3.9 Geology, Soils, Seismicity, and Paleontological Resources

3.9.1 Introduction

This section describes potential geology, soils, seismicity, mineral resource, and paleontological resource effects of the Palmdale to Burbank Section of the California High-Speed Rail (HSR) System. The following resource sections in this Palmdale to Burbank Project Section Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) provide additional information related to geology, soils, seismicity, and paleontology:

- Section 3.8, Hydrology and Water Resources, addresses project-related impacts on such resources. Certain geologic and soil conditions depend on proximity to streams and rivers.
- Section 3.11, Safety and Security, addresses responses to potential seismic safety issues related to the HSR system.
- Section 3.10, Hazardous Materials and Wastes, discusses subsurface conditions related to hazards and hazardous materials, oil and gas wells, and landfills.
- Section 3.4, Noise and Vibration, addresses vibration impacts.

Geology, Soils, Seismicity, and Paleontological Resources

Geology, soils, and seismicity often determine the design criteria for passenger rail improvements, particularly when grade-separation structures and tunneling are involved. This chapter summarizes the geologic materials, faults, seismic characteristics, and other subsurface conditions throughout the resource study area.

This section also addresses mineral resources and paleontological resources. Mineral resources are rock deposits of industrial or commercial value, such as aggregate used in construction. Paleontological resources are the fossilized remains or traces of plant and animal life, or other organisms, which offer insight into the history of life on Earth. They document the presence and evolutionary history of now-extinct organisms, expand knowledge of the life cycle of those organisms, and help in understanding the evolutionary history of the environment and geographic region in which those organisms lived.

Finally, this section evaluates the presence of economically valuable resources and the likelihood of their loss due to project construction or operation.

In addition, the following technical reports and appendices provide more detailed information:

- The *Palmdale to Burbank Project Section Geology, Soils, and Seismicity Technical Report* (California High-Speed Rail Authority [Authority] 2019a) provides detailed geologic, soils, and seismic information.
- The *Palmdale to Burbank Project Section Paleontological Resources Technical Report* (Authority 2019b) provides detailed information on paleontological resources.
- Appendix 2-E, Impact Avoidance and Minimization Features (IAMF), lists IAMFs incorporated into the project.
- Appendix 2-H, Regional and Local Policy Consistency Analysis, provides a Regional and Local Policy Consistency Table, which lists the geology, soils, seismicity, and paleontology goals and policies applicable to the Palmdale to Burbank Project Section and indicates the Build Alternatives' consistency or inconsistency with each.
- Appendix 3.1-B, United States Forest Service (USFS) Policy Consistency Analysis, assesses the consistency of the Palmdale to Burbank Project Section with applicable laws, regulations, plans, and policies governing proposed uses and activities within the Angeles National Forest (ANF) and the San Gabriel Mountains National Monument (SGMNM).

During stakeholder outreach efforts, commenters expressed concern about the following issues pertaining to geology, soils, seismicity, and paleontology:

- Risk of seismic activities and potential for construction activities to trigger earthquakes (seismic hazards addressed in Section 3.9.5)[1]
- Tunnel stability in mountainous areas near active fault zones and routes crossing several active fault zones (seismic hazards addressed in Section 3.9.5.5; refer to Section 3.11, Safety and Security, for a discussion of seismic safety)
- Soil compaction and subsidence (subsidence addressed in Section 3.9.5.4)
- Storage, transport, and disposal of fill material from tunnel construction (refer to Section 3.6, Hazards and Hazardous Materials, for an analysis of tunnel spoils off-haul and disposal)
- Disturbed soils during construction releasing fungal spores that lead to Valley fever (refer to Chapter 3.11, Safety and Security, for a discussion of Valley fever)

Spoils

Spoils are rock and dirt generated from construction-period earthwork and tunneling activities.

3.9.2 Laws, Regulations, and Orders

3.9.2.1 Federal

Federal Railroad Administration, Procedures for Considering Environmental Impacts (64 Federal Register 28545)

These Federal Railroad Administration (FRA) procedures state that an environmental impact statement should consider possible impacts on energy and mineral resources.

American Antiquities Act of 1906 (16 United Stated Code [U.S.C.] 431–433)

The American Antiquities Act protects cultural resources in the United States by prohibiting appropriation, excavation, injury, or destruction of “any historic or prehistoric ruin or monument, or any object of antiquity” located on lands owned or controlled by the federal government. The act also establishes penalties for such actions and sets forth a permit requirement for collection of antiquities on federally owned lands. Neither the American Antiquities Act itself nor its implementing regulations (Title 43, Code of Federal Regulations, Part 3) specifically mention paleontological resources. The Act also provides the authority for the creation of national monuments, which afford additional protection for natural, cultural, and scientific features, among other things.

However, many federal agencies have interpreted objects of antiquity as including fossils. Consequently, the American Antiquities Act represents an early cornerstone for efforts to protect the nation’s paleontological resources.

Paleontological Resources Preservation Act (16 U.S.C. 470)

Enacted as part of the Omnibus Public Land Management Act (2009), the Paleontological Resources Preservation Act requires the Secretaries of the Interior and Agriculture to manage and protect paleontological resources on federal land using scientific principles and expertise. The Paleontological Resources Preservation Act includes specific provisions addressing management of these resources by the Bureau of Land Management, the National Park Service, the Bureau of Reclamation, the U.S. Fish and Wildlife Service, and the USFS. The Paleontological Resources Preservation Act affirms the authority for many of the policies the federal land managing agencies already have in place for the management of paleontological

[1] Although excavation and tunneling activities associated with HSR construction would occur in a seismically active region, these construction activities would not be capable of triggering tectonic displacement that would result in an earthquake. Earthquakes in California originate through the release of stress deep in the earth (approximately 6 to 15 kilometers below ground). Stress release displacement radiates out from that origin (i.e., hypocenter) along an active fault plane. Tunnel construction activities are far too shallow (less than 1 kilometer) and take place in too small of an area to influence or trigger tectonic displacement as deep as typical hypocenters in California (CGS 2015).

resources, such as issuing permits for collecting paleontological resources, curation of paleontological resources, and confidentiality of locality data.

Materials Act

The Materials Acts provides for the disposal of mining materials from public lands of the United States. Under this Act, some common minerals, such as sand and gravel, are subject to sale.

United States Forest Service Authorities

Geology, soils, seismicity, and paleontology within the ANF including the SGMNM, is guided by several federal laws and their implementing regulations, as well as policies, plans, and orders. The primary laws governing geology, soils, seismicity, and paleontology are the Federal Land Policy and Management Act, the National Forest Management Act, and the Antiquities Act of 1906. Appendix 3.1-B provides an analysis of the consistency of the six Build Alternatives with these laws, regulations, policies, plans, and orders.

3.9.2.2 State

Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code [Cal. Public Res. Code], Sections 2621 et seq.)

This act provides policies and criteria to assist cities, counties, and State of California agencies in the exercise of their responsibilities to prohibit the location of developments and structures for human occupancy across the trace of active faults. The act also requires site-specific studies by licensed professionals for some types of proposed construction within delineated earthquake fault zones.

Seismic Hazards Mapping Act (Cal. Public Res. Code, Sections 2690–2699.6)

This act requires that site-specific hazards investigations be conducted by licensed professionals within the zones of required investigation. The licensed professionals will identify and evaluate seismic hazards and formulate mitigation measures prior to permitting most developments designed for human occupancy.

Surface Mining and Reclamation Act (Cal. Public Res. Code, Sections 2710 et seq.)

The Surface Mining and Reclamation Act was enacted to ensure a continual supply of mineral resources while minimizing the adverse impacts of surface mining on public health, property, and the environment. The act also assigns specific responsibilities to local jurisdictions for permitting and oversight of mineral resources extraction activities and establishes policies for the reclamation of mined lands.[2]

The Surface Mining and Reclamation Act also requires the State Geologist to prepare a geological inventory of select mineral commodities and assign appropriate mineral resource zones (MRZ) as described below:

- MRZ-1—Adequate information indicates that no significant mineral deposits are present or likely to be present
- MRZ-2—Adequate information indicates that significant mineral deposits are present or likely to be present
- MRZ-3—Significance of mineral deposits cannot be determined from the available data
- MRZ-4—Insufficient data exists to assign any other MRZ classification

Upon completion of the inventory report, the State Mining and Geology Board may designate deposits that are of regional or statewide significance. The purpose of such designations is to

[2] This should not be confused with the Surface Mining Control and Reclamation Act of 1977, which regulates environmental effects from coal mining.

identify deposits that are potentially available from a land use perspective and are of prime importance in meeting future needs of the region.

California Code of Regulations (CCR) Department of Industrial Relations, Chapter 4 Division of Industrial Safety, Subchapter 20, Articles 1-15

The CCR has specific orders requiring enforcement during construction of tunnels related to the safety of workers and protection of the project environment. These orders are related to tunnel classifications (i.e., presence of gas), safety precautions, protective equipment, emergency plan and precaution, rescue procedures, ventilation and air quality, and ground control (i.e., subsidence).

California Building Standards Code (Cal. Public Res. Code, Title 24)

The California Building Standards Code governs the design and construction of buildings, associated facilities, and equipment. It applies to buildings in California.

Oil and Gas Conservation (Cal. Public Res. Code, Sections 3000–3473)

The Division of Oil Gas and Geothermal Resources within the Department of Conservation oversees the drilling, operations, maintenance, and plugging and abandonment of oil, natural gas, and geothermal wells. The division's regulatory program emphasizes the wise development of oil, natural gas, and geothermal resources in the state through sound engineering practices that protect the environment, prevent pollution, and ensure public safety.

California Environmental Quality Act (Cal. Public Res. Code, Sections 21000 et seq.) and CEQA Guidelines Protection for Paleontological Resources

The California Environmental Quality Act (CEQA) statute includes "objects of historic … significance" in its definition of the environment PRC Section 21060.5, and Section 15064.5 of the State CEQA Guidelines further states that a resource is "historically significant" if the resource meets the criteria for listing on the California Register of Historical Resources (Pub. Res. Code § 5024.1, Title 14 CCR, Section 4852) including the criteria that the resource has "yielded, or may be likely to yield, information important in prehistory or history." This has been widely interpreted as extending CEQA consideration to paleontological resources, although neither the CEQA statute nor the CEQA Guidelines provide explicit direction regarding the treatment of paleontological resources.

California Public Resources Code

The Cal. Public Resources Code protects paleontological resources in specific contexts. In particular, Cal. Public Res. Code Section 5097.5 prohibits "knowing and willful" excavation, removal, destruction, injury, and defacement of any paleontological feature on public lands without express authorization from the agency with jurisdiction. Violation of this prohibition is a misdemeanor and is subject to fine and/or imprisonment (Cal. Public Res. Code § 5097.5(c)), and persons convicted of such a violation may be required to provide restitution (Cal. Public Res. Code § 5097.5(d)(1)). Additionally, Cal. Public Res. Code Section 30244 requires "reasonable mitigation measures" to address impacts on paleontological resources identified by the State Historic Preservation Officer.

California Administrative Code (California Code of Regulations, Title Sections 4307–4309)

The sections of the California Administrative Code relating to the State Division of Beaches and Parks afford protection to geologic features and "paleontological materials," but also assigns the director of the state park system the authority to issue permits for activities that may result in damage to such resources, if the activities are for state park purposes and are in the interest of the state park system.

Geologic Hazard Abatement Districts (Cal. Public Res. Code, Division 17, Sections 26500–26654)

The Beverly Act of 1979 (Senate Bill 1195) established Geologic Hazard Abatement Districts (GHAD) and allowed local residents to collectively mitigate geological hazards that pose a threat to their properties. GHADs may be formed for the following purposes: prevention, mitigation, abatement, or control of a geologic hazard; and mitigation or abatement of structural hazards that are partly or wholly caused by geologic hazards. Cal. Public Res. Code defines a geologic hazard as "an actual or threatened landslide, land subsidence, soil erosion, earthquake, fault movement, or any other natural or unnatural movement of land or earth."

3.9.2.3 Regional and Local

Table 3.9-1 provides an overview of the regional and local planning documents that include goals and objectives related to geology, soils, seismicity, mineral resources, and paleontological resources.

Table 3.9-1 Local Plans and Policies

Jurisdiction	Relevant Policy Documents
Los Angeles County	▪ *Los Angeles County General Plan 2035* (2015) ▪ *Antelope Valley Area Plan* (*2015*) ▪ *Santa Clarita Valley Area Plan* (*2012*) ▪ Los Angeles County Code of Ordinances, Title 26
City of Palmdale	▪ *Palmdale General Plan* (1993) ▪ Palmdale Municipal Code
City of Los Angeles	▪ *City of Los Angeles General Plan (2001)* ▪ Los Angeles Municipal Code
City of Burbank	▪ *Burbank 2035 General Plan* (2013) ▪ Burbank Municipal Code

Source: Los Angeles County, 2012, 2015; City of Palmdale 1993; City of Los Angeles, 2001; City of Burbank, 2013

3.9.3 Consistency with Plans and Laws

As indicated in Section 3.1.4.3, Consistency with Plans and Laws, the California Environmental Quality Act (CEQA) and the Council on Environmental Quality (CEQ) regulations require a discussion of inconsistencies or conflicts between a proposed undertaking and federal, state, regional, or local plans and laws. As such, this Draft EIR/EIS evaluates inconsistencies between the six Build Alternatives and federal, state, regional, and local plans, and laws to provide planning context.

The Authority, as the lead state and federal agency proposing to construct and operate the California HSR System, is required to comply with all federal and state laws and regulations and to secure all applicable federal and state permits prior to initiating construction on the selected Build Alternative. Therefore, there would be no inconsistencies between the six Build Alternatives and these federal and state laws and regulations.

The Authority is a state agency and therefore is not required to comply with local land use and zoning regulations; however, it has endeavored to design and construct the HSR project so that it is consistent with land use and zoning regulations. For example, the proposed Build Alternatives would incorporate IAMFs that require the contractor to prepare a construction management plan (CMP) to demonstrate how construction impacts will be maintained below applicable standards. The Authority has also adopted statewide policies that seek to reduce impacts associated with new sources of geologic, soil, seismicity, and paleontological resources.

Appendix 2-H provides a Regional and Local Policy Consistency Table, which lists the geology, soils, seismicity, and paleontological goals and policies applicable to the Palmdale to Burbank Project Section and notes the Build Alternatives' consistency or inconsistency with each. The Authority reviewed six plans and 24 policies. All six Build Alternatives are consistent with 20 policies, potentially inconsistent with one policy, and inconsistent with three policies. Policies for which each of the six Build Alternatives are inconsistent or potentially inconsistent are discussed below:

- **Los Angeles County General Plan Policy C/NR, 10.1**—Protect MRZ-2s and access to MRZ-2s from development and discourage inconsistent adjacent land uses.

  The Build Alternative footprint for each of the six Build Alternatives would overlie MRZ-2 areas (defined in Section 3.9.2.2), which would reduce access but could also permanently limit mineral resources recovery in these areas. However, the MRZ-2 affected by each of the Build Alternatives would be minimal, as discussed in Section 3.9.6.3.

- **Los Angeles County General Plan Policy C/NR, 10.5**—Manage mineral resources in a manner that effectively plans for access to, and development and conservation of, mineral resources for existing and future generations.

  Each of the six Build Alternative footprints would overlie MRZ-2 and MRZ-3 areas (defined in Section 3.9.2.2), which could reduce access to mineral resources recovery in these areas. Where the project would result in inconsistent land uses with existing mining facilities, this analysis assumes that mines would be closed, and the Authority would compensate lease owners for potential losses of available mineral resources. Continued access to existing mineral operations and MRZs would be evaluated on a case-by-case basis in coordination with the property owner.

- **Los Angeles County Department of Regional Planning Antelope Valley Area Plan; Town & Country Policy PS 2.3**—Prohibit construction of new structures on or across a fault trace.

  All six Build Alternative alignments would cross fault traces. However, there is no feasible routing between Palmdale and Burbank that does not cross one or more identified faults. Fault rupture, ground shaking, and other seismic hazards would be considered and addressed during project design and engineering to ensure safe HSR construction and operations under the anticipated seismic conditions. Additionally, the project would not create structures for permanent human occupancy on or across fault traces.

Despite the inconsistencies, the project is still consistent with the majority of regional and local policies and plans. Although it may not be possible to meet all local standards as outlined in Appendix 2-H, IAMFs and mitigation measures would generally minimize geologic, soil, seismicity, and paleontological impacts and would ultimately meet the overall objectives of the local policies.

3.9.4 Methods for Evaluating Impacts

The evaluation of impacts on geology, soils, seismicity, and paleontological resources is a requirement of the National Environmental Policy Act (NEPA) and CEQA. The following sections summarize the resource study areas (RSA) and the methods used to analyze geology, soils, seismicity, and paleontological resources.

3.9.4.1 Definition of Resource Study Areas

As defined in Section 3.1, Introduction, RSAs are the geographic boundaries in which the environmental investigations specific to each resource topic were conducted. The RSA is the area in which environmental investigations are conducted to determine the resource characteristics and impacts related to the Palmdale to Burbank Project Section. This includes the construction area of disturbance and footprint required for operations of alignments, stations, ancillary facilities, and roadway modification. Table 3.9-2 lists the RSAs employed in this section for geology, soils, seismicity, and paleontological resources.

Table 3.9-2 Geology, Soils, Seismicity, and Paleontological Resource Study Areas

Geology, Soils, Seismicity, and Paleontological Resources		Resource Study Area Boundaries
Geology, Soils, and Seismicity		
Geology, including physiography and the general geologic setting		Los Angeles County
Geologic Units[1]		150 feet of the Build Alternative footprint
Geologic Hazards		150 feet of the Build Alternative footprint
Soil Hazards		The Build Alternative footprint
Mineral and Energy Resources		2-mile buffer from station sites, 0.5-mile buffer from Build Alternative footprint
Primary Seismic Hazards		Los Angeles County
Secondary Seismic Hazards	Secondary seismic/geologic hazards, including liquefaction, lateral spreading, ground lurching, and seismically induced landslides	150 feet of the Build Alternative footprint
	Inundation, including seiche, tsunami, and dam failure/inundation	2-mile buffer from station sites, 0.5-mile buffer from Build Alternative footprint[2]
Paleontology		
Paleontological Resources		150 feet of the Build Alternative footprint

Source: Authority, 2019a, 2019b

[1] *Geologic unit* is a general term for a grouping of rocks or unlithified (i.e., not converted to stone) sediment of the same relative age with distinct lithologic characteristics.

[2] This analysis examined areas subject to inundation within the buffer area indicated above. However, this analysis also examined potential sources of flood waters throughout the entirety of Los Angeles County.

The geology, soils, seismicity, and paleontology RSAs are based on the Palmdale, Central, Burbank, and Maintenance Facility subsections (described in Chapter 2, Alternatives). Information on the Palmdale Subsection and Maintenance Facility is provided in this section for context; however, effects regarding geological, soils, seismicity, and paleontological resources for the Palmdale Subsection and Maintenance Facility are discussed in the Bakersfield to Palmdale Project Section EIR/EIS.

This method of RSA delineation could result in double counting of resources near the termini of two adjacent subsections. For example, the number of mining facilities within 0.5 mile of the Maintenance Facility RSAs and the Palmdale Subsection RSAs could be overestimated because some individual mining facilities could be located within both RSAs. Resource quantifications provided in this section (e.g., Table 3.9-6) calculate geology, soils, seismicity, mineral resources, and paleontological resources only within the Palmdale, Central, and Maintenance Facility subsections). Available data allowed for quantification of resources within the majority of the RSAs and was sufficient to compare the environmental impacts of the Build Alternatives.

3.9.4.2 Impact Avoidance and Minimization Features

IAMFs are project features the Authority has incorporated into each of the six Build Alternatives for purposes of the environmental impact analysis. The full text of the IAMFs that are applicable to the Palmdale to Burbank Project Section is provided in Volume 2, Appendix 2-E, Impact Avoidance and Minimization Features.

The following IAMFs were incorporated into the geology, soils, seismicity, and paleontological analysis:

- **GEO-IAMF#1**: Geologic Hazards—This IAMF describes the Authority's commitment to coordinating with the contractor who shall prepare a CMP addressing how the contractor will address geologic constraints and minimize or avoid impacts on geologic hazards during construction. The CMP will address constraints and resources, including groundwater withdrawal, unstable soils, subsidence, water and wind erosion, shrink-swell potential, and corrosive potential.

- **GEO-IAMF#2**: Slope Monitoring—This IAMF describes the Authority's commitment to incorporating slope monitoring by a Registered Engineering Geologist into the operation and maintenance procedures, during operation and maintenance.
- **GEO-IAMF#3**: Gas Monitoring—This IAMF describes the Authority's commitment to coordinating with the contractor who shall prepare a CMP addressing how gas monitoring would be incorporated into construction best management practices, prior to construction.
- **GEO-IAMF#4**: Historic or Abandoned Mines—This IAMF describes the Authority's commitment to coordinating with the contractor who shall prepare a CMP addressing how historic and abandoned mines would be incorporated into construction best management practices, prior to construction.
- **GEO-IAMF#5**: Hazardous Minerals—This IAMF describes the Authority's commitment to coordinating with the contractor preparing a CMP, prior to construction. The contractor shall prepare a CMP addressing how the contractor will minimize or avoid impacts related to hazardous minerals (i.e., radon, mercury, and naturally occurring asbestos) during construction.
- **GEO-IAMF#6**: Ground Rupture Early Warning Systems—This IAMF describes the Authority's commitment to coordinating with the contractor, prior to construction, to document how the design of the selected Preferred Alternative incorporates installation of early warning systems, triggered by strong ground motion associated with ground rupture.
- **GEO-IAMF#7**: Evaluate and Design for Large Seismic Ground Shaking—This IAMF describes the Authority's commitment to coordinating with the contractor, prior to construction, to document through preparation of a technical memorandum how all HSR components were evaluated and designed for large seismic ground shaking.
- **GEO-IAMF#8**: Suspension of Operations During an Earthquake—This IAMF describes the Authority's commitment to coordinating with the contractor, prior to operation and maintenance activities, to document in a technical memorandum how suspension of operations during or after an earthquake was addressed in the design of the selected Preferred Alternative.
- **GEO-IAMF#9**: Subsidence Monitoring—This IAMF describes the Authority's commitment to develop a stringent track monitoring program. Track inspection systems would provide early warning of reduced track integrity, prior to operation and maintenance of the HSR system.
- **GEO-IAMF#10**: Geology and Soils—This IAMF describes the Authority's commitment to coordinating with the contractor to document through issuance of a technical memorandum how the following guidelines and standards have been incorporated into facility design and construction: 2015 American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Bridge Design Specifications and the 2015 AASHTO Guide Specifications for Load and Resistance Factor Seismic Bridge Design, or their most recent versions, prior to construction.
- **GEO-IAMF#11**: Engage a Qualified Paleontological Resources Specialist—This IAMF describes the Authority's commitment to creating a 90 percent design milestone for each construction package[3] (CP) within the Palmdale to Burbank Project Section, the contractor

[3] Because of their length and complexity, most California HSR project sections are expected to be designed and constructed in segments, with separate construction documents (plans and specifications) developed for each segment. *Construction package* refers to a portion (segment) of a project section for which a discrete, stand-alone construction document set will be developed.

will retain a paleontological resources specialist (PRS) responsible for reviewing the final design for the CP, developing a detailed Paleontological Resources Monitoring and Mitigation Plan (PRMMP) for the CP, and the PRS will be responsible for implementing the PRMMP, including development and delivery of Worker Environmental Awareness Program (WEAP) Training, supervision of Paleontological Resource Monitors (PRMs), evaluation and treatment of finds, if any, and preparation of a final paleontological mitigation report, per the PRMMP and for each CP.

- **GEO-IAMF#12**: Perform Final Design Review and Triggers Evaluation—This IAMF describes the Authority's commitment for each CP within the Palmdale to Burbank Project Section, the responsible PRS will evaluate the 90 percent design submittal to identify the portions of the CP that will involve work in paleontologically sensitive geologic units (either at the surface or in the subsurface), based on findings of the final Paleontological Resources Technical Report prepared for the Palmdale to Burbank Project Section.
- **GEO-IAMF#13**: Prepare and Implement Paleontological Resources Monitoring and Mitigation Plan—This IAMF describes the Authority's commitment to following the Final Design Review and Triggers Evaluation developed by the PRS for each CP.
- **GEO-IAMF#14:** Provide Worker Environmental Awareness Program Training for Paleontological Resources—This IAMF describes the Authority's commitment to coordinate with the contractor to provide paleontological resources WEAP training delivered by the PRS, prior to groundbreaking for each CP within the Palmdale to Burbank Project Section.
- **GEO-IAMF#15:** Halt Construction, Evaluate, and Treat if Paleontological Resources Are Found—This IAMF describes the Authority's commitment to be consistent with the PRMMP, if fossil materials are discovered during construction; regardless of the individual making the discovery, all activity in the immediate vicinity of the discovery would halt and the find would be protected from further disturbance.

This environmental impact analysis considers these IAMFs as part of the project design. Within Section 3.9.6, Environmental Consequences, each impact narrative describes how these project features are applicable and, where appropriate, effective at avoiding or minimizing impacts.

3.9.4.3 Methods for NEPA and CEQA Impact Analysis

Overview of Impact Analysis

This section describes the sources and methods the Authority used to analyze impacts on geology, soil, seismicity, and paleontological resources. These methods apply to both NEPA and CEQA analyses unless otherwise indicated. Refer to Section 3.1.4.4, Methods for Evaluating Impacts, for a description of the general framework for evaluating impacts under NEPA and CEQA.

Refer to the *Palmdale to Burbank Project Section Geology, Soils, and Seismicity Technical Report* (Authority 2019a) and the *Palmdale to Burbank Project Section Paleontological Resources Technical Report* (Authority 2019b) for more information regarding the methods and data sources used in this analysis. Section 3.9.9 discusses CEQA impact findings, and Section 3.9.8 discusses effects in terms of context and intensity under NEPA. This evaluation of impacts on geology, soils, seismicity, minerals, and paleontological resources and hazards also considered applicable laws, regulations, and orders listed in Section 3.9.2, Laws, Regulations, and Orders.

Geology, Soils, Seismicity Methodology

The methodology used to describe the affected environment and evaluate environmental impacts related to geology, soils, and seismicity involved a review of the sources listed below. These data sources were used to quantify baseline geologic, soil, and seismic conditions throughout the geology, soils, and seismicity RSAs:

- United States Geological Survey (USGS)—Topographic maps
- USGS and California Geological Survey (CGS)—Geologic and landslide maps
- United States Department of Agriculture, Natural Resources Conservation Service—Soils maps
- CGS—Seismic hazard zone maps
- USGS and CGS—Active fault maps
- USGS and CGS—Ground shaking maps
- California Emergency Management Agency—Dam inundation maps
- USGS and State of California—Mineral commodity producer databases
- California Department of Conservation, Division of Oil, Gas, and Geothermal Resources—Online databases for mineral resources, fossil fuels, and geothermal resources
- California Department of Conservation, Office of Mine Reclamation—List of active quarries

These maps, publications, reports, and geographic information system data were used to establish the baseline for analysis and to describe existing geologic conditions (e.g., geologic setting, faults, mineral resources, fossil fuel/energy resources) and risks (e.g., primary and secondary seismic hazards, unstable slopes) relevant to the Palmdale to Burbank Project Section. Section 3.9.5 summarizes these geologic, soils, and seismic hazards and resources within the geology, soils, and seismicity RSAs, for all six Build Alternatives and the No Project Alternative. Although the E2A Build Alternative alignment would traverse different areas than the E2 Build Alternative alignment south of East Avenue S and north of Vincent Substation, E2A paleontological RSA would not substantially differ from that of the E2 Build Alternative.

Environmental Consequences

Environmental Consequences considers direct and indirect impacts related to geology, soils, seismicity, and mineral and fossil fuel resources associated with construction and operations of the HSR system. This evaluation includes quantitative and qualitative discussions of existing resource conditions, resource sensitivity, and extent/duration of proposed changes resulting from project implementation. Impacts are evaluated using professional judgment in accordance with current geotechnical engineering and engineering geology standards.

This analysis uses published information on known resources and hazards within the geology, soils, and seismicity RSAs to provide a high-level comparison of all six Build Alternatives. The available information is sufficient to analyze geologic, soil, seismic, and mineral resources impacts associated with the Build Alternatives. Site-specific field investigations will be completed during final design to further assess the specific characterization of geological resources and hazardous conditions in the geology, soils, and seismicity RSAs. During final design, the Authority would conduct geotechnical investigations that focus on defining precise geology, groundwater, seismic, and environmental conditions along the Preferred Alternative. Those investigations would provide a detailed assessment of soil and geologic hazards within the Preferred Alternative footprint to inform the final design and construction methods for trackway, structures, and ancillary facilities.

Geotechnical Investigations

In 2016, the Authority conducted a preliminary geotechnical investigation within the ANF including SGMNM to collect data pertinent to evaluating tunnel feasibility and subsurface conditions within the ANF including SGMNM. Key parameters included water pressure, hydraulic conductivity, potential water flow, ground conditions at significant fault zones, and ground temperature. Test bores at six exploration sites investigated in-situ rock conditions, fault crossings, and measured groundwater pressures and hydraulic conductivities. Depths of the test bores ranged from 506 to 2,703 feet below ground surface. Information from the test borings helps evaluate potentially challenging conditions for subsurface construction beneath the ANF including SGMNM by providing data on in-situ rock stresses and adverse geology including faults, gouge zones, and squeezing ground.

These field investigations were not conducted to investigate specific tunnel alignment, but rather to identify and evaluate field conditions within the ANF including SGMNM that could present feasibility constraints for tunnel design and construction.[4] Data yielded from the preliminary geotechnical investigations were used to evaluate hydrogeological impacts that could result from project construction or operations (see Section 3.8, Hydrology and Water Resources).

In-situ Stresses, Squeezing Ground, and Gouge Zones

In-situ stresses are developed due to the weight of overlying materials as well as confinement and past stress history at a point below the rock surface of the undisturbed rock mass.

Squeezing ground refers to weak material, generally clayed, that behaves plastically under the weight of overlying ground and has been squeezed into an excavation as a result of overstressing.

Gouge zones are areas of crushed and ground-up rock produced by friction between the two sides when a fault moves.

Recognizing the history of challenging tunnel design and construction in the region, the most challenging constraints with strong potential for influencing tunnel feasibility include the following:

- Rock quality and effects of squeezing ground
- In-situ stresses
- Intersections with faults and gouge zones
- Groundwater pressures on the tunnel lining system
- Potential for water leaking into the tunnel both during and after construction
- Impacts on USFS water resources due to tunneling activities

Paleontological Resources Methodology

Paleontological resources include fossils, which are the remains, imprints, or traces of once-living organisms preserved in geologic units that underlie the soil layer. Regional geology, stratigraphy, and previously recorded fossil localities are key resources for determining the potential to encounter paleontological resources within the paleontological RSA. To ascertain whether the paleontological RSA has the potential to contain significant paleontological resources, the *Palmdale to Burbank Project Section Paleontological Resources Technical Report* (Authority 2019b) included the following:

- **Geologic Map Review**—Because fossil materials often exist below ground, paleontological investigations must consider both surface and subsurface geologic units. The geologic map review included geologic cross-sections to determine geology and stratigraphy within the paleontological RSA.
- **Literature Review**—The paleontological investigations for the project reviewed scientific literature and regional environmental documents to determine the geological and paleontological context of the RSA.
- **Records Searches**—The paleontological records search reviewed online resources and museum repositories to locate previously uncovered fossils and assess the paleontological sensitivity of geologic units within the paleontological RSA.
- **Field Surveys**—Field surveys conducted in September 2009, September 2010, and April 2016 included a review of aerial photographs to locate areas of native sediment, pedestrian inspection of outcrops and available exposures within each of the accessible public land portions, and visual inspection of private land from public vantage points. Visual

[4] Refer to the *Palmdale to Burbank Project Section Preliminary Geotechnical Data Report for Tunnel Feasibility, Angeles National Forest* (Authority 2017a) and the *Geotechnical Tunnel Feasibility Evaluation for High Speed Rail Tunnels Beneath the Angeles National Forest* (Authority 2017b) for the results of this preliminary geotechnical investigation.

inspection from the public right-of-way was necessary where permission to access private property was not available.

Paleontological resource analyses predict the likelihood that the paleontological RSA might contain significant fossil resources and assess the risk to those resources during construction and operations. This process entails the following:

- Identify geologic units within the paleontological RSA, including surface-exposed units and subsurface units.
- Evaluate the potential for identified geologic units to contain significant fossils (i.e., their paleontological potential or paleontological sensitivity (defined below).
- Assess the nature and extent of ground-disturbing activities predicted throughout project construction and operations, including site preparation, excavation, grading, tunneling, and foundation drilling.
- Evaluate impact significance. Impact significance typically reflects damage or loss of significant fossils that provide taxonomic, taphonomic, phylogenetic, stratigraphic, ecologic, or climatic information. Significant fossils could include body fossils, traces, tracks, and trackways. In California, vertebrate fossils would be significant because of their comparative rarity and their informational potential. Invertebrate fossils, plant fossils, and microfossils could also be scientifically important and therefore significant.

Taphonomy, Phylogenetic, and Stratigraphy

Taphonomy is a branch of paleontology that deals with the processes of fossilization.

Phylogenetic relates to the evolutionary development and diversification of a species or group of organisms, or of a particular feature of an organism.

Stratigraphy is a branch of geology concerned with the study of rock layers (strata) and layering (stratification). It is primarily used in the study of sedimentary and layered volcanic rocks.

Paleontological Sensitivity Criteria

To identify geologic units with the potential to contain significant fossil resources (i.e., their paleontological sensitivity), the Authority adopted the guidelines established in the California Department of Transportation (Caltrans) Standard Environmental Reference, Chapter 8, Paleontology (Caltrans 2014), as follows:

- **High Potential**—Rock units that, based on previous studies, contain or are likely to contain significant vertebrate, significant invertebrate, or significant plant fossils. These units include, but are not limited to, sedimentary formations that contain significant nonrenewable paleontological resources anywhere within their geographical extent, and sedimentary rock units suitable for the preservation of fossils. These units could also include some volcanic and low-grade metamorphic rock units. Fossiliferous deposits with very limited geographic extent or an uncommon origin (e.g., tar pits and caves) would be highly sensitive. High sensitivity includes the potential for containing:
  - Abundant vertebrate fossils
  - A few significant fossils (large or small vertebrate, invertebrate, or plant fossils) that may provide new and significant taxonomic, phylogenetic, ecologic, and/or stratigraphic data
  - Areas that may contain datable organic remains older than Recent (i.e., older than the middle to late Holocene Epoch; older than 5,000 years)
  - Areas that may contain unique new vertebrate deposits, traces, and/or trackways
  - Areas with a high potential for containing significant paleontological resources require monitoring and mitigation.

- **Low Potential**—This category includes sedimentary rock units that:
  - Are potentially fossiliferous (and may have produced nonsignificant fossils in the past), but have not yielded significant fossils in the past
  - Have not yet yielded (either significant or nonsignificant) fossils, but possess a potential for containing fossil remains
  - Contain common and/or widespread invertebrate fossils if the taxonomy, phylogeny, and ecology of the species contained in the rock are well understood

  Although rock units designated as low potential generally would not require monitoring and mitigation, excavation may encounter new and unanticipated paleontological resources. If this occurs, a qualified Principal Paleontologist must evaluate the resource. If the resource is determined to be significant, monitoring and mitigation is required.
- **No Potential**—Rock units of intrusive igneous origin, most extrusive igneous rocks, and moderately to highly metamorphosed rocks would have no potential to contain significant paleontological resources.

  Areas with no potential for containing significant paleontological resources do not require monitoring and mitigation.

3.9.4.4 Methods for Evaluating Impacts under NEPA

CEQ NEPA regulations (40 *Code of Federal Regulations* Parts 1500–1508) provide the basis for evaluating project effects (Section 3.1.4.4). As described in Section 1508.27 of these regulations, the criteria of context and intensity are considered together when determining the severity of the change introduced by the Palmdale to Burbank Project Section. “Context” is defined as the affected environment in which a proposed project occurs. “Intensity” refers to the severity of the effect, which is examined in terms of the type, quality, and sensitivity of the resource involved, location and extent of the effect, duration of the effect (short- or long-term); and other considerations of context. Beneficial effects are also considered. When no measurable effect exists, no impact is found to occur. For the purposes of NEPA compliance, the same methods used to identify and evaluate impacts under CEQA are applied here.

3.9.4.5 Method for Determining Significance under CEQA

The Authority is using the following thresholds to determine if a significant impact on geology, soils, seismicity, and paleontological resources would occur as a result of each of the six Build Alternatives.[5] A significant impact is one that would:

- Directly or indirectly cause substantial adverse effects, including the risk of loss, injury, or death involving:
  - 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 [CGS 1997]);
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - Landslides;
- Result in substantial soil erosion or the loss of topsoil;

[5] In general, impacts on a project or its users caused by existing environmental conditions or hazards are not considered environmental impacts under CEQA, unless the project would risk exacerbating the existing hazard. (See *California Building Industry Assn. v. Bay Area Air Quality Management Dist.* (2015) 62 Cal.4th 369.)

- Be located on 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;
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (*International Conference of Building Officials 1994*), creating substantial direct or indirect risks to life or property;
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater; or
- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.
- Result in the loss of availability of a known mineral resource that would be of value to the region and residents of the state.
- Result in the loss of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan.

3.9.5 Affected Environment

3.9.5.1 Geologic Setting

The Palmdale to Burbank Project Section is located at the junction of two major geomorphic provinces: the Mojave Desert and the Transverse Ranges.

Mojave Desert Geomorphic Province

The Mojave Desert geomorphic province comprises broad inland expanses of high desert plains separated by isolated mountain ranges. This area contains alluvial basins resulting from uplifted rock, volcanic activity, and hydrology, which includes sedimentation associated with an extensive lake network and drainage of the ancestral Mojave River. The Mojave Desert, entirely landlocked, is at an average of 2,500 feet above mean sea level in elevation. Rivers and streams within this province do not reach the ocean, instead draining to internal lakes and playas located within closed basins.

The geology RSA and paleontological RSA are near the southern boundary of the Antelope Valley, which is a broad, relatively flat, closed basin at the western edge of the Mojave Desert geomorphic province. Typical elevations in the Antelope Valley range between 2,270 and 3,500 feet above mean sea level. The valley floor slopes gently toward playas north and east of the central part of the geomorphic province. The Garlock and San Andreas Faults bound the Antelope Valley to the northwest and southwest, respectively. The Tehachapi Mountains to the northwest and San Gabriel Mountains to the southwest align with these major fault zones,

Geomorphic Province and Alluvium

A *geomorphic province* is a region of topography and geology that is unique from neighboring regions based on its landforms and diastrophic history.

Alluvium refers to deposits of clay, silt, sand, or gravel left by flowing streams.

San Andreas Fault

The San Andreas transform fault extends roughly 800 miles up and down California, forming the tectonic boundary between the Pacific Plate and the North American Plate. This active fault is responsible for many large earthquakes in California.

Syncline and Lithology

Syncline is a trough or fold of stratified rock in which the strata slope upward from the axis.

Lithology refers to the study of the general physical characteristics of rocks.

Deposition

Deposition is the laying down of sediment carried by wind, water, or ice. Sediment can be transported as pebbles, sand, or mud, or as salts dissolved in water.

A *terrestrial deposit* is a sedimentary deposit resulting from glaciers, wind, rain wash, and streams. By comparison, marine deposits are influenced by tidal or marine systems.

enclosing much of the valley. The San Gabriel Mountains reach elevations greater than 10,000 feet above mean sea level and are the source of modern sedimentary deposits within the valley. Thicknesses of sedimentary deposits vary considerably because of widespread faulting but could reach 7,000 feet below the ground surface in the deepest parts of the valley.

The San Andreas Fault system is a significant geomorphic feature in the southern Mojave Desert geomorphic province, forming the boundary between the relatively flat floor of the Mojave Desert and the rugged terrain of the San Gabriel Mountains to the south. The San Andreas Fault is a transform fault, which is a location where two tectonic plates slide past one another. The motion of the tectonic plates sliding past one another generates friction that gradually accumulates until a sudden release in the form of seismic energy (earthquake).

Transverse Ranges Geomorphic Province

The Transverse Ranges geomorphic province is a series of steep mountain ranges that includes the San Gabriel Mountains. The Transverse Ranges display a unique east-west orientation, running perpendicularly to most north-south trending mountain ranges in California. This east-west orientation is the result of movement along the San Andreas Fault system. Active uplift and erosion in the San Gabriel Mountains have produced steep canyons, rugged topography, landslide deposits, and extensive alluvial sedimentation. The Transverse Ranges contain a range of depositional environments resulting from tectonic movement, various climatic regimes, and fluctuations in relative sea level, over a geologic timescale. These factors created both marine and terrestrial sedimentary deposits throughout the geology RSA and paleontological RSA.

San Fernando Valley

The San Fernando Valley is an alluviated lowland plain southwest of the San Gabriel Mountains. Although the San Fernando Valley is part of the Transverse Ranges geomorphic province, it has distinct geomorphology. Previous lithological and structural analyses describe the San Fernando Valley as a broad syncline belonging to the greater Los Angeles Basin, which is a structural depression that was once the site of extensive accumulation of fluvial, alluvial, floodplain, and shallow marine and deep shelf deposits. Sediment has continued to accumulate since the Late Cretaceous period, reaching a maximum thickness of more than 20,000 feet. Significant geologic features in that area include the San Fernando, Verdugo, and Benedict Canyon Faults; the Los Angeles River; and the Cretaceous granite of the Verdugo Mountains, near the city of Burbank.

3.9.5.2 Geology

Geology within Los Angeles County is exceptionally diverse and includes a complex assemblage of igneous and metamorphic rocks formed from 66 million to 2,500 million years ago; terrestrial and marine sedimentary deposits formed in the past 66 million years; and widespread active faulting. The varied conditions of the geology RSA and the paleontological RSA, which has formed over nearly 1.7 billion years, is due in part to tectonic movement, fluctuations in relative sea level, and displacement of rocks along fault zones.

Table 3.9-3 lists the geologic units underlying the geology RSA. Refer to the *Palmdale to Burbank Project Section Paleontological Resources Technical Report* (Authority 2019b) for a description of the location, lithology, stratigraphy, and paleontology related to these geologic units.

Table 3.9-3 Geologic Units Underlying the Resource Study Area

Age	Geologic Unit	Lithology	Build Alternative					
			Refined SR14	SR14A	E1	E1A	E2	E2A
Precambrian	Anorthosite-Gabbro Complex	Plutonic Igneous	X	X	X	X	X	X
Precambrian	Gneissic Rocks	Intermediate to High-grade Metamorphic	X	X	X	X	X	X
Mesozoic (or older)	Hornblende Diorite Gabbro	Plutonic Igneous	X	X	X	X	X	X
Mesozoic	Older Plutonic Rocks	Plutonic Igneous	X	X	X	X	X	X
Triassic	Lowe Granodiorite	Plutonic Igneous	X	X	X	X	X	X
Eocene	Santa Susana Formation	Marine Shale, Mudrock, Sandstone, Conglomerate	N/A	N/A	X	X	X	X
Oligocene	Vasquez Formation	Nonmarine Conglomerate, Fanglomerate	X	X	X	X	X	X
Miocene	Tick Canyon Formation	Nonmarine Siltstone, Sandstone, Conglomerate	X	X	N/A	N/A	N/A	N/A
Miocene	Topanga Formation	Marine Sandstone, Siltstone, Shale, and Volcanic	X	X	X	X	N/A	N/A
Miocene	Mint Canyon Formation	Nonmarine Sandstone, Conglomerate	X	X	N/A	N/A	N/A	N/A
Miocene	Modelo (Monterey) Formation	Marine Shale, Siltstone, Sandstone, Conglomerate	X	X	X	X	X	X
Miocene	Punchbowl Formation	Nonmarine Sandstone Conglomerate	X	X	X	X	X	X
Pliocene	Anaverde Formation	Nonmarine Sandstone, Clay Shale	X	X	X	X	X	X
Pliocene	Pico Formation	Marine Sandstone, Conglomerate	X	X	X	X	N/A	N/A

Age	Geologic Unit	Lithology	Build Alternative					
			Refined SR14	SR14A	E1	E1A	E2	E2A
Pliocene	Towsley Formation	Marine Sandstone, Siltstone	X	X	X	X	X	X
Plio-Pleistocene	Saugus Formation	Marine and Nonmarine Mudstone, Sandstone, Conglomerate	X	X	X	X	X	X
Pleistocene	Pacoima Formation	Nonmarine Conglomerate	X	X	N/A	N/A	N/A	N/A
Pleistocene	Older Quaternary Deposits	Unconsolidated Silt, Sand, Gravel	X	X	X	X	X	X
Holocene	Younger Quaternary Deposits	Unconsolidated Silt, Sand, Gravel	X	X	X	X	X	X
Late Holocene	Artificial Fill	Undefined and unconsolidated sediments derived from a variety of geologic formations	X	X	X	X	N/A	N/A

Source: Authority, 2019a
N/A = Not applicable; geologic unit is not present in the Build Alternative geologic unit RSA
RSA = resource study area
X = geologic unit is present in the Build Alternative geologic unit RSA

3.9.5.3 Geologic Hazards

Ground Subsidence

Ground subsidence results from subsurface fluid extraction, which causes the collapse and compaction of voids previously occupied by the removed fluid and results in a gradual drop in ground surface elevation. Subsidence often occurs in areas where there are large withdrawals from underground reservoirs. Most subsidence in California has resulted from excessive groundwater pumping for municipal, industrial, and agricultural uses, but oil withdrawal can also lead to subsidence (Authority 2019a). Increases in weight loads and/or improper ground compaction can also cause pore spaces in the underlying soil to collapse.

Refined SR14 Build Alternative

The northern portion of the Refined SR14 Build Alternative ground geologic hazard RSA encompasses an area of high subsidence potential through Palmdale. Refined SR14 Build Alternative trackway and ancillary facilities would be located in this subsidence-prone area. The Refined SR14 Build Alternative geologic hazard RSA encompasses other areas of high subsidence risk in drainages north of State Route (SR) 14 between the California Aqueduct and the Santa Clara River. Finally, the Refined SR14 Build Alternative geologic hazard RSA encompasses several areas of low to medium subsidence potential between the Interstate (I)-210/SR 118 interchange and the Burbank Airport Station. Outside of these areas, the Refined SR14 Build Alternative alignment encounters only areas of low or unmapped subsidence.

SR14A Build Alternative

Although the SR14A Build Alternative alignment would take a more southeasterly course through areas prone to subsidence south of Palmdale and north of the Santa Clara River, the SR14A Build Alternative geologic hazard RSA would encounter subsidence-prone areas in the same general locations as the Refined SR14 geologic hazard RSA.

E1 Build Alternative

The northern portion of the E1 Build Alternative geologic hazard RSA encompasses an area of high subsidence potential through Palmdale. The E1 Build Alternative would include underground alignment through areas of high subsidence potential near the Pearblossom Highway/SR 14 interchange. In addition, E1 tunnel portal facilities and alignment in Aliso Canyon and Arrastre Canyon would be located in areas of high subsidence potential. Outside of these areas, the E1 Build Alternative alignment encounters only areas of low or unmapped subsidence.

E1A Build Alternative

Although the E1A Build Alternative alignment would take a more easterly course through areas prone to subsidence south of Palmdale and north of Vincent Substation, the E1A Build Alternative geologic hazard RSA would encounter subsidence-prone areas in the same general locations as the E1 Build Alternative geologic hazard RSA.

E2 Build Alternative

The northern portion of the E2 geologic hazard RSA encompasses an area of high subsidence potential through Palmdale. The E2 Build Alternative would include underground alignment through areas of high subsidence potential near the Pearblossom Highway/SR 14 interchange. E2 tunnel portal facilities and alignment in Aliso Canyon and Arrastre Canyon would be located in areas of high subsidence potential. Finally, the E2 geologic hazard RSA encompasses several areas of low to medium subsidence potential between Big Tujunga Wash and the Burbank Airport Station. Outside of these areas, the E2 Build Alternative alignment encounters only areas of low or unmapped subsidence.

E2A Build Alternative

Although the E2A Build Alternative alignment would take a more easterly course through areas prone to subsidence south of Palmdale and north of Vincent Substation, the E2A Build Alternative geologic hazard RSA would encounter subsidence-prone areas in the same general location as the E2 Build Alternative ground subsidence RSA.

Karst Terrain

The term “karst” describes a landscape feature in which subsurface voids form because of the dissolution of evaporite (i.e., water soluble) rock by surface and groundwater. Karsts occur in areas with soluble rock and can result in landscapes that are composed of or underlain by features such as sinkholes, caves, unstable surfaces, or springs. The Refined SR14 Build Alternative geologic hazard RSA encompasses approximately 502 acres of karst terrain between Acton and the Santa Clara River crossing (Figure 3.9-1). The E1 and E2 geology, soils, and seismicity RSAs do not encompass karst terrain. The E1A and E2A Build Alternative geology, soils, and seismicity RSAs also do not encompass karst terrain. The SR14A Build Alternative would encounter karst terrain in the same areas as the Refined SR14 Build Alternative. However, the SR14A Build Alternative geology, soils, and seismicity RSA would encompass less karst terrain (377 acres) than the Refined SR14 Build Alternative (502 acres).

Landslides

Landslides result from the downgradient movement of earthen material along a slope or hillside. Landslides can result from a variety of causes such as steepness of slope, type of material, water content of slope soils, amount and type of vegetation, and major natural hazards such as earthquakes, volcanic eruptions, wildfires, and floods. Landslides can occur as rapid deterioration or slow, progressive movements over time. The CGS maps historic and potential landslide zones.

Landslide-prone areas are present throughout the geologic hazard RSA for all six Build Alternatives and are extremely prevalent in the San Gabriel Mountains (Figure 3.9-2).

Refined SR14 Build Alternative

The Refined SR14 Build Alternative geologic hazard RSA encompasses potential landslide hazards zones near Agua Dulce Canyon where the alignment would include underground alignment through a series of at-grade/viaduct/tunnel transitions (Figure 3.9-2). Other portions of the Refined SR14 Build Alternative would pass underground beneath landslide hazards or would be in areas that do not pose known landslide hazards. Unstable slopes could also be present within or immediately adjacent to the Build Alternative footprint, especially at portals.

SR14A Build Alternative

The SR14A Build Alternative geologic hazard RSA would encompass landslide hazards in the same primary areas as the Refined SR14 Build Alternative. Unstable slopes could also be present within or immediately adjacent to the Build Alternative footprint.

E1 Build Alternative

Surface features associated with the E1 Build Alternative would not be exposed to known landslide hazards (Figure 3.9-2), but unstable slopes could also be present within or immediately adjacent to the Build Alternative footprint at portals.

E1A Build Alternative

The E1 Build Alternative would also not be exposed to known landslide hazards, but unstable slopes could also be present within or immediately adjacent to the Build Alternative footprint, especially at portals.

E2 Build Alternative

Most surface features associated with the E2 Build Alternative would not be located near landslide hazard zones (Figure 3.9-2). The exception would be the tunnel portal directly north of Big Tujunga Wash and the Lake View Terrace neighborhood; this portal would be located on a hillside with potential landslide hazards. Unstable slopes could also be present within or immediately adjacent to the project footprint, especially at portals.

E2A Build Alternative

The landslide hazards encountered by E2A Build Alternative would be identical to those encountered by the E2 Build Alternative, especially at portals.

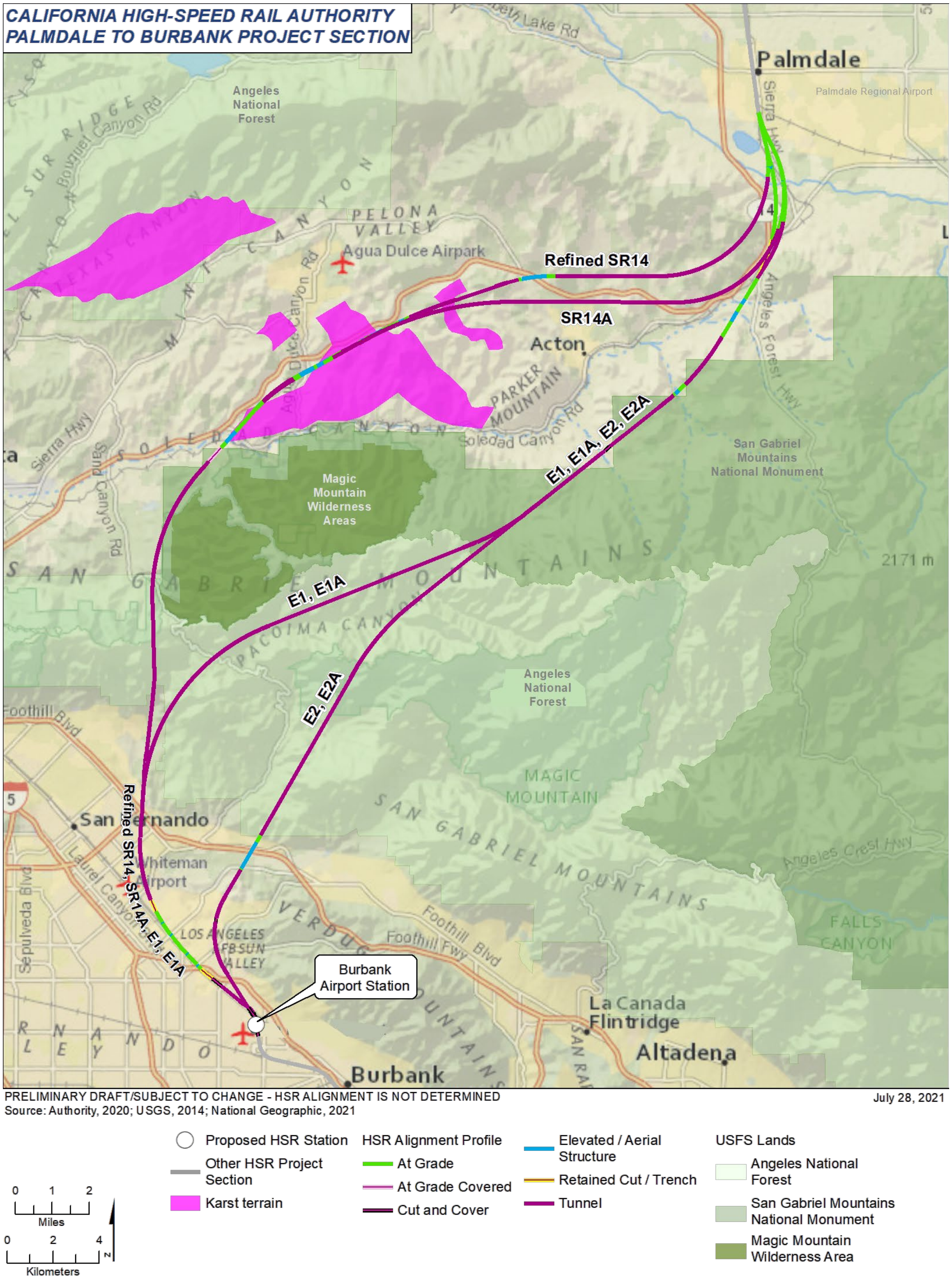

Figure 3.9-1 Known Areas of Karst Terrain

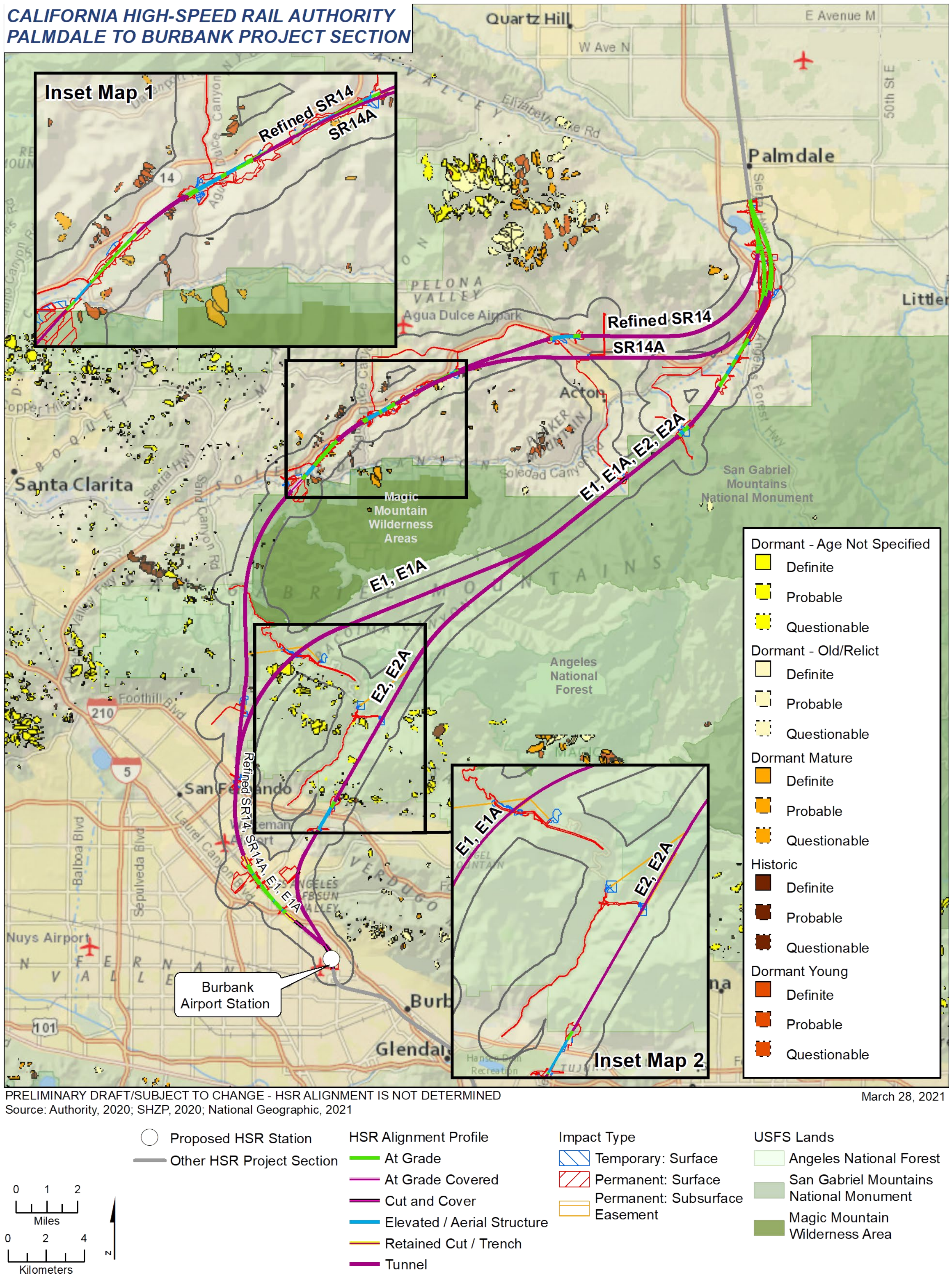

Figure 3.9-2 Landslide Hazard Areas

3.9.5.4 Soil Hazards

Soil makeup is governed by many factors, including climatic conditions (precipitation, temperature, and wind), the parent material from which the soil is derived, topographic position (e.g., slope, elevation, and aspect), geomorphic processes, and time. Extreme faulting and geologic processes have created a multitude of soil conditions throughout the soil hazard RSA. As a result, there are dozens of soil types throughout the Palmdale to Burbank Project Section region.[6] Depending on soil characteristics, topography, and climate, some soils are susceptible to hazardous qualities, as described below.

Erodible Soils

Erodible soils are susceptible to erosion from surface runoff and wind. A soil's vulnerability to erosion is quantified by a factor designated "Kw." Kw values range from 0.02 to 0.69, and soils with Kw values in excess of 0.4 are considered highly susceptible to erosion. Factors that influence erodibility include soil permeability, grain size, degree of slope, and vegetation. Medium-grained soils, such as silt, are the most susceptible to erosion because of their low permeability and low cohesion of silt-size particles. Fine-grained clay and coarse-grained sand are not as susceptible to erosion because of the cohesive nature of clay and the relatively high permeability of sand.

Refined SR14 Build Alternative

Erosion potential varies greatly throughout the Refined SR14 Build Alternative soil hazard RSA (Figure 3.9-3 through Figure 3.9-5). Scattered areas of high-erosion potential exist throughout the city of Palmdale. The Refined SR14 Build Alternative soil hazard RSA encompasses areas of high-erosion potential near Agua Dulce Canyon and Vulcan Mine. South of Vulcan Mine, the Refined SR14 Build Alternative alignment would pass underground beneath areas of significant erosion potential. Portions of the two Refined SR14 Build Alternative intermediate window options (SR14-W1 and SR14-W2) would be in areas of high-erosion potential. The SR14-A1 adit option would not be in areas with high erosion potential.

SR14A Build Alternative

Although it would avoid minor areas with high-erosion potential south of the California Aqueduct and north of the Santa Clara River, the SR14A Build Alternative soil hazard RSA would encounter such areas in the same general locations as the Refined SR14 Build Alternative soil hazard RSA.

E1 Build Alternative

Erosion potential varies greatly throughout the E1 Build Alternative soil hazard RSA (Figure 3.9-3 through Figure 3.9-5). Erosion potential ranges from moderate to high in the Palmdale area. Erosion potential would be low and moderate where the alignment would continue south toward Acton and enter the ANF including SGMNM. Soils within Aliso Canyon and Arrastre Canyon exhibit low and medium erosion potential. The two E1 Build Alternative intermediate window options north of the I-210/SR 118 interchange (E1-W2 and E1-W3) would also be located in areas of moderate erosion potential.

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[6] The primary source of information concerning soils in the soil hazard RSA is the NRCS Web Soil Survey website. This database includes inventories and assessments of many soils in Los Angeles County, including the soil hazard RSAs throughout the Antelope Valley, ANF including SGMNM, and San Fernando Valley.

E1A Build Alternative

Although it would avoid minor areas with high-erosion potential south of the California Aqueduct and north of Vincent Substation, the E1A Build Alternative soil hazard RSA would encounter such areas in the same general locations as the E1 Build Alternative soil hazard RSA.

E2 Build Alternative

Because the E1 and E2 Build Alternative alignment and surface features would be identical from Palmdale south into the ANF including SGMNM past Aliso Canyon, erosion potential through Palmdale, Acton, Aliso Canyon, and Arrastre Canyon would be the same as described above for the E1 Build Alternative (Figure 3.9-3 through Figure 3.9-5). After departing from the E1 corridor beneath the ANF, the E2 Build Alternative would exit the ANF and cross Big Tujunga Wash, where there would be high and unmapped erosion potential. The E2 Build Alternative options north of I-210 (E2-A1 and E2-A2) would be located in areas of moderate and high-erosion potential.

E2A Build Alternative

Although it would avoid minor areas with high-erosion potential south of the California Aqueduct and north of Vincent Substation, the E2A Build Alternative soil hazard RSA would encounter the same general areas as the E2 Build Alternative soil hazard RSA.

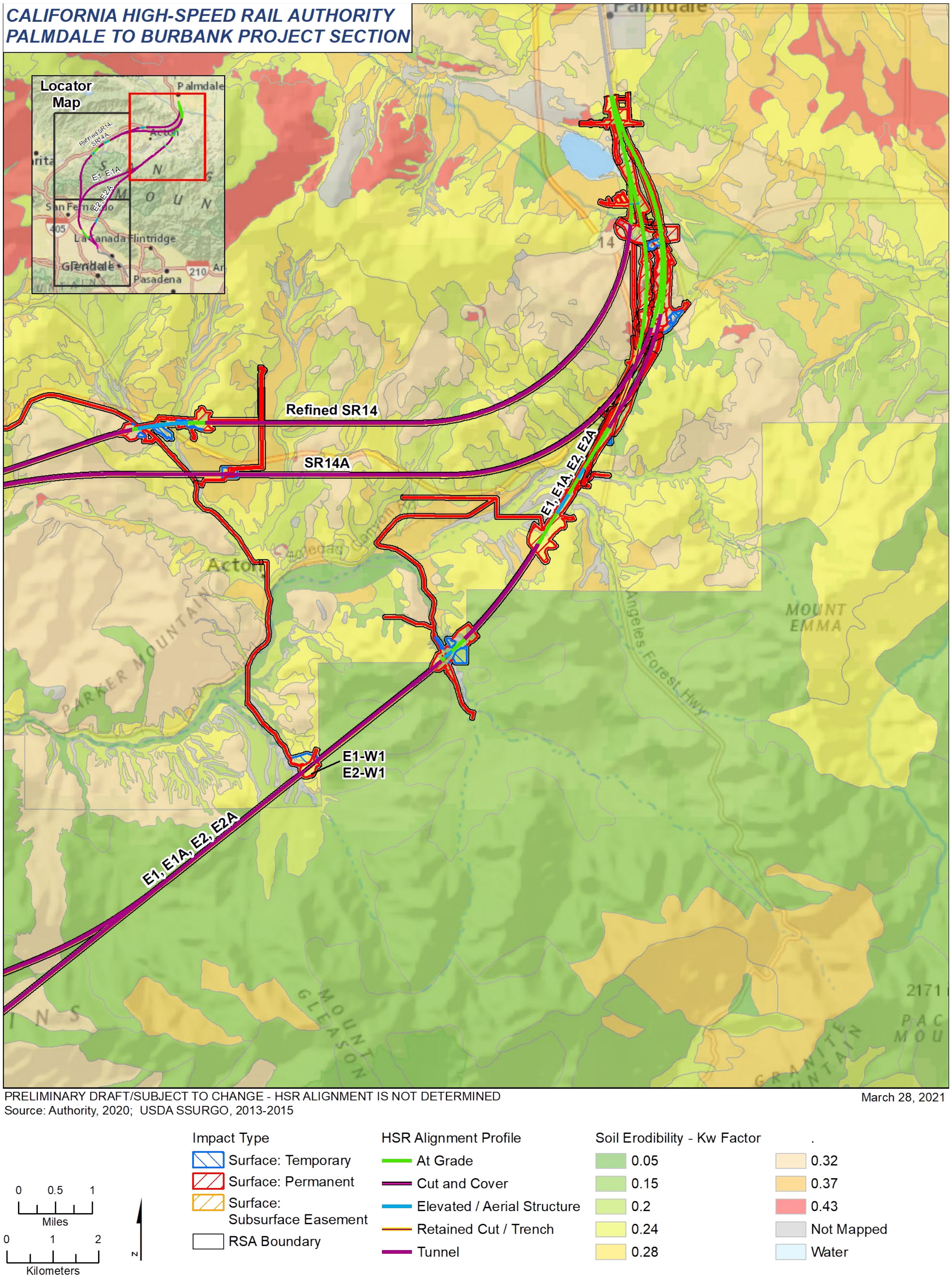


Figure 3.9-3 Erodible Soils (Map 1 of 3)

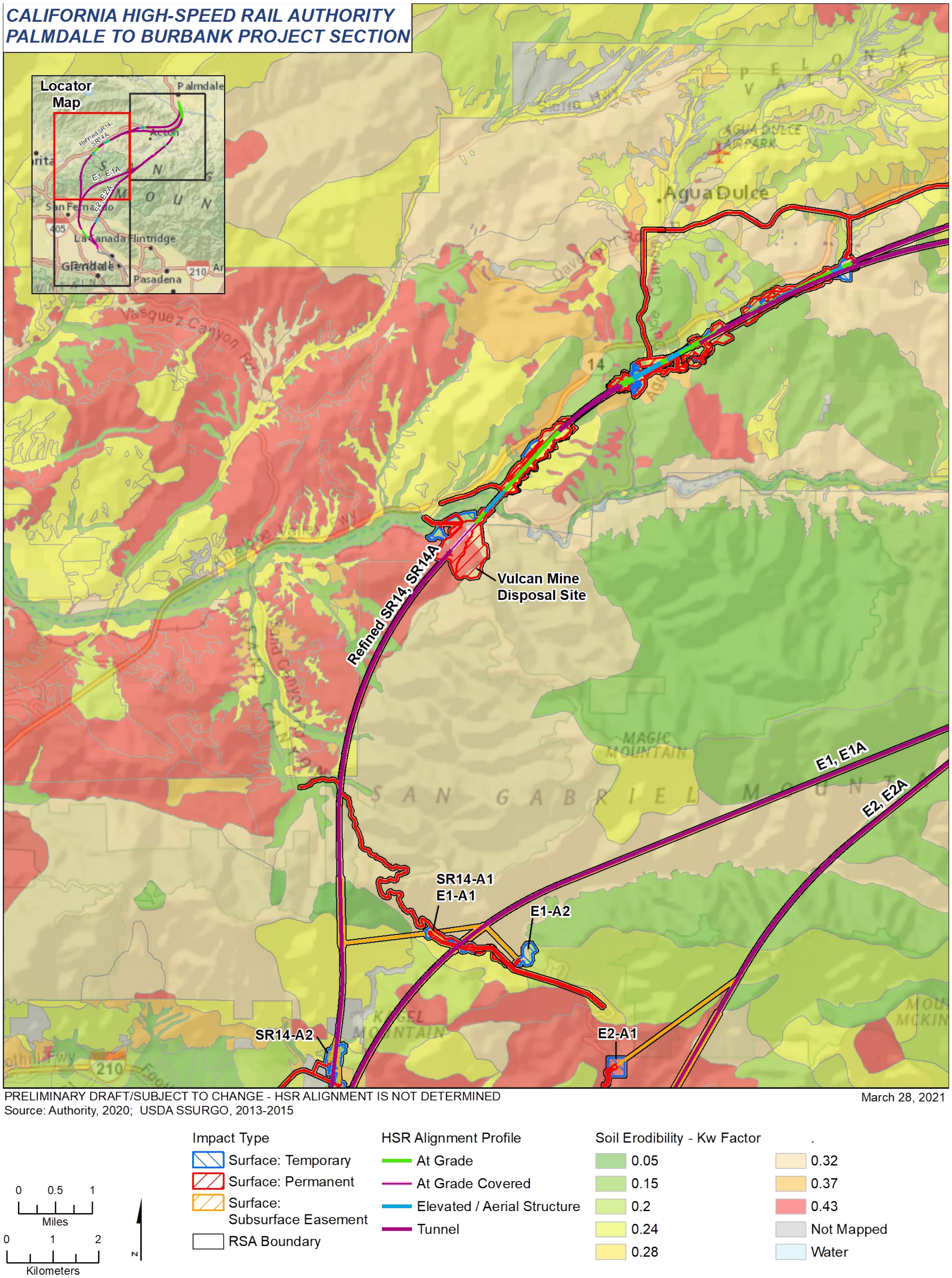


Figure 3.9-4 Erodible Soils (Map 2 of 3)

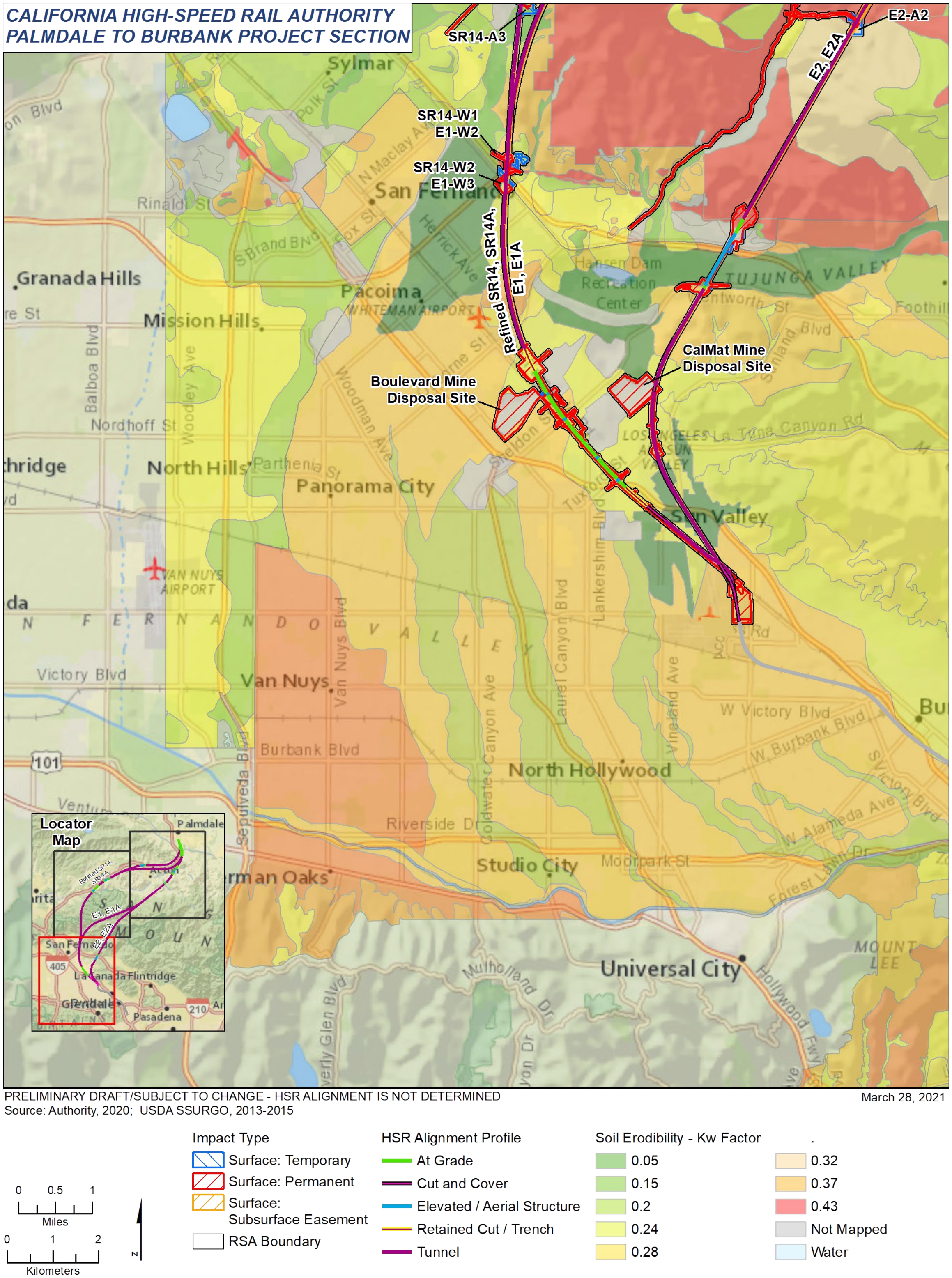


Figure 3.9-5 Erodible Soils (Map 3 of 3)

Expansive Soils

Expansive soils exhibit shrink-swell properties in response to wetting and drying because clay particles in these soils can exude water (shrink) or absorb water (swell). The resultant changes in soil volumes exert stress on and can damage structures and other loads placed on these soils. Predominantly fine-grained soils containing a high percentage of clays are potentially expansive, whereas predominantly coarse-grained soils such as sands and gravels are generally non-expansive. Soil classifications designate low-, moderate-, or high-expansive potential, based on the type and percentage of clay particles in the soil. Design-level geotechnical investigations are necessary to locate and characterize expansive soils within the soil hazard RSA because there are no existing maps that capture these localized hazards in sufficient detail.

Corrosive Soils

Soils with high moisture content, high electrical conductivity, high acidity, and high dissolved salts content can corrode steel and concrete materials. Sandy soils generally have high resistivity and are the least corrosive, while clay soils can be highly corrosive. Figure 3.9-6 through Figure 3.9-11 show corrosive soils throughout the soil hazard RSA.

Refined SR14 Build Alternative

The Refined SR14 Build Alternative would include alignment portions over soils with low, moderate, and unknown potential to corrode concrete north of the San Andreas Fault Zone. Soils within the San Andreas Fault Zone exhibit high potential to corrode concrete. Between the California Aqueduct and the Santa Clara River crossing, the Refined SR14 Build Alternative alignment would mostly include alignment portions over soils with low potential to corrode concrete. South of the Santa Clara River Crossing, the Refined SR14 Build Alternative alignment would generally include alignment portions over soils with low corrosion potential, except for soils in the Vulcan Mine area and soils in the vicinity of the three Refined SR14 Build Alternative adits (SR14-A1, SR14-A2, and SR14-A3), which exhibit moderate concrete corrosion potential.

The Refined SR14 Build Alternative would include alignment portions over soils that generally exhibit high and moderate steel corrosion potential north of the California Aqueduct. Soils between the California Aqueduct and Vulcan Mine exhibit low, moderate, and high corrosion potential. Soils overlying the Refined SR14 Build Alternative tunnel beneath the ANF generally have low corrosion potential, but the Refined SR14 intermediate windows would be located in areas of moderate corrosion potential between the San Gabriel Mountain foothills and the I-210/SR 118 interchange.

SR14A Build Alternative

The SR14A Build Alternative alignment would take a more easterly course across soils with the potential to corrode concrete north of the San Andreas Fault compared to the Refined SR14 Build Alternative alignment. South of the San Andreas Fault, the SR14A Build Alternative alignment would encounter soils corrosive to concrete in the same locations as the Refined SR14 Build Alternative alignment.

South of the California Aqueduct and north of Agua Dulce Canyon, the SR14A Build Alternative alignment would traverse additional areas of soils corrosive to steel compared to the Refined SR14 Build Alternative alignment. Apart from these locations, the SR14A Build Alternative alignment would traverse the same areas of soils corrosive to steel as would the Refined SR14 Build Alternative.

E1 Build Alternative

The E1 Build Alternative would include alignment portions over soils with low, moderate, and unknown potential to corrode concrete north of the San Andreas Fault Zone. Soils within the San Andreas Fault Zone exhibit high potential to corrode concrete. E1 would not encounter other areas with moderate or high corrosion potential within the ANF.

Between the California Aqueduct and the San Fernando Valley, the E1 Build Alternative includes alignment portions over soils with low potential to corrode concrete except for one area north of the San Fernando Valley. That's where E1 includes a 0.25-mile portion of alignment through an area of soil that exhibits moderate potential to corrode concrete.

The E1 Build Alternative alignment includes alignment portions over soils that generally exhibit high and moderate potential to corrode steel north of the California Aqueduct. South of the California Aqueduct, the E1 Build Alternative alignment would include alignment portions over soil with moderate and low potential to corrode steel until entering the ANF where soils exhibit high potential to corrode steel in Aliso Canyon and Arrastre Canyon. Soils within the remainder of the alignment path in the ANF, including the E1 Build Alternative locations (E1-A1 and E1-A2), generally exhibit low potential for steel corrosion. As the E1 Build Alternative alignment approaches the San Fernando Valley, it includes an alignment portion beneath approximately 3 miles of soil with moderate potential to corrode steel. The two E1 Build Alternative intermediate window options would be located in this area near the I-210/SR 118 interchange.

E1A Build Alternative

The E1A Build Alternative alignment would take a more easterly course across soils with the potential to corrode concrete north of the San Andreas Fault compared to the E1 Build Alternative alignment. South of the San Andreas Fault, the E1A Build Alternative alignment would encounter soils corrosive to concrete in the same locations as the E1 Build Alternative.

Although it would take a more easterly course through soils corrosive to steel south of Palmdale and north of Vincent Substation, the E1A Build Alternative alignment would traverse the same areas of soils corrosive to steel as the E1 Build Alternative alignment.

E2 Build Alternative

The E2 Build Alternative would include alignment over soils with low, moderate, and unknown concrete corrosion potential north of the San Andreas Fault Zone. Soils within the San Andreas Fault Zone exhibit high concrete corrosion potential. Between the California Aqueduct and the San Fernando Valley, the E2 Build Alternative includes alignment over soils generally with low to moderate corrosion potential. Corrosion potential would be high at the locations of two options (E2-A1 and E2-A2) as well as at the tunnel portal north of Big Tujunga Wash.

The E2 Build Alternative would include alignment over soils that generally exhibit high and moderate steel corrosion potential north of the California Aqueduct. South of the California Aqueduct, the E2 Build Alternative alignment includes alignment over soil with moderate and low steel corrosion potential until entering the ANF. There, soils exhibit high steel corrosion potential in Aliso Canyon and Arrastre Canyon. Soils within the remainder of the ANF including the E2-A1 and E2-A2 adit locations utility lines, generally exhibit low steel corrosion potential. As the E2 Build Alternative alignment approaches Big Tujunga Wash, it includes alignment beneath approximately 0.5 mile of soil with moderate steel corrosion potential.

E2A Build Alternative

The E2A Build Alternative alignment would take a more easterly course across soils with the potential to corrode concrete north of the San Andreas Fault compared to the E2 Build Alternative alignment. South of the San Andreas Fault, the E2A Build Alternative alignment would encounter soils corrosive to concrete in the same locations as the E2 Build Alternative alignment.

Although it would take a more easterly course through soils corrosive to steel south of Palmdale and north of Vincent Substation, the E2A Build Alternative alignment would traverse the same areas of soil corrosive to steel as the E2 Build Alternative alignment.

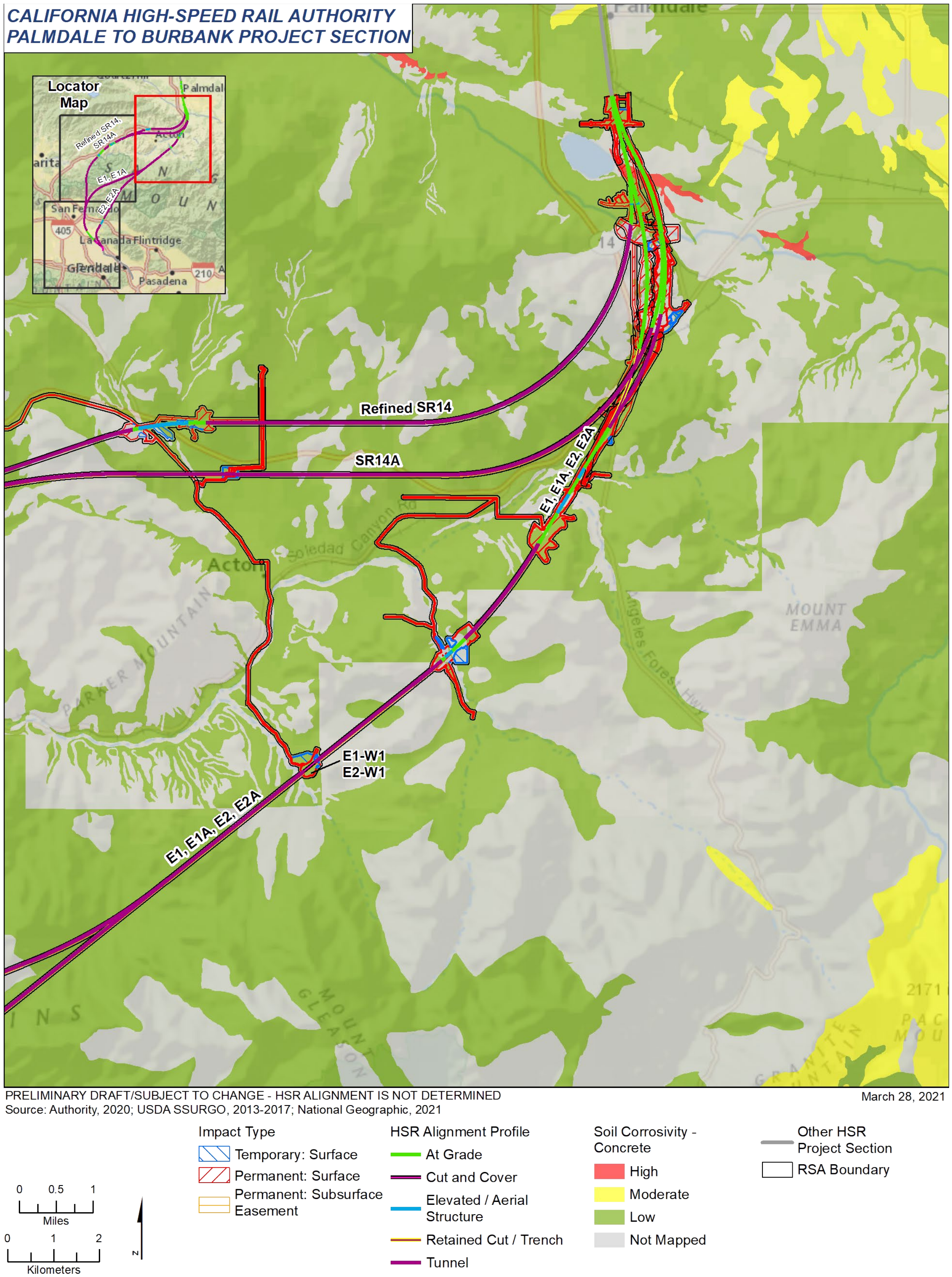
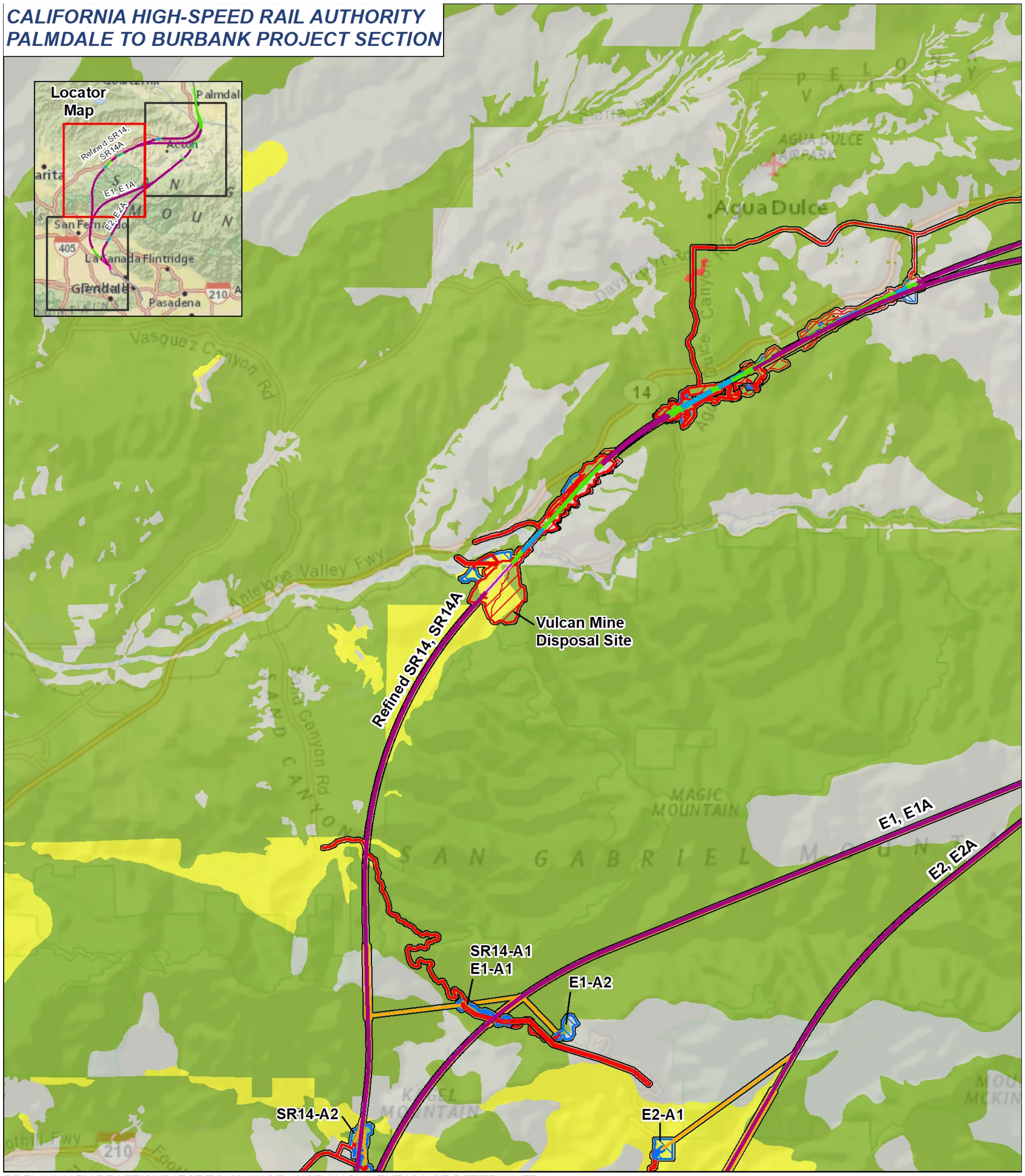


Figure 3.9-6 Soils Corrosive to Concrete (Map 1 of 3)



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED
Source: Authority, 2020; USDA SSURGO, 2013-2017; National Geographic, 2021

March 28, 2021

Impact Type
- Temporary: Surface
- Permanent: Surface
- Permanent: Subsurface Easement

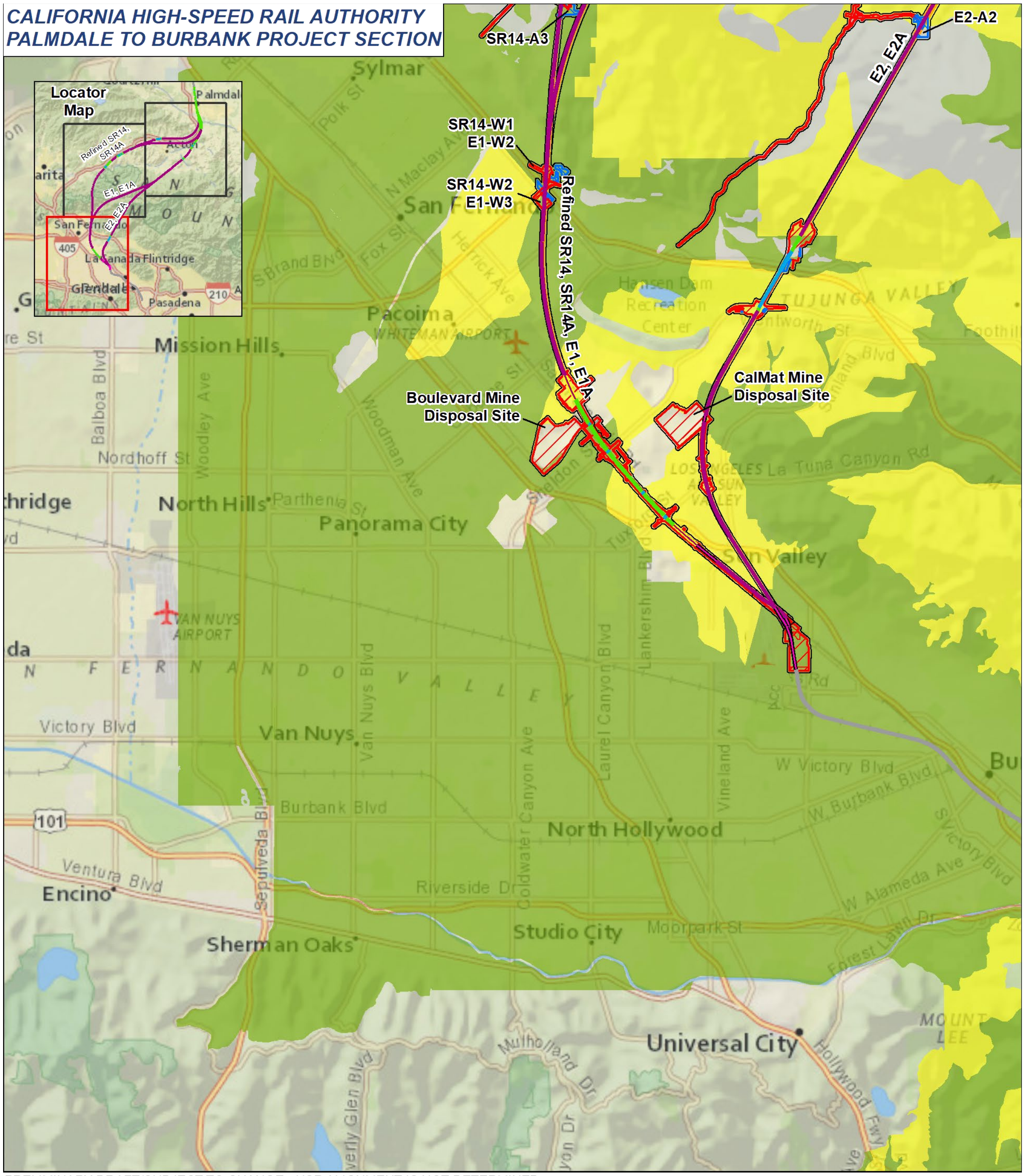
HSR Alignment Profile
- At Grade
- At Grade Covered
- Elevated / Aerial Structure
- Tunnel

Soil Corrosivity - Concrete
- High
- Moderate
- Low
- Not Mapped

RSA Boundary

0 0.5 1 Miles
0 1 2 Kilometers
N

Figure 3.9-7 Soils Corrosive to Concrete (Map 2 of 3)



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED

Source: Authority, 2020; USDA SSURGO, 2013-2017; National Geographic, 2021

March 28, 2021

Impact Type
- Temporary: Surface
- Permanent: Surface
- Permanent: Subsurface Easement

HSR Alignment Profile
- At Grade
- Cut and Cover
- Elevated / Aerial Structure
- Retained Cut / Trench
- Tunnel

Soil Corrosivity - Concrete
- High
- Moderate
- Low
- Not Mapped

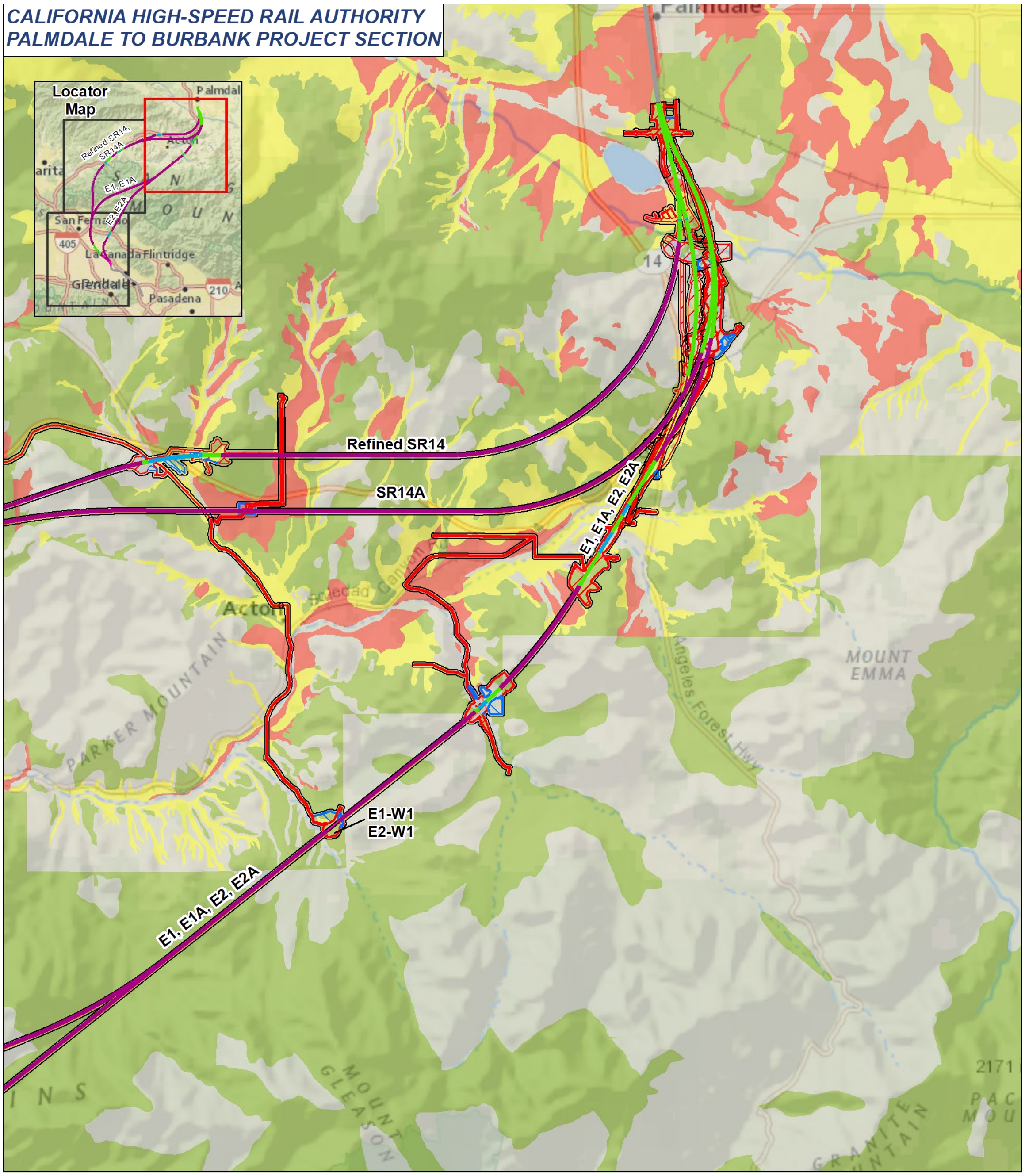
- Other HSR Project Section
- RSA Boundary

0 0.5 1 Miles

0 1 2 Kilometers

N

Figure 3.9-8 Soils Corrosive to Concrete (Map 3 of 3)



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED

Source: Authority, 2020; USDA SSURGO, 2013-2015

March 29, 2021

Impact Type
- Temporary: Surface
- Permanent: Surface
- Permanent: Subsurface Easement

HSR Alignment
- At Grade
- Cut and Cover
- Elevated / Aerial Structure
- Retained Cut / Trench
- Tunnel

Soil Corrosivity - Steel
- High
- Moderate
- Low
- Not Mapped

Other HSR Project Section

RSA Boundary

0 0.5 1 Miles

0 1 2 Kilometers

N

Figure 3.9-9 Soils Corrosive to Steel (Map 1 of 3)

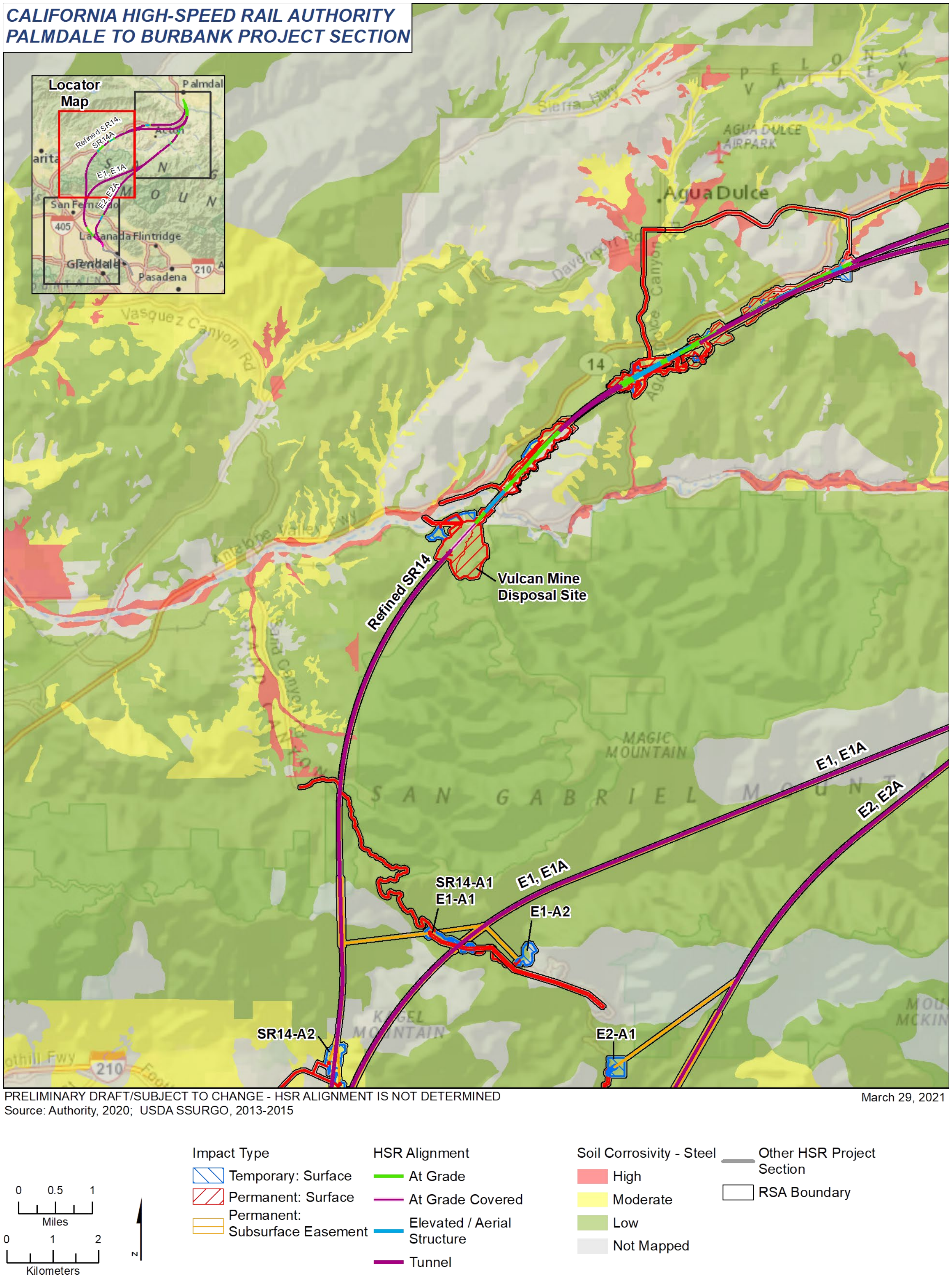


Figure 3.9-10 Soils Corrosive to Steel (Map 2 of 3)

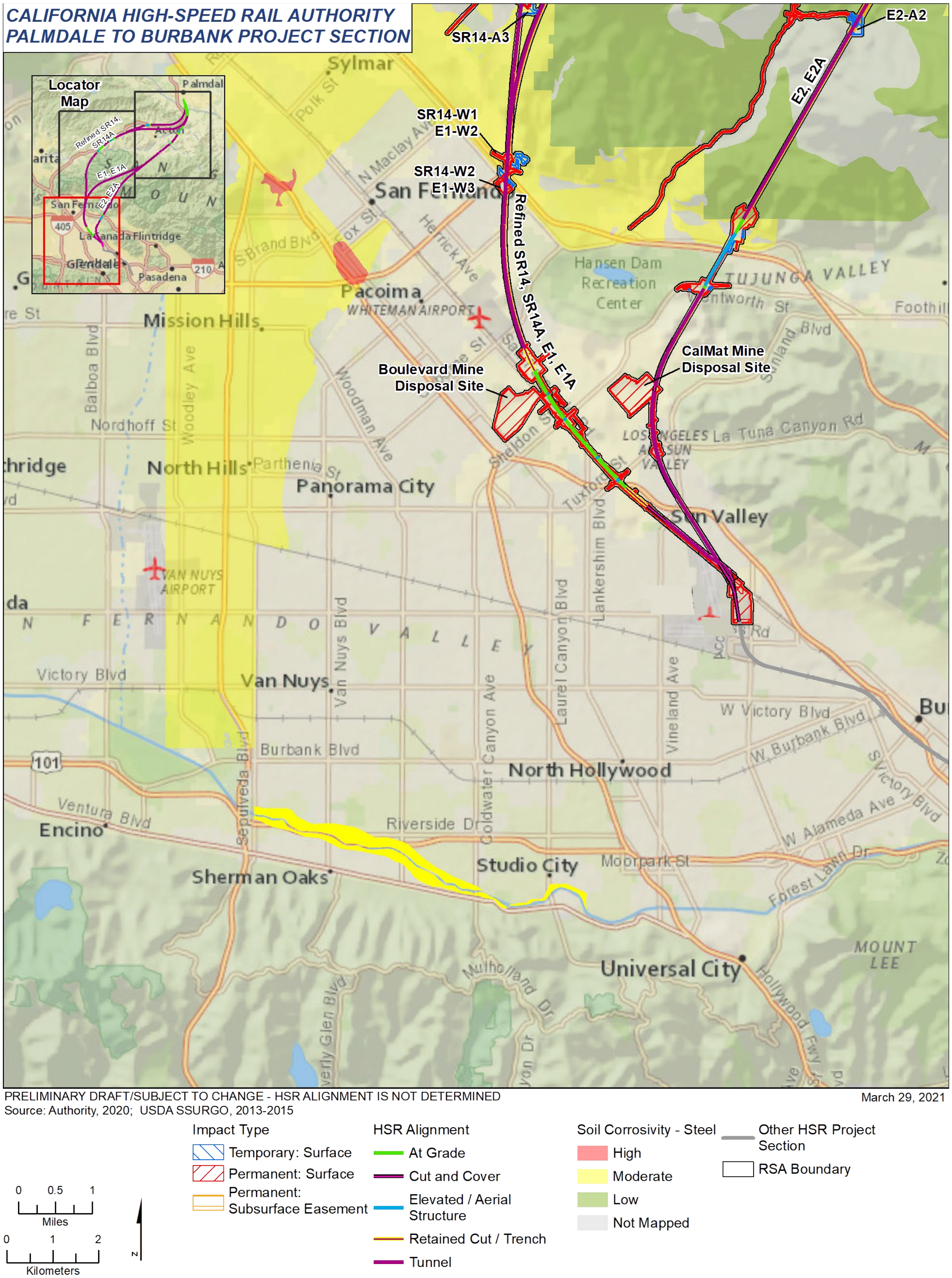


Figure 3.9-11 Soils Corrosive to Steel (Map 3 of 3)

Collapsible Soils

Similar to expansive soils, collapsible soils are subject to changes in volume and settlement from the introduction of water, which can break down soil grain bonds in dry, low-density, unconsolidated soils, resulting in soil collapse. Another mechanism for soil collapse is the sudden closure of voids in a soil; the sudden decrease in volume results in loss of the soil's internal structure, causing the soil to collapse. Soils within soil hazard RSAs for all six Build Alternatives could exhibit collapsible tendencies. Design-level geotechnical investigations would locate and characterize collapsible soils because no existing maps capture these localized hazards.

Areas of Difficult Excavation

Some soils with zones of hardpan (a layer commonly cemented by calcium carbonate or other mineral constituents) and bedrock formations could pose local excavation difficulties. Difficult excavation is most likely to occur in bedrock formations and possibly cemented or hardpan strata not amendable to excavation with a ripper-equipped dozer. These difficult excavation areas require special equipment or procedures, such as the use of tunnel boring machine. Areas of moderate and high excavation difficulty exist throughout the soil hazard RSAs for all six Build Alternatives (Figure 3.9-12 through Figure 3.9-14).

Refined SR14 Build Alternative

The Refined SR14 Build Alternative alignment would generally traverse areas of low excavation difficulty, with some areas of high excavation difficulty north of the San Andreas Fault Zone. Upon reaching this geologic feature, the Refined SR14 Build Alternative alignment would traverse large areas of high excavation difficulty, interspersed with areas of moderate excavation difficulty, until reaching the San Fernando Valley.

SR14A Build Alternative

South of East Avenue S and north of Agua Dulce Canyon, the SR14A Build Alternative alignment would traverse fewer areas of high and moderate excavation difficulty compared to the Refined SR14 Build Alternative alignment. Apart from these locations, the SR14A Build Alternative alignment would traverse areas of excavation difficulty identical to those of the Refined SR14 Build Alternative alignment.

E1 Build Alternative

The E1 Build Alternative would generally be constructed through areas of low excavation difficulty, with some areas of high excavation difficulty, north of the San Andreas Fault Zone. Upon reaching this geologic feature, the E1 Build Alternative alignment would be constructed through large areas of high excavation difficulty, interspersed with areas of moderate excavation difficulty, until reaching the San Fernando Valley.

E1A Build Alternative

South of East Avenue S and north of Vincent Substation, the E1A Build Alternative alignment would traverse more areas of high excavation difficulty compared to the E1 Build Alternative alignment. Apart from these locations, the E1A Build Alternative alignment would traverse areas of excavation difficulty identical to those of the E1 Build Alternative alignment.

E2 Build Alternative

The E2 Build Alternative would generally be constructed through areas of low excavation difficulty, with some areas of high excavation difficulty north of the San Andreas Fault Zone. Upon reaching this geologic feature, the E2 Build Alternative alignment would be constructed through large areas of high excavation difficulty, interspersed with areas of moderate excavation difficulty, until reaching the San Fernando Valley.

E2A Build Alternative

South of East Avenue S and north of Vincent Substation, the E2A Build Alternative alignment would traverse greater areas of high excavation difficulty compared to the E2 Build Alternative alignment. Apart from these locations, the E2A Build Alternative alignment would traverse areas of excavation difficulty identical to those of the E2 Build Alternative alignment.

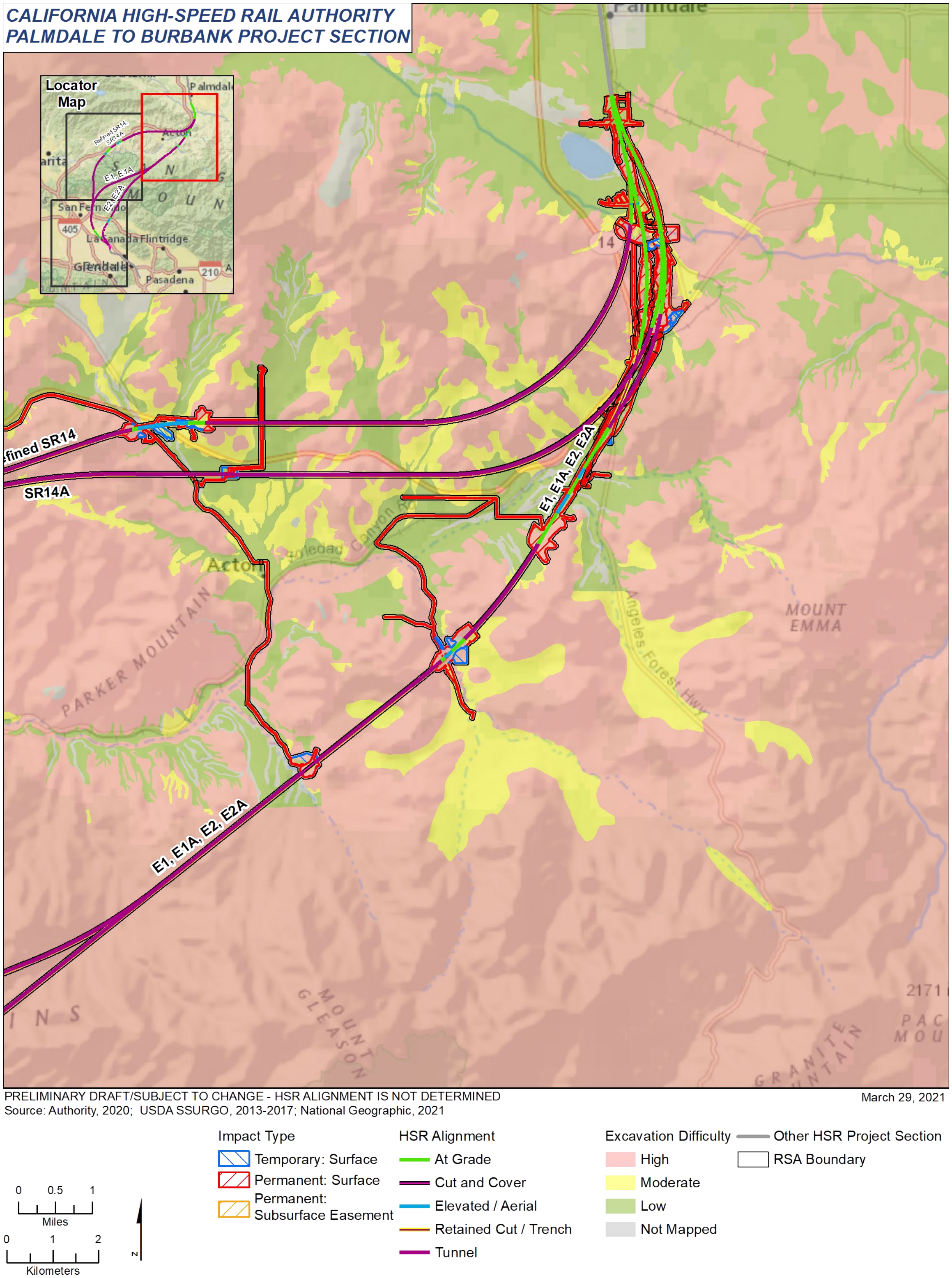
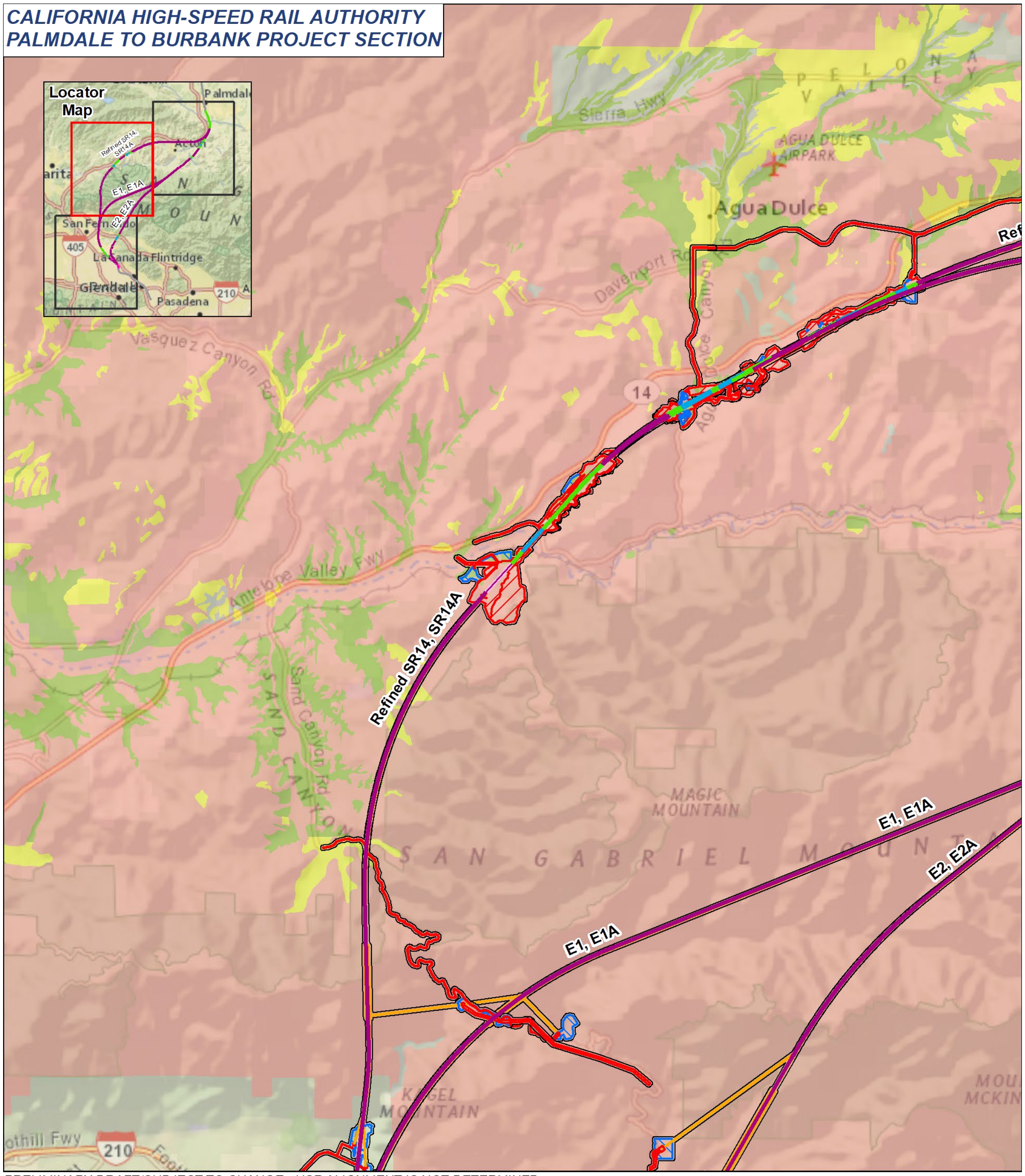


Figure 3.9-12 Areas of Difficult Excavation (Map 1 of 3)



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED
Source: Authority, 2020; USDA SSURGO, 2013-2017; National Geographic, 2021

March 29, 2021

Impact Type: Temporary: Surface; Permanent: Surface; Permanent: Subsurface Easement

HSR Alignment: At Grade; At Grade Covered; Elevated / Aerial; Tunnel

Excavation Difficulty: High; Moderate; Low; Not Mapped

Other HSR Project Section

RSA Boundary

0 0.5 1 Miles

0 1 2 Kilometers

N

Figure 3.9-13 Areas of Difficult Excavation (Map 2 of 3)

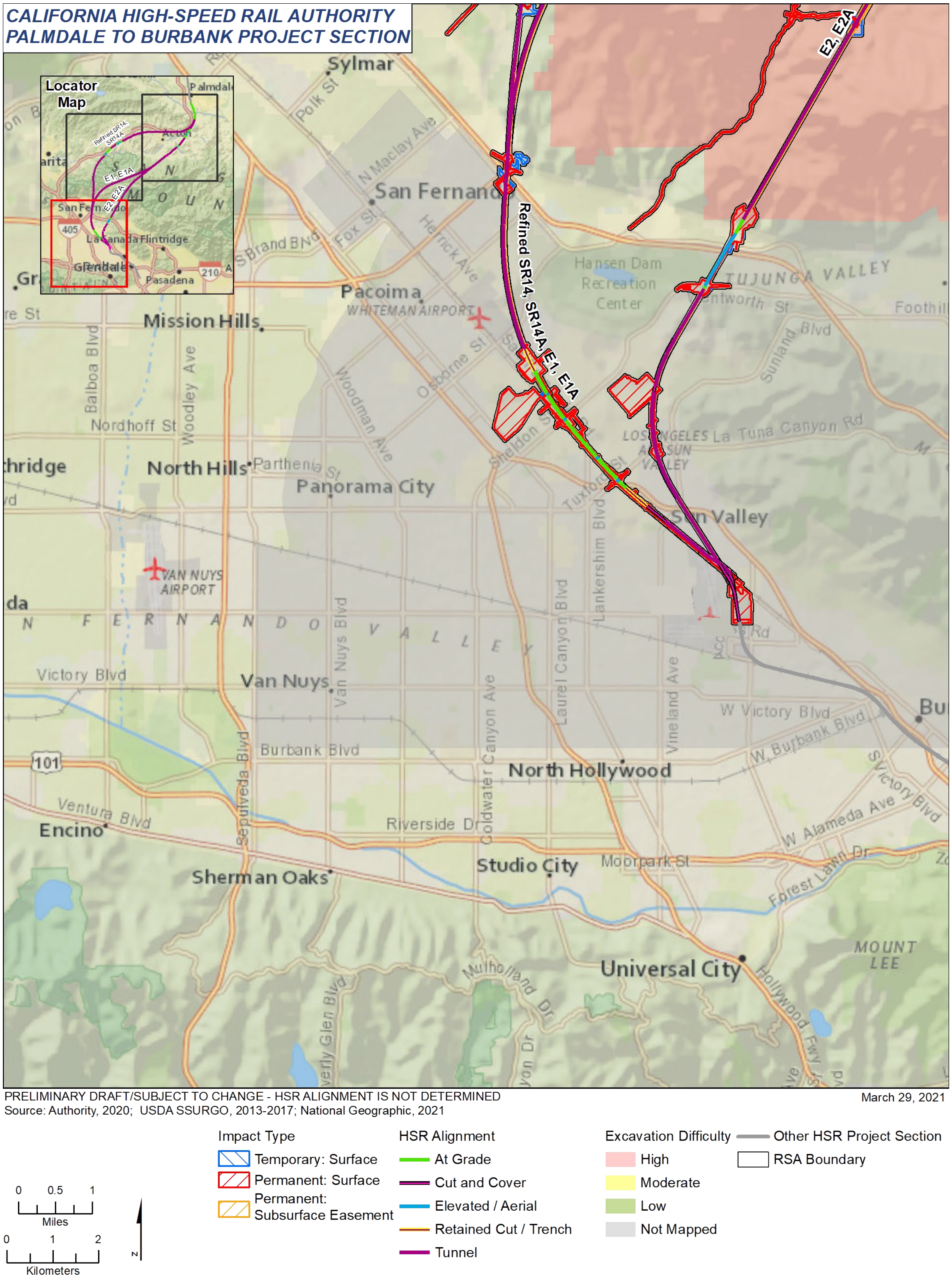


Figure 3.9-14 Areas of Difficult Excavation (Map 3 of 3)

3.9.5.5 Seismicity

Faults

A *fault* is a fracture or zone of closely associated fractures along which rocks on one side displace with respect to those on the other side. An earthquake occurs when two blocks of the earth suddenly slip past one another; the surface where they slip is the *fault* or *fault plane*.

Seismic hazards result from earthquake activity along active faults. Most faults are the result of repeated displacement that could have taken place suddenly and/or by slow creep over time.

Los Angeles County experiences regular seismic activity from multiple hazardous fault complexes in the region. For the purpose of this analysis, “hazardous faults” experienced ruptures within the last 11,000 years, and “potentially hazardous faults” experienced ruptures between 11,000 years and 1.6 million years ago. Table 3.9-4 lists fault zones within the primary seismic hazard RSA; of these, the San Andreas Fault Zone, San Gabriel Fault Zone, Sierra Madre Fault Zone – San Fernando Section, and Verdugo Fault Zone are considered hazardous or potentially hazardous. Figure 3.9-15 through Figure 3.9-17 depict the regional system of faults; Figure 3.9-18 shows a history of seismic activity throughout Los Angeles County. Additionally, faults that are classified as “unknown” are typically nonhazardous faults where either no data is available or the alignment would not cross the fault.[7] Seismic activity along one of these faults/fault zones could result in primary seismic hazards (fault rupture and ground shaking) or secondary seismic hazards (liquefaction; lateral spreading; ground lurching; seismically induced landslides; or seismically induced flooding from tsunami, seiche, or dam failure).

[7] Refer to the most recent Alquist-Priolo Earthquake Fault Zoning map issued by the State Geologist for the area or other substantial known evidence of known faults to identify known faults in the project area.

Table 3.9-4 Faults and Fault Crossings in the Resource Study Area

Fault Zone	Fault	Crossing Arrangement					
		Refined SR14	SR14A	E1	E1A	E2	E2A
San Andreas Fault (Mojave Section)		Crosses (At-grade)	Crosses (At-grade)	Crosses (At-grade)	Crosses (At-grade)	Crosses (At-grade)	Crosses (At-grade)
Not Applicable (no associated Fault Zone)	Kashmir Valley Fault	Crosses (Tunnel)	Crosses (Tunnel)	Not Applicable (no associated Fault Zone)	Not Applicable (no associated Fault Zone)	Not Applicable (no associated Fault Zone)	Not Applicable (no associated Fault Zone)
	Transmission Line Fault	No Data Available	No Data Available	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)
	Little Escondido Fault	Crosses (At-grade, Viaduct, Tunnel)	Crosses (Tunnel)	Would not cross (located 4.7 miles from fault)	Would not cross (located 4.7 miles from fault)	Would not cross (located 4.7 miles from fault)	Would not cross (located 4.7 miles from fault)
	Agua Dulce Fault	Crosses (At-grade, Viaduct, Tunnel)	Crosses (At-grade, tunnel)	Would not cross (located 3.9 miles from fault)	Would not cross (located 3.9 miles from fault)	Would not cross (located 6.1 miles from fault)	Would not cross (located 6.1 miles from fault)
	Soledad Fault	Crosses (At-grade, Viaduct)	Crosses (At-grade, Viaduct)	Would not cross (alignment located 0.7 mile from fault)	Would not cross (alignment located 0.7 mile from fault)	Would not cross (alignment located 0.7 mile from fault)	Would not cross (alignment located 0.7 mile from fault)
	Magic Mountain Fault	Crosses (Tunnel)	Crosses (Tunnel)	No Data Available	No Data Available	No Data Available	No Data Available
	Lone Tree Fault	No Data Available	No Data Available	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)
San Gabriel Fault Zone (Newhall Section)		Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)
Western Sierra Madre Fault Zone (San Fernando Section)		Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)
Western Sierra Madre Fault Zone (Santa Susana Section)		Would not cross (alignment located 1.0 mile from fault)	Would not cross (alignment located 1.0 mile from fault)	Would not cross (alignment located 2.0 miles from fault)	Would not cross (alignment located 2.0 miles from fault)	Would not cross (alignment located 4.2 miles from fault)	Would not cross (alignment located 4.2 miles from fault)
San Fernando Fault Zone		Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)	Crosses (Tunnel)

Fault Zone	Fault	Crossing Arrangement					
		Refined SR14	SR14A	E1	E1A	E2	E2A
Verdugo Fault Zone		Crosses (At-grade, Viaduct, Retained cut/trench, Tunnel)	Crosses (At-grade, Viaduct, Retained cut/trench, Tunnel)	Crosses (At-grade, Viaduct, Retained cut/trench, Tunnel)	Crosses (At-grade, Viaduct, Retained cut/trench, Tunnel)	Crosses (At-grade, Viaduct, Retained cut/trench, Tunnel)	Crosses (At-grade, Viaduct, Retained cut/trench, Tunnel)

Source: Authority, 2019a

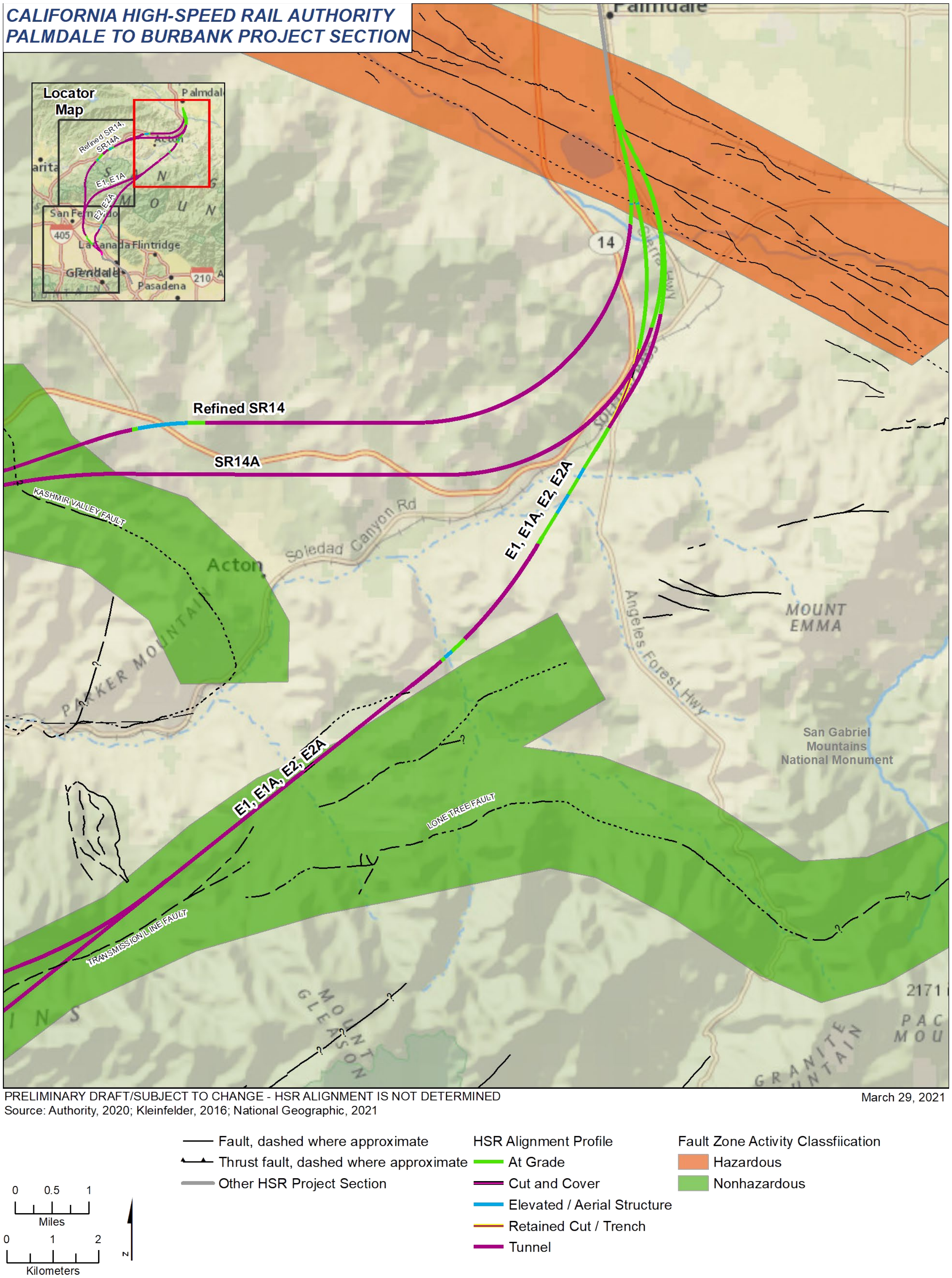
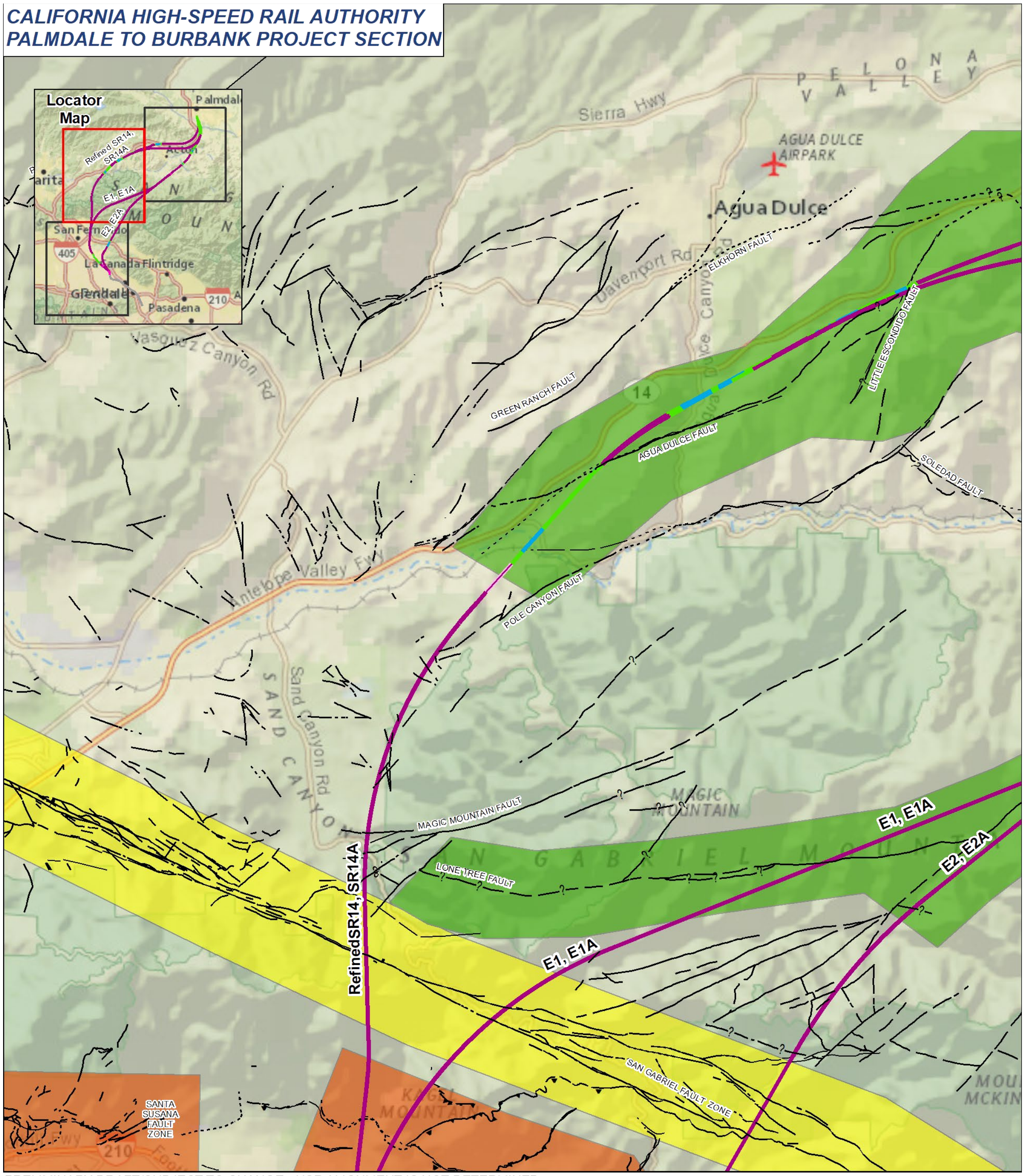


Figure 3.9-15 Regional Fault Systems (Map 1 of 3)



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED
Source: Authority, 2020; Kleinfelder, 2016; National Geographic, 2021

March 29, 2021

0 0.5 1 Miles
0 1 2 Kilometers
N

Fault, dashed where approximate
Thrust fault, dashed where approximate

HSR Alignment Profile
- At Grade
- At Grade Covered
- Elevated / Aerial Structure
- Tunnel

Fault Zone Activity Classfiication
- Hazardous
- Potentially hazardous
- Nonhazardous

Figure 3.9-16 Regional Fault Systems (Map 2 of 3)

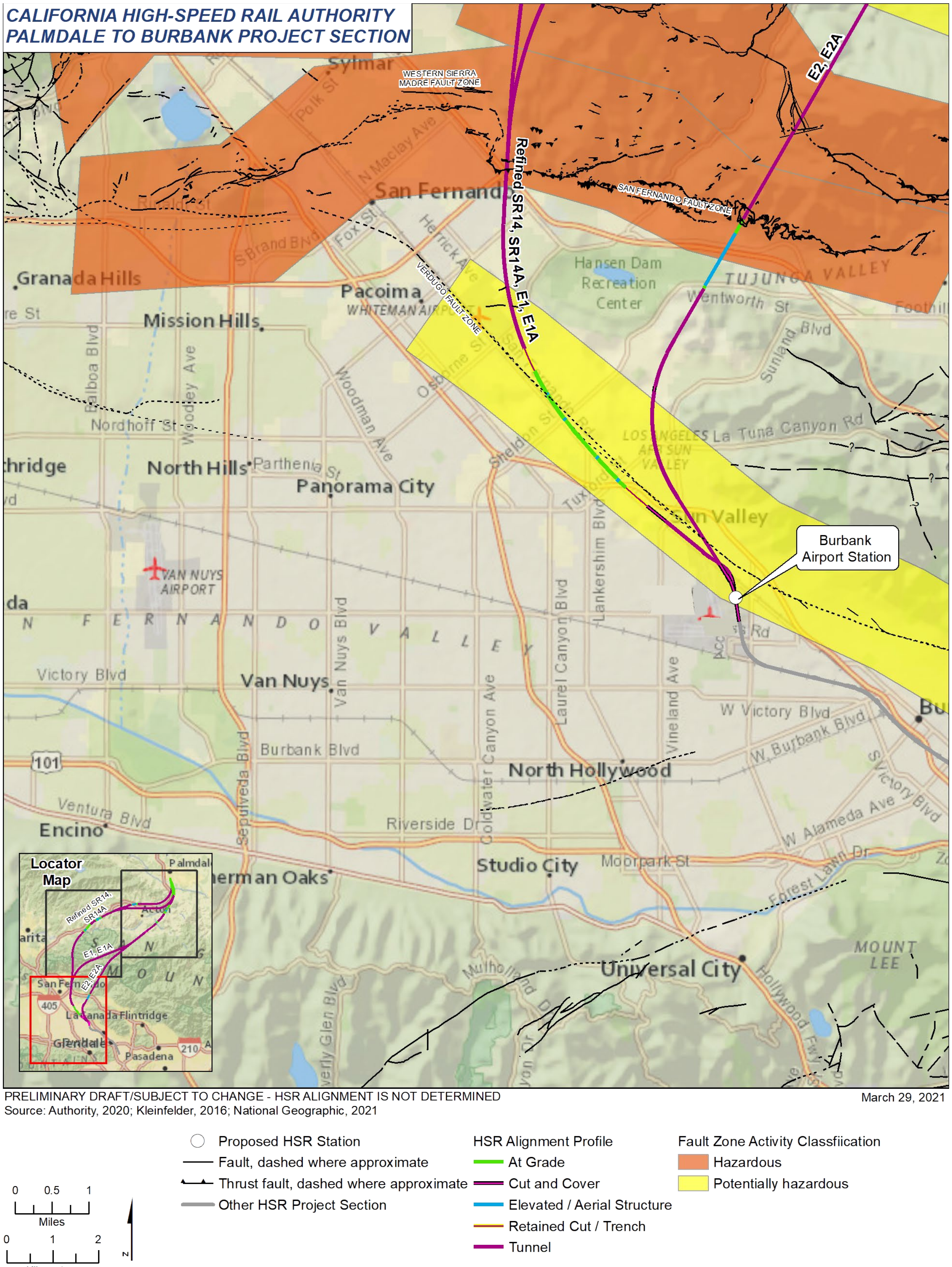
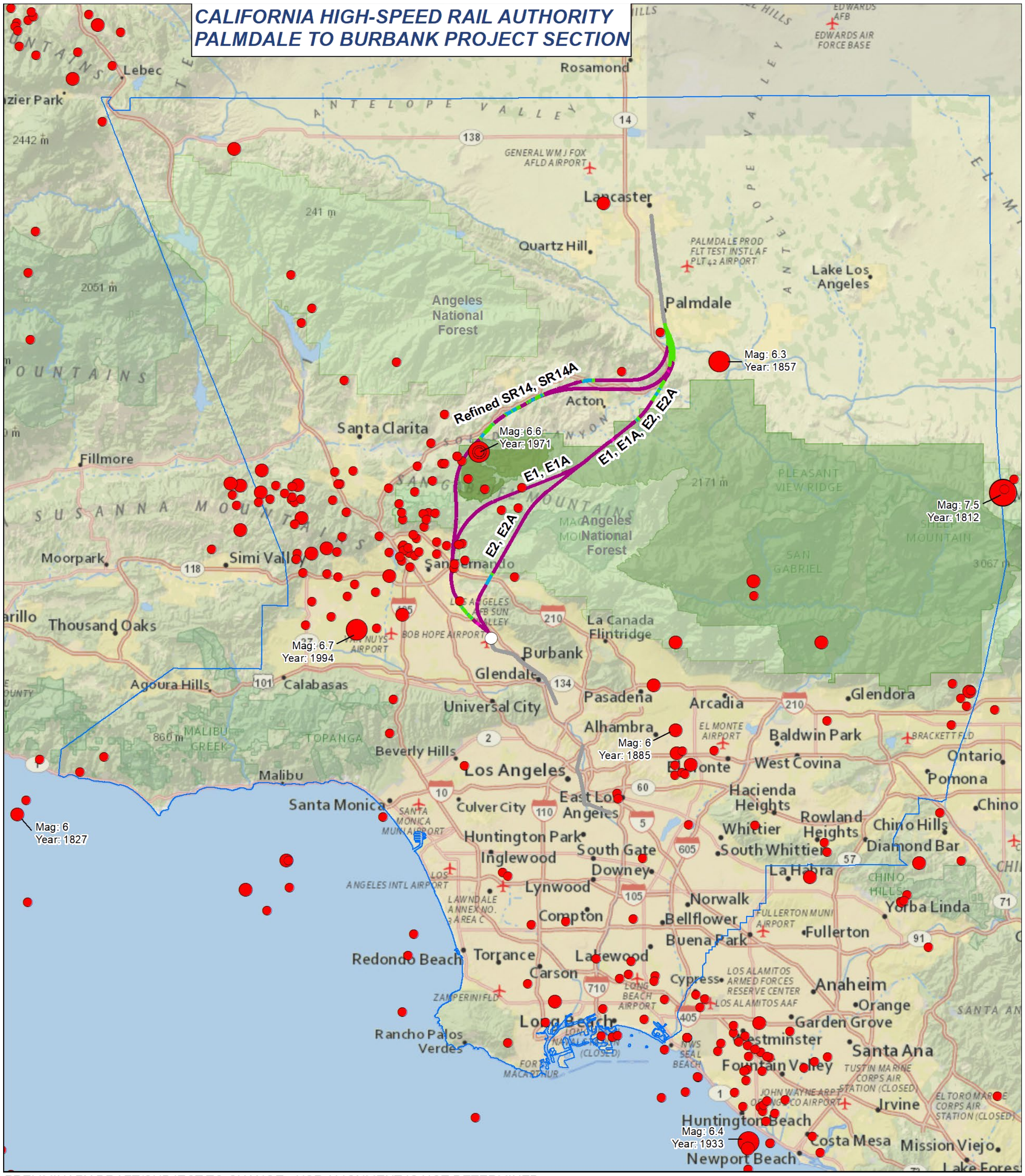


Figure 3.9-17 Regional Fault Systems (Map 3 of 3)



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED
Source: Authority, 2020;SCSN, 2016; CGS, 2015; National Geographic, 2021

March 29, 2021

Proposed HSR Station
Other HSR Project Section
County of Los Angeles

Earthquake / Magnitude
4.0 - 5.0
5.0 - 6.0
6.0 - 7.0
7.0 - 8.0

HSR Alignment Profile
At Grade
At Grade Covered
Cut and Cover
Elevated / Aerial Structure
Retained Cut / Trench
Tunnel

USFS Lands
Angeles National Forest
Magic Mountain Wilderness Areas
San Gabriel Mountains National Monument

0 2 4 Miles
0 4 8 Kilometers
N

Figure 3.9-18 Historic Earthquake Activity in Los Angeles County

3.9.5.6 *Primary Seismic Hazards*

Surface Fault Rupture

Fault rupture refers to the extension of a fault surface in which the ground breaks, which can cause abrupt vertical and/or horizontal ground displacement. Surface fault ruptures result from stress relief during seismic activity such as earthquakes and can damage structures that sit astride the fault. Earthquakes of 6.0 magnitude or greater are likely to generate noticeable or damaging surface fault rupture. Earthquakes in lower magnitude (under 6.0 magnitude) would be unlikely to cause damage to at-grade structures (University of Illinois at Urbana-Champaign 2001). The six Build Alternatives primary seismic hazard RSAs transect multiple potentially hazardous and hazardous faults (Figure 3.9-15 through Figure 3.9-17).

Refined SR14 Build Alternative

The Refined SR14 Build Alternative alignment would cross the hazardous San Andreas Fault Zone at grade south of the city of Palmdale. Through the San Gabriel Mountains, the Refined SR14 Build Alternative alignment would be constructed at grade, on viaduct, and in tunnel through several nonhazardous faults, including the Kashmir Valley Fault, Little Escondido Fault, Agua Dulce Fault, Pole Canyon Fault, Magic Mountain Fault, and Lone Tree Fault. It would intersect the potentially hazardous San Gabriel Fault in tunnel within the San Gabriel Mountains. Upon entering the San Fernando Valley, the Refined SR14 Build Alternative alignment would traverse both the potentially hazardous Western Sierra Madre Fault Zone – San Fernando Section within a bored tunnel. Finally, the Refined SR14 Build Alternative alignment would cross the potentially hazardous Verdugo Fault Zone at grade, elevated, trenched, and within tunnels.

SR14A Build Alternative

The SR14A Build Alternative alignment would traverse the same faults as the Refined SR14 Build Alternative alignment. However, the SR14A Build Alternative alignment would cross the Little Escondido Fault via tunnel where the Refined SR14 Build Alternative alignment would cross this fault at grade, viaduct, and within tunnels. The SR14A Build Alternative alignment would also cross the Agua Dulce Fault only at grade and within tunnels, compared to the Refined SR14 Build Alternative alignment which would cross this fault via at grade, viaduct, and tunneled alignment.

E1 Build Alternative

The E1 Build Alternative alignment would cross the hazardous San Andreas Fault Zone at grade south of the city of Palmdale. Through the San Gabriel Mountains, the E1 Build Alternative alignment would be constructed at grade, on viaduct, and in tunnel through several nonhazardous faults, including the Transmission Line Fault and the Lone Tree Fault. It would traverse the potentially hazardous San Gabriel Fault in tunnel beneath the San Gabriel Mountains. Upon entering the San Fernando Valley, the E1 Build Alternative alignment would traverse the potentially hazardous Western Sierra Madre Fault Zone – San Fernando Section within a bored tunnel. Finally, the E1 Build Alternative alignment would cross the potentially hazardous Verdugo Fault Zone at grade, elevated, trenched, and within tunnels.

E1A Build Alternative

The E1A Build Alternative alignment would cross the same faults as the E1 Build Alternative alignment and would use identical alignment profiles at these crossings.

E2 Build Alternative

The E2 Build Alternative alignment would cross the hazardous San Andreas Fault Zone at grade south of the city of Palmdale. Through the San Gabriel Mountains, the E2 Build Alternative alignment would be constructed at grade, on viaduct, and in tunnel through several nonhazardous faults, including the Transmission Line Fault and the Lone Tree Fault.

It would cross the potentially hazardous San Gabriel Fault in tunnel beneath the San Gabriel Mountains. Upon entering the San Fernando Valley, the alignment would traverse the potentially hazardous Western Sierra Madre Fault Zone – San Fernando Section, through a tunnel and at grade. Finally, the E2 Build Alternative alignment would cross the potentially hazardous Verdugo Fault Zone at grade, elevated, trenched, and within tunnels.

E2A Build Alternative

The E2A Build Alternative alignment would cross the same faults as the E2 Build Alternative alignment and would use identical alignment profiles at these crossings.

Ground Shaking

Strong ground motion can occur as energy is released during an earthquake. The intensity of ground motion depends on the distance to the fault rupture, the earthquake magnitude, and the surrounding geologic conditions. For moderate earthquakes, peak ground acceleration is considered the most appropriate and accurate measurement to correlate ground shaking with damage of the surrounding environment. Peak ground acceleration is a percent of the force exerted by gravity. Although the correlation between peak ground acceleration and potential hazards from ground shaking is not absolute, this correlation is a relatively accurate means of conveying the potential damage to the environment. Peak ground acceleration between 65 and 124 percent would cause violent perceived shaking and heavy potential damage. The USGS has developed maps that depict the potential shaking hazard from future earthquakes. Trackway profiles, stations, and ancillary features associated with all six Build Alternatives could experience violent seismic ground shaking, particularly near the San Andreas Fault (Figure 3.9-19).

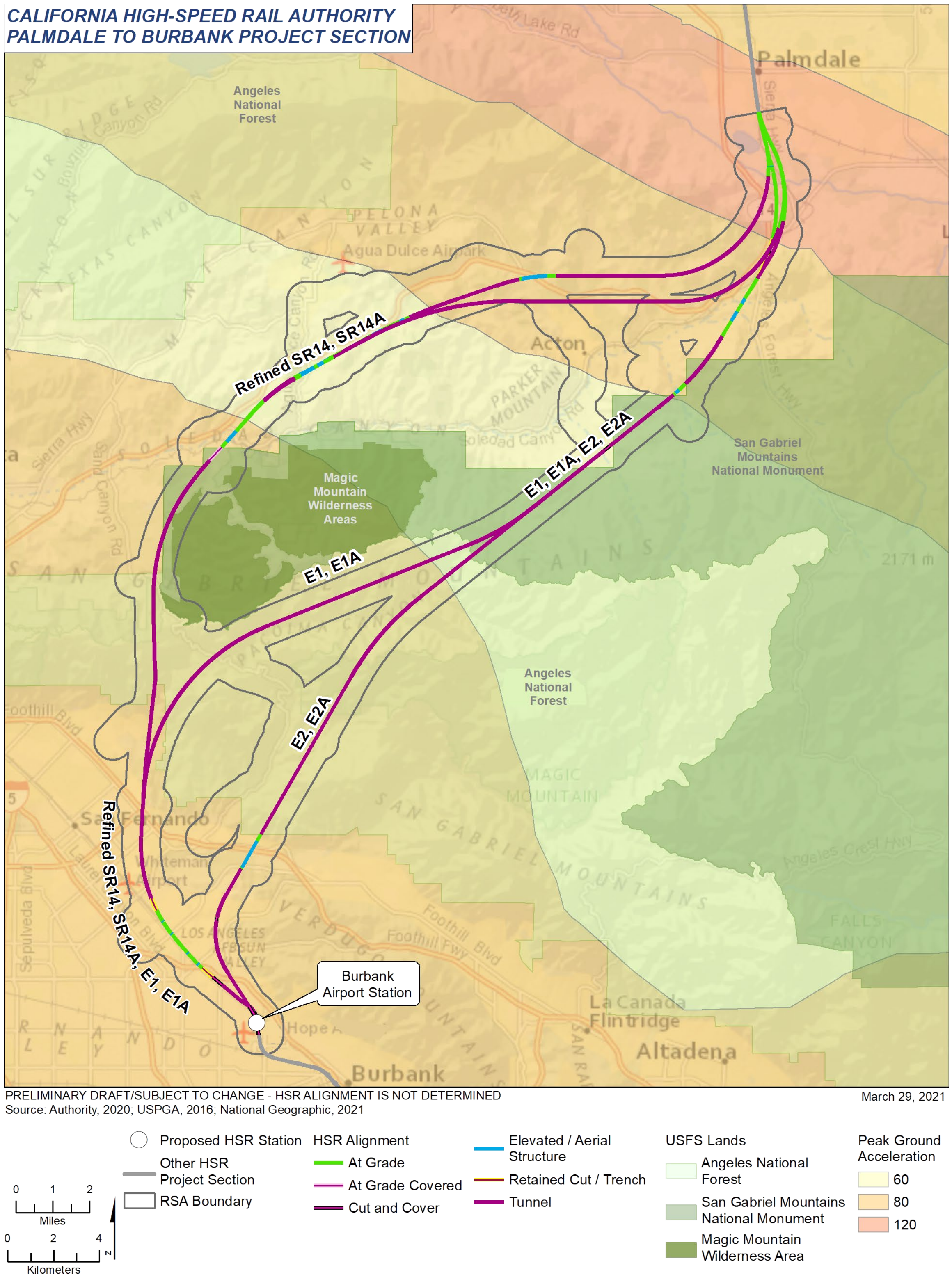


Figure 3.9-19 Peak Ground Acceleration

3.9.5.7 Secondary Seismic Hazards

Secondary seismic hazards include phenomena that can occur because of ground shaking. These include liquefaction, lateral spreading, seismically induced landslides, and seismically induced flooding.

Liquefaction, Lateral Spreading, and Ground Lurching

Liquefaction refers to the phenomenon in which loose soil material saturated or partially saturated with water behaves like a liquid when disturbed by an earthquake. Soils most susceptible to liquefaction are clean, loose, uniformly graded, fine-grained sands; and non-plastic silts that are saturated and within 50 feet of the ground surface. Geologic units that are generally susceptible to liquefaction include artificial fill and certain naturally deposited soils (late Quaternary alluvial and fluvial sedimentary areas). Structures located in liquefaction-prone areas are at risk for damage if liquefaction occurs. Liquefaction zones are predominantly located in drainages and waterways, as shown on Figure 3.9-20 through Figure 3.9-22.

Lateral spreading results from liquefaction in gently sloping areas when land shifts laterally after the loss of support caused by liquefaction. For lateral spreading to result, the liquefied area must be relatively near a sloping face such as a road cut or riverbank, or sloping ground. Ground lurching occurs when seismic ground motion during an earthquake causes fracture and displacement on slopes or surfaces perpendicular to the ground, resulting in jutted materials or blocks. Physiologic features susceptible to ground lurching include stream and canal banks, cliffs, and artificial embankments. Ground materials that are most susceptible to lurching during an earthquake are unconsolidated and have low cohesion. Portions of the secondary seismic/geologic hazard RSA for all six Build Alternatives identified as susceptible to liquefaction, including cut slopes, low-lying drainages, canyons, and watercourses, would be susceptible to lateral spreading and/or ground lurching during a seismic event.

Refined SR14 Build Alternative

The Refined SR14 Build Alternative secondary seismic/geologic hazard RSA encompasses liquefaction, lateral spreading, and ground lurching susceptibility zones as it crosses over the San Andreas Fault Zone south of Palmdale. Through Acton, the Refined SR14 Build Alternative alignment crosses tributaries that exhibit liquefaction, lateral spreading, and ground lurching hazards. Similar conditions exist at Agua Dulce Canyon Road and the Santa Clara River, where the alignment crosses liquefaction, lateral spreading, and ground lurching susceptibility zones at-grade and on elevated structures. The Vulcan Mine disposal site is also susceptible to liquefaction, lateral spreading, and ground lurching. The SR14-A1 adit option is also within a liquefaction zone (Figure 3.9-21).

SR14A Build Alternative

The SR14A Build Alternative alignment would take a more easterly course through liquefaction, lateral spreading, and ground lurching susceptibility zones south of East Avenue S compared to the Refined SR14 Build Alternative alignment. North of the Santa Clara River, the SR14A Build Alternative alignment would traverse similar tributaries that exhibit liquefaction, lateral spreading, and ground lurching susceptibility. However, the SR14A Build Alternative alignment would traverse more such tributaries via tunnel than the Refined SR14 Build Alternative, which would require more at-grade and viaduct crossings. Apart from these areas, the SR14A Build Alternative alignment would encounter the same liquefaction, lateral spreading, and ground lurching susceptibility zones as the Refined SR14 Build Alternative.

E1 Build Alternative

The E1 Build Alternative secondary seismic/geologic hazard RSA encompasses liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone south of Palmdale, north of Vincent Substation, along Aliso Canyon, and along Arrastre Canyon. A utility line associated with the E1-A1/E1-A2 adit options would also encounter a liquefaction zone along Sand Canyon Road (Figure 3.9-21).

E1A Build Alternative

The E1A Build Alternative alignment would take a more easterly course through liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone and north of Vincent Substation compared to the E1 Build Alternative alignment. Apart from these areas, the E1A Build Alternative alignment would encounter the same liquefaction, lateral spreading, and ground lurching susceptibility zones as the E1 Build Alternative alignment.

E2 Build Alternative

The E2 secondary seismic/geologic hazard RSA encompasses liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone south of Palmdale, north of Vincent Substation, within Aliso Canyon, within Arrastre Canyon, and at the Big Tujunga Wash crossing location. A utility line associated with E2-A1/E2-A2 adit options would also encounter a liquefaction zone along Little Tujunga Canyon Road (Figure 3.9-21).

E2A Build Alternative

The E2A Build Alternative alignment would take a more easterly course through liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone and north of Vincent Substation compared to the E2 Build Alternative alignment. Apart from these areas, the E2A Build Alternative alignment would encounter the same liquefaction, lateral spreading, and ground lurching susceptibility zones as the E2 Build Alternative alignment.

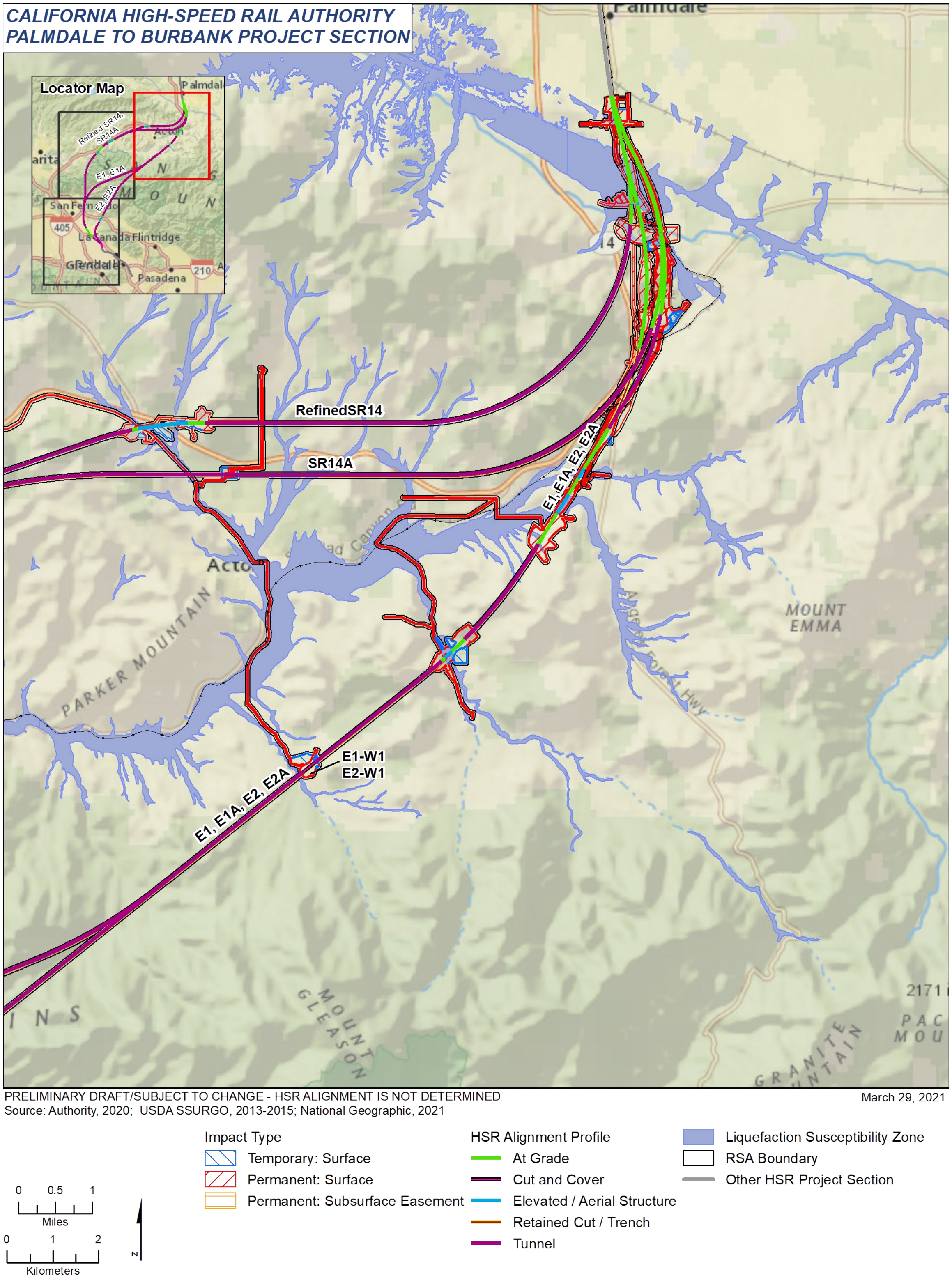


Figure 3.9-20 Liquefaction Zones (Map 1 of 3)

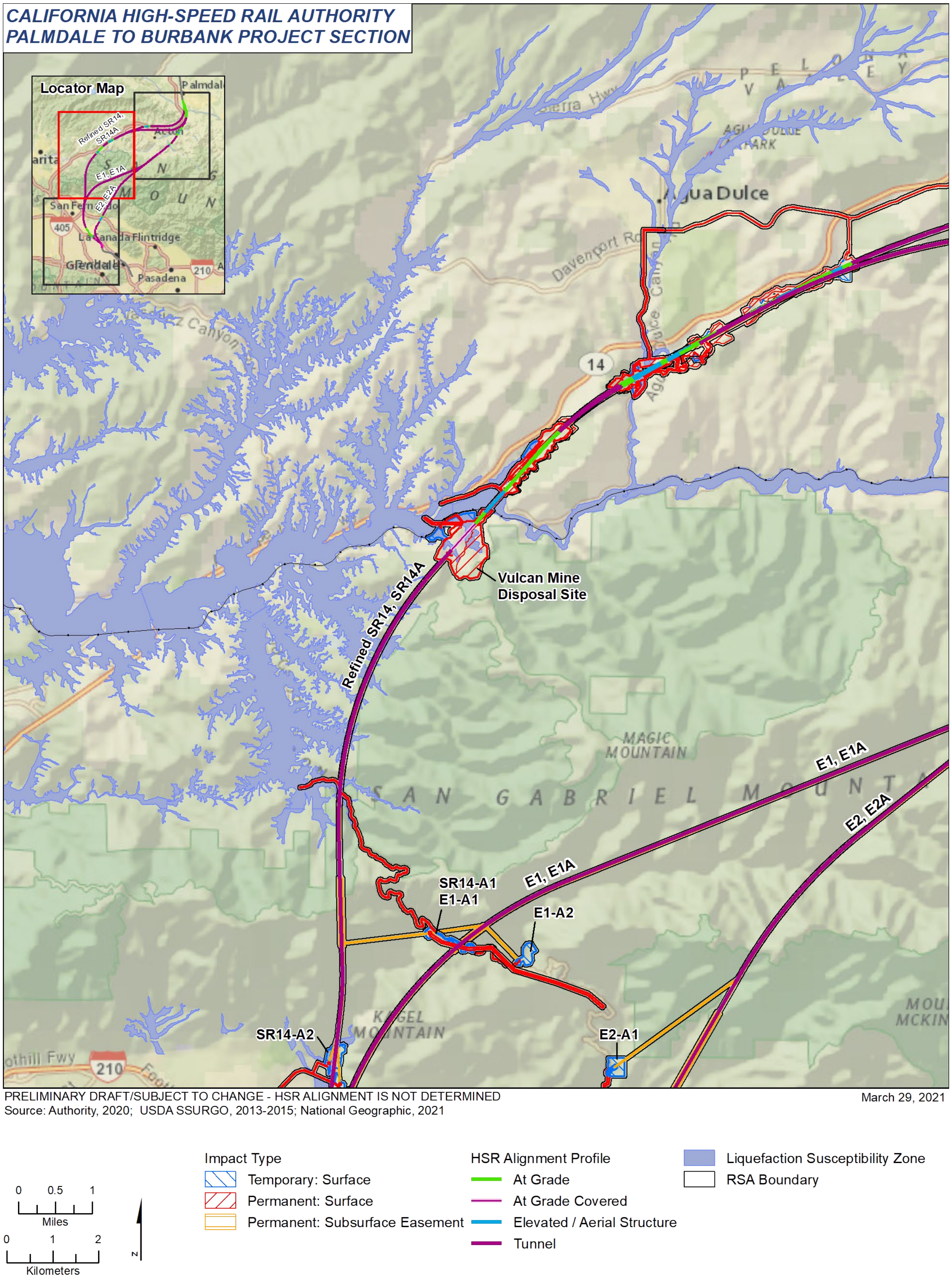


Figure 3.9-21 Liquefaction Zones (Map 2 of 3)

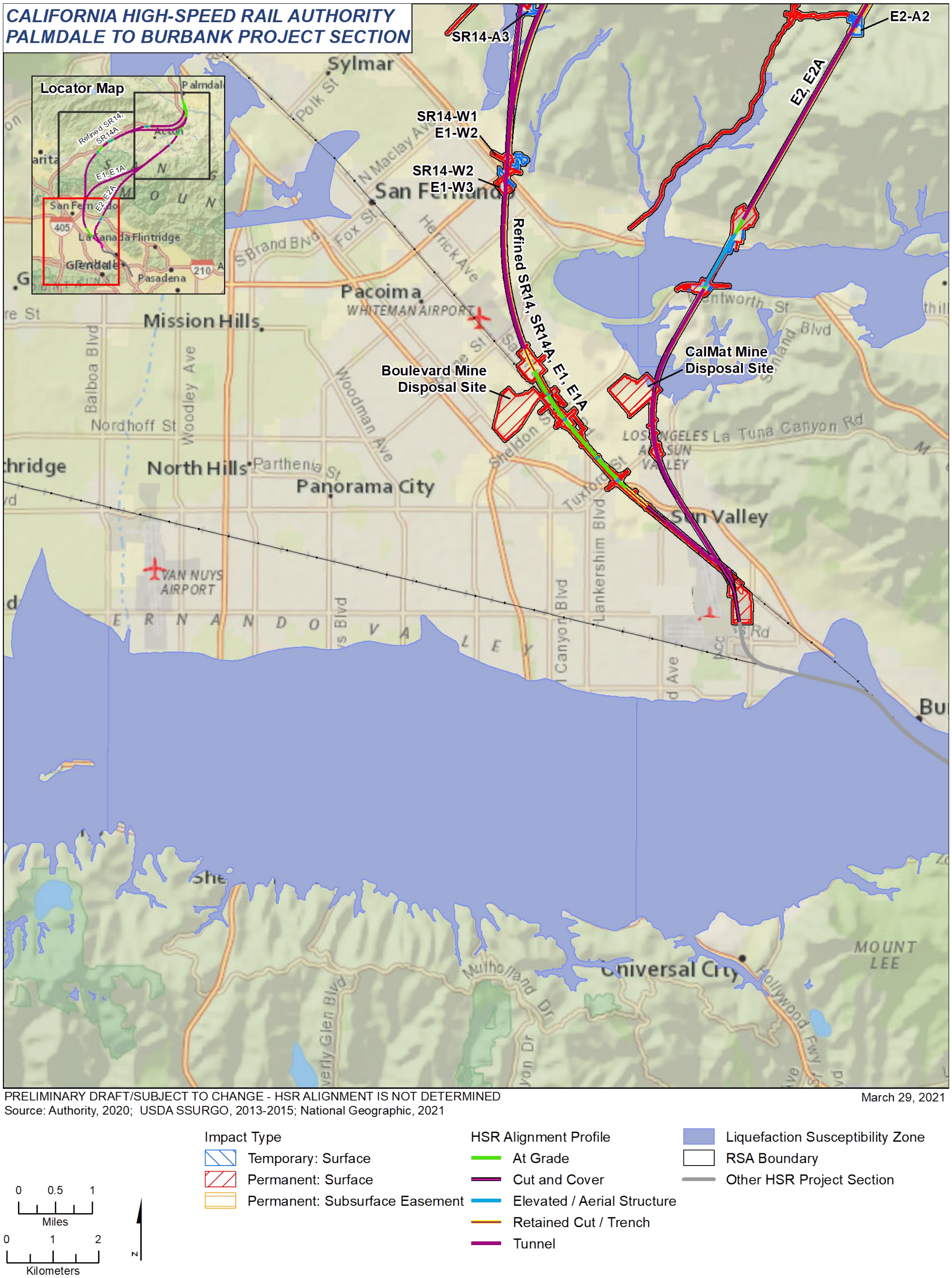


Figure 3.9-22 Liquefaction Zones (Map 3 of 3)

Seismically Induced Landslides

Seismically induced landslides consist of landslides induced by seismic events and are a significant risk in California. Areas that are most susceptible to earthquake-induced landslides are steep slopes in poorly cemented or highly fractured rocks; areas underlain by loose, weak soils; and areas on or adjacent to existing landslide deposits. Refer to Figure 3.9-23 through Figure 3.9-25 for areas prone to seismically induced landslides. In addition to these known areas, unknown or unidentified unstable slopes could also be present in the secondary seismic/geologic hazard RSAs for all six of the Build Alternatives.

Refined SR14 Build Alternative

The Refined SR14 Build Alternative would not be susceptible to seismically induced landslides north of the California Aqueduct owing to relatively flat topography in this area. Between the California Aqueduct and Vulcan Mine, the secondary seismic/geologic hazard RSA includes areas with seismically induced landslide risks. Before exiting the San Gabriel Mountains, Refined SR14 Build Alternative alignment passes below a large seismically induced landslide risk area. The Refined SR14 Build Alternative options would be in this area. The SR14-W1 and SR14-W2 intermediate window options and portions of the Vulcan Mine and Boulevard Mine disposal sites would also be located within a zone where there is risk of seismically induced landslides (Figure 3.9-24 and Figure 3.9-25). A utility line associated with the SR14-A1 adit option would also be within a seismically induced landslide hazard area along Little Tujunga Canyon Road within the ANF (Figure 3.9-24).

SR14A Build Alternative

The SR14A Build Alterative alignment traverses a more southerly route that has more land prone to seismically induced landslides between the California Aqueduct and the Vulcan Mine compared to the Refined SR14 Build Alternative alignment. Apart from these locations, the SR14A Build Alternative alignment would encounter the same areas of land prone to seismically induced landslides as the Refined SR14 Build Alternative alignment.

E1 Build Alternative

Similar to the Refined SR14 Build Alternative, the E1 Build Alternative would not be susceptible to seismically induced landslides north of the California Aqueduct because of the relatively flat topography of this area. However, multiple zones with potential for seismically induced landslides exist within the E1 Build Alternative secondary seismic/geologic hazard RSA between the California Aqueduct and Aliso Canyon. South of Aliso Canyon, the alignment would continue south in bored tunnels, and thus would not be vulnerable to seismically induced landslides. In the San Fernando Valley, portions of the Boulevard Mine are located within seismically induced landslides zone (Figure 3.9-25). The E1-A1/E1-A2 adit options would also propose a utility line through seismically induced landslide hazard areas along Little Tujunga Canyon Road within the ANF (Figure 3.9-24).

E1A Build Alternative

The E1A Build Alternative alignment would traverse the same areas prone to seismically induced landslides as the E1 Build Alternative alignment.

E2 Build Alternative

The E2 Build Alternative would not be susceptible to seismically induced landslides north of the California Aqueduct owing to relatively flat topography in this area, but multiple zones with potential for seismically induced landslides exist within the E2 secondary seismic/geologic hazard RSA between the California Aqueduct and Aliso Canyon. South of Aliso Canyon, the alignment would continue south in bored tunnels, and therefore would not be vulnerable to seismically induced landslides. One exception would be the tunnel portal exiting the ANF in Tujunga Valley. This portal would be in an area susceptible to seismically induced landslides (Figure 3.9-25). The E2-A1/E2-A2 adit options would also propose construction staging areas and utility lines through seismic hazards areas within the ANF (Figure 3.9-24). Finally, E2 proposes a tunnel portal in the southern portion of the ANF north of Big Tujunga Wash (Figure 3.9-24).

E2A Build Alternative

The E2A Build Alternative alignment traverses the same areas prone to seismically induced landslides as the E2 Build Alternative alignment.

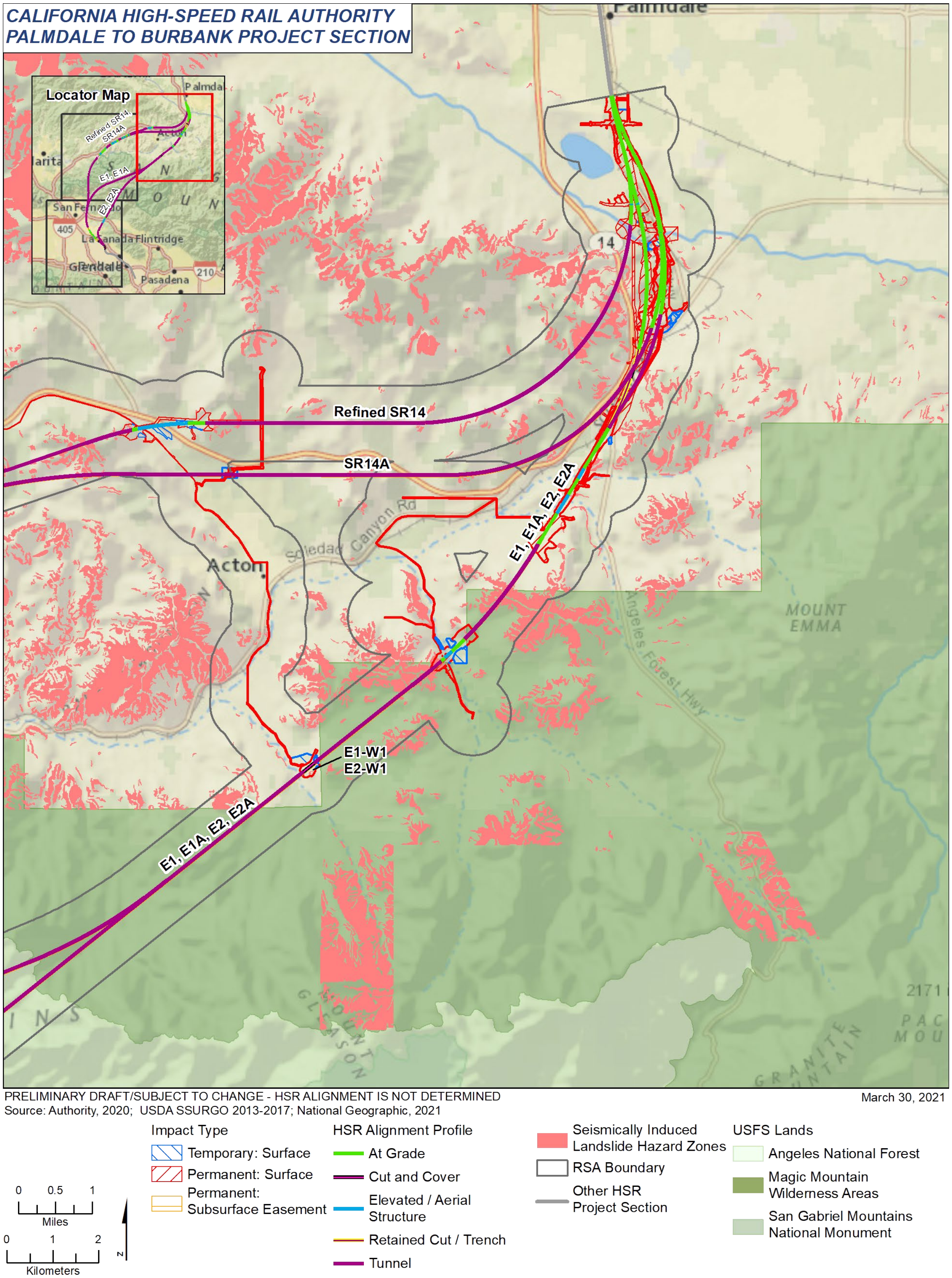


Figure 3.9-23 Seismically Induced Landslide Hazard Areas (Map 1 of 3)

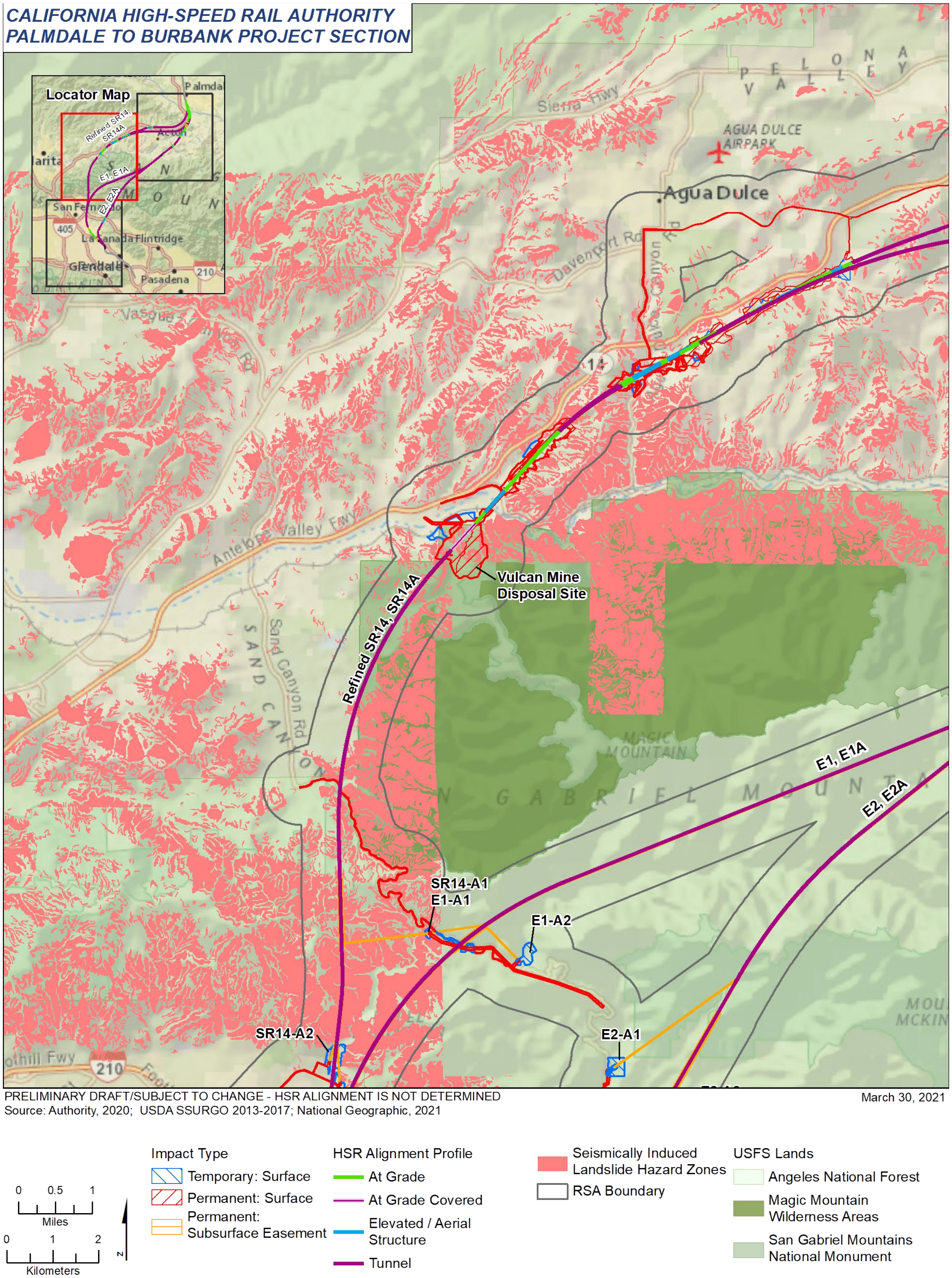


Figure 3.9-24 Seismically Induced Landslide Hazard Areas (Map 2 of 3)

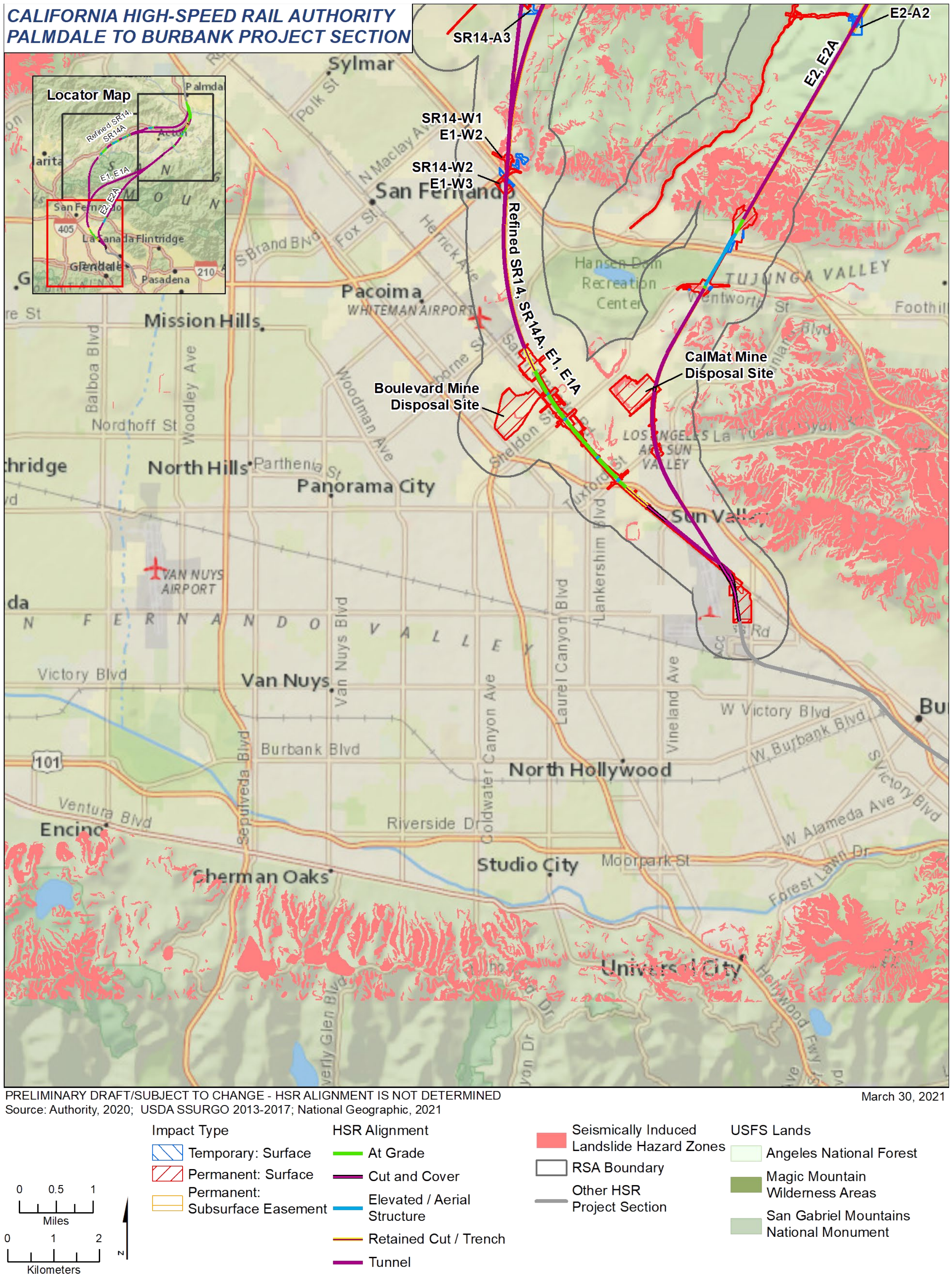


Figure 3.9-25 Seismically Induced Landslide Hazard Areas (Map 3 of 3)

Seiche

A seiche refers to the movement of an enclosed body of water such as a bay, lake, river, or reservoir due to periodic oscillation. Seiches commonly occur because of intense seismic shaking or catastrophic landslides that displace large amounts of water in a short period of time. The period of oscillation varies and depends on the body of water's size. The period of a seiche can last for minutes to several hours and depends on the magnitude of oscillations and the geometry of the body of water. Seiches have caused significant damage to nearby structures, including dams, shoreline facilities, and levees or embankments.

All six Build Alternatives would be built immediately east of Lake Palmdale, which could be the source of a seiche during an earthquake. Because of the small size and shallow depth of this lake, wave volume above the dam during a seiche would not likely be substantial, and damaging floods would thus be unlikely. Other enclosed waterbodies adjacent to the inundation RSA, including Pacoima Reservoir (Refined SR14 and E1 Build Alternative inundation RSAs) and Hansen Dam Reservoir (Refined SR14, E1, and E2 Build Alternative inundation RSAs) would be unlikely to generate seiches that would affect the Palmdale to Burbank Project Section because of the relatively small size of these waterbodies, the location of such water relative to facilities, and regulatory controls imposed by state and local governments. The SR14A, E1A, and E2A Build Alternatives would also be located in the vicinity of enclosed waterbodies. Such impacts would be identical to those resulting from the implementation of the Refined SR14, E1, and E2 Build Alternatives, respectively.

Tsunami

A tsunami is an ocean wave resulting from the rapid displacement of water. Tsunamis are commonly associated with underwater faults. The effect of a tsunami on a shoreline is closely associated with the bathymetric properties of an ocean basin. Tsunamis can also occur when submarine or land-based landslides displace large volumes of water. The inundation RSA is not within the Los Angeles County tsunami inundation zone. The southernmost portions of the inundation RSA are more than 15 miles inland and separated from the ocean by the Hollywood Hills/Santa Monica Mountains. Given these factors, the probability of the project experiencing a tsunami would be low, and this issue is not discussed further.

Dam Failure/Dam Inundation Areas

A seismic event could result in dam failure, which could release impounded water. Several dam inundation areas are present within the inundation RSA (Figure 3.9-26 through Figure 3.9-28). These inundation areas represent conservative scenarios, insofar as the areas assume that the retained bodies of water are at their maximum elevation, and that there would be catastrophic failure of the retaining structures during seismic shaking.

Refined SR14 Build Alternative

Portions of the Refined SR14 Build Alternative footprint would be located within the dam inundation area associated with Lake Palmdale (Figure 3.9-26). In the San Fernando Valley, tunnel portions of the alignment, two Refined SR14 Build Alternative intermediate window options, and the Boulevard Mine disposal site would be located within the Pacoima Dam inundation area. Above-ground and below-ground portions of the Refined SR14 Build Alternative alignment would also be constructed across northern reaches of the Hansen Dam inundation area (Figure 3.9-28). The Burbank Airport Station area would also be within the Hansen Dam inundation area.

SR14A Build Alternative

The SR14A Build Alternative would require a greater footprint area within inundation areas associated with Lake Palmdale compared to the Refined SR14 Build Alternative but would require identical footprint within inundation areas associated with Pacoima Dam and Hansen Dam.

E1 Build Alternative

At-grade portions of the E1 Build Alternative footprint would be located within the dam inundation area associated with Lake Palmdale (Figure 3.9-26). No other dam inundation areas are present between Palmdale and the northeast San Fernando Valley. Within the Pacoima Dam inundation area, the E1 Build Alternative alignment would be constructed primarily in bored tunnel along with a cut-and-cover section near the intersection of I-210 and SR 118. Other elements of the E1 Build Alternative alignment within the Pacoima Dam inundation area include the Boulevard Mine disposal site and the E1-W1 and E1-W2 intermediate window options. Because the E1 Build Alternative alignment would mirror Refined SR14 Build Alternative alignment starting in the Pacoima area, the E1 Build Alternative alignment, like Refined SR14 Build Alternative alignment described above, would also be constructed across northern reaches of the Hansen Dam inundation area. The Burbank Airport Station area would also be within the Hansen Dam inundation area (Figure 3.9-27 and Figure 3.9-28).

E1A Build Alternative

The E1A Build Alternative would require a greater footprint area within inundation areas associated with Lake Palmdale compared to the E1 Build Alternative but would require identical footprint within inundation areas associated with Pacoima Dam and Hansen Dam.

E2 Build Alternative

At-grade portions of the E2 Build Alternative footprint would be located within the dam inundation area associated with Lake Palmdale (Figure 3.9-26). No other dam inundation is present within the E2 Build Alternative inundation RSA until south of the Big Tujunga Wash. In the Shadow Hills and Sun Valley neighborhoods, tunnel portions of the E2 Build Alternative would be constructed through portions of the Hansen Dam inundation area. The CalMat Mine Disposal site and Burbank Airport Station area would also be located within the Hansen Dam inundation area (Figure 3.9-28).

E2A Build Alternative

The E2A Build Alternative would require a greater footprint area within inundation areas associated with Lake Palmdale compared to the E2 Build Alternative but would require identical footprint within inundation areas associated with Pacoima Dam and Hansen Dam.

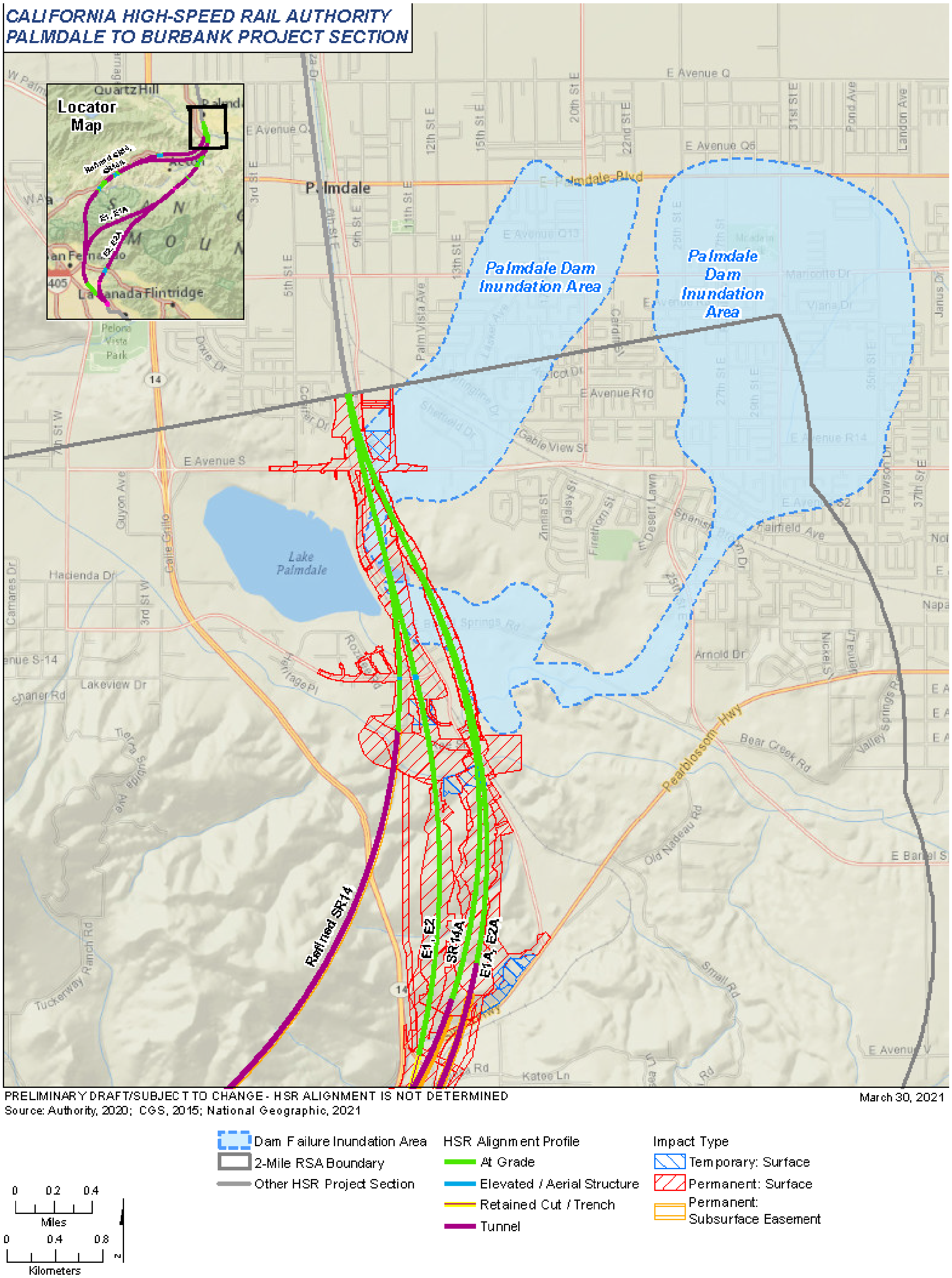


Figure 3.9-26 Lake Palmdale Dam Inundation Area

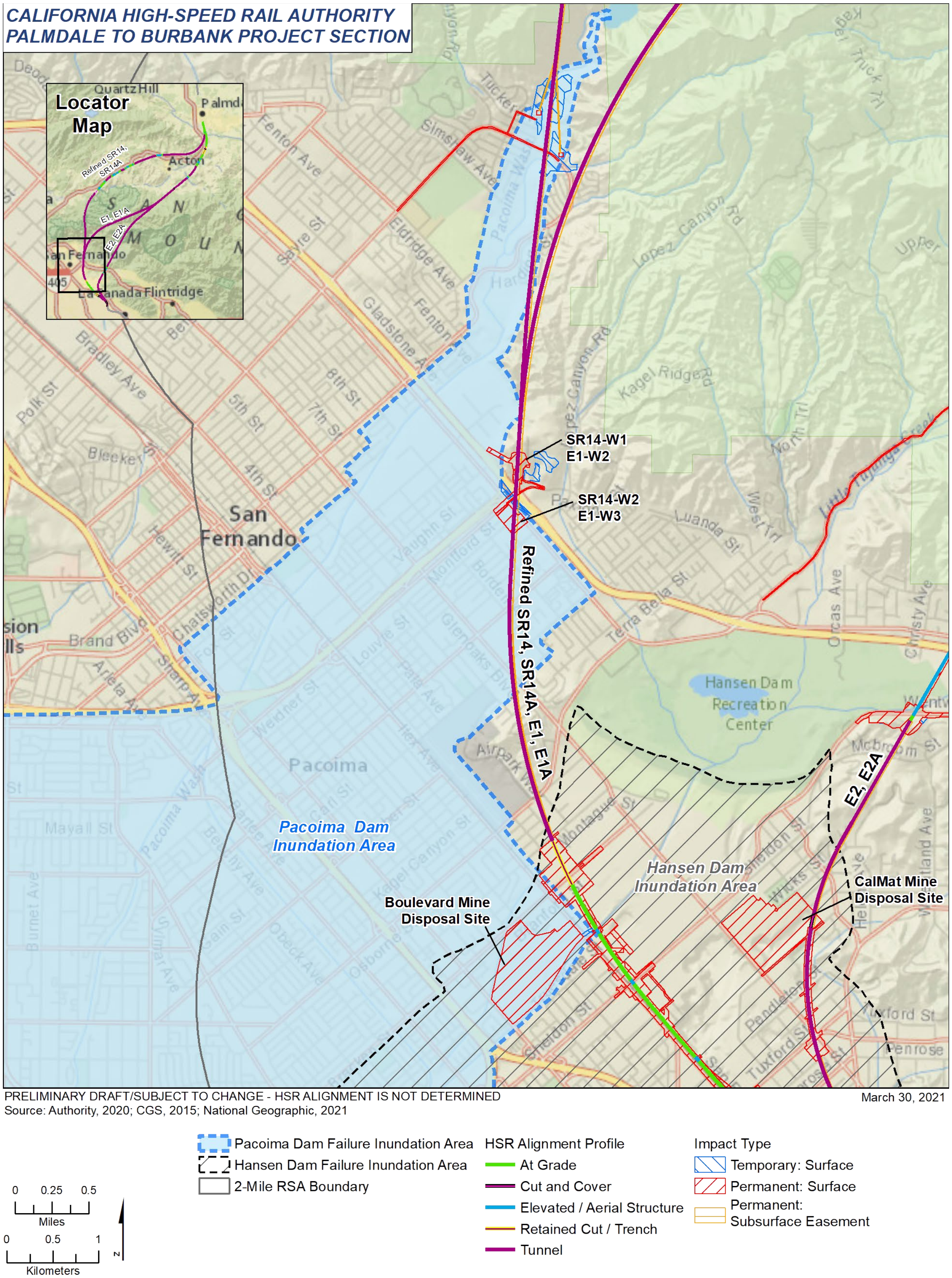
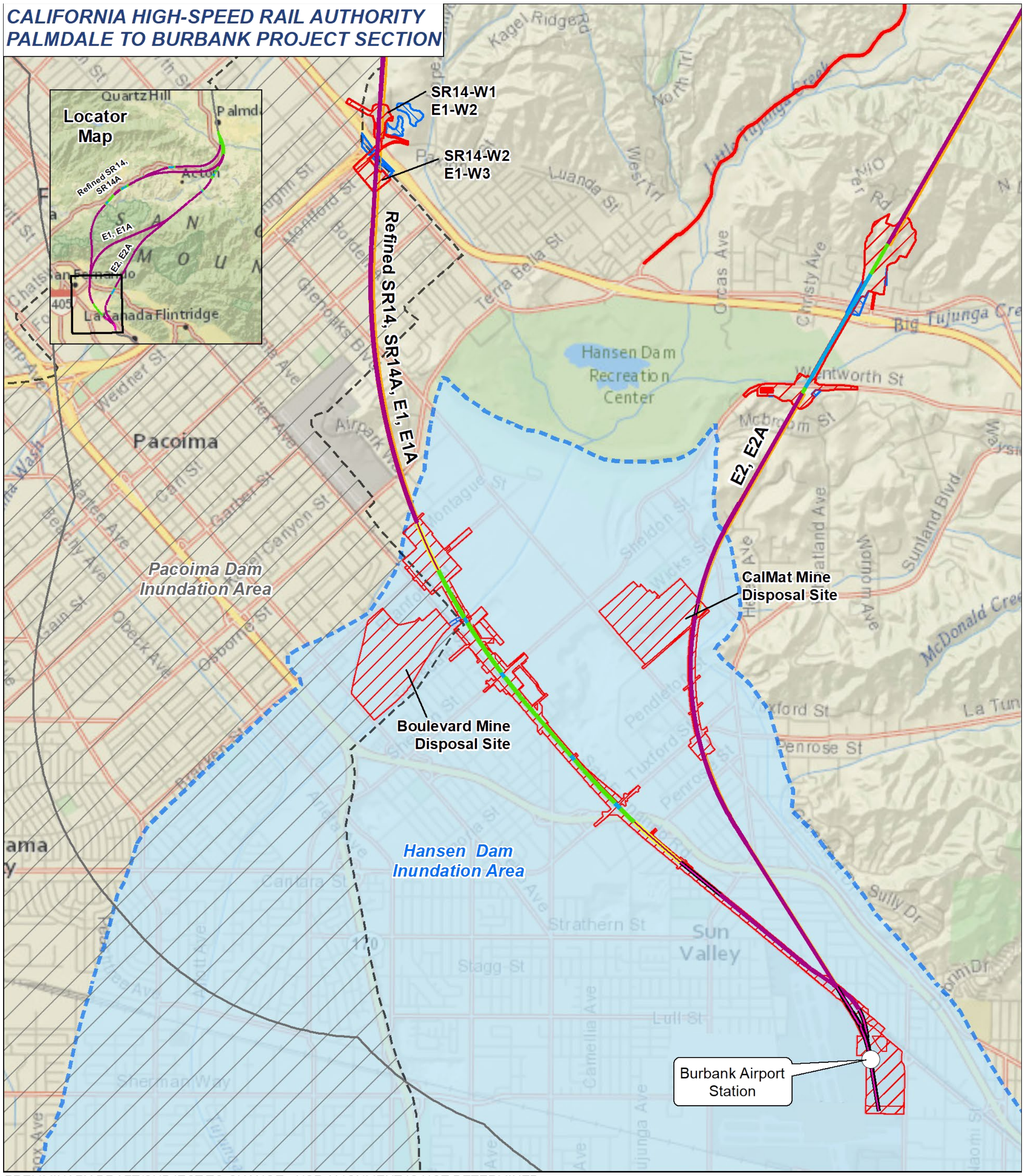


Figure 3.9-27 Pacoima Dam Inundation Area



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED
Source: Authority, 2020; CGS, 2015; National Geographic, 2021

March 30, 2021

0 0.25 0.5
Miles
0 0.5 1
Kilometers

Proposed HSR Station
Hansen Dam Failure Inundation Area
Pacoima Dam Failure Inundation Area
2-Mile RSA Boundary

HSR Alignment Profile
At Grade
Cut and Cover
Elevated / Aerial Structure
Retained Cut / Trench
Tunnel

Impact Type
Temporary: Surface
Permanent: Surface
Permanent: Subsurface Easement

Figure 3.9-28 Hansen Dam Inundation Area

3.9.5.8 Mineral and Energy Resources

Geothermal Resources

No geothermal wells or springs are located within the mineral and energy resource RSA. The nearest geothermal wells are located approximately 55 to 65 miles southeast in the city of San Bernardino. Geothermal resources are not discussed further in this document.

Mineral Resources

Los Angeles County has yielded many different types of mineral resources. Primary mineral commodities in the mineral and energy resource RSA include construction aggregate (such as sand, gravel, and crushed stone) and gold. In addition to these primary commodities, the mineral and energy resources RSA also includes mining operations for metals, gems, and other mineral resources. Mining activities are prohibited in the SGMNM due to this area's protected status as a National Monument. In contrast, mining is allowed in specific areas of the ANF.

Mineral Resource Zones

Construction aggregate is a key component of various construction materials, including concrete, asphalt, plaster, and stucco. Aggregate is also used as a road base, sub-base, and fill. Local sources of aggregate are essential for the construction industry because transporting aggregate from great distances can have high economic and environmental costs. Maps of the mineral resource zones are depicted in Figure 3.9-29 though Figure 3.9-31

> *Construction Aggregate*
>
> *Construction aggregate* is a broad category of particulate mineral material—including sand, gravel, and crushed stone—that is used in construction.

The CGS inventories important mineral deposits and classifies MRZ-2 and MRZ-3 that could be subject to irreversible land uses that would effectively preclude the extraction of valuable mineral resources.

- **Refined SR14 Build Alternative**—The Refined SR14 Build Alternative would encounter MRZ-2 and MRZ-3 areas between Vulcan Mine and Sand Canyon Road (Figure 3.9-30). The Refined SR14 Build Alternative would encounter additional MRZ-2 and MRZ-3 areas located underground near the SR14-A2/SR14-A3 adit options (Figure 3.9-30).
- **SR14A Build Alternative**—The SR14A Build Alternative would encounter identical mineral resources to those encountered by the Refined SR14 Build Alternative within the ANF including the SGMNM.
- **E1 Build Alternative**—The E1 tunnels would encounter MRZ-3 areas in the center of the ANF (Figure 3.9-29) and again near the southern ANF perimeter (Figure 3.9-30).
- **E1A Build Alternative**—The E1A Build Alternative would encounter identical mineral resources to those encountered by the E1 Build Alternative within the ANF including the SGMNM.
- **E2 Build Alternative**—The E2 tunnels would encounter MRZ-3 areas in the center of the ANF (Figure 3.9-29). The E2 tunnel alignment and a E2-A1/E2-A2 utility line along Little Tujunga Canyon Road would also encounter MRZ-2 and MRZ-3 areas (Figure 3.9-30).
- **E2A Build Alternative**—The E2A Build Alternative would encounter identical mineral resources to those encountered by the E2 Build Alternative within the ANF including the SGMNM.

The mineral and energy resource RSA would include MRZ-2 and MRZ-3 zones associated with aggregate (Figure 3.9-29 through Figure 3.9-31).

Construction Aggregate Availability

Mineral land classification studies in Los Angeles County define production-consumption (P-C) regions, which cover aggregate production districts (a group of producing aggregate mines) and the market area they serve. The project would be located within the following two P-C regions:

- San Fernando Valley/Saugus-Newhall P-C region
- Palmdale P-C region

According to CGS's 2012 aggregate study, the Palmdale P-C region contained 152 million tons of remaining permitted aggregate reserves, which could meet projected regional demand until 2023–2033. The San Fernando Valley/Saugus-Newhall P-C region had 77 million tons of remaining permitted aggregate reserves, which would be insufficient to meet projected regional demand until 2022.

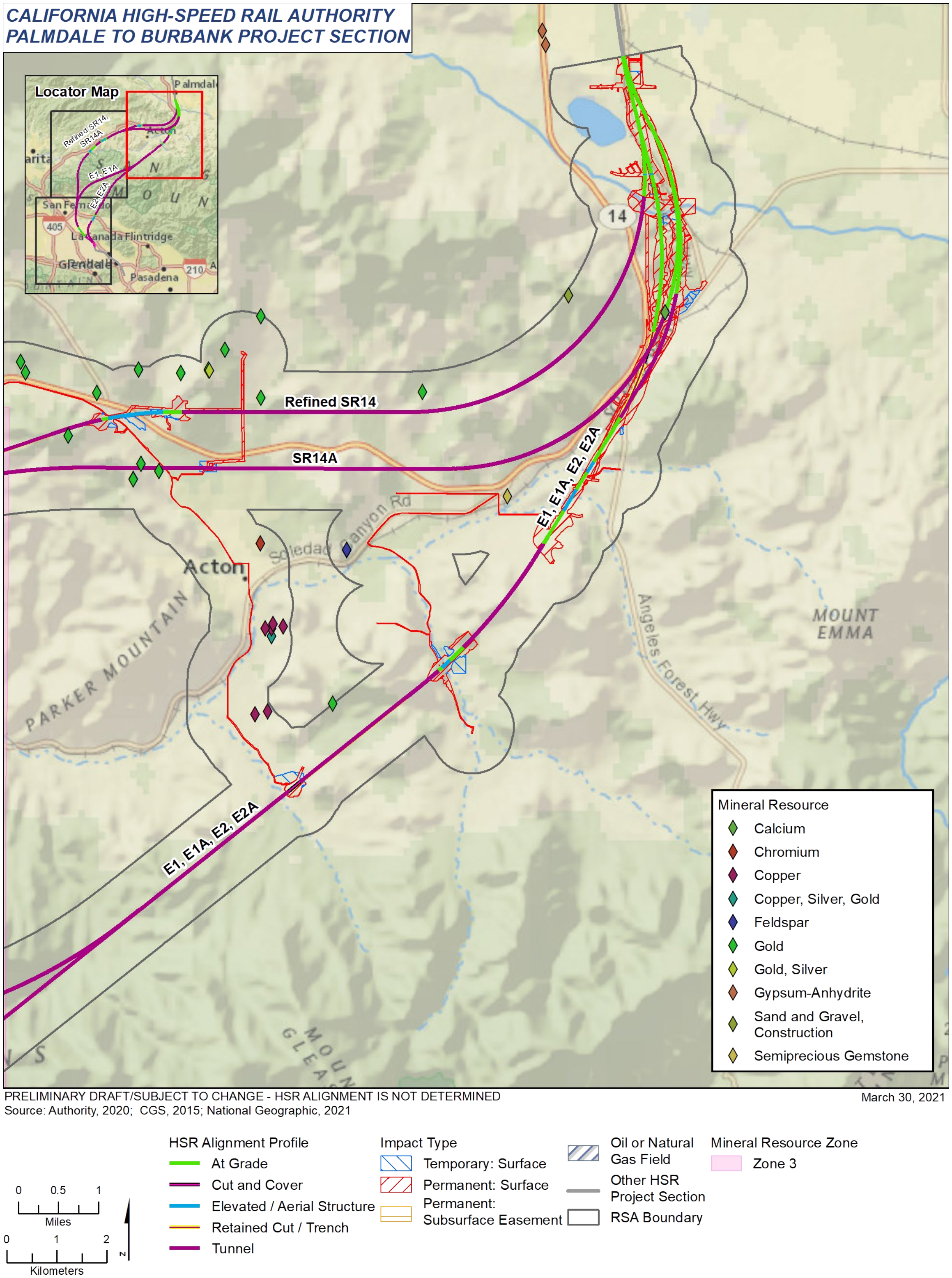


Figure 3.9-29 Mining Facilities and Mineral Resource Zones (Map 1 of 3)

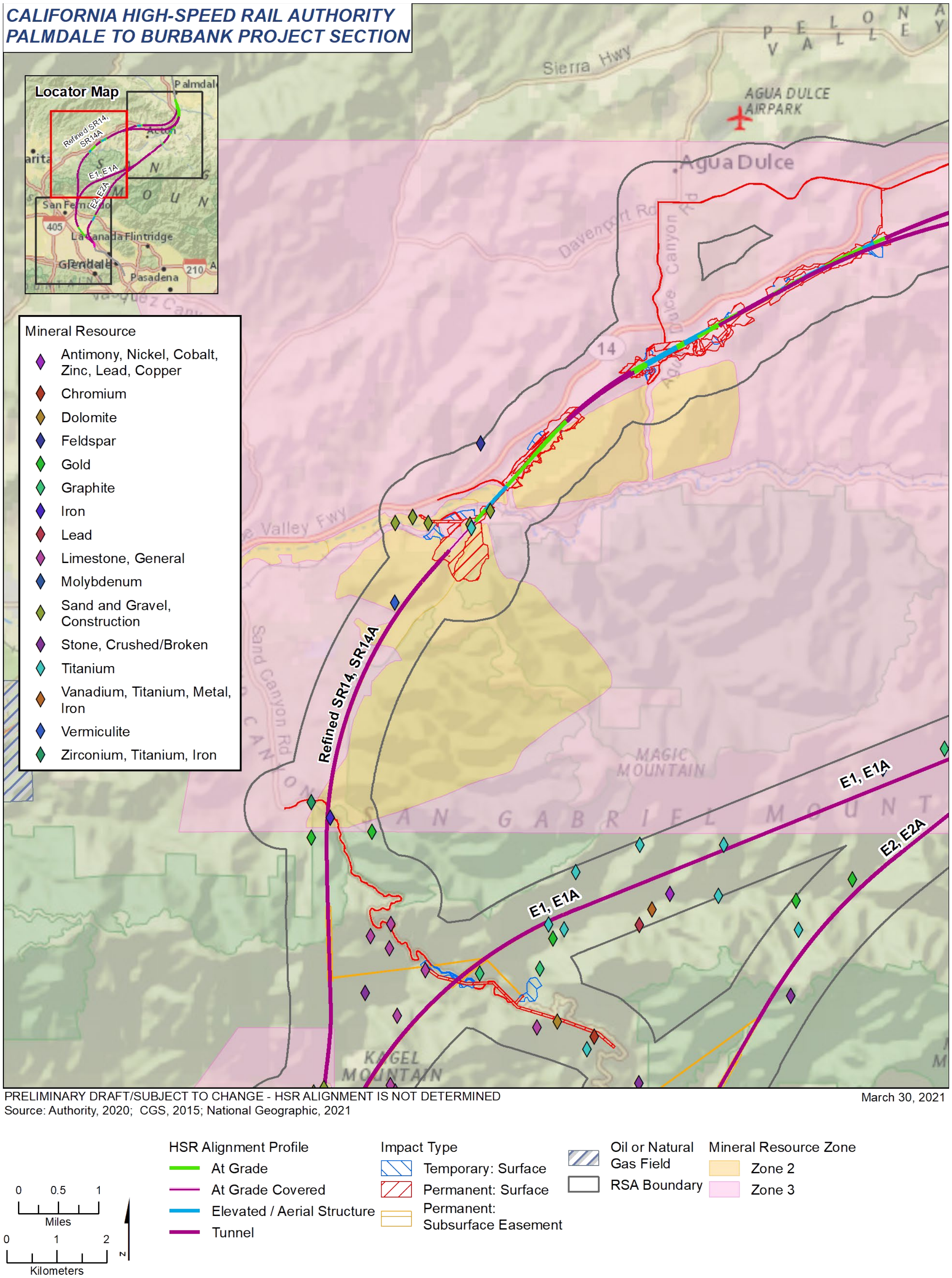


Figure 3.9-30 Mining Facilities and Mineral Resource Zones (Map 2 of 3)

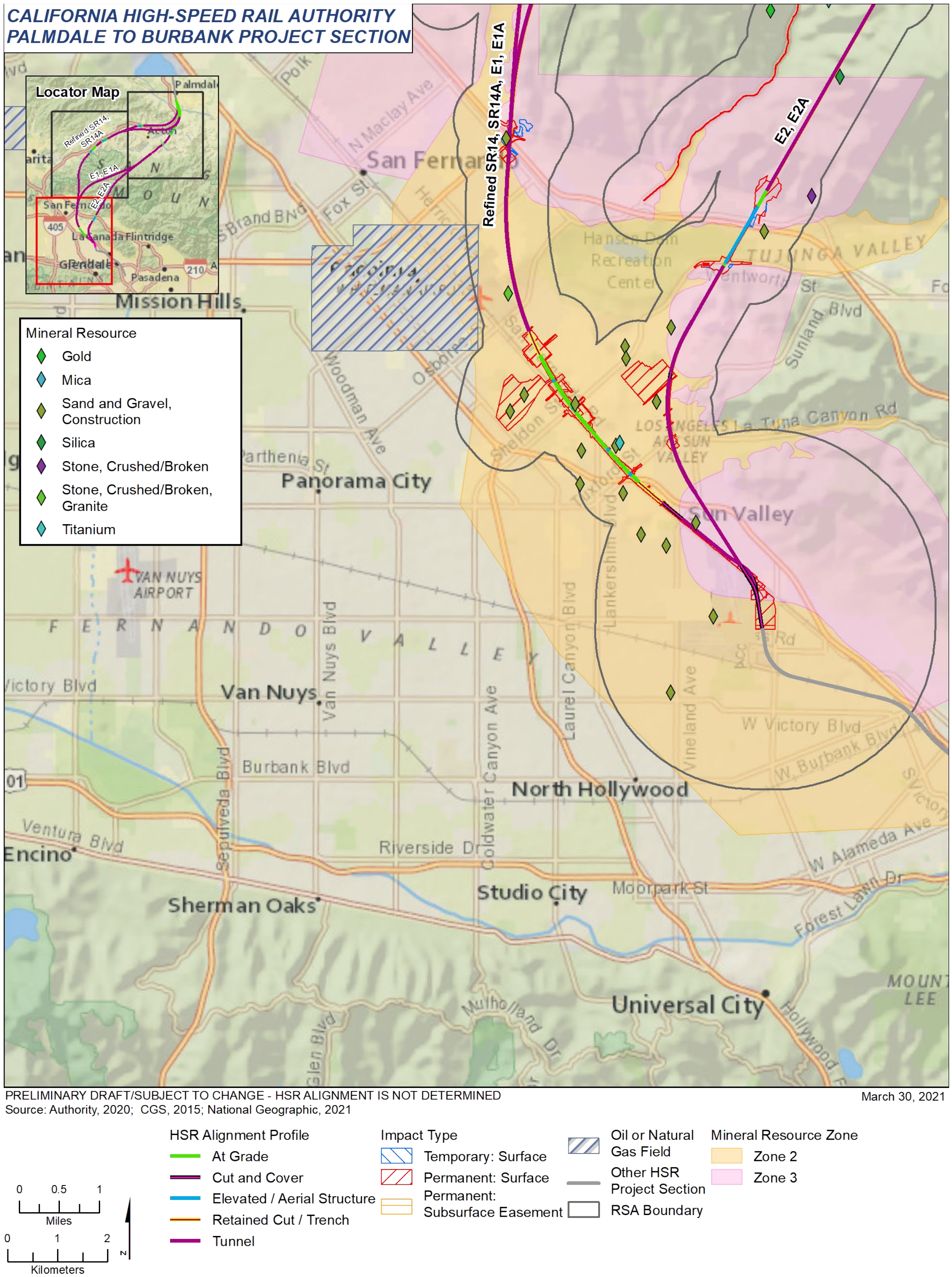


Figure 3.9-31 Mining Facilities and Mineral Resource Zones (Map 3 of 3)

Existing Mining Operations

The mineral and energy resource RSAs encompass active and inactive mining sites Figure 3.9-29 through Figure 3.9-31 show the location of these sites and indicate the specific commodity associated with each operation. Most of these facilities are historical or previous producers, though several active mining facilities operate within the area. Based on the prevalence of mining activities, there is a high probability that abandoned and undocumented mines exist in the mineral and energy resource RSA in addition to known active/inactive sites. Section 5 of the *Palmdale to Burbank Project Section Geology, Soils, and Seismicity Technical Report* (Authority 2019a) contains a complete list of recorded mining operations within the mineral and energy resource RSA, including facility type and status.

Oil and Natural Gas

Los Angeles County includes numerous oil and gas production sites. Oil and gas wells occur within the mineral and energy resource RSAs for all six Build Alternatives.[8] However, each of the wells are dry holes and have been plugged. Refer to Chapter 3.10, Hazardous Materials and Wastes, for maps of the existing oil and natural gas wells/fields within the RSA (Figure 3.10-A-1 through Figure 3.10-A-25).

3.9.5.9 Paleontological Resources

Certain geologic units within the paleontological RSA might contain paleontological resources. Although the paleontological RSA includes rocks that record the last 1.7 billion years of geologic history, the presence of fossils is limited to the geologic units formed during the Cenozoic Era (65 million years to the present) because older geologic units within the paleontological RSA are igneous rocks that formed in extreme heat and pressure environments. Those rocks are not conducive to fossil preservation. Literature review, museum records searches, and field surveys indicate that 10 geologic units underlying the paleontological RSA have high paleontological sensitivity or low to high paleontological sensitivity; five geologic units underlying the paleontological RSA have low paleontological sensitivity; and five geologic units underlying the paleontological RSA have no paleontological sensitivity. Table 3.9-5 lists the paleontologically sensitive geologic units underlying the paleontological RSA, and Figure 3.9-32 through Figure 3.9-34 map paleontological sensitivity of the geologic units underlying the paleontological RSA.

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[8] While energy development is prohibited in the SGMNM due to this area's protected status as a National Monument, energy resources within the ANF are available for extraction.

Table 3.9-5 Paleontologically Sensitive Geologic Units Underlying the Resource Study Area

Map Symbol	Geologic Unit	Paleontological Sensitivity	Presence within paleontological RSA					
			Refined SR14	SR14A	E1	E1A	E2	E2A
Tsu	Santa Susana Formation	Low	N/A	N/A	X	X	X	X
Ttcg	Tick Canyon Formation	High	X	X	N/A	N/A	N/A	N/A
Tva, Tvb, Tvcal, Tvcg, Tvcgl, Tvcs, Tvsb, Tvss, Tvt	Vasquez Formation	No to Low	X	X	X	X	X	X
Ttucg, Ttr	Topanga Formation	High	X	X	X	X	N/A	N/A
Tmc, Tmcv	Mint Canyon Formation	High	X	X	N/A	N/A	N/A	N/A
Tucg, Tush, Tm, Tmss	Modelo (Monterey) Formation	High	X	X	X	X	X	X
Tpf, Tpc	Punchbowl Formation	High	X	X	X	X	X	X
Ttoc, Ttog, Ttos	Towsley Formation	High	X	X	X	X	X	X
Tas	Anaverde Formation	Low	X	X	X	X	X	X
Tps	Pico Formation	High	X	X	X	X	N/A	N/A
QTs	Saugus Formation	High	X	X	X	X	X	X
Qp	Pacoima Formation	Low	X	X	N/A	N/A	N/A	N/A
Qoa, Qae, Qog, Qos	Older Quaternary Deposits	Low to High[1]	X	X	X	X	X	X
Qa, Qg, Qf, Qls	Younger Quaternary Deposits	Low to High[2]	X	X	X	X	X	X
af	Artificial Fill	Low	X	X	X	X	X	X

Source: Authority, 2019b
[1] Some older Quaternary (Pleistocene-age) deposits within the paleontological RSA are composed of coarse-grained material, which is not typically conducive to the preservation of fossils; however, older, finer-grained alluvial sediments could contain significant paleontological resources.
[2] Younger Quaternary deposits are generally not paleontologically sensitive at the surface but could become sensitive at unknown depths where they reach an age of early Holocene or greater (>5,000 years old) and where they overlie Pleistocene-age sediments of high paleontological sensitivity.
RSA = resource study area
X = paleontologically sensitive geologic unit is present in the Build Alternative paleontological RSA
N/A = Not applicable because paleontologically sensitive area is not present in the Build Alternative paleontological RSA

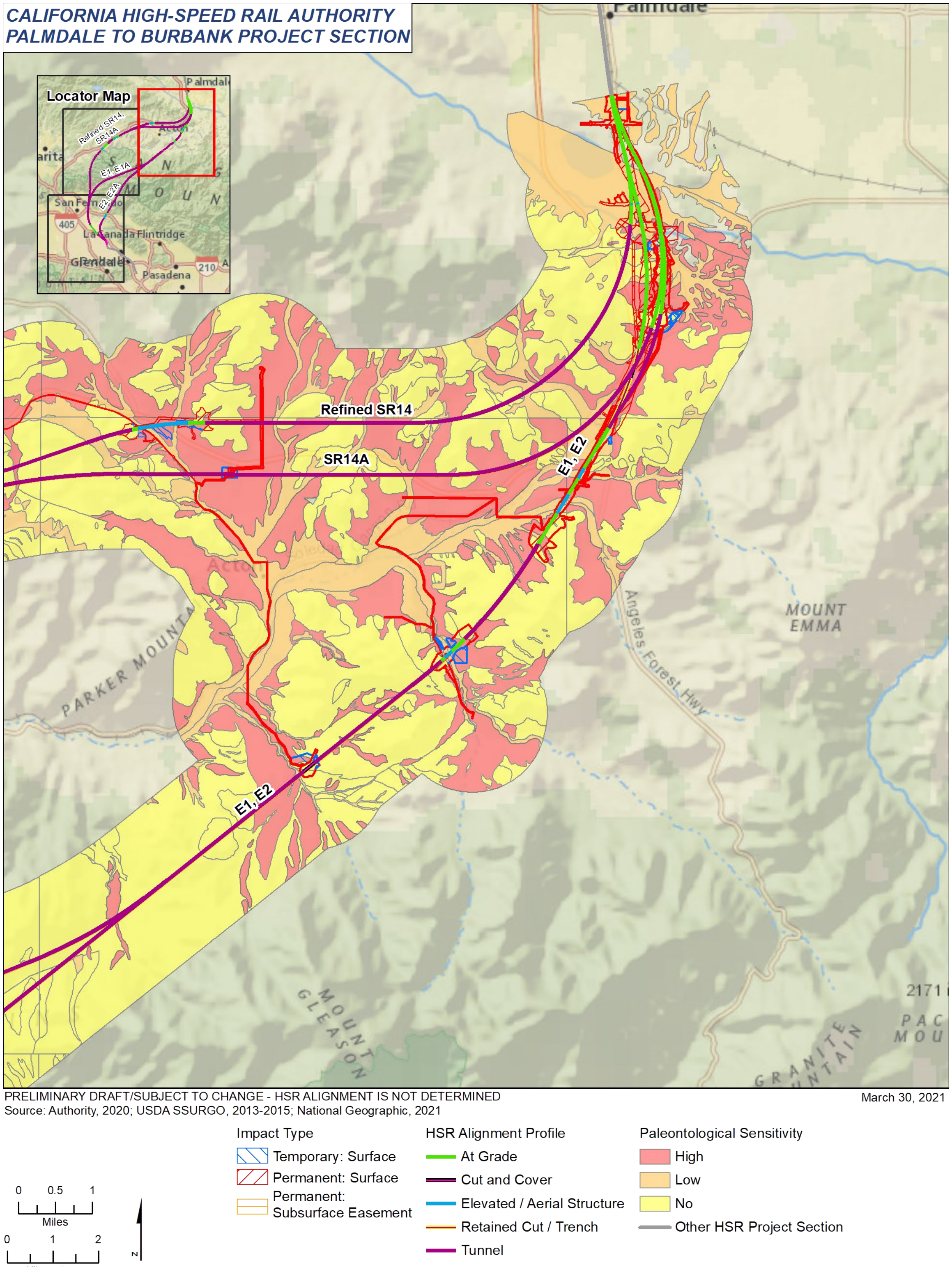

Figure 3.9-32 Paleontologically Sensitive Geologic Units in the Resource Study Area (Map 1 of 3)

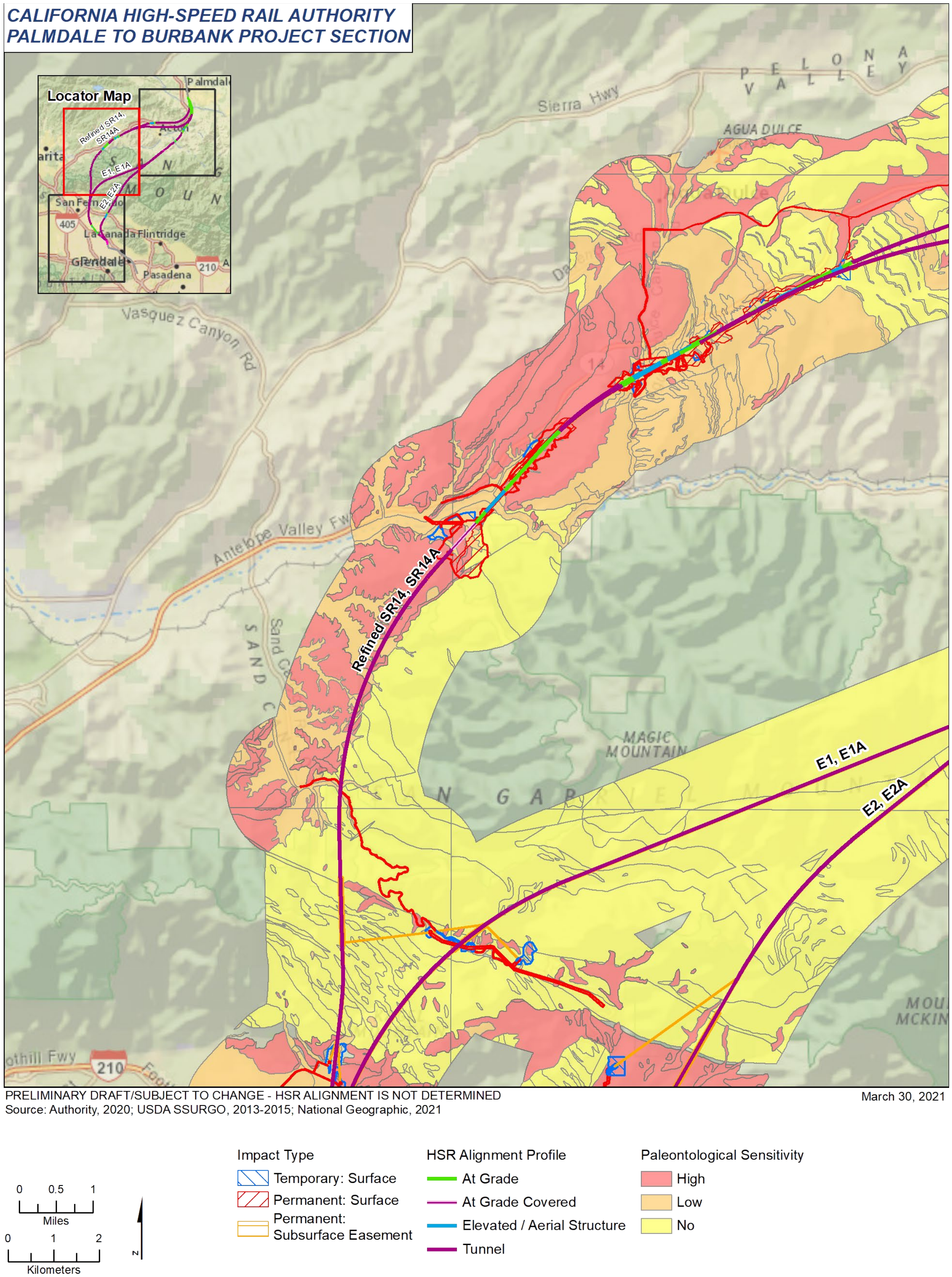

Figure 3.9-33 Paleontologically Sensitive Geologic Units in the Resource Study Area (Map 2 of 3)

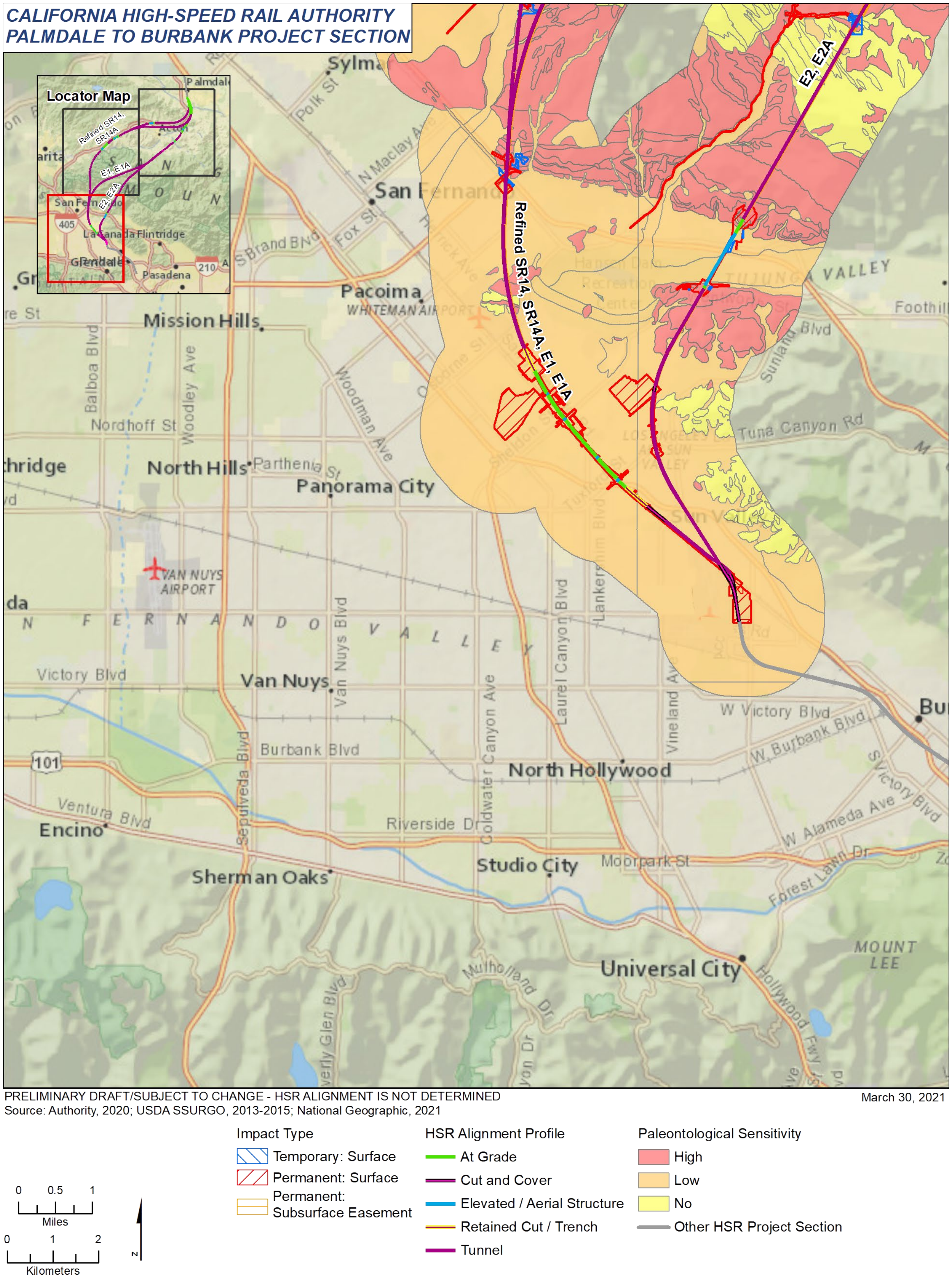

Figure 3.9-34 Paleontologically Sensitive Geologic Units in the Resource Study Area (Map 3 of 3)

Refined SR14 Build Alternative

Geologic units underlying the Refined SR14 Build Alternative paleontological RSA through Palmdale to the San Andreas Fault Zone generally exhibit low potential to yield fossil resources (Figure 3.9-32). Through Acton and Agua Dulce Canyon, the Refined SR14 Build Alternative would be constructed through multiple geologic units that exhibit no, low, and high paleontological sensitivity (Figure 3.9-32 and Figure 3.9-33). A portion of the Refined SR14 Build Alternative would be within areas of high paleontological sensitivity between Vulcan Mine and Sand Canyon Road, which is also within the ANF, and before exiting the southern portion of the ANF (Figure 3.9-33). After Soledad Canyon Road, the tunneled alignment would be constructed through predominantly high and low paleontological potential areas over the Santa Clara River and throughout the ANF (Figure 3.9-34). Most of the geologic units underlying the paleontological RSA through the urbanized San Fernando Valley have low paleontological potential, with pockets of high potential north of the I-210/SR 118 interchange and west of Hansen Dam (Figure 3.9-34).

SR14A Build Alternative

Although the SR14A Build Alternative alignment would traverse different areas than the Refined SR14 Build Alternative alignment between East Avenue S and the Vulcan mine, the SR14A paleontological RSA would not substantially differ from that of the Refined SR14 Build Alternative.

E1 Build Alternative

Geologic units underlying the E1 paleontological RSA through Palmdale exhibit low potential to yield fossil resources (Figure 3.9-32). Between the San Andreas Fault Zone and the ANF, the E1 Build Alternative alignment would be constructed above ground and below ground through multiple geologic units that exhibit no, low, and high paleontological sensitivity (Figure 3.9-32). Geologic units within the ANF generally exhibit no paleontological sensitivity, except for Aliso Canyon and Arrastre Canyon, which have areas of high paleontological sensitivity where the E1 Build Alternative would require ground disturbance (Figure 3.9-32 and Figure 3.9-33). The E1-A1/E1-A2 adit footprints would also encounter areas of high paleontological sensitivity. Most of the geologic units underlying the paleontological RSA through the urbanized San Fernando Valley have low paleontological potential, with pockets of high potential north of the I-210/SR 118 interchange and west of Hansen Dam (Figure 3.9-34).

E1A Build Alternative

Although the E1A Build Alternative alignment would traverse different areas than the E1 Build Alternative alignment south of East Avenue S and north of Vincent Substation, the E1A paleontological RSA would not substantially differ from that of the E1 Build Alternative.

E2 Build Alternative

Geologic units underlying the E2 paleontological RSA through Palmdale exhibit low potential to yield fossil resources until the San Andreas Fault Zone (Figure 3.9-32). Between the San Andreas Fault Zone and the ANF, the E2 Build Alternative alignment would be constructed above ground and below ground through multiple geologic units that exhibit no, low, and high paleontological sensitivity (Figure 3.9-32). Geologic units within the ANF generally exhibit no paleontological sensitivity, except for Aliso Canyon and Arrastre Canyon, which have areas of high paleontological sensitivity where the E2 Build Alternative would require ground disturbance (Figure 3.9-32 and Figure 3.9-33). The E2-A1/E2-A2 adit footprints would also encounter areas of high paleontological sensitivity. Most of the geologic units underlying the E2 paleontological RSA in the urbanized San Fernando Valley have low paleontological potential, with a section of high potential south of Big Tujunga Wash (Figure 3.9-34).

E2A Build Alternative

Although the E2A Build Alternative alignment would traverse different areas than the E2 Build Alternative alignment south of East Avenue S and north of Vincent Substation, the E2A paleontological RSA would not substantially differ from that of the E2 Build Alternative.

3.9.6 Environmental Consequences

3.9.6.1 Overview

This section evaluates direct and indirect geology, soils, seismicity, minerals, and paleontology impacts for the No Project and Build Alternatives. All six Build Alternatives would generally experience similar types of impacts (listed below), but they would vary in the degree of effect, likelihood, or amount of resource/hazard type. Section 3.9.6.3 addresses construction and operation impacts separately for all six Build Alternatives, as follows:

Construction Impacts

Geologic Hazards

- Impact GSSP#1: Ground Subsidence and Ground Settlement Could Endanger People or Structures During Construction.
- Impact GSSP#2: Karst Terrain Could Endanger People or Structures During Construction.
- Impact GSSP#3: Landslides Could Endanger People or Structures During Construction.

Soil Hazards

- Impact GSSP#4: Construction Could Expose Erodible Soils During Construction.
- Impact GSSP#5: Expansive, Corrosive, and Collapsible Soils Could Endanger People or Structures During Construction.
- Impact GSSP#6: Areas of Difficult Excavation Could Potentially Endanger Workers and Facilities.

Primary Seismic Hazards

- Impact GSSP#7: Fault Rupture and Seismic Ground Shaking Could Endanger People or Structures During Construction.
- Impact GSSP#8: Liquefaction, Lateral Spreading, and Ground Lurching Could Endanger People or Structures During Construction.

Secondary Seismic Hazards

- Impact GSSP#9: Seiches Could Endanger People or Structures During Construction.
- Impact GSSP#10: Inundation Related to Seismically Induced Dam Failure Could Endanger People or Structures During Construction.

Mineral and Energy Resources

- Impact GSSP#11: Regional Availability of Aggregate Resources During Construction.
- Impact GSSP#12: HSR Footprint Could Reduce Availability of Mineral Resources.
- Impact GSSP#13: Mine Conditions Could Pose Hazards During Construction.
- Impact GSSP#14: Construction Could Interfere with Oil/Natural Gas Extraction.

Paleontological Resources

- Impact GSSP#15: Surface Excavation and Subsurface Tunneling Could Destroy Unique Paleontological Resources.

Operations Impacts

- Impact GSSP#16: Effects of Geologic Hazards During Operations.

3.9.6.2 No Project Alternative

No Project Alternative conditions assume that currently known, programmed, and funded improvements to the intercity transportation system (highway, rail, and transit) and reasonably foreseeable local development projects (with funding sources already identified) would be developed as planned by 2040.

Intercity and regional transportation projects and reasonably foreseeable local development projects considered as part of the No Project Alternative would be constructed in the same general region as the Palmdale to Burbank Project Section. Such development would experience similar types of hazards and constraints related to geology, soils, seismicity, and mineral resources as would be faced by the Build Alternatives. It is likely that such development would also be subject to NEPA and/or CEQA environmental review to identify feasible avoidance, minimization, and/or mitigation measures.

However, development of the No Project Alternative would generally be of a smaller scale than the Build Alternatives. Therefore, the magnitude of geology, soils, seismic impacts, and mineral resources on such development would be expected to be similarly lesser in scale. Fault rupture and seismically induced dam failure also endanger aboveground development as part of the No Project Alternative. Smaller-scale development would also be likely to result in a lesser level of removal of mineral resources and interference with the future extraction of such resources. The No Project Alternative would be likely to avoid significant impacts on paleontological resources that would result from the Build Alternatives. Under the No Project Alternative, other projects would generally be built only on the ground surface, where there would be increased opportunities to implement monitoring as a means to observe and protect fossils and other paleontological resources. Thus, the No Project Alternative would be expected to have fewer paleontological impacts than the Build Alternatives.

3.9.6.3 Build Alternatives

Construction Impacts

This section evaluates impacts associated with HSR construction activities (site preparation and installation of HSR facilities) and permanent impacts associated with the long-term presence of infrastructure associated with each of the six Build Alternatives.

Geologic Hazards

Impact GSSP#1: Ground Subsidence and Ground Settlement Could Endanger People or Structures During Construction.

Each of the six Build Alternatives would encounter high subsidence hazard areas between Palmdale and Acton, and medium to low subsidence hazard areas in the San Fernando Valley, as discussed in Section 3.9.5 and quantified in Table 3.9-6. Unknown, unidentified, or unmapped subsidence areas could endanger HSR footprint and facilities. Subsidence in areas subjected to increased weight loads could damage facilities associated with each of the six Build Alternatives.

GEO-IAMF#1 would require the CMP to identify subsidence-prone areas and minimize the potential for loss or damage during construction. Specifically, the CMP would include topographic surveys to identify whether subsidence has occurred since initial design and establish the final top-of-rail elevations for the HSR system. Where the HSR system is located within floodplain areas, overbuilding the height of the rail bed would anticipate future subsidence. GEO-IAMF#9 requires subsidence monitoring where the potential for long-term subsidence exists, to allow for proactive risk management. In addition, GEO-IAMF#10 identifies established engineering and safety guidelines that, when applied, would minimize hazards related to ground subsidence and settlement. These measures could include improving settlement-prone soils by using preloads and wick drains to prepare soils for new loads, or using well points and sheet pile walls to transfer new ground loads to deeper soils.

CEQA Conclusion

Per GEO-IAMF#1, the CMP would identify subsidence hazard areas and engineering controls to reduce the Palmdale to Burbank Project Section's vulnerability to ground subsidence or settlement during construction. GEO-IAMF#9 would monitor for subsidence along the HSR corridor and GEO-IAMF#10 would apply engineering controls to reduce long-term ground subsidence or settlement hazards. With incorporation of GEO-IAMF#1, GEO-IAMF#9, and GEO-IAMF#10, the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives are not likely to result in hazards such as on- or off-site subsidence or collapse due to the presence of unstable soils. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, Build Alternatives. Therefore, CEQA does not require mitigation.

Impact GSSP#2: Karst Terrain Could Endanger People or Structures During Construction.

The Refined SR14 Build Alternative would encounter karst terrain between Acton and Vulcan Mine within approximately 302 acres of surface construction footprint and 14 acres of subsurface construction footprint (Figure 3.9-1). The SR14A Build Alternative would require 209 acres of surface construction footprint and 29 acres of subsurface construction footprint within areas of karst terrain. The E1, E1A, E2, and E2A Build Alternatives would not encounter karst terrain.

Construction in or above karst terrain could encounter caves, sinkholes, or unstable surfaces. Permanent HSR structures atop areas of karst terrain could result in differential settlement, which could damage facilities and cause life safety concerns. If unaddressed, the potential for this direct impact would persist throughout the project construction. GEO-IAMF#10 would ensure that HSR design and construction implement adopted geotechnical standards to withstand karst hazards.

CEQA Conclusion

GEO-IAMF#10 will require the contractor to incorporate established engineering design guidelines and standards during the design phase of each of the six Build Alternatives to minimize hazards associated with karst terrain. The Refined SR14 Build Alternative and the SR14A Build Alternative would involve construction within areas of karst terrain, where hazards such as caves, sinkholes, or unstable surfaces could be encountered. Adherence to GEO-IAMF#10 would require the characterization of soils, as well as methods, to be used in the design of bridge foundations and structures, retaining walls, and buried structures to provide specifications that would address the structures' seismic response in soils such as karst terrain. This impact would be less than significant for the Refined SR14 and SR14A Build Alternatives. Therefore, CEQA does not require mitigation.

The E1, E1A, E2, and E2A Build Alternatives would not encounter karst terrain, and no impact would occur for these Build Alternatives. Therefore, CEQA does not require mitigation.

Impact GSSP#3: Landslides Could Endanger People or Structures During Construction.

Mapped and unidentified landslide zones (including seismically induced landslide hazard areas) could endanger HSR facilities. Landslide-prone areas exist along each of the six Build Alternative alignments within the San Gabriel Mountains, as discussed in Section 3.9.5.3, quantified in Table 3.9-6, and mapped on Figure 3.9-2. Excavation and grading could also create new areas of slope instability.

Landslides or slope failures could damage environmental resources, structures associated with each of the six Build Alternatives, or equipment could cause injuries or result in loss of life of workers and the public. Slope failures would be unlikely to impact subsurface construction activities but could block or damage tunnel portals and adits. If unaddressed, this direct impact would persist throughout construction and operations of the Palmdale to Burbank Project Section.

Geosynthetics and Jet Grouting

Geosynthetics is a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical-engineering-related material as an integral part of a built project, structure, or system.

Jet grouting is a construction process using a high-kinetic-energy jet of fluid to break up and loosen the ground and to mix it with a thin slurry.

With incorporation of GEO-IAMF#1, the project would include measures to minimize the risk of ground failure from unstable slopes. Potential remediation entails excavation and replacement with competent soils. To limit the excavation depth, replacement materials can also be strengthened using geosynthetics. Improvements to deeper unsuitable soils could include ground improvement methods such as stone columns, cement deep-soil-mixing, or jet grouting (Soletanche Bachy 2018). Alternatively, preloading—in combination with prefabricated vertical drains (wicks) and staged construction—can gradually improve the strength of the soil without causing bearing-capacity failures, which would be built into the construction schedule.

CEQA Conclusion

Per GEO-IAMF#1, the CMP would identify potential slope hazards and implement engineering controls to minimize landslide vulnerability during construction. With adherence to GEO-IAMF#1, construction of the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not directly or indirectly cause substantial adverse effects, including the risk of loss, injury, or death involving landslides on- or off-site. This impact would be less than significant for the Refined SR14, E1, and E2 Build Alternatives. Therefore, CEQA does not require mitigation.

Soil Hazards

Impact GSSP#4: Construction Could Expose Erodible Soils During Construction.

Erosion could result from earthmoving activities and from deposition of spoil material into the spoils disposal sites before such spoils are compacted. These areas could experience elevated erosion rates if exposed to wind, precipitation, and runoff. In addition, spoils temporarily stockpiled within construction staging areas could increase the quantity of soils exposed to erosive forces. Exposed soils would be subject to erosion throughout the duration of construction or until soils are stabilized. These indirect impacts would be temporary and limited to the construction period.

Erosion potential varies greatly throughout the soil hazard RSA, as discussed in Section 3.9.5.4 and mapped on Figure 3.9-3 through Figure 3.9-5. However, each of the six Build Alternatives would encounter areas with high erosion potential, as discussed below.

- **Refined SR14 Build Alternative**—The Refined SR14 Build Alternative would have surface facilities in areas of high erosion near Agua Dulce Canyon, Vulcan Mine, and near the SR14-W1 and SR14-W2 intermediate window options.
- **SR14A Build Alternative**—Although it would avoid minor areas with high erosion potential south of the California Aqueduct and north of the Santa Clara River, the SR14A Build Alternative would have surface facilities within the same areas of land with high erosion potential as the Refined SR14 Build Alternative.
- **E1 Build Alternative**—Erosion potential for the E1 Build Alternative would be low and moderate along the alignment to the south between Palmdale and Aliso Canyon. The E1-W2 and E1-W3 intermediate window options north of the I-210/SR 118 interchange would also be located in areas of moderate erosion potential.
- **E1A Build Alternative**—Although it would avoid minor areas with high erosion potential south of the California Aqueduct and north of Vincent Substation, the E1A Build Alternative would have surface facilities within the same areas of land with high erosion potential as the E1 Build Alternative.
- **E2 Build Alternative**—Erosion potential for the E2 Build Alternative would be low and moderate along the alignment to the south between Palmdale and Aliso Canyon. There would be high and unmapped erosion potential where the E2 Build Alternative would cross Big Tujunga Wash. The E2-A1 and E2-A2 adit options would be in areas of moderate and high erosion potential.
- **E2A Build Alternative**—Although it would avoid minor areas with high erosion potential south of the California Aqueduct and north of Vincent Substation, the E2A Build Alternative

would have surface facilities within the same areas of land with high erosion potential as the E2 Build Alternative.

GEO-IAMF#1 would require the CMP to identify areas with high wind and water erosion potential and develop practices to limit soil loss during construction. The contractor will also implement appropriate erosion control methods documented in a Storm Water Pollution Prevention Plan (which would be developed per HYD-IAMF#3) and the Caltrans Construction Manual. Water and wind erosion control methods could include, but are not limited to, re-vegetation, stabilizers, mulches, and biodegradable geotextiles.

Soil stabilization procedures implemented throughout project construction would generally prevent the long-term exposure of disturbed soils. Spoils deposited at the Vulcan Mine (Refined SR14 and SR14A Build Alternatives) would cover approximately 74 acres of highly erosive soils, reducing the amount of erodible soils within the project footprint. Exposed soils at the Vulcan Mine would be placed in stable locations that meets the USFS visual and re-vegetation requirements. The Boulevard Mine (Refined SR14, SR14A, E1, and E1A Build Alternatives) and CalMat Mine (E2 and E2A Build Alternatives) disposal site would be regraded to a new base elevation (expected to remain below surrounding grade) and managed as an open pit. Exposed soils at the Boulevard Mine and CalMat disposal site would be subject to standard engineering guidelines and applicable regulations to minimize exposure to erosive forces. However, natural erosive forces would continue to act on soils at these sites over time.

CEQA Conclusion

GEO-IAMF#1 and HYD-IAMF#3 would identify areas with high erosion potential and implement best management practices to limit soil loss in disturbed areas throughout the HSR footprint. However, the Boulevard Mine and CalMat disposal sites, spoil material deposited at these sites could be exposed to erosive forces over time. This represents a significant impact. As discussed in Section 3.9.7, GEO-MM#1 will require a restoration plan, temporary soil stabilization plan, or interim reclamation plan for the Boulevard Mine and CalMat Mine disposal sites to protect exposed soils. This plan would ensure that the Boulevard Mine and CalMat disposal sites are not left with soils vulnerable to wind or water erosion. With implementation of GEO-MM#1, this impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives.

Impact GSSP#5: Expansive, Corrosive, and Collapsible Soils Could Endanger People or Structures During Construction.

Soils within the construction footprint could exhibit expansive, corrosive, and collapsible characteristics, which could endanger project structures, equipment, employees, and passengers throughout project construction and operations.

- **Refined SR14 Build Alternative**—The Refined SR14 Build Alternative would be constructed over soils that generally exhibit high and moderate steel corrosion potential north of the California Aqueduct. Soils between the California Aqueduct and Vulcan Mine exhibit low-, moderate-, and high-corrosion potential. Soils overlying the Refined SR14 Build Alternative tunnel beneath the ANF generally have low corrosion potential, but the Refined SR14 intermediate windows would be in areas of moderate corrosion potential between the San Gabriel Mountain foothills and the I-210/SR 118 interchange.
- **SR14A Build Alternative**—South of the California Aqueduct and north of Agua Dulce Canyon, the SR14A Build Alternative alignment would traverse additional areas of soils corrosive to steel via tunnel compared to the Refined SR14 Build Alternative alignment. Apart from these locations, the SR14A Build Alternative alignment would traverse the same areas of soil corrosive to steel as the Refined SR14 Build Alternative alignment.
- **E1 Build Alternative**—The E1 Build Alternative would be constructed over soils that generally exhibit high and moderate potential to corrode steel north of the California Aqueduct. South of the California Aqueduct, the E1 Build Alternative alignment would be constructed over soil with moderate and low potential to corrode steel until entering the ANF,

where soils exhibit high potential to corrode steel in Aliso Canyon and Arrastre Canyon. Soils within the remainder of the alignment path in ANF, including the E1-A1 and E1-A2 adit locations, generally exhibit low potential for steel corrosion. As the E1 Build Alternative alignment approaches the San Fernando Valley, it would be constructed beneath approximately 3 miles of soil with moderate potential to corrode steel, including two E1 Build Alternative intermediate window options near the I-210/SR 118 interchange.

- **E1A Build Alternative**—Although it would take a more easterly course through soils corrosive to steel south of Palmdale and north of Vincent Substation, the E1A Build Alternative alignment would traverse the same areas of soil corrosive to steel as the E1 Build Alternative alignment.
- **E2 Build Alternative**—The E2 Build Alternative would be constructed over soils that generally exhibit high and moderate potential to corrode steel north of the California Aqueduct. South of the California Aqueduct, the E2 Build Alternative alignment would be constructed over soil with moderate and low potential to corrode steel until entering the ANF, where soils exhibit high potential to corrode steel in Aliso Canyon and Arrastre Canyon. Soils within the remainder of the ANF, including the E2-A1 and E2-A2 adit locations, generally exhibit low steel corrosion potential. As the E2 Build Alternative alignment approaches Big Tujunga Wash, it would be constructed beneath approximately 0.5 mile of soil with moderate steel corrosion potential.
- **E2A Build Alternative**—Although it would take a more easterly course through soils corrosive to steel south of Palmdale and north of Vincent Substation, the E2A Build Alternative alignment would traverse the same areas of soil corrosive to steel as the E2 Build Alternative alignment.

Standard design-level geotechnical investigations completed for projects of a similar size and scope to the California HSR System are necessary to locate and characterize expansive and collapsible soils within the Build Alternative soil hazard RSAs, because there are no existing maps that capture these localized hazards. Additionally, GEO-IAMF#1 requires identification of potential soil hazards areas and incorporation of design guidelines to minimize or avoid associated risks. For locations where structures containing steel and/or concrete are intended, a site-specific corrosion study would evaluate corrosive characteristics of soil and groundwater. Corrosive soil abatement could entail removal of potentially corrosive soils, design of buried structures to account for corrosive conditions, and the use of corrosion-resistant materials. Expansive soil abatement could entail removal and replacement or soil treatment to reduce expansive characteristics. Collapsible and unstable soils abatement could entail removal and replacement or ground improvement treatments, such as stone columns, cement deep-soil-mixing, jet grouting, or preloading to improve the strength of the soil. Prior to construction, geotechnical and design features would be documented in a technical memorandum to ensure adherence to established engineering procedures listed in GEO-IAMF#10.

CEQA Conclusion

Geotechnical data collection and testing during the design phase would identify expansive, corrosive, and collapsible soil hazard areas. As described above, GEO-IAMF#1 will employ methods to limit the risk of damage or injury resulting from expansive, corrosive, and collapsible soils. GEO-IAMF#1 will require preparation of a CMP prior to construction to address geologic constraints and minimalization or avoidance of impacts on geologic hazards during construction. GEO-IAMF#10 will ensure HSR design and construction implement adopted geotechnical standards to withstand poor soil conditions. A technical memorandum documenting how adopted geotechnical standards will be incorporated into facility design and construction would be required prior to construction. With these IAMFs, the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not increase hazards to people or structures as a result of expansive (as defined in Table 18 1 B of the Uniform Building Code), corrosive, or collapsible soils. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives. Therefore, CEQA does not require mitigation.

Impact GSSP#6: Areas of Difficult Excavation Could Potentially Endanger Workers and Facilities.

Soils within the construction footprint could pose substantial excavation or tunneling difficulty due to the presence of features such as hardpan and shallow bedrock and thus require the use of specialized construction equipment. As discussed in Section 3.9.5.4 and quantified in Table 3.9-6, each of the six Build Alternatives would generally be constructed over areas of low excavation difficulty, with some areas of high excavation difficulty north of the San Andreas Fault Zone. Interspersed areas of moderate to high excavation difficulty exist south of the San Andreas Fault Zone until San Fernando Valley (Figure 3.9-12 through Figure 3.9-14). If unaddressed, areas of difficult excavation would result in direct, temporary impacts during construction.

GEO-IAMF#10 would reduce this risk by requiring the contractor to document adherence to industry standards throughout soil testing, design, and construction in a technical memorandum prior to construction. These guidelines and standards would inform specifications and design to avoid impacts during construction. As described in GEO-IAMF#10, the Authority will conform to the guidelines specified by relevant transportation and building agencies and codes, requiring Authority contractors to account for geotechnical properties during the HSR Build Alternative design and construction and thus address risk factors associated with difficult excavation conditions. Methods in the Caltrans Construction Site Best Management Practices Manual and Construction Site Best Management Practice Field Manual and Troubleshooting Guide related to difficult excavation conditions would be used per GEO-IAMF#10. It is anticipated that standard construction equipment would be used in excavations. With implementation of GEO-IAMF#10 and standard safety practices as outlined in the aforementioned manuals, there would not be an increased potential for injury or loss of life during construction.

CEQA Conclusion

Implementation of GEO-IAMF#10 requires the Authority to account for geotechnical properties during design and construction. Additionally, design and construction practices would address risk factors associated with difficult excavation conditions, such as cobbles and boulders, and would not exacerbate the risks of personal injury, loss of life, or property damage in areas of difficult excavation. With implementation of GEO-IAMF#10, construction of the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not increase hazards to people or structures due to areas of difficult excavation. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives. Therefore, CEQA does not require any mitigation.

Primary Seismic Hazards

Impact GSSP#7: Fault Rupture and Seismic Ground Shaking Could Endanger People or Structures During Construction.

All six Build Alternatives would cross hazardous and potentially hazardous faults that would be susceptible to rupture during a seismic event. Intense ground shaking could also result from fault systems in the Palmdale to Burbank Project Section region. Although there would be a low probability of a seismic event occurring during the construction period, if an event were to occur, it could endanger in-progress structures, construction equipment, workers, and members of the public. Fault rupture could affect the tunnel structures and alter tunnel integrity. Direct impacts associated with fault rupture and ground shaking could include damage or collapse of construction equipment, facilities, project trackway, ancillary features, or nearby structures, including tunnels. Depending on the severity of the seismic event, jolting could cause construction workers on elevated structures to fall, resulting in injuries or loss of life.

The following discussion highlights hazardous and potentially hazardous fault zones within the secondary seismic/geologic hazard RSA for all six Build Alternatives, as listed in Table 3.9-4 and depicted on Figure 3.9-15 through Figure 3.9-17. The Build Alternatives would encounter the following hazardous and potentially hazardous fault zones:

- San Andreas Fault Zone (at grade, south of the city of Palmdale)
- San Gabriel Fault Zone (tunnel, beneath the San Gabriel Mountains)
- Western Sierra Madre Fault Zone, San Fernando Section (tunnel, San Fernando Valley)
- Verdugo Fault Zone (at grade, elevated, trenched, and tunneled, within the city of Burbank)

GEO-IAMF#6 ensures that project design would incorporate early warning systems to track strong ground motion associated with fault rupture. This would help identify situations where fault creep or rupture have the potential to damage facilities and enable control of trains in a manner that would reduce the potential for accidents. GEO-IAMF#7 requires the preparation of a technical memorandum to address fault rupture for construction components. As established in GEO-IAMF#7, potentially hazardous faults crossed by the HSR Build Alternatives would be evaluated by conducting field investigations to establish updated estimates of levels of ground motion prior to construction and during final design. Final design would be further supported by additional seismic studies and compliance with Caltrans seismic design criteria. Geotechnical and design protocol would adhere to established engineering procedures listed in GEO-IAMF#10 to minimize hazards associated with fault rupture and ground shaking.

CEQA Conclusion

GEO-IAMF#6 will ensure that project design would implement warning systems to reduce seismic damage to the project's trackway and ancillary features. GEO-IAMF#7 will require evaluation of fault rupture potential and GEO-IAMF#10 will implement engineering and safety protocols to limit fault rupture and ground shaking hazards during construction. With these IAMFs, the Refined SR14, SR14A, E1, E1A, E2, and E2A Alternatives would not directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving the rupture of a known earthquake fault, strong seismic ground shaking, or seismic-related ground failure. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A. Therefore, CEQA does not require mitigation.

Impact GSSP#8: Liquefaction, Lateral Spreading, and Ground Lurching Could Endanger People or Structures During Construction.

Liquefaction, lateral spreading, and/or ground lurching could occur during construction of the Build Alternatives. If unaddressed, these secondary seismic hazards could damage or destroy structures, delay construction, and/or result in injury or death. The potential for these direct impacts would persist during construction.

- **Refined SR14 Build Alternative**—The Refined SR14 Build Alternative would encounter liquefaction, lateral spreading, and ground lurching susceptibility zones near the San Andreas Fault Zone south of Palmdale. The Refined SR14 Build Alternative alignment would cross tributaries that exhibit liquefaction, lateral spreading, and ground lurching hazards through Acton, along Agua Dulce Canyon Road, and near the Santa Clara River. The Vulcan Mine disposal site is also susceptible to liquefaction, lateral spreading, and ground lurching.
- **SR14A Build Alternative**—Although it would take a more southeasterly course and include more tunneled alignment south of East Avenue S and north of the Santa Clara River, the SR1A Build Alternative alignment would encounter liquefaction, lateral spreading, and ground lurching susceptibility zones in the same general areas as the Refined SR14 Build Alternative alignment.
- **E1 Build Alternative**—The E1 Build Alternative would encounter liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone south of Palmdale, north of Vincent Substation, along Aliso Canyon, and along Arrastre Canyon.
- **E1A Build Alternative**—The E1A Build Alternative alignment would take a more easterly course through liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone and north of Vincent Substation compared to the E1 Build Alternative alignment. Apart from these areas, the E1A Build Alternative alignment would encounter the same liquefaction, lateral spreading, and ground lurching susceptibility zones as the E1 Build Alternative alignment.

- **E2 Build Alternative**—The E2 Build Alternative would encounter liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone south of Palmdale, north of Vincent Substation, within Aliso Canyon, within Arrastre Canyon, and at the Big Tujunga Wash crossing location.
- **E2A Build Alternative**—The E2A Build Alternative alignment would take a more easterly course through liquefaction, lateral spreading, and ground lurching susceptibility zones in the San Andreas Fault Zone and north of Vincent Substation compared to the E2 Build Alternative alignment. Apart from these areas, the E2A Build Alternative would encounter the same liquefaction, lateral spreading, and ground lurching susceptibility zones as the E2 Build Alternative alignment.

Technical Memorandum 2.9.10, Geotechnical Analysis and Design Guidelines (Authority 2011), outlines liquefaction analysis and design criteria for HSR infrastructure facilities. In addition, GEO-IAMF#10 identifies engineering standards that address liquefaction, lateral spreading, and ground lurching hazards.

CEQA Conclusion

Technical Memorandum 2.9.10 and GEO-IAMF#10 provide specific design criteria, such as the design of bridge foundations and structures, retaining walls, and construction specifications for HSR infrastructure that would reduce vulnerability to liquefaction, lateral spreading, and ground lurching during construction. With adherence to Technical Memorandum 2.9.10 and GEO-IAMF#10, the Refined SR14, E1, and E2 Build Alternatives would not increase exposure to loss of life, injuries, or destruction resulting from liquefaction, lateral spreading, or ground lurching hazards. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternative. Therefore, CEQA does not require mitigation.

Secondary Seismic Hazards

Impact GSSP#9: Seiches Could Endanger People or Structures During Construction.

Portions of the each of the six Build Alternatives would be built close to enclosed bodies of water that could expose people or structures to seiches. Lake Palmdale (Refined SR14, E1, and E2 Build Alternative inundation RSAs), Pacoima Reservoir (Refined SR14 and E1 RSAs), and Hansen Dam Reservoir (Refined SR14, E1, and E2 Build Alternative inundation RSAs) could experience a seiche during an earthquake, which could endanger HSR facilities and personnel. This represents a direct impact that could persist through project construction. The SR14A, E1A, and E2A Build Alternatives would also be located in the vicinity of enclosed waterbodies. Such impacts would be identical to those resulting from the implementation of the Refined SR14, E1, and E2A Build Alternatives, respectively.

At Lake Palmdale, damaging floods associated with seiches would be unlikely. The projected seiche event at Lake Palmdale would not be expected to result in substantial water displacement that could overtop the dam and imperil construction equipment or personnel below within the dam floodway because the potential wave volume of the dam would be approximately 1 acre-foot.

Regarding seiche events at Pacoima Dam and Hansen Dam, the Los Angeles Department of Water and Power has implemented regulations regarding maintaining water levels in its storage facilities and providing walls of extra height to contain seiches and prevent overflow. Dams and reservoirs, including the Hansen Dam and Pacoima Reservoir, are monitored during storms, and measures are instituted if there is potential for overflow. The Division of Safety of Dams of the California Department of Water Resources has jurisdiction over large dams throughout California and enforces strict safety requirements and annual inspections. Dam owners delineate and submit inundation zone maps to the California Office of Emergency Services to ensure effective emergency planning and adequate preparations for a catastrophic event.

CEQA Conclusion

As identified above, city and state agencies implement protocols to minimize potential seiche events and hazards. With adherence to these protocols, the Refined SR14, E1, and E2 Build Alternatives would not increase exposure to loss of life, injuries, or destruction resulting from increased seiche hazards. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2 and E2A Build Alternative. Therefore, CEQA would not require mitigation.

Impact GSSP#10: Inundation Related to Seismically Induced Dam Failure Could Endanger People or Structures During Construction.

Dam failures could cause significant damage to structures and equipment or result in injuries or death. Each of the six Build Alternatives would be located within several dam inundation areas (Figure 3.9-26 through Figure 3.9-28).

- **Refined SR14 Build Alternative**—The Lake Palmdale and Hansen Dam inundation areas encompass portions of the Refined SR14 Build Alternative footprint (Figure 3.9-26 and Figure 3.9-27). In the San Fernando Valley, tunnel portions of the alignment, two Refined SR14 Build Alternative intermediate window options, and the Boulevard Mine disposal site would be within the Pacoima Dam inundation area (Figure 3.9-27). The entire Burbank Airport Station would be within the Hansen Dam inundation area.
- **SR14A Build Alternative**—The SR14A Build Alternative would consist of a footprint within dam inundation areas that is identical to the Refined SR14 Build Alternative.
- **E1 Build Alternative**—At-grade portions of the E1 Build Alternative would be within the dam inundation area associated with Lake Palmdale (Figure 3.9-26). Within the Pacoima Dam inundation area, the E1 Build Alternative would be constructed primarily in bored tunnel along with a cut-and-cover section near the intersection of I-210 and SR 118 (Figure 3.9-27). Other elements of the E1 Build Alternative that would be within the Pacoima Dam inundation area include the Boulevard Mine disposal site and the E1-W1 and E1-W2 intermediate window options. The entire Burbank Airport Station would be within the Hansen Dam inundation area.
- **E1A Build Alternative**—The E1A Build Alternative would consist of a footprint within dam inundation areas that is identical to the E1 Build Alternative.
- **E2 Build Alternative**—At-grade portions of the E2 Build Alternative would be located within the dam inundation area associated with Lake Palmdale (Figure 3.9-26). No other dam inundation is present within the E2 inundation RSA until south of the Big Tujunga Wash. In the Shadow Hills and Sun Valley neighborhoods, tunnel portions of the E2 Build Alternative would be constructed through portions of the Hansen Dam inundation area. The entire Burbank Airport Station and CalMat Mine Disposal site area would be within the Hansen Dam inundation area (Figure 3.9-28).
- **E2A Build Alternative**—The E2A Build Alternative would consist of a footprint within dam inundation areas identical to the E2 Build Alternative.

A seismically induced release of water from the Pacoima Reservoir could flood the Boulevard Mine disposal site, and a seismically induced release of water from the Hansen Dam could flood the CalMat Mine disposal site. As the Boulevard Mine and CalMat Mine disposal sites are currently depressions in the landscape, they could store a substantial amount of displaced water. Flooding could pose a risk to construction workers and/or equipment within the Boulevard Mine CalMat Mine disposal sites and could also result in construction delays.

As the Boulevard Mine and CalMat Mine disposal sites fill with spoils, their ability to retain floodwaters would diminish. This could increase the total size of the seismically induced dam failure inundation area. However, the Boulevard Mine disposal site represents approximately 0.5 percent of the Pacoima Reservoir dam inundation zone (Figure 3.9-27), and the CalMat Mine disposal site represents 0.5 percent of the Hansen Dam inundation zone. Given the low probability of a dam failure event, coupled with the relatively small mine sizes within the overall inundation zone, spoils disposal would be unlikely to result in flooding in areas not previously mapped as a dam inundation hazard area.

CEQA Conclusion

Construction of the project would not cause or accelerate the potential for dam inundation. However, seismically induced flooding could pose a risk to construction workers and/or equipment within the Boulevard Mine and CalMat disposal sites. This represents a significant impact. As discussed in Section 3.9.7, GEO-MM#2 will require the construction contractor to develop an evacuation plan where grading, building, or disposal activities would occur underground or below grade. This plan would evaluate inundation hazards at the spoils disposal sites and would implement evacuation procedures to minimize the risk of injury resulting from accident conditions. With implementation of GEO-MM#2, this impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2 and E2A Build Alternatives.

Mineral and Energy Resources

Impact GSSP#11: Regional Availability of Aggregate Resources During Construction.

Project construction would require substantial aggregate resources, which represents a direct impact. The project would be in two P-C regions that could be impacted by project buildout: the San Fernando Valley/Saugus-Newhall P-C region and the Palmdale region. The Refined SR14 and E1 Build Alternatives would require approximately 8.1 million tons of construction aggregate and the E2 Build Alternative would require approximately 8.9 million tons of construction aggregate. The SR14A, E1A, and E2A Build Alternatives would also require construction aggregate. The SR14A Build Alternative would require approximately 9.3 million tons of construction aggregate, while the E1A and E2A Build Alternatives would require 8.7 and 8.4 million tons, respectively. According to the 2012 aggregate study conducted by the CGS, the Palmdale P-C region and the San Fernando Valley/Saugus-Newhall P-C regions contain 229 million tons of remaining permitted aggregate reserves. Based on this estimate, there would be sufficient aggregate available to provide material for the project without harmfully depleting available sources.

CEQA Conclusion

Given that there are sufficient aggregate resources to accommodate HSR construction, construction of the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not result in the loss of availability of aggregate mineral resources that would be of value to the region and residents of the state. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives. Therefore, CEQA would not require mitigation.

Impact GSSP#12: HSR Footprint Could Reduce Availability of Mineral Resources.

Within all of the six Build Alternative footprints are three closed, previously producing surface mines, one active processing plant, and MRZ-2 areas (Figure 3.9-29 through Figure 3.9-31 and Table 3.9-6). MRZ-2 areas can be found along the alignment of the Build Alternatives between Agua Dulce and Sand Canyon and around the urbanized areas of the San Fernando Valley. Earthmoving activities in these areas could directly remove aggregate material and/or temporarily prevent mineral recovery during construction period. Installation of permanent HSR facilities would fragment MRZ areas, limiting the continuity of potential recovery operations in areas where each of the six Build Alternative footprints would permanently convert land to a transportation use.

Although each of the six Build Alternatives would convert MRZ-2 areas to a transportation use, such areas would be minimal considering the available MRZ-2 lands within Los Angeles County. Los Angeles County has a total MRZ-2 inventory of 119,268 acres. Out of all six Build Alternatives, the SR14A Build Alternative would require the greatest permanent conversion of MRZ-2 areas (up to 674 surface acres and 95 subsurface acres). Thus, the six Build Alternatives would permanently convert a maximum of 0.6 percent of Los Angeles County’s total MRZ-2 areas. Additionally, large portions of these MRZ-2 areas encompass extensive developed areas, particularly in the San Fernando Valley. Development in these areas currently limits access to underlying mineral resources and introduction of each of the six Build Alternatives would not alter this condition. In undeveloped areas, including areas in which mining is permitted within the ANF, mineral extraction would only be obstructed in the immediate vicinity of each of the Build Alternatives. Extraction activities could still occur beneath surface footprint and near subsurface footprint.

CEQA Conclusion

The Build Alternatives could reduce the availability of regionally significant minerals. However, the impact of each of the six Build Alternatives would be minimal considering the availability of MRZ-2 areas in Los Angeles County and that existing development currently obstructs potential extraction activities in impacted areas. Furthermore, mineral resources underlaying and overlaying the Build Alternative footprint may still be partially available for extraction. Thus, the six Build Alternatives would result in a minimal loss of availability of a known mineral resource that would be of value to the region and residents of the state. This impact would be less than significant for the SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives. Therefore, CEQA does not require mitigation.

Impact GSSP#13: Mine Conditions Could Pose Hazards During Construction.

The mineral and energy resource RSA encompass active and inactive mining sites (Figure 3.9-29 through Figure 3.9-31). Unknown, undocumented, and abandoned mining facilities would pose hazards during project construction and operations related to the presence of toxic substances, subsurface gases, or unstable ground conditions. In addition, dumping, filling, and grading activities would destabilize existing or constructed slopes within or around the Vulcan Mine and Boulevard Mine disposal sites, which could trap or injure construction workers. Hazardous mine conditions could endanger project structures, equipment, construction workers, or members of the public in the construction vicinity. If unaddressed, these direct impacts would last throughout the construction period. Mine reclamation activities would be subject to Surface Mining and Reclamation Act regulations. GEO-IAMF#3 requires the CMP to incorporate monitoring procedures and construction practices to reduce risks related to gas accumulation. Practices would include using safe and explosion-proof equipment during construction, and testing for gases regularly. Installation of passive or active gas venting systems, gas collection systems, active monitoring systems, and alarms would be required in underground construction areas and facilities where subsurface gases are present. Installing gas-detection systems can monitor the effectiveness of these systems. GEO-IAMF#4 requires the CMP to address abandoned mines through application of procedures that could include:

- Environmental cleanups at sites that are releasing or threatening to release hazardous substances such as heavy metals from acid mine drainage
- Cleanup of non-hazardous, substance-related surface disturbance such as re-vegetation of disturbed areas, stabilization of mine tailings, reconstruction of stream channels and floodplains
- Minimization of physical safety hazards such as closure of adits and shafts and removal of dangerous structures

CEQA Conclusion

GEO-IAMF#3 and GEO-IAMF#4 will prescribe a CMP that would provide monitoring and construction practices to reduce most impacts associated with hazardous mine conditions. However, construction activities or accident conditions could result in entrapment of construction workers within the Vulcan Mine and Boulevard Mine disposal sites. Although adherence to the above measures would lessen such risks, such hazards cannot be fully avoided. All six Build Alternatives would therefore increase exposure of people to loss of life or structures to destruction due to geologic hazards associated with existing mine sites. Although impacts on a project or its users caused by existing environmental conditions are generally not environmental impacts under CEQA, this is conservatively considered a significant impact for purposes of this analysis. As discussed in Section 3.9.7, GEO-MM#2 will require a slope failure evaluation and evacuation plan for areas where grading, building, or disposal activities would occur underground or below grade. This plan would evaluate slope failure hazards at existing mine disposal sites and would implement evacuation procedures to minimize the risk of injury resulting from accident conditions. With implementation of GEO-MM#2, this impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives.

Impact GSSP#14: Construction Could Interfere with Oil/Natural Gas Extraction.

The Refined SR14 and E1 Build Alternative mineral and energy resource RSAs encompass a known oil/natural gas field; however, the eastern boundary of this oil/natural gas field is approximately 0.25 mile from the Refined SR14/E1 tunnel alignment south of the I-210/SR 118 interchange, outside the permanent HSR construction footprint (Figure 3.9-31). Owing to this distance, the project would not interfere with existing oil and natural gas wells or leases associated with this oil/natural gas field. The E2 mineral and energy resources RSA does not encompass known oil/natural gas fields.

The Refined SR14 and E1 Build Alternative footprints encompass one inactive, plugged oil/natural gas well near the I-210/SR 118 interchange. There are also two plugged dry-hole oil and gas wells within the E2 construction footprint underlying the E2 Build Alternative adit footprints within the ANF. The E2 Build Alternative could disrupt access to the wells and result in the decommissioning of associated infrastructure. However, because these wells are no longer active, the project would not result in a loss of access to oil and gas resources in the area. Refer to Section 3.10, Hazardous Materials and Wastes, for a discussion of subsurface hazards associated with oil/natural gas infrastructure and fields. The SR14A, E1A, and E2A Build Alternatives would also encounter oil/and natural gas fields. Such impacts would be identical to those resulting from the Refined SR14, E1, and E2 Build Alternatives, respectively.

CEQA Conclusion

The Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not interfere with oil/natural gas fields or active extraction infrastructure and would not make a known petroleum or natural gas resource unavailable through the physical presence of the project. No impact would occur. Therefore, CEQA does not require mitigation.

Paleontological Resources

Impact GSSP#15: Surface Excavation and Subsurface Tunneling Could Destroy Unique Paleontological Resources.

Destruction or alteration of paleontological resources is possible during ground-disturbing activities, including tunneling through paleontologically sensitive geologic units. Although surface activities (such as vegetation removal and construction staging) generally would not disturb fossil-bearing geologic units, excavation, grading, and other ground-disturbing construction activities would affect paleontologically sensitive geologic units in the Refined SR14, E1, and E2 Build Alternative paleontological RSAs. Destruction or alteration of a paleontological resource during construction would be a direct, permanent impact.

Geologic units underlying the Refined SR14, E1, and E2 Build Alternative paleontological RSAs through Palmdale to the San Andreas Fault Zone generally exhibit low potential to yield fossil resources (Figure 3.9-32). Through Acton and Agua Dulce Canyon, the Refined SR14, E1, and E2 Build Alternatives would be constructed through multiple geologic units that exhibit no, low, and high paleontological sensitivity (Figure 3.9-32 and Figure 3.9-33). Although the SR14A, E1A, and E2A Build Alternatives would have different footprint areas in the northern portions of the Central Subsection, their impacts would not differ substantially from the Refined SR14, E1, and E2 Build Alternatives, respectively. Refer to the Palmdale to Burbank Project Section Paleontological Resources Technical Report for a detailed discussion of paleontologically sensitive geologic units within the paleontological RSAs.

As outlined in GEO-IAMF#11 through GEO-IAMF#15, the construction contractor will implement measures to protect paleontological resources. GEO-IAMF#11 will require the contractor to retain a PRS tasked with establishing a framework for protecting paleontological resources affected by construction. The PRS would analyze the 90 percent design plans, as required by GEO-IAMF#12, to evaluate the location, extent, and anticipated depth of disturbance to inform paleontological monitoring. GEO-IAMF#13 will require the PRS to prepare and implement a PRMMP, that would outline the use of construction monitoring and emergency discovery procedures in project construction. The PRMMP would also establish protocols for pre-construction surveys and procedures for fossil specimen recovery. GEO-IAMF#14 will require the contractor to provide training to workers involved in ground-disturbing activities to increase workers' awareness of paleontological resources procedures. GEO-IAMF#15 will require a protocol for addressing the unexpected discover of paleontological resources, which will include a halt to construction to allow for evaluation of discovered resources.

As discussed in Section 3.9.4, paleontological field surveys were limited to areas with public access, so there could be undocumented fossils at or near the ground surface in paleontologically sensitive units within the Build Alternative footprints. The Paleontological Resource Monitoring and Mitigation Plan would require pre-construction surveys for unsurveyed geologic units with high or low paleontological sensitivity, as determined by the PRS.

Visual surveying and monitoring are not feasible during tunnel boring machine operations because the enclosed machine drill head would prevent inspection of geologic units prior to, and during, excavation. Thus, tunnel boring machine excavation would likely destroy paleontological resources encountered beneath the ground surface.

Tunnel Boring Machines

A *tunnel boring machine* is a machine used to excavate tunnels with a circular cross-section through a variety of soil and rock strata. It is used as an alternative to drilling and blasting methods in rock and conventional hand mining in soil. Tunnel boring machines have the advantages of limiting the disturbance to the surrounding ground and producing a smooth tunnel wall.

CEQA Conclusion

As required by GEO-IAMF#11 through GEO-IAMF#15, paleontological monitoring and recovery plans would protect paleontological resources encountered during surficial construction activities. While adherence to these measures would avoid or reduce some paleontological impacts, tunnel boring could result in significant impacts that may directly or indirectly destroy a unique paleontological resource or site that could be encountered during tunneling activities for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives. There is no feasible mitigation to reduce this impact, which would remain significant and unavoidable for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives.

Operations Impacts

HSR operations would consist of rail service, inspections, maintenance, testing, and repairs. Project operations would not require substantial new ground disturbance or facility installation that would deplete regional construction aggregate reserves; exacerbate geologic, soil, or seismic hazards; or encounter paleontological or mineral resources beyond those analyzed in Construction Impacts, above.

Impact GSSP#16: Effects of Geologic Hazards During Operations.

The following evaluates the potential effects of geologic hazards during operations, as related to fault rupture and ground shaking, subsidence, Karst terrain, landslides, seiches, and dam inundation.

Effects of Fault Rupture and Ground Shaking

All six Build Alternatives would cross hazardous and potentially hazardous faults that would be susceptible to rupture during a seismic event (discussed in Section 3.9.5.6 and Table 3.9-4). Intense ground shaking could also result from fault systems in the project region. A seismic event in one of these fault systems could result in fault rupture or ground shaking at or near project trackway (including at grade, viaduct, and tunneled profiles) or ancillary features (tunnel portals, adits, access roads, power substations, utility corridors, spoil disposal sites, and drainage facilities). Fault rupture could affect the tunnel structures, alter tunnel integrity, and could damage or destroy project elements and could result in injury or loss of life of HSR passengers and personnel. The potential for these direct impacts would last for the project's operating lifetime.

At the San Gabriel and Sierra Madre Fault Zones, the tunnel design would include fault chambers, additional excavated spaces designed to help accommodate fault displacement at subsurface fault crossings. Fault chambers would reduce the amount of earthwork needed for maintenance if there were a displacement event, which would reduce costs and the need for closures to perform repairs.

GEO-IAMF#6 ensures that project design would incorporate early warning systems to track strong ground motion associated with fault rupture. This would help identify situations where fault creep or rupture have the potential to damage facilities and enable control of trains in a manner that would reduce the potential for accidents.

As established in GEO-IAMF#7, the construction contractor would prepare a technical memorandum documenting large seismic ground shaking evaluation and project design criteria. Prior to final design, the contractor will conduct additional seismic studies to establish up-to-date estimation of levels of ground motion and utilize the most current Caltrans seismic design criteria in the design of structures supported in or on the ground. These design procedures and features reduce to the greatest practical extent for potential movements, shear forces, and displacements that result from inertial response of the structure. Pendulum base isolators would reduce the levels of inertial forces in critical locations. New composite materials could also enhance seismic performance.

GEO-IAMF#8 requires the suspension of operations during earthquakes to reduce the potential for injuries or loss of life from surface fault rupture and ground shaking during operations. GEO-IAMF#10 requires incorporation of design guidelines to limit vulnerability to fault ruptures. Seismic design shall meet applicable portions of state and local regulations, along with the HSR Design Criteria seismic performance objectives (Authority 2014).

CEQA Conclusion

Standard engineering practices, legal requirements, GEO-IAMF#6, GEO-IAMF#7, GEO-IAMF#8, and GEO-IAMF#10 would keep fault rupture and ground shaking hazards within established safety thresholds, which would prevent the direct and indirect endangerment of people and structures to increased seismic hazards. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives. Therefore, CEQA does require mitigation.

Effects of Subsidence

Permanent structures and trackway that experience differential settlement, in which soils underlying a structure settle at different rates, could sustain foundational and structural damage. If unaddressed, ground subsidence and settlement would represent a direct, permanent hazard throughout the project's operating lifetime. In addition, the removal of soil, introduction of fill soils, and increased weight loads from new structures could increase the potential for the loss in elevation in the project footprint. Areas where soil is improperly compacted or areas that have shallow groundwater would pose an increased risk of structural damage from land settlement.

High subsidence risks are expected within approximately 742 acres of the Refined SR14 and SR14A Build Alternative footprint. The E1 and E1A Build Alternatives include approximately 670 acres of temporary disturbance and 630 acres of permanent disturbance, which include 16 acres of subsurface easements, within areas with a high estimated potential for future subsidence. Approximately 928 acres of permanent and temporary disturbance under the E1 and E1A Build Alternatives would occur within areas with a medium to low estimated potential for future subsidence. The potential also exists for unknown subsidence-prone areas within the RSA.

GEO-IAMF#9 requires subsidence monitoring where the potential for long-term subsidence exists, to allow for proactive risk management. With adherence to GEO-IAMF#9, the potential for long-term subsidence would be reduced by subsidence monitoring, which would be encompassed in the risk management.

CEQA Conclusion

With adherence to GEO-IAMF#9, the operation of all six Build Alternatives would be properly assessed during subsidence monitoring, and therefore would not result in on- or off-site subsidence or collapse during operation. This impact would be less than significant for all six Build Alternatives. Therefore, CEQA does not require mitigation.

Effects of Karst Terrain

There are no mapped karst areas within the Build Alternatives. Although not anticipated, permanent project facilities during project operations may be located in or atop areas of karst terrain. Permanent HSR structures atop areas of karst terrain could result in differential settlement, which could damage facilities and cause life safety concerns. If unaddressed, the potential for this direct impact would persist throughout the project operations. GEO-IAMF#10 will ensure that HSR design and construction implement adopted geotechnical standards to withstand karst hazards after completion of construction.

CEQA Conclusion

As identified above in Impact GSSP#2, with adherence to GEO-IAMF#10, which requires the characterization of soils, as well as methods to be used in the design of bridge foundations and structures, retaining walls, and buried structures to provide specifications addressing structures' seismic response in soils such as karst terrain, the construction of the Refined SR14 and SR14A Build Alternatives would not result in karst terrain hazards. This impact would be less than significant for the Refined SR14 and SR14A Build Alternatives. Therefore, CEQA does not require mitigation.

The E1, E1A, E2, and E2A Build Alternatives would not encounter karst terrain, and no impact would occur for these Build Alternatives. Therefore, CEQA does not require mitigation.

Effects of Slope Failure Hazards

Topography surrounding the Refined SR14 and SR14A Build Alternatives is relatively flat, so no mapped landslide hazard zones were identified within the RSA. Under the E1 and E1A Build Alternatives, approximately 15 acres of subsurface easements would occur in mapped landslide-prone areas. Approximately 39 to 48 acres of surface disturbance and 45 acres of subsurface easements would occur in seismically induced landslide zones. Under the E2 and E2A Build Alternatives, approximately 5 acres of temporary and permanent surface disturbance and 3 acres of subsurface easement would occur in landslide prone areas. Approximately 119 acres of temporary and permanent disturbance and 31 acres of subsurface easement would occur in seismically induced landslide prone areas. However, unidentified, or unknown unstable slopes could exist within the RSA. Destabilization of natural or constructed slopes could also occur during construction.

CEQA Conclusion

GEO-IAMF#10 will implement engineering and safety protocols to limit slope failure hazards during construction, which would alleviate potential slope failures during operations in permanent facilities. With adherence to the measure, the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving the rupture of a known earthquake fault during operation. This impact would be less than significant for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives. Therefore, CEQA does not require mitigation.

Effects of Seiches

As identified above in Impact GSSP#9, all six Build Alternatives would be built close to enclosed bodies of water that could expose people or structures to seiche events during operation of the project.

Due to the potential wave volume of the Lake Palmdale Dam (approximately 1 acre-foot), it is not expected to result in substantial water displacement that could overtop the dam and affect operations of the project.

Regarding seiche events at Hansen Dam and Pacoima Reservoir, the Los Angeles Department of Water and Power has implemented regulations regarding the level of water in its storage facilities and providing walls of extra height to contain seiches and prevent overflow. Dams and reservoirs, including the Hansen Dam and Pacoima Reservoir, are monitored during storms, and measures are instituted if there is potential for overflow.

CEQA Conclusion

With adherence to city and state agencies' protocols to minimize potential seiche event and hazards, the six Build Alternatives would not increase exposure to loss of life, injuries, or destruction during operation of the project. This impact would be less than significant for all six Build Alternatives. Therefore, CEQA would not require mitigation.

Effects of Dam Inundation

Dam failures could cause significant damage to permanent facilities and structures or result in injuries or death of passengers or workers. During operations of the project, seismically induced flooding could pose a risk to passengers and workers within the Boulevard Mine and CalMat disposal sites. However, the project would not cause or accelerate the potential for dam inundation during operation. Therefore, the project would not increase the potential to expose people or structures to potential loss of life, injuries, or destruction due to dam inundation.

The Division of Safety of Dams of the California Department of Water Resources has jurisdiction over large dams throughout California and enforces strict safety requirements and annual inspections. Dam inundation areas have been mapped by dam owners and submitted to the California Office of Emergency Services to ensure effective emergency planning and adequate preparations in the event of a catastrophic event.

CEQA Conclusion

Operation of the project would not cause or risk exacerbating the potential for dam inundation. The potential for a seismically induced flooding event to affect the project as a result of dam failure is low. The six Build Alternatives would not directly or indirectly cause potential risk of loss of life, injuries, or destruction during operation due to seismically induced dam failure beyond what people currently experience in the RSA. This impact would be less than significant for all six Build Alternatives. Therefore, CEQA would not require mitigation.

3.9.7 Mitigation Measures

The following mitigation measures would be required to reduce geology, soils, seismicity, mineral resources, and paleontological resources impacts during construction and operations of the project.

GEO-MM#1: Temporary and permanent soil stabilization at disposal sites

The contractor and/or Authority shall develop a restoration plan or temporary soil stabilization plan (interim reclamation plan) for spoil disposal sites. This plan would ensure that these locations are not left with exposed soils that would be vulnerable to wind and water erosion. Each restoration plan would address the final grade and elevation, temporary or permanent ground cover, stormwater and erosion control best management practices, expected future land use, and maintenance and inspection requirements. A restoration plan for the Vulcan Mine will be drafted if Vulcan Mine is to be used for spoils retention. The restoration plan or temporary soil stabilization plan would be prepared prior to spoils being deposited within the disposal sites.

GEO-MM#2: Inundation and slope failure minimization at spoil disposal sites

Prior to commencing construction activities, the construction contractor shall develop an evacuation plan for areas where grading, building, or disposal activities would occur underground or below grade. This plan would consider accident conditions including flood inundation and slope failure. If required, the contractor will obtain adequate Federal Emergency Management Agency flood rate insurance for activities occurring within a floodplain or dam inundation zone. The Authority will notify dam owners or managing agencies where new fill material could displace floodwaters from a seismically induced failure of the Palmdale, Pacoima, or Hansen dams. The volume of fill within the dam inundation zone should be provided to dam owners and managing agencies to allow for necessary revisions to dam inundation zone maps.

3.9.7.1 Impacts from Implementing Mitigation Measures

The following impacts from implementing mitigation measures relevant to geology, soils, seismicity, and paleontology could occur:

- **GEO-MM#1** will require a restoration plan, temporary soil stabilization plan, or interim reclamation plan for the Boulevard Mine and CalMat Mine disposal sites to protect exposed soils that would be vulnerable to wind and water erosion. Soil management procedures implemented under GEO-MM#1 will occur within the spoil disposal sites and would not result in new impacts outside of the construction footprint.
- **GEO-MM#2** will require the Authority to prepare emergency evacuation plans for work within disposal sites. Development and implementation of these plans would not result in physical impacts outside of the project footprint.

3.9.8 NEPA Impacts Summary

This section summarizes geology, soils, seismicity, minerals, and paleontology impacts associated with each of the six Build Alternatives. Table 3.9-6 compares the impacts of each of the six Build Alternatives, summarizing the more detailed information provided in Section 3.9.6.3. A comparison of the geology, soils, seismicity, minerals, and paleontology impacts for all six Build Alternatives follows Table 3.9-6.

All six Build Alternatives incorporate IAMFs that would minimize impacts related to geology, soils, seismicity, mineral resources, and paleontological resources (Section 3.9.4.2). GEO-IAMF#1 through GEO-IAMF#10 include testing, monitoring, and design standards that would keep most geology, soils, and seismic hazards within generally established safety thresholds, but as discussed in this section, mitigation measures would address the following:

- Long-term exposure of erosive soils at the Boulevard Mine and CalMat Mine disposal sites (GEO-MM#1)
- Accident conditions (inundation and slope failure hazards) that could entrap or injure construction workers in tunnels and disposal sites (GEO-MM#2)

Application of GEO-MM#1 and GEO-MM#2 would minimize hazards associated accident conditions and exposed soils at disposal sites.

Paleontological monitoring and recovery plans would protect paleontological resources encountered by surficial construction activities (GEO-IAMF#11 through GEO-IAMF#15). However, tunnel boring would likely destroy paleontological resources encountered beneath the ground surface.

Table 3.9-6 Comparison of High-Speed Rail Build Alternative Impacts for Geology, Soils, Seismicity, and Paleontological Resources

Impacts	Build Alternative						NEPA Conclusion before Mitigation (All Build Alternatives)	Mitigation	NEPA Conclusion post Mitigation (All Build Alternatives)
	Refined SR14	SR14A	E1	E1A	E2	E2A			
Construction Impacts									
Geologic Hazards									
Impact GSSP#1: Ground Subsidence and Ground Settlement Could Endanger People or Structures During Construction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.1
Acres of temporary surface footprint within high subsidence potential zones	1,710	1,635	1,886	1,651	1,886	1,651			
Acres of permanent surface footprint within high subsidence potential zones	1,680	1,613	1,855	1,609	1,854	1,609			
Acres of permanent subsurface footprint within high subsidence potential zones	30	95	16	35	16	35			
Acres of temporary surface footprint within low to medium subsidence potential zones	383	403	928	423	383	310			
Acres of permanent surface footprint within low to medium subsidence potential zones	549	357	928	417	273	274			
Acres of permanent subsurface footprint within low to medium subsidence potential zones	80	31	80	80	74	74			

Impacts	Build Alternative						NEPA Conclusion before Mitigation (All Build Alternatives)	Mitigation	NEPA Conclusion post Mitigation (All Build Alternatives)
	Refined SR14	SR14A	E1	E1A	E2	E2A			
Impact GSSP#2: Karst Terrain Could Endanger People or Structures During Construction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.1
Acres of temporary and permanent surface footprint in areas of known karst terrain	302	209	0	0	0	0			
Acres of temporary and permanent subsurface footprint in areas of known karst terrain	14	29	0	0	0	0			
Soil Hazards									
Impact GSSP#3: Landslides Could Endanger People or Structures During Construction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.2
Acres of temporary surface footprint within non-seismic landslide hazard areas	4	3	0	0	5	5			
Acres of permanent subsurface footprint within non-seismic landslide hazard areas	5	6	15	15	3	3			
Acres of temporary surface footprint within seismic landslide hazard areas	147 – 160	123 – 137	40 – 49	40 – 49	119	90			
Impact GSSP#4: Construction Could Expose Erodible Soils During Construction.							Adverse Effect	GEO-MM#1	No Adverse Effect See Section 3.9.8.2
Acres of temporary footprint within highly erodible soil areas	288 – 299	282 – 292	161 – 168	100 – 104	223 – 241	156 – 183			
Acres of permanent footprint within highly erodible soils	288 – 299	274 – 284	153 – 160	98 – 102	215 – 233	147 – 152			

Impacts	Build Alternative						NEPA Conclusion before Mitigation (All Build Alternatives)	Mitigation	NEPA Conclusion post Mitigation (All Build Alternatives)
	Refined SR14	SR14A	E1	E1A	E2	E2A			
Impact GSSP#5: Expansive, Corrosive, and Collapsible Soils Could Endanger People or Structures During Construction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.2
The Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives have similar likelihood to encounter expansive and collapsible soils.									
Acres of temporary and permanent surface footprint within soil areas that are highly corrosive to steel	447	464	447	436	447	399			
Acres of temporary and permanent subsurface footprint within soil areas that are highly corrosive to steel	8	20	5	5	5	5			
Acres of temporary and permanent footprint within soil areas that are highly corrosive to concrete	24	13	24	13	24	13			
Impact GSSP#6: Areas of Difficult Excavation Could Potentially Endanger Workers and Facilities.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.2
Acres of footprint within areas of difficult excavation	2,681	2,271	1,879	1,938	1,808	1,869			
Primary Seismic Hazards									
Impact GSSP#7: Fault Rupture and Seismic Ground Shaking Could Endanger People or Structures During Construction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.3
The Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would encounter a similar risk of fault rupture and ground shaking.									
Impact GSSP#8: Liquefaction, Lateral Spreading, and Ground Lurching Could Endanger People or Structures During Construction.							No Adverse Effect	No mitigation needed	N/A

Impacts	Build Alternative: Refined SR14	SR14A	E1	E1A	E2	E2A	NEPA Conclusion before Mitigation (All Build Alternatives)	Mitigation	NEPA Conclusion post Mitigation (All Build Alternatives)
Acres of temporary and permanent surface footprint within liquefaction-prone areas	289–296	218–277	180	151	217	190			See Section 3.9.8.3
Secondary Seismic Hazards									
Impact GSSP#9: Seiches Could Endanger People or Structures During Construction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.4
Portions of the Refined SR14 and E1 Build Alternatives would be constructed within the Lake Palmdale, Pacoima Reservoir, and Hansen Dam seiche hazard areas. Portions of the E2 Build Alternative would be constructed within the Lake Palmdale and Hansen Dam seiche hazard areas. Apart from minor footprint variations within the Palmdale Dam Inundation Area, the SR14A, E1A, and E2A Build Alternatives would have identical footprint within dam inundation areas compared to the Refined SR14, E1, and E2 Build Alternatives, respectively. See Figure 3.9-26 through Figure 3.9-28 for potential inundation areas associated with each of the six Build Alternatives.									
Impact GSSP#10: Inundation Related to Seismically Induced Dam Failure Could Endanger People or Structures During Construction.							Adverse Effect	GEO-MM#2	No Adverse Effect See Section 3.9.8.4
Acres of temporary footprint within dam inundation zones	475 – 517	538 – 590	480 – 496	551 – 570	173	331			
Acres of permanent footprint within dam inundation zones	469 – 517	524 – 571	480 – 496	535 – 555	260	320			
Mineral and Energy Resources									
Impact GSSP#11: Regional Availability of Aggregate Resources During Construction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.5
Tons of construction aggregate required for construction[2]	8.1	9.3	8.1	8.7	8.9	8.4			

Impacts	Build Alternative						NEPA Conclusion before Mitigation (All Build Alternatives)	Mitigation	NEPA Conclusion post Mitigation (All Build Alternatives)
	Refined SR14	SR14A	E1	E1A	E2	E2A			
Impact GSSP#12: HSR Footprint Could Reduce Availability of Mineral Resources.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.5
Acres of temporary footprint within MRZ-2 Zones (surface only)	602 – 628	662 – 699	408 – 423	419 – 433	246	247			
Acres of permanent surface footprint within MRZ-2 Zones	602 – 628	651 – 674	408 – 423	415 – 429	246	247			
Acres of permanent subsurface footprint within MRZ-2 Zones	94 – 96	95	45	45	10	31			
Acres of temporary and permanent surface footprint within MRZ-3 Zones	0	0	0	0	0	0			
Active mining facilities within construction footprint	1	1	0	0	0	0			
Closed mining facilities within construction footprint	3	3	1	1	1	1			
Impact GSSP#13: Mine Conditions Could Pose Hazards During Construction.							Adverse Effect	GEO-MM#2	No Adverse Effect See Section 3.9.8.5
Total number of mining facilities within the Central Subsection	65	58	60	60	42	42			
Total number of mining facilities within the Burbank Subsection	5	5	N/A	N/A	N/A	N/A			
Impact GSSP#14: Construction Could Interfere with Oil/Natural Gas Extraction.							No Adverse Effect	No mitigation needed	N/A See Section 3.9.8.5
Active oil/gas wells within construction footprint.	0	0	0	0	0	0			

Impacts	Build Alternative: Refined SR14	Build Alternative: SR14A	Build Alternative: E1	Build Alternative: E1A	Build Alternative: E2	Build Alternative: E2A	NEPA Conclusion before Mitigation (All Build Alternatives)	Mitigation	NEPA Conclusion post Mitigation (All Build Alternatives)
Inactive oil/gas wells within construction footprint	1	1	1	1	2	2			
Paleontological Resources									
Impact GSSP#15: Surface Excavation and Subsurface Tunneling Could Destroy Unique Paleontological Resources.							Adverse Effect	No feasible mitigation measures	Adverse Effect See Section 3.9.8.6
Linear miles of bored tunnel through paleontologically sensitive geologic units (high/low sensitivity)	7.80/ 6.51	9.54/ 8.57	4.76/ 3.42	6.06/ 3.58	4.77/ 3.31	6.07/ 3.47			
Linear miles of surface profile through paleontologically sensitive geologic units (high/low sensitivity)[1]	2.50/ 11.87	1.84/ 11.59	2.81/ 10.40	1.77/ 10.49	3.02/ 9.46	1.93/ 8.60			
Acres of surface footprint within paleontologically sensitive geologic units (high/low sensitivity)	493.37/ 1,975.64	581.22/ 1,907.45	410.19/ 1,630.67	386.51/ 1,608.10	499.52/ 1,428.92	478.93/ 1,395.99			
Operations Impacts									
Impact GSSP#16: Effects of Geologic Hazards During Operations.							No Adverse Effect	No mitigation needed	N/A See Sections 3.9.8.2 and 3.9.8.4
Operation of the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would encounter a similar risk of fault rupture and ground shaking, subsidence, karst terrain, land sliding, seiches, and dam inundation as the effects of construction.									

Source: Authority, 2019a

[1] This row includes construction profiles that would occur from the ground surface, including retained cut/trench, cut-and-cover, at-grade, and at-grade covered tunnel.

[2.] Construction aggregate is quantified by million tons.

3.9.8.1 Geologic Hazards

All six Build Alternatives would encounter subsidence-prone zones throughout the geologic hazard RSA, particularly in the lower-lying Antelope Valley and San Fernando Valley (Table 3.9-6). Ground subsidence and settlement could directly affect the HSR system by damaging equipment and facilities during construction and operations. The E1 Build Alternative proposes the most permanent surface footprint within low to moderate subsidence areas. Per GEO-IAMF#1, the CMP will identify subsidence hazard areas and apply engineering controls to reduce vulnerability to ground subsidence or settlement during construction. GEO-IAMF#9 will provide for monitoring HSR facilities for subsidence during operations, and GEO-IAMF#10 will ensure that HSR design and construction implement adopted geotechnical standards to withstand subsidence hazards. Implementation of these IAMFs would minimize ground subsidence or settlement risks throughout construction and operations.

The Refined SR14 Build Alternative and SR14A Build Alternative are the only Build Alternatives that would encounter karst terrain, which could directly affect the Refined SR14 Build Alternative and SR14A Build Alternative by creating ground instability or collapse conditions during construction and operations for at-grade, elevated, and tunnel sections of the alignments. The E1, E1A, E2, and E2A Build Alternatives would avoid such impacts because these Build Alternatives would not traverse karst terrain. GEO-IAMF#10 will ensure that the Refined SR14 Build Alternative and SR14A Build Alternative design and engineering operations implement adopted geotechnical standards to withstand karst hazards throughout construction and operations.

Landslide hazards exist throughout the Palmdale to Burbank project area, specifically in the rugged San Gabriel Mountains. Previously mapped as well as thus-far-unidentified landslide and seismically induced hazard zones could endanger HSR construction and operations footprint, representing a direct impact. The Refined SR14 Build Alternative would require the most acres of surface disturbance within known seismic and nonseismic landslide hazard areas.

Per GEO-IAMF#1, the CMP will identify slope hazards and implement engineering controls to minimize landslide vulnerability. GEO-IAMF#2 will require the CMP to incorporate slope monitoring and remediation where there is potential for long-term instability, thus minimizing landslide impacts. Implementation of these IAMFs would minimize landslide risks throughout construction and operations.

3.9.8.2 Soil Hazards

Soil hazards within the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternative soil hazard RSAs include erodible, expansive, corrosive, and collapsible soils, bedrock formations, and areas of difficult excavation. Hazards related to expansive, corrosive, and collapsible soils could directly affect both construction activities and long-term presence of infrastructure associated with the Build Alternatives.

Erodible soils exist throughout the Refined SR14, SR14A, E1, E1A, E2, and E2A Alternative soil hazard RSAs. Erosion could result from earthmoving activities, soil stockpiling, and deposition of spoil material into the disposal sites before such spoils are compacted. These areas could experience elevated erosion rates if exposed to wind, precipitation, and runoff. The Refined SR14, and SR14A Build Alternatives propose the most temporary surface disturbance in areas underlain by erodible soils and feature the largest permanent footprint within areas underlain by highly erodible soils. Once exposed during earthmoving activities, these soils would be subject to erosion throughout the construction period until the soils are stabilized, which represents an indirect impact. GEO-IAMF#1 will require the CMP to identify areas with high erosion potential and develop practices to limit soil loss during construction. The contractor will also implement appropriate erosion control methods documented in the Storm Water Pollution Prevention Plan (HYD-IAMF#3) and the Caltrans Construction Manual (Caltrans 2007). Implementation of these IAMFs would minimize soil loss throughout construction and operations.

However, at the outset of construction activities, the Boulevard Mine (Refined SR14, SR14A, E1, and E1A Build Alternatives) and CalMat Mine (E2 and E2A Build Alternatives) disposal sites would be regraded to a new base elevation (expected to remain below grade) and managed as open pits. Exposed soils at the Boulevard Mine and CalMat Mine disposal sites would be subject to standard engineering guidelines and applicable regulations to minimize exposure to erosive forces, but depending on the end use of these sites, long-term soil loss could occur. The contractor and/or Authority shall develop a restoration plan, temporary soil stabilization plan, or interim reclamation plan for the Boulevard Mine and CalMat Mine disposal sites to protect exposed soils that would be vulnerable to wind and water erosion (GEO-MM#1).

Soils along the six Build Alternatives could exhibit expansive, corrosive, and collapsible characteristics that could endanger project structures, equipment, employees, and passengers throughout construction and operations. Based on existing information, the six Build Alternatives would encounter similar risks related to hazardous soil conditions. Geotechnical data collection and testing during the design phase would identify expansive, corrosive, and collapsible soil hazard areas throughout the project area. GEO-IAMF#1 will employ methods to limit the risk of damage or injury resulting from expansive, corrosive, and collapsible soils, and GEO-IAMF#10 will ensure that HSR design and construction implement adopted geotechnical standards to withstand poor soil conditions. These IAMFs would minimize vulnerability to expansive, corrosive, and collapsible soil risks throughout project construction and operations.

Certain soils within the soil hazard RSA pose excavation or tunneling difficulty that would necessitate specialized construction equipment. All six Build Alternatives would include features constructed over areas of difficult excavation, but the Refined SR14 Build Alternative would encounter the most areas of difficult excavation. GEO-IAMF#10 will require contractors to incorporate established engineering design guidelines and standards to limit risks related to areas of difficult excavation. Project operations would not require substantial ground disturbance through areas of difficult excavation.

3.9.8.3 Primary Seismic Hazards

The project would be in a seismically active region. As such, potential HSR corridors between Palmdale and Burbank would encounter fault rupture and ground shaking hazards, which could directly affect the HSR system. The Refined SR14 Build Alternative would entail the most temporary and permanent footprint within hazardous and potentially hazardous fault zones, would encounter the most fault zones, and would entail the most fault crossings via profile types. Impacts related to ground shaking would be the same for the Build Alternatives. GEO-IAMF#6 ensures that project design would incorporate early warning systems to track strong ground motion associated with fault rupture. GEO-IAMF#7 requires the preparation of a technical memorandum to address fault rupture for construction components. GEO-IAMF#8 requires the suspension of operations during earthquakes to reduce the potential for injuries or loss of life from surface fault rupture and ground shaking during operations. GEO-IAMF#10 will evaluate fault rupture potential and employ engineering protocols to limit ground shaking hazards. Implementation of these IAMFs, along with standard engineering practices and legal requirements, would keep fault rupture and ground shaking hazards within standard safety thresholds throughout construction and operations.

The Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives could encounter liquefaction susceptibility zones between Palmdale and Burbank, but the Refined SR14 Build Alternative proposes the most temporary and permanent surface footprint within known liquefaction zones. Liquefaction, lateral spreading, or ground lurching along slopes, cliffs, or embankments within the project footprint could directly affect the HSR system by causing damage, delays, and injury or loss of life. *Technical Memorandum 2.9.10, Geotechnical Analysis and Design Guidelines* (Authority 2011), outlines liquefaction analysis and design criteria for HSR infrastructure. In addition, GEO-IAMF#10 requires incorporation of engineering and design standards to reduce vulnerability to liquefaction, lateral spreading, and ground lurching. Implementation of this IAMF would keep potential liquefaction, lateral spreading, and ground lurching risks within established safety thresholds throughout construction and operations.

3.9.8.4 Secondary Seismic Hazards

Secondary seismic hazards include seiche, tsunami, and seismically induced dam failure. The Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternative inundation RSAs are not within the Los Angeles County tsunami inundation zone. The southernmost portions of the inundation RSA are more than 15 miles inland and separated from the ocean by the Hollywood Hills/Santa Monica Mountains. Given these factors, the probability of the project experiencing a tsunami would be low.

Construction and operations of the Refined SR14, SR14A, E1 and E1A Build Alternatives would occur near Lake Palmdale, Pacoima Reservoir, and Hansen Dam. Construction and operations of the E2 and E2A Build Alternative would occur near Lake Palmdale and Hansen Dam. These waterbodies could experience a seiche during an earthquake, which could directly affect the HSR system. Damaging floods associated with seiches at Lake Palmdale are unlikely because a seiche event would not result in substantial water displacement overtopping the dam. City and state agencies implement protocols to address potential seiche events, which would minimize seiche hazards associated with the Pacoima Reservoir and Hansen Dam. Though Refined SR14, SR14A, E1, and E1A Build Alternatives would be constructed near more seiche-prone waterbodies relative to the E2 and E2A Build Alternatives, seiche risks would be minimal for the Build Alternatives.

The Palmdale Dam inundation area encompass similar portions of the Refined SR14, SR14A, E1, E1A, E2, and E2A footprints. The Refined SR14, SR14A, E1, and E1A Build Alternatives would require surface footprint and tunnel construction through the Pacoima Dam inundation area, and the E2 and E2A Build Alternatives would require surface footprint and tunnel construction through the Hansen Dam inundation area. Construction of the project would not cause or accelerate the potential for dam inundation. However, seismically induced flooding could pose a risk to construction workers and/or equipment within the Boulevard Mine and CalMat disposal sites. Prior to construction, the contractor will develop an evacuation plan to consider flood inundation accident conditions (GEO-MM#2). Application of this mitigation measure would minimize dam inundation risks throughout construction.

3.9.8.5 Mineral and Energy Resources

Project construction would require substantial aggregate resources—approximately 4 percent of permitted aggregate reserves within the project region. The Refined SR14 and E1 Build Alternative would require the least construction aggregate, and the SR14A Build Alternative would require the most construction aggregate. There would be sufficient aggregate available to provide material for the project without harmfully depleting available sources. Project operations would not require substantial aggregate material.

Mineral resources are common in the Palmdale to Burbank project area, and this region contains numerous active and inactive mining facilities. The Refined SR14 and SR14A Build Alternatives propose the most construction footprint within MRZ areas and encompass the most known mining facilities. HSR facilities would convert MRZ-2 areas to a transportation use. However, the six Build Alternatives would permanently convert only a maximum of 0.6 percent of Los Angeles County’s total MRZ-2 areas. Additionally, large portions of these MRZ-2 areas encompass extensive developed areas, particularly in the San Fernando Valley. Development in these areas currently limits access to underlying mineral resources and introduction of each of the six Build Alternatives would not alter this condition. In undeveloped areas, mineral extraction would only be obstructed in the immediate vicinity of each of the six Build Alternatives. Extraction activities could still occur beneath surface footprint and near subsurface footprint. Therefore, each of the six Build Alternatives would have a minimal effect on the availability of mineral resources.

Known, undocumented, and abandoned mining facilities could pose hazards related to the presence of toxic substances, subsurface gases, or unstable ground conditions throughout project construction and operations. This represents a direct impact. All six Build Alternatives would have similar likelihoods of encountering abandoned mine facilities due to historical mining throughout the project area. GEO-IAMF#3 and GEO-IAMF#4 will prescribe monitoring and construction practices to reduce most impacts associated with hazardous mine conditions. However, construction activities or accident conditions could result in entrapment of construction workers within the Vulcan Mine and Boulevard Mine disposal sites. All six Build Alternatives would have similar entrapment risks at disposal sites. Prior to commencing construction activities, the construction contractor would develop an evacuation plan to address accident conditions at the disposal sites (GEO-MM#2).

Folding and faulting of thick petroleum-rich sedimentary rocks throughout the San Gabriel Mountains created an important oil-producing region. As such, the area between Palmdale and Burbank includes numerous oil and gas production sites. The Refined SR14, SR14A, E1, E1A, E2, and E2A construction footprints would not encounter a known oil/natural gas field; however, the Refined SR14, SR14A, E1, and E1A construction footprints would encompass one inactive oil/natural gas well, and the E2 and E2A construction footprint would encompass two inactive oil/gas wells in the ANF including SGMNM. The E2 and E2A Build Alternatives could disrupt access to these wells and result in the decommissioning of associated infrastructure. However, because these wells are no longer active, the project would not result in a loss of access to oil and gas resources in the area.[9] Refer to Section 3.10, Hazardous Materials and Wastes, for a discussion of subsurface gas risks associated with oil/natural gas infrastructure and fields.

3.9.8.6 Paleontological Resources

All six Build Alternatives would be constructed over a complex variety of geologic units. Several geologic units within the Refined SR14, SR14A, E1, E1A, E2, and E2A paleontological resources RSAs would have potential to yield paleontological resources. The Refined SR14 and SR14A Build Alternatives would have the most surface profile and surface footprint through geologic units with high or low paleontological sensitivity and would have the highest likelihood to encounter paleontological resources during surface construction activities. As required by GEO-IAMF#11 through GEO-IAMF#15, paleontological monitoring and recovery plans would protect paleontological resources encountered by surficial construction activities. However, bored tunnel construction would likely destroy paleontological resources encountered beneath the ground surface. This represents a direct impact. The Refined SR14 and SR14A Build Alternatives would have the most tunnel profile through geologic units with high and low paleontological sensitivity and would have the highest likelihood to encounter paleontological resources during subsurface construction activities.

Operations would consist of rail service, inspections, maintenance, testing, and minor repairs. There would be no ground-disturbing activities that encounter paleontological resources remaining within the footprint after project construction.

3.9.9 CEQA Significance Conclusions

Table 3.9-7 summarizes impacts, the level of significance before mitigation, mitigation measures, and the level of CEQA significance for all six Build Alternatives. With application of GEO-MM#1 and GEO-MM#2, the six Build Alternatives would result in geology, soils, seismicity, mineral resources, and paleontological resources impacts that are mostly less than significant. However, the project would result in significant, unavoidable impacts associated with the loss of paleontological resources during construction.

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[9] While energy development is prohibited in the SGMNM due to this area's protected status as a National Monument, energy resources within the ANF are available for extraction.

Table 3.9-7 Summary of CEQA Significance Conclusions and Mitigation Measures for Geology, Soils, Seismicity, Mineral Resources, and Paleontological Resources

Impact	Level of CEQA Significance before Mitigation						Mitigation Measure	Level of CEQA Significance after Mitigation					
	Refined SR14	SR14A	E1	E1A	E2	E2A		Refined SR14	SR14A	E1	E1A	E2	E2A
Construction Impacts													
Geologic Hazards													
Impact GSSP#1: Ground Subsidence and Ground Settlement Could Endanger People or Structures During Construction.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Impact GSSP#2: Karst Terrain Could Endanger People or Structures During Construction.	LTS	LTS	No Impact	No Impact	No Impact	No Impact	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Impact GSSP#3: Landslides Could Endanger People or Structures During Construction.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Soil Hazards													
Impact GSSP#4: Construction Could Expose Erodible Soils During Construction.	S	S	S	S	S	S	GEO-MM#1	LTS	LTS	LTS	LTS	LTS	LTS
Impact GSSP#5: Expansive, Corrosive, and Collapsible Soils Could Endanger People or Structures During Construction.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Impact GSSP#6: Areas of Difficult Excavation Could Potentially Endanger Workers and Facilities.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A

Impact	Level of CEQA Significance before Mitigation						Mitigation Measure	Level of CEQA Significance after Mitigation					
	Refined SR14	SR14A	E1	E1A	E2	E2A		Refined SR14	SR14A	E1	E1A	E2	E2A
Primary Seismic Hazards													
Impact GSSP#7: Fault Rupture and Seismic Ground Shaking Could Endanger People or Structures During Construction.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Impact GSSP#8: Liquefaction, Lateral Spreading, and Ground Lurching Could Endanger People or Structures During Construction.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Secondary Seismic Hazards													
Impact GSSP#9: Seiches Could Endanger People or Structures During Construction.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Impact GSSP#10: Inundation Related to Seismically Induced Dam Failure Could Endanger People or Structures During Construction.	S	S	S	S	S	S	GEO-MM#2	LTS	LTS	LTS	LTS	LTS	LTS
Mineral and Energy Resources													
Impact GSSP#11: Regional Availability of Aggregate Resources During Construction.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Impact GSSP#12: HSR Footprint Could Reduce Availability of Mineral Resources.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A
Impact GSSP#13: Mine Conditions Could Pose Hazards During Construction.	S	S	S	S	S	S	GEO-MM#2	LTS	LTS	LTS	LTS	LTS	LTS
Impact GSSP#14: Construction Could Interfere with Oil/Natural Gas Extraction.	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A

Impact	Level of CEQA Significance before Mitigation						Mitigation Measure	Level of CEQA Significance after Mitigation					
	Refined SR14	SR14A	E1	E1A	E2	E2A		Refined SR14	SR14A	E1	E1A	E2	E2A
Paleontological Resources													
Impact GSSP#15: Surface Excavation and Subsurface Tunneling Could Destroy Unique Paleontological Resources.	S	S	S	S	S	S	No feasible mitigation measures.	SU	SU	SU	SU	SU	SU
Operations Impacts													
Impact GSSP#16: Effects of Geologic Hazards During Operations.	LTS	LTS	LTS	LTS	LTS	LTS	No mitigation measures are required.	N/A	N/A	N/A	N/A	N/A	N/A

LTS = Less than Significant, N/A = not applicable, N/I = No Impact, S = Significant, SU = Significant and Unavoidable

3.9.10 United States Forest Service Impact Analysis

This section summarizes geology, soils, seismicity, and paleontology-related effects associated with the Refined SR14, SR14A, E1, E1A, and E2A Build Alternatives on the ANF including lands within the ANF that are part of the SGMNM.

3.9.10.1 Consistency with Applicable United States Forest Service Regulations

Appendix 3.1-B, USFS Policy Consistency Analysis, contains a comprehensive evaluation of relevant laws, regulations, plans, and policies relative to areas within the ANF including SGMNM. Policies in the Angeles National Forest Management plan regarding geology, soils, seismicity, and paleontology are related to managing geologic hazards, protecting soil properties, minimizing hazards from abandoned mines and landfills, and addressing hazards from slope instability. Policies also relate to the protection of mineral, energy, and paleontological resources.

3.9.10.2 United States Forest Service Resource Analysis

Construction Effects

Geologic Hazards

Areas with documented slope instability exist along the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternative corridors within the San Gabriel Mountains. Although the Build Alternative alignments would primarily be located beneath the surface of the ANF surface facilities associated the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives could be exposed to landslide risks in the following portions of the ANF:

- **Refined SR14 Build Alternative**—The portion of Refined SR14 Build Alternative located in and around the Vulcan Mine would be vulnerable to seismically induced landslide hazards (Figure 3.9-24). A utility line associated with the SR14-A1 adit option would also be within a seismically induced landslide hazard area along Little Tujunga Canyon Road within the ANF (Figure 3.9-24).
- **SR14A Build Alternative**—The SR14A Build Alternative would encounter identical landslide hazards to those encountered by the Refined SR14 Build Alternative within the ANF including SGMNM.
- **E1 Build Alternative**—E1 surface alignment, tunnel portals, and ancillary features within Aliso Canyon would be adjacent to seismically induced landslide hazard areas on USFS lands (Figure 3.9-23). The E1-A1/E1-A2 adit options would also propose a utility line through seismically induced landslide hazard areas along Little Tujunga Canyon Road within the ANF (Figure 3.9-24).
- **E1A Build Alternative**—The E1A Build Alternative would encounter identical landslide hazards to those encountered by the E1 Build Alternative within the ANF.
- **E2 Build Alternative**—E2 surface alignment, tunnel portals, and ancillary features within Aliso Canyon would be adjacent to seismically induced landslide hazard areas on USFS lands (Figure 3.9-23). The E2-A1/E2-A2 adit options would also propose construction staging areas and utility lines through seismic hazards areas within the ANF (Figure 3.9-24). Finally, E2 proposes a tunnel portal in the southern portion of the ANF north of Big Tujunga Wash (Figure 3.9-24). This tunnel would be adjacent to seismically induced landslide hazard areas within USFS lands.
- **E2A Build Alternative**—The E2A Build Alternative would encounter identical landslide hazards to those encountered by the E2 Build Alternative within the ANF.

As discussed in Impact GSSP #3 (Section 3.9.6.3), GEO-IAMF#1 will require a CMP to identify potential slope hazards and implement engineering controls to minimize landslide vulnerability during construction. With adherence to GEO-IAMF#1, both construction activities and long-term presence of infrastructure associated with the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not result in a landslide or slope-instability hazard that would result in increased exposure of people to loss of life or structures to destruction within USFS lands during project construction and operations.

Soils Hazards

Soils exhibiting expansive, corrosive, and collapsible characteristics could endanger HSR structures and equipment within the ANF. Design-level geotechnical investigations are necessary to locate and characterize expansive and collapsible soils within the soil hazard RSA, because there are no existing maps that capture these localized hazards. The Build Alternatives would encounter soils with corrosive potential in the following areas of the ANF:

- **Refined SR14 Build Alternative**—Soils within the area occupied by the Vulcan Mine exhibit moderate concrete corrosion potential, and small areas along the proposed SR14-A1 utility lines exhibit moderate concrete corrosion (Figure 3.9-7). The Refined SR14 Build Alternative would not encounter other areas with moderate or high corrosion potential within the ANF.
- **SR14A Build Alternative**—The SR14A Build Alternative would encounter identical soil hazards to those encountered by the Refined SR14 Build Alternative within the ANF.
- **E1 Build Alternative**—Soils along the proposed E1-A1/E1-E2 utility lines exhibit moderate concrete corrosion potential (Figure 3.9-7). The E1 Build Alternative would not encounter other areas with moderate or high corrosion potential within the ANF.
- **E1A Build Alternative**—The E1A Build Alternative would encounter identical soil hazards to those encountered by the E1 Build Alternative within the ANF.
- **E2 Build Alternative**—Soils within the proposed E2-A1/E2-A2 footprints exhibit moderate concrete corrosion potential. A portion of the E2-A1/E2-A2 utility lines would encounter soils that exhibit moderate steel corrosion potential (Figure 3.9-7). E2 would not encounter other areas with moderate or high corrosion potential within the ANF.
- **E2A Build Alternative**—The E2A Build Alternative would encounter identical soil hazards to those encountered by the E2 Build Alternative within the ANF.

As discussed in Impact GSSP#5 (Section 3.9.6.3), GEO-IAMF#1 requires identification of potential soil hazards areas and incorporation of design guidelines to minimize the risk of damage or injury resulting from expansive, corrosive, and collapsible soils. GEO-IAMF#10 will ensure HSR design and construction implement adopted geotechnical standards to withstand poor soil conditions. With adherence to these measures, both construction activities and long-term presence of infrastructure associated with each of the six Build Alternatives would not increase exposure of people to loss of life or structures to destruction as a result of the expansive, corrosive, or collapsible soils on USFS lands during project construction and operations.

Construction activities on USFS lands could expose erodible soils, which could cause elevated erosion rates if exposed to wind, precipitation, and runoff. The Build Alternatives would encounter soils with high erosion potential in the following areas within the ANF:

- **Refined SR14 Build Alternative**—Refined SR14 Build Alternative would be situated in areas with soil with high erosion potential at the Vulcan Mine disposal site (Figure 3.9-4). The SR14-A1 adit option would not be in areas with high erosion potential.
- **SR14A Build Alternative**—The SR14A Build Alternative would result in identical erosion impacts to those resulting from the implementation of the Refined SR14 Build Alternative within the ANF.
- **E1 Build Alternative** —E1 surface facilities would not encounter soil with high erosion potential within the ANF including SGMNM.
- **E1A Build Alternative**—The E1A Build Alternative would result in identical erosion impacts to those resulting from the implementation E1 Build Alternative within the ANF.

- **E2 Build Alternative** —The E2-A1/E2-A2 adit options would encounter soils with high erosion potential north of the Big Tujunga Wash within the ANF. The E2 tunnel portal south of the ANF perimeter (north of the Big Tujunga Wash) would also encounter this high erosion potential area (Figure 3.9-4).
- **E2A Build Alternative**—The E2A Build Alternative would result in identical erosion impacts to those resulting from the implementation E2 Build Alternative within the ANF.

Exposed soils would be subject to erosion throughout the duration of construction or until soils are stabilized, potentially altering soil properties within the ANF including SGMNM. As discussed in Impact GSSP#5 (Section 3.9.6.3), GEO-IAMF#1 and HYD-IAMF#3 will identify areas with high erosion potential and implement best management practices to limit soil loss during construction. With adherence to these IAMFs, the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not result in substantial soil erosion or alteration of soil properties within USFS lands.

Soils within the construction footprint could pose substantial excavation or tunneling difficulty, requiring the use of specialized construction equipment, which would increase the duration of the construction period. Figure 3.9-12 and Figure 3.9-13 show that the entire ANF represents an area of high excavation difficulty. Alignments and ancillary features within the ANF including the SGMNM, would be located primarily within an area of high excavation difficulty. As discussed in Impact GSSP#6 (Section 3.9.6.3), GEO-IAMF#10 would reduce this risk by implementing industry standards throughout design, soil testing, and construction. With adherence to standard engineering and design practices identified in GEO-IAMF#10, both construction activities and long-term presence of infrastructure associated with the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not increase exposure of people to loss of life or structures to destruction due to areas of difficult excavation within USFS lands during project construction and operations.

Primary Seismic Hazards

Each of the alignments associated with the six Build Alternatives would bisect potentially hazardous faults within the ANF. Specifically, all six Build Alternatives alignments would traverse the potentially hazardous San Gabriel Fault Zone in tunnel beneath the San Gabriel Mountains (Figure 3.9-17). Intense ground shaking could also result from fault systems in the project region. A seismic event along the San Gabriel Fault Zone could result in fault rupture or ground shaking at or near HSR tunnels, adits, or ancillary features (access roads, utility corridors, spoil disposal sites) within the ANF. Fault rupture or ground shaking could damage or destroy project elements and could result in injury or loss of life of HSR passengers and personnel. Refer to Impact GSSP#7 and Impact GSSP#17 (Section 3.9.6.3) for additional detail on fault rupture and ground shaking hazards.

Each Build Alternative would include a fault chamber where the Build Alternative would cross the San Gabriel Fault Zone to accommodate fault displacement and reduce the amount of earthwork needed for maintenance should a displacement event occur, which would reduce costs and the need for closures to perform repairs. GEO-IAMF#6 ensures that project design would incorporate early warning systems to track strong ground motion associated with fault rupture. GEO-IAMF#7 requires the preparation of a technical memorandum to address fault rupture for the construction components. GEO-IAMF#10 will evaluate fault rupture potential and employ engineering protocols to limit ground shaking hazards. Implementation of these IAMFs, along with standard engineering practices, standard safety thresholds, and legal requirements, would keep fault rupture and ground shaking hazards throughout construction and operations. With adherence to these measures, neither construction activities nor the long-term presence of infrastructure associated with the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would expose people or structures to heightened seismic hazards within USFS lands during project construction and operations.

Secondary Seismic Hazards

Liquefaction, lateral spreading, or ground lurching along slopes, cliffs, or embankments within the project footprint could directly affect the HSR system by causing damage, delays, and injury or loss of life. The Build Alternatives would encounter the following areas within the ANF that could be prone to liquefaction, lateral spreading, or ground lurching:

- **Refined SR14 Build Alternative**—Refined SR14 Build Alternative at Vulcan Mine would be within a liquefaction susceptibility zone (Figure 3.9-21). The SR14-A1 adit option is also within a liquefaction zone (Figure 3.9-21).
- **SR14A Build Alternative**—The SR14A Build Alternative would encounter identical liquefaction hazards to those encountered by the Refined SR14 Build Alternative within the ANF.
- **E1 Build Alternative**—E1 surface alignment, tunnel portals, and ancillary features within Aliso Canyon would be adjacent to liquefaction hazard areas on USFS lands (Figure 3.9-20). A utility line associated with the E1-A1/E1-A2 adit options would also encounter a liquefaction zone along Sand Canyon Road (Figure 3.9-21).
- **E1A Build Alternative**—The E1A Build Alternative would encounter identical liquefaction hazards to those encountered by the E1 Build Alternative within the ANF.
- **E2 Build Alternative**—E2 surface alignment, tunnel portals, and ancillary features within Aliso Canyon would be adjacent to liquefaction hazard areas on USFS lands. A utility line associated with E2-A1/E2-A2 adit options would also encounter a liquefaction zone along Little Tujunga Canyon Road (Figure 3.9-21).
- **E2A Build Alternative**—The E2A Build Alternative would encounter identical liquefaction hazards to those encountered by the E2 Build Alternative within the ANF.

As discussed in Impact GSSP#8 (Section 3.9.6.3), Technical Memorandum 2.9.10 and GEO-IAMF#10 provide design and construction specifications that would reduce vulnerability to liquefaction, lateral spreading, and ground lurching. With adherence to Technical Memorandum 2.9.10 and GEO-IAMF#10, both construction activities and long-term presence of infrastructure associated with the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives would not increase exposure to loss of life, injuries, or destruction resulting from liquefaction, lateral spreading, or ground lurching hazards within USFS lands during project construction and operations.

Mineral and Energy Resources

The Build Alternatives would encounter areas underlain by valuable mineral resources in the ANF including the SGMNM. Under the provisions of the monument proclamation, lands within the SGMNM have been appropriated and withdrawn from mining activities, with some exceptions. In contrast, mining in the ANF may be allowed within certain areas not designated as national monument. The Build Alternatives would encounter the following MRZ-2 and MRZ-3 areas within the ANF:

- **Refined SR14 Build Alternative**—The Refined SR14 Build Alternative would encounter MRZ-2 and MRZ-3 areas between Vulcan Mine and Sand Canyon Road (Figure 3.9-30). The Refined SR14 Build Alternative would encounter additional MRZ-2 and MRZ-3 areas located underground near the SR14-A2/SR14-A3 adit options (Figure 3.9-30).
- **SR14A Build Alternative**—The SR14A Build Alternative would encounter identical mineral resources to those encountered by the Refined SR14 Build Alternative within the ANF including the SGMNM.
- **E1 Build Alternative**—The E1 tunnels would encounter MRZ-3 areas in the center of the ANF (Figure 3.9-29) and again near the southern ANF perimeter (Figure 3.9-30).

- **E1A Build Alternative**—The E1A Build Alternative would encounter identical mineral resources to those encountered by the E1 Build Alternative within the ANF including the SGMNM.
- **E2 Build Alternative**—The E2 tunnels would encounter MRZ-3 areas in the center of the ANF (Figure 3.9-29). E2 tunnel alignment and a E2-A1/E2-A2 utility line along Little Tujunga Canyon Road would also encounter MRZ-2 and MRZ-3 areas (Figure 3.9-30).
- **E2A Build Alternative**—The E2A Build Alternative would encounter identical mineral resources to those encountered by the E2 Build Alternative within the ANF including the SGMNM.

The presence of HSR facilities could fragment MRZ areas within the ANF including the SGMNM, reducing regional mineral resource availability in areas where project elements permanently convert land to transportation uses (see Section 3.9.6.3, Impact GSSP#12). As discussed in Section 3.9.7, such impacts would be minimal considering the overall availability of MRZ areas within Los Angeles County. Additionally, extraction activities could still occur beneath surface footprint and near subsurface footprint.

The Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives mineral and energy resource RSAs encompass known, undocumented, and abandoned mining facilities within the ANF including the SGMNM. Each of the six Build Alternatives would also encounter landfills within the ANF, as discussed in Section 3.10, Hazardous Materials and Wastes. Such facilities could pose hazards during project construction and operations related to the presence of toxic substances, subsurface gases, or unstable ground conditions. In addition, dumping, filling, and grading activities would destabilize existing or constructed slopes within or around the Vulcan Mine disposal site (Refined SR14 and SR14A Build Alternatives only), which could trap or injure construction workers. As discussed in Impact GSSP#13 (Section 3.9.6.3), GEO-IAMF#3 and GEO-IAMF#4 will prescribe monitoring and construction practices to reduce impacts associated with hazardous mine and landfill conditions. In addition, GEO-MM#2 (Section 3.9.7) will require a slope failure evaluation and evacuation plan for Vulcan Mine. With implementation of GEO-IAMF#3, GEO-IAMF#4, and GEO-MM#2, the Refined SR14, E1, and E2 Build Alternatives would minimize the risk of injury resulting from accident conditions at mining facilities on USFS lands.

The Refined SR14, SR14A, E1 and E1A Build Alternatives' footprints would not encompass oil/gas facilities within the ANF. However, there are two plugged dry-hole oil and gas wells underlying the E2 Build Alternative adit footprints within the ANF, which includes areas within the SGMNM. The E2 and E2A Build Alternatives could disrupt access to the wells and result in the decommissioning of associated infrastructure. However, because these wells are no longer active, the project would not result in a loss of access to oil and gas resources in the area.[10]

Paleontological Resources

Destruction or alteration of paleontological resources may occur during ground-disturbing activities, including tunneling, through paleontologically sensitive geologic units. As shown on Figure 3.9-32 and Figure 3.9-33, the six Build Alternatives propose tunnel alignment and ancillary facilities throughout the following portions of the ANF including the SGMNM, that exhibit high paleontological sensitivity:

- **Refined SR14 Build Alternative**—A portion of the Refined SR14 Build Alternative would be within areas of high paleontological sensitivity between Vulcan Mine and Sand Canyon Road, which is also within the ANF, and before exiting the southern portion of the ANF (Figure 3.9-33).

[10] While energy development is prohibited in the SGMNM due to this area's protected status as a National Monument, energy resources within the ANF are available for extraction.

- **SR14A Build Alternative**—The SR14A Build Alternative would result in identical paleontological resources impacts to those resulting from the implementation of the Refined SR14 Build Alternative within the ANF including the SGMNM.
- **E1 Build Alternative**—The E1 Build Alternative would encounter areas of high paleontological sensitivity within Aliso Canyon, south of Arrastre Canyon, and periodically in underground portions of the alignment throughout the ANF, including the SGMNM (Figure 3.9-32 and Figure 3.9-33).The E1-A1/E1-A2 adit footprints would also encounter areas of high paleontological sensitivity.
- **E1A Build Alternative**—The E1A Build Alternative would result in identical paleontological resources impacts to those resulting from the implementation of the E1 Build Alternative within the ANF including the SGMNM.
- **E2 Build Alternative**—The E2 Build Alternative would encounter areas of high paleontological sensitivity within Aliso Canyon, south of Arrastre Canyon, and periodically in underground portions of the alignment throughout the ANF including the SGMNM (Figure 3.9-32 and Figure 3.9-33).The E2-A1/E2-A2 adit footprints would also encounter areas of high paleontological sensitivity.
- **E2A Build Alternative**—The E2A Build Alternative would result in identical paleontological resources impacts to those resulting from the implementation of the E2 Build Alternative within the ANF including the SGMNM.

As discussed in Impact GSSP#15 (Section 3.9.6.3), GEO-IAMF#11 through GEO-IAMF#15 will require paleontological monitoring and recovery plans that would protect paleontological resources encountered during construction. However, bored tunnel construction would likely destroy paleontological resources encountered beneath the ground surface on USFS lands. There is no feasible mitigation to reduce this effect, which would be adverse and unavoidable for the Refined SR14, SR14A, E1, E1A, E2, and E2A Build Alternatives.

Operations Effects

As discussed in Impact GSSP#16, each of the six Build Alternatives would cross active faults susceptible to rupture during a seismic event. As described above, the San Gabriel Fault Zone could experience rupture, impacting operations in tunnels within the ANF including SGMNM. However, IAMFs incorporated into each of the six Build Alternatives would minimize these impacts during operations. GEO-IAMF#8 requires the suspension of operations during earthquakes to reduce the potential for injuries or loss of life from surface fault rupture and ground shaking during operations. GEO-IAMF#6 ensures that design of the Build Alternatives would incorporate early warning systems to track strong ground motion associated with fault rupture. As established in GEO-IAMF#7, the construction contractor will prepare a technical memorandum documenting large seismic ground shaking evaluation and design criteria for the selected Preferred Alternative. Prior to final design, the contractor will conduct additional seismic studies to establish up-to-date estimation of levels of ground motion and utilize design practices to minimize the effects of seismic activity. GEO-IAMF#9 will monitor for subsidence along the HSR corridor. GEO IAMF#10 requires incorporation of design guidelines to limit vulnerability to fault ruptures. Seismic design shall meet applicable portions of state and local regulations. Thus, operations of the Refined SR14, SR14A, E1, E1A, E2, or E2A Build Alternatives within the ANF would be unlikely to cause fault ruptures.