related concerns. The CBC modified UBC regulations for specific conditions found in California and included a large number of more detailed and/or more restrictive regulations. For example, the CBC includes common engineering practices requiring special design and construction methods that reduce or eliminate potential expansive soil related impacts. The CBC requires structures to be built to withstand ground shaking in areas of high earthquake hazards and the placement of strong motion instruments in larger buildings to monitor and record the response of the structure and the site of seismic activity. Compliance with CBC regulations ensures the adequate design and construction of building foundations to resist soil movement. In addition, the CBC also contains drainage requirements in order to control surface drainage and to reduce seasonal fluctuations in soil moisture content.

Seismic Hazards and Mapping Act

The Seismic Hazards Mapping Act of 1990 (Public Resources Code, Chapter 7.8, Section 2690-2699.6) directs the Department of Conservation, California Geological Survey to identify and map areas prone to earthquake hazards of liquefaction, earthquake-induced landslides, and amplified ground shaking. The purpose of the act is to reduce the threat to public safety and to minimize the loss of life and property by identifying and mitigating these seismic hazards. The act was passed by the State Legislature following the 1989 Loma Prieta earthquake and pertains to seismic hazards other than the fault surface rupture hazard regulated by the Alquist-Priolo Earthquake Fault Zoning Act of 1972.

The maps produced per the Seismic Hazards Mapping Act are the Seismic Hazard Zone Maps, prepared by California Geological Survey geologists in the Seismic Hazard Mapping Program. The program will ultimately map all of California's principal urban and major growth areas. Each map covers an area of approximately 60 square miles and uses a scale of 1 inch = 2,000 feet (1:24,000 scale). The Seismic Hazard Zone maps include designated "Zones of Required Investigation" for areas prone to liquefaction and earthquake-induced landslides. Once a map becomes available for a certain area, cities and counties within that area are required to withhold development permits for projects proposed within a Zone of Required Investigation until geologic and soil conditions are investigated and appropriate mitigations, if any, are incorporated into development plans.

California Water Code – Division 3, Dams and Reservoirs

Since 1929, the State of California has supervised dams to prevent failure in order to safeguard life and protect property. The legislation resulted from the failure of St. Francis Dam in March of 1928. Legislation enacted in 1965, as a result of the failure of Baldwin Reservoir in 1963, revised the statutes to include off-stream storage. This legislation is regulated by the California Department of Water Resources, Division of Safety of Dams. Two classifications of dam types are covered: (1) dam structures that are or will be in the future 25 feet or more in height from the natural bed of the stream or water course at the downstream toe of the barrier and (2) dams that have an impounding capacity of 50 acre feet or more (California Department of Water Resources, 2004).

Implementing the legislation involves use of geology and geotechnical engineering over the entirety of the dam's useful life for site selection, dam design and construction, and ongoing inspection of the impounding structures.

4.8.3 IMPACTS AND MITIGATION MEASURES

STANDARDS OF SIGNIFICANCE

Based on Appendix G of the CEQA Guidelines, a geology, soils, or mineral resources impact is considered significant if project implementation would result in any of the following:

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

    a. 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.

    b. Strong seismic ground shaking.

    c. Seismic-related ground failure, including liquefaction.

    d. Landslides.

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

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

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

5) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

A project's mineral resources impacts are considered significant if project implementation would be of value to the region and the residents of the state; or

6) 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.

7) 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.

According to the findings of the Initial Study for the proposed General Plan Update, released along with the Notice of Preparation on December, 27, 2007, the proposed General Plan Update does not have the potential to affect the availability of any state or locally designated mineral resource, and no impact was expected. As such, this EIR does not address impacts related to mineral resources, and standards 6 and 7 above are not discussed further.

PROJECT IMPACTS AND MITIGATION MEASURES

Seismic Events

Impact 4.8.1 Implementation of the proposed General Plan Update, and the resulting increase in population, employment, and development activity within the Planning Area, would not expose people, structures, and development to substantial ground shaking and seismic hazards as a consequence of earthquakes resulting in the risk of loss, injury, or death. This is considered a **less than significant** impact.

The hazards related to ground shaking include the risk of loss, injury, or death. Buildings that were constructed within the City's Planning Area prior to 1930, including unreinforced masonry (URM) buildings that have not been seismically retrofitted, are most likely to have structural failure or collapse occur. Buildings that have been seismically retrofitted would have a decreased chance of failure. However, even structurally enhanced buildings and newer buildings could still experience significant damage and present a hazard to occupants.

Ground shaking can result in significant structural damage or structural failure in the absence of appropriate seismic design. However, as previously discussed, the Planning Area is not located within an Alquist-Priolo earthquake hazard zone and there are no known active faults occurring within the Planning Area. The Planning Area, as with virtually all sites within the State of California, is, however, subject to minor ground shaking and potential secondary hazards as a result of earthquakes. The Planning Area is in the area of Seismic Zone 2, which is considered an area of low ground shaking potential, as defined by the California Department of Mines and Geology on the Preliminary Map of Maximum Expectable Earthquake Intensity in California, and the Madera County Code. A Seismic Zone 2 is an area that can expect to experience ground motion of low severity. Based upon the seismologic and geologic conditions discussed above, the maximum level of ground motion potentially experienced in the Planning Area would occur as a result of a 6.5 magnitude earthquake on the Foothills fault zone or Great Valley fault. Minor ground shaking can result in partial collapse of buildings and extensive damage in poorly built or substandard structures.

The combination of the Planning Area characteristics and compliance with the UBC and CBC would be sufficient to prevent significant damage from ground shaking during seismic events resulting from movement on any of the faults or fault systems described within this EIR.

Proposed General Plan Policies and Action Items that Provide Mitigation

The following proposed General Plan Update policies and action items that address seismic hazards are identified in the General Plan Health and Safety Element:

Policy HS-7: *The City supports efforts by federal, state, and other local organizations to investigate local seismic and geological hazards and support those programs that effectively mitigate these hazards.*

Policy HS-8: *The City shall seek to ensure that new structures are protected from damage caused by earthquakes, geologic conditions, or soil conditions.*

Adherence to the Uniform Building Code and the California Building Code would reduce to a minimum the exposure of people and structures to potential substantial adverse effects. Thus, this impact is considered **less than significant**.

Mitigation Measures

None required.

Soil Erosion

Impact 4.8.2 Implementation of the proposed General Plan Update could include construction and site preparation activities. These activities can increase the potential for soil, wind, and water erosion, due to minor or major grading over large areas of land. This is considered a **less than significant** given current City standards and requirements.

Implementation of the proposed General Plan Update would include new roadways, improvements to existing roadways, substantial infrastructure (water and sanitary sewer facilities), and extensive densities of commercial, residential, and industrial development.

Grading and site preparation activities associated with proposed development would remove topsoil, disturbing and potentially exposing the underlying soils to erosion from a variety of sources, including wind and water. In addition, construction activities generally involve the use of water, which may further erode the topsoil as the water moves across the ground. The reader is referred to Section 4.9, Hydrology and Water Quality, for a further discussion regarding erosion and water quality.

Construction activities involving clearing, grading, or excavation that causes soil disturbance on one or more acres (or any project involving less than one acre that is part of a larger development plan and includes clearing, grading, or excavation) would be subject to coverage under the State's National Pollutant Discharge Elimination System (NPDES) General Construction Storm Water Permit. Project applicants are required to prepare and comply with a Storm Water Pollution Prevention Plan (SWPPP) that specifies Best Management Practices (BMPs) to avoid soil erosion and associated pollution of waterways and are also required to report any water pollution and remediate the pollution occurrence.

The City of Madera operates under a statewide NPDES permit to discharge urban runoff from Municipal Separate Storm Sewer Systems (MS4s) within their municipal jurisdiction. Under the NPDES permit, the City of Madera was required to prepare and implement a Stormwater Quality Improvement Plan (SQIP) to reduce pollutants in runoff from construction sites during all construction phases. A Storm Water Quality Management Program (SWQMP) was completed in 2004 by the City of Madera which outlines the City's approach to compliance with the requirements of the NPDES permit and addresses the program areas required under the MS4 permit. The SWQMP also includes a voluntary water quality monitoring program. The purpose of the City's SWQMP is to implement and enforce a series of management practices, referred to as Best Management Practices.

Proposed General Plan Policies and Action Items that Provide Mitigation

The following proposed General Plan Update policies and action items are identified in the General Plan Conservation Element that address soil erosion through the use of enforceable performance standards:

Policy CON-8: *The City encourages Low Impact Development practices in all residential, commercial, office, and mixed-use discretionary projects and land division projects to reduce, treat, infiltrate, and manage runoff flows caused by storms, urban runoff, and impervious surfaces. Low impact development practices may include:*

- *Use of small scale stormwater controls such as bioretention, grass swales and channels, vegetated rooftops, rain barrels and cisterns.*
- *Reduction of impervious surfaces through site design and use of pervious paving materials.*
- *Retention of natural features such as trees and ponds on site.*
- *The use of drought tolerant plant materials and/or water-conserving irrigation systems.*

Policy CON-9: *The City shall protect and maintain water quality for the health of all users, including natural plant and animal communities.*

Policy CON-10: *The City shall seek to minimize toxic runoff from such sources as homes, golf courses, and roadways. Examples of potential programs include:*

- *The use of "bioswales" and similar features (such as infiltration trenches, filter trips, and vegetated buffers) to trap contaminants*
- *Installation of grease/oil separators to keep these contaminants out of storm runoff*

- *Regular street sweeping programs to prevent the buildup of oil, grease, and other contaminants and keep them from being swept into creeks and rivers*

- *Minimizing pesticide use and promoting the use of natural pest controls*

- *Encouraging the installation of "gray water" systems*

Action Item CON-10.1: Implement the City's "Storm Water Quality Management Plan."

Action Item CON-10.2: Update the "Storm Water Quality Management Plan" as needed to incorporate the measures included in Policy CON-10 and other new measures that become available.

As noted above, the City is subject to the NPDES Permit for stormwater quality that involves the implementation of the SQIP that calls for the use of BMPs to mitigate potential soil erosion impacts. In addition, development in the city would be subject to the National Pollutant Discharge Elimination System General Construction Storm Water Permit. Project applicants are required to prepare and comply with a Storm Water Pollution Prevention Plan that specifies Best Management Practices to avoid soil erosion and associated pollution of waterways and are also required to report any water pollution and remediate the pollution occurrence. The proposed General Plan Update policies identified above would involve further implementation of these water quality protection requirements. As result, this impact is **less than significant**.

Mitigation Measures

None required.

Expansive and Unstable Soils

Impact 4.8.3 Implementation of the proposed General Plan Update could place development in areas with unstable soils or expose buildings, pavements, and utilities to significant damage as a result of underlying expansive or unstable soils. This impact is considered a **significant and mitigable** impact.

Implementation of the proposed General Plan Update results in construction activities overlying expansive or unstable soils. Newly constructed buildings, pavements, and utilities could be damaged by differential settlement due to soil expansion and contraction. When structures are located on expansive soils, foundations have the tendency to rise during the wet season and shrink during the dry season. Movements can vary under the structures, which in turn create new stresses on various sections of the foundation and connected utilities. These variations in ground settlement can lead to structural failure and damage to infrastructure.

As discussed previously, the City of Madera adopted the Uniform Building Code and the California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code or California Building Code (CBC). The CBC includes common engineering practices requiring special design and construction methods that reduce or eliminate potential expansive soil related impacts. Compliance with CBC regulations ensures the adequate design and construction of building foundations to resist soil movement. In addition, the CBC also contains drainage related requirements in order to control surface drainage and reduce seasonal fluctuations in soil moisture content.

Proposed General Plan Policies and Action Items that Provide Mitigation

The following proposed General Plan Update policy is identified in the General Plan Health and Safety Element to address soil and geologic stability:

Policy HS-8: *The City shall seek to ensure that new structures are protected from damage caused by earthquakes, geologic conditions, or soil conditions.*

Mitigation Measures

The following mitigation measure shall be incorporated into the City of Madera proposed General Plan Update as an action item in the Health and Safety Element.

MM 4.8.3 Require a geotechnical report or other appropriate analysis be conducted that determines the shrink/swell potential and stability of the soil for public and private construction projects and identifies measures necessary to ensure stable soil conditions.

Compliance with CBC regulations ensures the adequate design and construction of building foundations to resist soil movement. In addition, the CBC also contains drainage related requirements in order to control surface drainage and reduce seasonal fluctuations in soil moisture content. In addition, implementation of the above policy, as well as mitigation measure MM 4.8.3, would reduce the impacts of expansive soils to **less than significant**.

Septic System Operation

Impact 4.8.4 Implementation of the proposed General Plan Update could impact areas where soils may be incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems. This would be a **less than significant** impact given that new development would either connect to the City's wastewater system or meet applicable septic design standards.

The impacts associated with the soils suitability of soils can be reduced or avoided through proper site inspection and project monitoring and maintenance on a project-by-project basis as well as through compliance with Madera County septic system design requirements. Site inspection should include percolation testing to determine soil suitability. When soil suitability is identified, septic systems should be designed accordingly. When appropriate field-testing is conducted and current system location and design standards are used combined with post construction monitoring and maintenance, the potential adverse impacts to septic suitability of soils can be reduced to acceptable levels. Urban development associated with the proposed General Plan Update would connect to the City's wastewater system, while rural development may involve the use of a septic system. Thus, this impact would be **less than significant**.

Mitigation Measures

None required.

4.8.4 CUMULATIVE SETTING, IMPACTS, AND MITIGATION MEASURES

CUMULATIVE SETTING

Site-specific topography, soil conditions, and surrounding development generally determine geological, soil, and mineral resource related impacts, which generally are not considered cumulative in nature. However, surficial deposits, namely erosion and sediment deposition, can be cumulative in nature, depending on the type and the amount of development proposed in a given geographical area. The cumulative setting for seismic hazards, expansive soils, and soil erosion consists of existing, planned, proposed, and reasonably foreseeable land use conditions in the region including buildout of the Planning Area, as described in Section 4.0 of this document.

CUMULATIVE IMPACTS AND MITIGATION MEASURES

Cumulative Seismic Hazards, Expansive Soils, and Soil Erosion Impacts

Impact 4.8.5 Implementation of the proposed General Plan Update, in combination with existing, planned, proposed, and reasonably foreseeable development, would not contribute to cumulative seismic hazards, expansive soils, and soil erosion impacts given the area-specific nature of the impact. This is considered a **less than cumulatively considerable** impact.

Implementation of the proposed General Plan Update, along with potential development in the Planning Area as well as continued development within Madera County, would result in cumulative soil erosion and other geologic impacts. Compliance with the City's NPDES permit would reduce the City's contribution to cumulative soil erosion impacts. Development projects are analyzed on an individual basis and must comply with established requirements of the City and the UBC as they pertain to protection against known geologic hazards and potential geologic and expansive soil related impacts. There are no known active faults in the Planning Area, there is a low incidence of historical geologic activity in the vicinity, and there is no contribution with other regional geologic impacts. Therefore, the proposed General Plan Update's contribution to cumulative geology-related impacts is considered **less than cumulatively considerable**.

The reader is referred to Section 4.9, Hydrology and Water Quality, for additional information regarding soil erosion and water quality.

Mitigation Measures

None required.

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