3.7 Geology and Soils

This section describes the regulatory and environmental setting for geology and soils. It also describes impacts on geology and soils that would result from implementation of the Climate Action 2020: Community Climate Action Plan (CAP) and includes mitigation for significant impacts, where feasible and appropriate.

3.7.1 Environmental Setting

This section describes the geologic, seismic, and soil hazards present in Sonoma County. This information has been drawn and modified from the *Sonoma County General Plan 2020 EIR* (Sonoma County 2006).

3.7.1.1 Regional Geology

Topography

The topography in Sonoma County is varied, including several mountain ranges, distinctive valleys, and coastal terraces. The geology is quite complex and is continually evolving because of its location at an active plate margin. The County is bounded on the south by the San Pablo Bay and associated wetlands. The Cotati and Petaluma Valleys create the wide basin stretching from Santa Rosa to the Bay. Rolling hills and grasslands predominate here, as well as in Marin County to the south. The rugged Mayacamas and Sonoma mountains geographically form the eastern boundary and physically separate Sonoma County from Lake and Napa Counties. The Sonoma Valley runs north-south between the Sonoma Mountains on the west and the taller Mayacamas Mountains to the east. The Geysers geothermal field, located in the northeastern section of the County, extends into both Sonoma and Lake Counties. The Mendocino Highlands form a common geographic unit with Mendocino County to the north. The Alexander Valley runs from northwest to southeast, bounded on the east by the Mayacamas Mountains and on the west by the Coast Range. The Pacific Ocean forms the western County boundary, including an interesting assemblage of steep hills, marine terraces, beaches, and offshore sea stacks.

Geology

The geology of Sonoma County is a result of the past tectonic, volcanic, erosion, and sedimentation processes of the California Coast Range geomorphic province. Ongoing tectonic forces resulting from the collision of the North American Plate with the Pacific Plate, combined with more geologically recent volcanic activity, have resulted in mountain building and down warping of parallel valleys. The margin of the two tectonic plates is defined by the San Andreas Fault system: a broad zone of active, dormant, and inactive faults dominated by the San Andreas Fault which trends along the western margin of the County. This fault system results in the northwestern structural alignment that controls the overall orientation of the County's ridges and valleys. The land has been modified by more recent volcanic activity, evidenced by Mount St. Helena that dominates the northeastern part of the County. Erosion, sedimentation, and active faulting occurring in recent times have further modified Sonoma County's landscape to its current form.

3.7.1.2 Geologic Hazards

Seismicity

Earthquakes are most common along geologic faults that are planes of weakness or fractures along which rocks have been displaced. Faults located within Sonoma County are part of the San Andreas Fault system which extends along most of the length of California and represents the boundary between the Pacific and North American plates of the earth's crust. These faults show significant surface evidence of lateral or vertical movement in the past two million years (i.e., the Quaternary geologic period) and are defined as active or are considered to be potentially active in the future. Sudden movement or displacement along faults generally causes earthquakes. However, earthquakes are also caused by volcanic activity. Although there are no known active volcanic sources in Sonoma County, the Geysers' Known Geothermal Resource Area is a source of similar seismic events related to movement within deep seated hot or semi-molten rock.

The two most important faults for purposes of planning for seismic impacts in Sonoma County are the San Andreas and Rodgers Creek faults. Current seismic data indicates that the highest magnitude earthquakes to be expected for the northern San Andreas Fault and the Rodgers Creek faults are 8.0 and 7.5, respectively, on the Richter scale. It has been accepted for many years that earthquakes of magnitude 8.0 or more somewhere on the San Andreas Fault can be expected to reoccur every 50 to 200 years.

Ground Shaking and Liquefaction

Seismic ground-shaking and seismic-induced liquefaction can result in damaging impacts to both close to and at great distances from the source of the earthquake. Seismic ground shaking causes liquefaction by increasing pore water pressure between the sand or silt grains, which temporarily transforms certain water saturated soils to a semi-liquid state. This results in loss of shear strength, thereby removing support from foundations and causing differential settlement, subsidence or total collapse of buildings, bridges, roadways, or other structures. The most susceptible areas are the silty "Bay muds" south of Petaluma and Sonoma and near Bodega Bay. Deposits that are also susceptible to liquefaction are areas underlain by saturated unconsolidated alluvium that has fairly uniform grain size. Thus, in alluvial basins within Sonoma County, the potential for liquefaction failures will tend to increase in the winter and spring when the ground water table is higher. These areas include the largest population centers and most intensely developed areas of Sonoma County.

Earthquake-Induced Landslides

Beyond the immediate area of surface fault rupture, ground deformation can distort the surface, secondary ground cracks can open, and both can damage structures. These kinds of ground failures are caused by the torsion effects on the ground adjacent to the fault trace as blocks of the earth move past each other. Seismic lurching is the movement of a soil or rock mass toward an unsupported free face such as a sea cliff, road cut, or steep natural hillside. These kinds of ground failures are caused by seismic accelerations and are transitional to seismically triggered landslides.

3.7.1.3 Soil Hazards

Soil characteristics can greatly influence land-use activities. Within Sonoma County there are soils with characteristics that include seasonal shrink and swell (i.e., expansive soils), weak or collapsing soils that compress under a load or when wet, soils that are corrosive to certain materials, soils that may liquefy during seismic shaking, and soils that are susceptible to erosion.

Slope Stability and Landslides

The most frequent and widespread type of ground failure in Sonoma County is landsliding. In the broadest sense, a landslide is a downward and outward movement of slope forming materials composed of rock, soils, artificial fills, or a combination of these. Because of the highly fractured rock formations, steep topography, long coastline, and the area's seismicity, extensive land areas of the County are subject to this destructive hazard. Virtually all parts of the County except the flat lying alluvial valleys are subject to damaging landslides of various kinds. Landslides vary in size, speed of movement, and mechanism.

Areas prone to landsliding include locations of past landslides in the County and hillsides where clay and silt-rich soils absorb water and loose strength and where rock strata are parallel to surface slopes. In addition, landslides occur where faults have fractured rock and along the base of slopes or cliffs where supporting material has been removed by stream or wave erosion, or human activities. Heavy rainfall, human actions, or earthquakes can trigger landslides. They may take the form of a slow continuous movement such as a slump or may move very rapidly as a semi-liquid mass such as a debris flow or avalanche.

Subsidence and Differential Settlement

Most subsidence is caused by the withdrawal of fluids (e.g., ground water or oil) from subsurface reservoirs or from the collapse of surface and near surface soils and rocks over subterranean voids such as mines and caves. The extent over which subsidence occurs can be very localized, or it can impact large areas.

Settlement is a more localized phenomenon and is related to the loading of soils and their subsequent compression as a result of construction activities. Differential settlement results when settlement across an area settles at different rates or in different amounts. Settlement can result if the native soils are porous or weak such that the weight to a building or other structure causes the soil to compress. This can occur in native soils or in manmade fills. The amount of settlement depends on the thickness of the weak compressible soils or fill, the load imposed by the construction, as well as the original density of the soils. Non-uniform or differential settlement can occur if the compressible soil section beneath the structure is variable, if the soil is heterogeneous, or if there are variable loads imposed across the footprint of the structure. If a structure is constructed such that it spans native soil and bedrock or native soil and a section of fill, differential settlements can be expected. The kinds of damage cause by settlement and differential settlement are similar to that caused by expansive soil (tilted and cracked floor slabs, uneven floors in buildings, cracked pavements, etc.).

Expansive and Creeping Soil

Expansive soils, which are found in various parts of Sonoma County, greatly increase in volume when they absorb water and shrink when they dry out. Expansion of the soil or rock is due to the attraction and absorption of water into the expansible crystal lattices of the clay minerals. The water may be derived from moisture in the air or ground water beneath the foundations of buildings. When buildings are placed on expansive soils, foundations may rise each wet season and fall each dry season. Roadways, pavements, and other flat construction are highly susceptible to damage from expansive soils. Movements may vary under different parts of a building with the result that foundations crack, various structural portions of the building are distorted, and doors and windows are warped so that they do not function properly. Where expansive soils are located on hill slopes which are common in parts of Sonoma County, they undergo a process of seasonal down slope movement called "soil creep". Soil creep forces can be substantial and need to be evaluated to determine their effects on foundation elements, retaining walls, and other structures.

3.7.2 Regulatory Setting

3.7.2.1 Federal

There are no relevant federal regulations for geology and soils other than Section 402 of the Clean Water Act which contains requirements relative to erosion control, and this regulation is discussed in Section 3.8, *Hydrology and Water Quality*.

3.7.2.2 State

Alquist-Priolo Earthquake Fault Zoning Act

California's Alquist-Priolo Earthquake Fault Zoning Act (Alquist-Priolo Act) (Public Resources Code [PRC] Section 2621 et seq.), originally enacted in 1972 as the Alquist-Priolo Special Studies Zones Act and renamed in 1994, is intended to reduce risks to life and property from surface fault rupture during earthquakes. The Alquist-Priolo Act prohibits the location of most types of structures intended for human occupancy[1] across the traces of active faults and strictly regulates construction in the corridors along active faults (earthquake fault zones). It also defines criteria for identifying active faults, giving legal weight to terms such as *active*, and establishes a process for reviewing building proposals in and adjacent to earthquake fault zones.

Under the Alquist-Priolo Act, faults are zoned, and construction along or across them is strictly regulated if they are sufficiently active and well defined. A fault is considered sufficiently active if one or more of its segments or strands shows evidence of surface displacement during Holocene time (defined for purposes of the act as referring to approximately the last 11,000 years). A fault is considered well-defined if its trace can be identified clearly by a trained geologist at the ground surface or in the shallow subsurface using standard professional techniques, criteria, and judgment (Bryant and Hart 2007).

Seismic Hazards Mapping Act

Similar to the Alquist-Priolo Act, the Seismic Hazards Mapping Act of 1990 (PRC Sections 2690–2699.6) is intended to reduce damage resulting from earthquakes. While the Alquist-Priolo Act addresses surface fault rupture, the Seismic Hazards Mapping Act addresses other earthquake-

[1] With reference to the Alquist-Priolo Act, a *structure for human occupancy* is defined as one "used or intended for supporting or sheltering any use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year" (California Code of Regulations, Title 14, Div. 2, Section 3601[e]).

related hazards, including strong groundshaking, liquefaction, and seismically induced landslides. Its 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 groundshaking, 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 sites within seismic hazard zones until appropriate site-specific geologic and/or geotechnical investigations have been carried out and measures to reduce potential damage have been incorporated into the development plans.

California Uniform Building Code

The major state regulations regarding geo-seismic hazards, other than surface faulting, are contained in Title 24, Part 2, California Uniform Building Code (CUBC). The CUBC applies to public building and a large percentage of private building in the state. It is based on the current federal Uniform Building Code, but contains additional amendments, and repeals that are specific to building conditions and structural requirements in the state of California. Local codes are permitted to be more restrictive than Title 24 but are required to be no less restrictive. Chapter 23 of the CUBC deals with general design requirements, including (but not limited to) regulations governing seismically resistant construction. Chapters 29 and 70 deal with excavations, foundations, retaining walls, and grading including (but not limited to) requirements for seismically resistant design, foundation investigations, stable cut and fill slopes, and drainage and erosion control.

National Pollutant Discharge Elimination System General Construction Stormwater Permit

The General National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities (Order 2009-0009-DWQ as amended by Order No.2010-0014-DWQ and 2012-0006-DWQ) (Construction General Permit) regulates stormwater discharges for construction activities under CWA Section 402. Dischargers whose projects disturb 1 or more acres of soil, or whose projects disturb less than 1 acre but are part of a larger common plan of development that in total disturbs 1 or more acres, are required to obtain coverage under the Construction General Permit. The Construction General Permit requires the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP).

National Pollutant Discharge Elimination System General Municipal Stormwater Permit

MS4 permits require that cities and counties develop and implement programs and measures to reduce the discharge of pollutants in stormwater discharges to the maximum extent possible, including management practices, control techniques, system design and engineering methods, and other measures as appropriate.

3.7.2.3 Local

Appendix C, *Local General Plan Goals, Objectives, and Policies*, provides a list of the goals, objectives, and policies in the local general plans of the participating jurisdictions including those related to geology and soils. These goals, objectives, and policies were reviewed to assess whether the project is consistent with the general plans of participating jurisdictions. Disclosure of this consistency analysis is for informational purposes. An additional purpose of providing a list of relative local policies is, where appropriate, to provide the context within which the CAP will be locally implemented. As described in the CAP, most of the CAP measures represent implementation of many of the priorities outlined in existing local policies.

Inconsistencies with general plan policies are not necessarily considered significant impacts under CEQA unless they are related to physical impacts on the environment that are significant in their own right.

Implementation of the CAP is consistent with the applicable general plan goals, objectives, and policies of the participating jurisdictions in relation to geology and soils.

3.7.3 Impacts Analysis

3.7.3.1 Methodology

This analysis is based on a review of the soils and geologic information contained in the Sonoma County General Plan. Effects related to geology and soils are analyzed qualitatively and are focused on the implementation of the CAP's potential to increase the risk of personal injury, loss of life, or damage to property, including new or upgraded facilities, as a result of existing geologic conditions in the County.

3.7.3.2 Significance Criteria

The State California Environmental Quality Act (CEQA) Guidelines Appendix G (14 California Code of Regulations [CCR] 15000 et seq.) has identified significance criteria to be considered for determining whether a project could have significant impacts on geology and soils.

An impact would be considered significant if construction or operation of the project would have any of the following consequences.

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving any of the following:
  - 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];
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - 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 an onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse.
- 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.

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

Pursuant to the recent California Supreme Court ruling in the *California Building Industry Association vs. Bay Area Air Quality Management District* (BIA vs. BAAQMD) case, the impacts of a project placing new residents or structures in an area of existing geological, soil, or seismic risk is not considered an impact under CEQA unless the project itself exacerbates the existing environmental hazard. As such, CEQA impacts would occur where the project results in a geological, soil, or seismic risk and not where risks may occur due to the mere introduction of new receptors or structures in areas of existing risk. However, local lead agencies have numerous policies requiring the safe design of projects to avoid undue risks to people and structures and have local police power to require actions as conditions of approval whether or not they are defined as CEQA impacts in the end. As such, the text below notes when certain on-site impacts might not be considered as CEQA impacts, but are nevertheless considered impacts and mitigation is recommended as a condition of approval, in the event an impact may be determined to not meet the requirements as a CEQA impact.

3.7.3.3 Impacts and Mitigation Measures

Impact GEO-1: Implementation of the CAP could expose people or structures to risks involving earthquake induced seismic hazards, such as surface fault ruptures, groundshaking, ground failures including liquefaction, and landslides (less than significant).

The CAP is a policy-level document that does not include any site-specific designs or proposals, or grant any entitlements for development that would have the potential to expose people or structures to increased risks associated with seismic hazards. As a policy document, the CAP would have no direct impact on geology and soils, but future implementation of activities supported by the CAP could increase risks involving with seismic hazards.

There are several CAP measures that promote and could include the construction of new facilities or retrofits aimed to increase renewable energy use, increase solid waste diversion, increase capture/use of methane from landfills, promote recycled water use, and reduce emission from livestock operations. The CAP also promotes mixed-use and transit-oriented development and additional transit facilities and electric-vehicle charging stations aimed to reduce fuel use and travel demand through smart land use and development. The siting of these new facilities and buildings could expose on-site people or structures to risk from earthquake induced seismic hazards if the structures are sited within active seismic fault zone areas.

Under CEQA, this could result in a significant impact if on-site structural failure were to result in impact on off-site people or structures. This could occur for example if an on-site structure were to collapse into an adjacent structure or facility, or catch fire due to ruptured gas lines following an earthquake that then spread to adjacent structures or areas thus endangering off-site people or structures. These sorts of risks are routinely addressed in both ministerial and discretionary projects. Where there is the potential for these impacts, they are routinely addressed through project-level environmental review and permitting. Many existing city and county policies and ordinances address such impacts. Where existing ordinances do not address these impacts, then project-level CEQA review will assess the specific significance of the project impact and, where appropriate, identify mitigation to address those impacts. In particular, this impact is routinely addressed with standard mitigation identified during project-level review such as preparing site-specific geotechnical investigations for new structures and incorporating site-specific recommendations into the structure's design and construction. Projects in furtherance of the CAP will be subject to CEQA review, and RCPA has no basis to conclude there is any significant risk.

Impact GEO-2: Implementation of the CAP could result in substantial soil erosion or loss of topsoil (less than significant).

Although the CAP does not directly involve the construction of structures, future implementation of activities supported by the CAP could result in ground-disturbing activities that could result in soil erosion or loss of topsoil. There are several CAP measures that promote and could include the construction of new facilities aimed to increase renewable energy use, increase solid waste diversion, increase capture/use of methane from landfills, promote recycled water use, and reduce emission from livestock operations. The CAP also promotes mixed-use and transit-oriented development and additional transit facilities and electric-vehicle charging stations aimed to reduce fuel use and travel demand through smart land use and development. Ground-disturbing activities associated with the construction of these structures and facilities could result in soil erosion or the loss of topsoil.

However, as discussed above, the CAP does not directly involve the construction of any structures. Any structures that could be constructed consistent with the CAP would be subject to further CEQA analysis of project-specific impacts and State Water Resources Control Board (State Water Board) regulations regarding construction activities, including the preparation of a SWPPP for a project per the NPDES General Construction Permit. A project's SWPPP would include site-specific pollution prevention measures (erosion and sediment control measures and measures to control non-stormwater discharges and hazardous spills), demonstration of compliance with all applicable local and regional erosion and sediment control standards, identification of responsible parties, a detailed construction timeline, and best management practices (BMPs) monitoring and maintenance schedule to determine quantities of pollutants leaving the site. SWPPP BMPs are recognized as effective methods to prevent or minimize the potential releases of pollutants into drainages, surface waters, or groundwater. SWPPP compliance coupled with using the appropriate BMPs would reduce potential erosion and water quality impacts during construction activities. Post-construction, implementation of the CAP as a component of a specific project would be subject to the NPDES and local ordinances and regulations to reduce the potential for erosion and loss of topsoil. With compliance to local regulations, and the NPDES and SWPPP requirements, impacts associated with soil erosion and loss of topsoil would be less than significant.

Impact GEO-3: Facilities promoted by the CAP could be located on an unstable geological unit/soil or expansive soil, potentially resulting in increased risks of geologic and soil hazards or damage to project structures (less than significant).

There are several CAP measures that promote and could include the construction of new facilities aimed to increase renewable energy use, increase solid waste diversion, increase capture/use of methane from landfills, promote recycled water use, and reduce emission from livestock operations. The CAP also promotes mixed-use and transit-oriented development and additional transit facilities and electric-vehicle charging stations aimed to reduce fuel use and travel demand through smart land use and development. The siting of these new facilities and buildings in areas underlain with unstable or expansive soils could pose risk to life or property due to facility upset conditions.

Under CEQA, this could result in a significant impact if the risks due to structural failure were to affect off-site people or structures. These sorts of risks are site specific and routinely addressed in both ministerial and discretionary projects. Where there is the potential for these impacts, they are routinely addressed through project-level environmental review and permitting. Many existing city and county policies and ordinances address such impacts. Where existing ordinances do not address these impacts, then project-level CEQA review will assess the specific significance of the project impact and, where appropriate, identify mitigation to address those impacts. In particular, this impact is routinely addressed with standard mitigation identified during project-level review such as preparing site-specific geotechnical investigations for new structures and incorporating site-specific recommendations into the structure's design and construction. Projects in furtherance of the CAP will be subject to CEQA review, and RCPA has no basis to conclude there is any significant risk.

Impact GEO-4: Implementation of the CAP would not involve the use of septic tanks or alternate wastewater disposal systems that would result in soil impacts (no impact).

Implementation of the CAP does not include any measures that would directly involve the use of or support the use of septic tanks or alternate wastewater disposal systems. Thus, there would be no impact.

3.7.3.4 Cumulative Impacts

Impact C-GEO-1: Implementation of the CAP, in combination with other foreseeable development in the surrounding area, could have a significant cumulative impact to geology and soils (less than considerable contribution).

The context for the evaluation of cumulative impacts on geology and soils addresses the effects of the CAP in combination with other development in Sonoma County. The geographic context for the analysis of impacts resulting from geologic hazards is generally site specific rather than cumulative in nature. Every project has unique geologic considerations that are subject to existing state and local site development and construction standards. As such, the potential for cumulative impacts to occur is limited. For impacts related to exposure to seismic hazards, the geographic context is the Bay Area because the entire region is seismically active, with people subject to risk of injury and structures subject to damage as a result of seismic ground shaking. Where there is the potential for impacts, they are routinely addressed through project-level environmental review and permitting. Many existing city and county policies and ordinances address such impacts. Where existing ordinances do not address these impacts, then project-level CEQA review will assess the specific significance of the project impact and, where appropriate, identify mitigation to address those impacts. In particular, this impact is routinely addressed with standard mitigation identified during project-level review such as preparing site-specific geotechnical investigations for new structures and incorporating site-specific recommendations into the structure's design and construction. There is no basis to conclude there is any cumulatively considerable contribution to existing risk.

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