CALIFORNIA HIGH-SPEED TRAIN

Program Environmental Impact Report/Environmental Impact Statement

Bakersfield to Los Angeles

GEOLOGY & SOILS TECHNICAL EVALUATION

January 2004

Prepared for:

California High-Speed Rail Authority

U.S. Department of Transportation
Federal Railroad Administration

CALIFORNIA HIGH SPEED RAIL AUTHORITY

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CALIFORNIA HIGH-SPEED TRAIN PROGRAM EIR/EIS

Bakersfield to Los Angeles Geology and Soils Technical Evaluation

Prepared by:

Kleinfelder, Inc.

in association with

P&D Consultants, Inc.

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ACRONYMS

AUTHORITY	CALIFORNIA HIGH-SPEED RAIL AUTHORITY
CEQA	CALIFORNIA ENVIRONMENTAL QUALITY ACT
COG	COUNCIL OF GOVERNMENTS
CGS	CALIFORNIA GEOLOGIC SURVEY
EIR	ENVIRONMENTAL IMPACT REPORT
EIS	ENVIRONMENTAL IMPACT STATEMENT
EPA	ENVIRONMENTAL PROTECTION AGENCY
FAA	FEDERAL AVIATION ADMINISTRATION
FHWA	FEDERAL HIGHWAY ADMINISTRATION
FRA	FEDERAL RAILROAD ADMINISTRATION
FTA	FEDERAL TRANSIT ADMINISTRATION
HST	HIGH SPEED TRAIN
MTA	METROPOLITAN TRANSPORTATION AUTHORITY
RTP	REGIONAL TRANSPORTATION PLAN
USGS	UNITED STATES GEOLOGIC SURVEY

1 INTRODUCTION

The California High-Speed Rail Authority (Authority) was created by the Legislature in 1996 to develop a plan for the construction, operation, and financing of a statewide, intercity high-speed passenger train system.[1] After completing a number of initial studies over the past six years to assess the feasibility of a high-speed train system in California and to evaluate the potential ridership for a variety of alternative corridors and station areas, the Authority recommended the evaluation of a proposed high-speed train system as the logical next step in the development of California's transportation infrastructure. The Authority does not have responsibility for other intercity transportation systems or facilities, such as expanded highways, or improvements to airports or passenger rail or transit used for intercity trips.

The Authority adopted a *Final Business Plan* in June 2000, which reviewed the economic feasibility of a 1,127-kilometer-long (700-mile-long) high-speed train system. This system would be capable of speeds in excess of 321.8 kilometers per hour (200 miles per hour [mph]) on a dedicated, fully grade-separated track with state-of-the-art safety, signaling, and automated train control systems. The system described would connect and serve the major metropolitan areas of California, extending from Sacramento and the San Francisco Bay Area, through the Central Valley, to Los Angeles and San Diego. The high-speed train system is projected to carry a minimum of 42 million passengers annually (32 million intercity trips and 10 million commuter trips) by the year 2020.

Following the adoption of the Business Plan, the appropriate next step for the Authority to take in the pursuit of a high-speed train system is to satisfy the environmental review process required by federal and state laws which will in turn enable public agencies to select and approve a high speed rail system, define mitigation strategies, obtain necessary approvals, and obtain financial assistance necessary to implement a high speed rail system. For example, the Federal Railroad Administration (FRA) may be requested by the Authority to issue a *Rule of Particular Applicability*, which establishes safety standards for the high-speed train system for speeds over 200 mph, and for the potential shared use of rail corridors.

The Authority is both the project sponsor and the lead agency for purposes of the California Environmental Quality Act (CEQA) requirements. The Authority has determined that a Program Environmental Impact Report (EIR) is the appropriate CEQA document for the project at this conceptual stage of planning and decision-making, which would include selecting a preferred corridor and station locations for future right-of-way preservation and identifying potential phasing options. No permits are being sought for this phase of environmental review. Later stages of project development would include project-specific detailed environmental documents to assess the impacts of the alternative alignments and stations in those segments of the system that are ready for implementation.

The decisions of federal agencies, particularly the Federal Railroad Administration (FRA) related to high-speed train systems, would constitute major federal actions regarding environmental review under the National Environmental Policy Act (NEPA). NEPA requires federal agencies to prepare an Environmental Impact Statement (EIS) if the proposed action has the potential to cause significant environmental impacts. The proposed action in California warrants the preparation of a Tier 1 Program-level EIS under NEPA, due to the nature and scope of the comprehensive high-speed train system proposed by the Authority, the need to narrow the range of alternatives, and the need to protect/preserve right-of-way in the future. FRA is the federal lead agency for the preparation of the Program EIS, and the Federal Highway Administration (FHWA), the U.S. Environmental Protection Agency (EPA), the U.S. Corps of Engineers (USACE), the Federal Aviation Administration (FAA), the U.S. Fish and Wildlife Service (USFWS), and the Federal Transit Administration (FTA) are cooperating federal agencies for the EIS.

[1] Chapter 796 of the Statutes of 1996; SB 1420, Kopp and Costa

A combined Program EIR/EIS is to be prepared under the supervision and direction of the FRA and the Authority in conjunction with the federal cooperating agencies. It is intended that other federal, state, regional, and local agencies will use the Program EIR/EIS in reviewing the proposed program and developing feasible and practicable programmatic mitigation strategies and analysis expectations for the Tier 2 detailed environmental review process which would be expected to follow any approval of a high speed train system.

The statewide high-speed train system has been divided into five regions for study: Bay Area-Merced, Sacramento-Bakersfield, Bakersfield to Los Angeles, Los Angeles-San Diego via the Inland Empire, and Los Angeles-Orange County-San Diego. This Soils and Geology Technical Evaluation for the Bakersfield to Los Angeles region is one of five such reports being prepared for each of the regions on the topic, and it is one of fifteen technical reports for this region. This report will be summarized in the Program EIR/EIS and it will be part of the administrative record supporting the environmental review of alternatives.

1.1 ALTERNATIVES

1.1.1 No-Project Alternative

The No-Project Alternative serves as the baseline for the comparison of Modal and High-Speed Train alternatives. The No-Project Alternative represents the state's transportation system (highway, air, and conventional rail) as it existed in 1999-2000 and as it would be after implementation of programs or projects currently programmed for implementation and projects that are expected to be funded by 2020. The No-Project Alternative addresses the geographic area serving the same intercity travel market as the proposed high-speed train (generally from Sacramento and the San Francisco Bay Area, through the Central Valley, to Los Angeles and San Diego). The No-Project Alternative satisfies the statutory requirements under CEQA and NEPA for an alternative that does not include any new action or project beyond what is already committed.

The No-Project Alternative defines the existing and future statewide intercity transportation system based on programmed and funded (already in funded programs/financially constrained plans) improvements to the intercity transportation system through 2020, according to the following sources of information:

- State Transportation Improvement Program (STIP)
- Regional Transportation Plans (RTPs) for all modes of travel
- Airport plans

Intercity passenger rail plans (California Rail Plan 2001-2010, Amtrak Five- and Twenty-year Plans)

1.1.2 Modal Alternative

There are currently only three main options for intercity travel between the major urban areas of San Diego, Los Angeles, the Central Valley, San Jose, Oakland/San Francisco, and Sacramento: vehicles on the interstate highway system and state highways, commercial airlines serving airports between San Diego and Sacramento and the Bay Area, and conventional passenger trains (Amtrak) on freight and/or commuter rail tracks. The Modal/System Alternative consists of expansion of highways, airports, and intercity and commuter rail systems serving the markets identified for the High-Speed Train Alternative. The Modal Alternative uses the same inter-city travel demand (not capacity) assumed under the high-end sensitivity analysis completed for the high-speed train ridership in 2020. This same travel demand is assigned to the highways and airports and passenger rail described under the No-Project Alternative, and

the additional improvements or expansion of facilities is assumed to meet the demand, regardless of funding potential and without high-speed train service as part of the system.

1.1.3 High-Speed Train Alternative

The Authority has defined a statewide high-speed train system capable of speeds in excess of 200 miles per hour (mph) (320 kilometers per hour [km/h]) on dedicated, fully grade-separated tracks, with state-of-the-art safety, signaling, and automated train control systems. State of the art high-speed steel-wheel-on-steel-rail technology is being considered for the system that would serve the major metropolitan centers of California, extending from Sacramento and the San Francisco Bay Area, through the Central Valley, to Los Angeles and San Diego.

The High-Speed Train Alternative includes several corridor and station options. A steel-wheel on steel-rail, electrified train, primarily on exclusive right-of-way with small portions of the route on shared track with other rail is planned. Conventional "non-electric" improvements are also being considered along the existing LOSSAN rail corridor from Los Angeles to San Diego. The train track would be either at-grade, in an open trench or tunnel, or on an elevated guideway, depending on terrain and physical constraints.

For purposes of comparative analysis the HST corridors will be described from station-to-station within each region, except where a by-pass option is considered when the point of departure from the corridor will define the end of the corridor segment. The corridors and design options for HST for this region are shown on plans and profiles drawn on aerial photos in Appendix A.

Table 1.4-1 below presents the criteria for ranking the impacts.

Table 1.4-1
Ranking System for Summary Table
Impacts to Geology/Soils/Seismicity
Bakersfield to Los Angeles

	Seismic Hazards (% of Length)	Active Faults Crossings (No. of Crossings)	Slope Stability (% of length -unstable slopes)	Difficult Excavation (percent of length)	Oil/Gas Fields (% of Length)	Mineral Resources (present or not present)
Alignments						
High	> 50	2+	>10	>25	>20	If resource present
Medium	10-50	1	5-10	10-25	10-20	N/A
low	< 10	0	< 5	<10	<10	If not present
Stations						
High	Present	Present	Present	Present	Present	Present
Low	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present

2 BASELINE/AFFECTED ENVIRONMENT

2.1 STUDY AREA

The Study Area for geology and soils is defined as 200 ft from corridors and around stations. Two hundred feet incorporates all cross-sections with the exception of deep cuts and fills. Comparisons of alternative alignments were generally made for this screening-level document based on length of alignment or number of impact sites within the various geologic conditions. The overall project setting is shown on Plate 1. Due to the scale of this statewide project, the HST environmental impact analysis was performed by a project-wide Program Management Team (Parsons Brinkerhoff) who retained five segment, or Regional Analysis Teams. This portion of the report addresses the Bakersfield to Los Angeles segment, as shown on Plate 2. This segment generally follows two alternate routes both extending from Bakersfield to Los Angeles traversing the San Gabriel and a portion of the Tehachapi Mountains. The westerly alignment generally follows Interstate 5 (I-5) from Bakersfield to Los Angeles. The easterly alignment branches east of I-5 at the north end of the San Fernando Valley in Sylmar where the south end of State Route 14 (SR14) begins. This route extends from Sylmar through Palmdale, and Lancaster along SR14 to Mojave where it bends west along State Route 58 (SR58) to Bakersfield. This segment traverses from central and northern Los Angeles County to the southern portion of Kern County.

2.2 GEOLOGY

2.2.1 Geologic Setting

The Bakersfield to Los Angeles segment of the HST traverses highly variable terrain in terms of geologic, soils, and seismic conditions. The segment begins in the Los Angeles Basin and crosses the San Gabriel and Tehachapi Mountains reaching the southern end of the San Joaquin Valley at the northern extent of the segment. Regional geology for the study area is shown on Plate 3 (Jennings, 1977, 1991). This location places the majority of the project geologically in the Transverse Ranges Geomorphic Province with its northern extent reaching the Great Valley Geomorphic Province (Norris, 1976). The SR14-SR58 alignment traverses the western extent of the Mojave Geomporphic Province. The Transverse Ranges Geomorphic Province is characterized primarily by the east-west trending mountain ranges unique to most of California's and other North American regions' north-northwest trending geomorphic features. This structure is controlled largely by the San Andreas Fault Zone (SAFZ) forming the northern boundary of the Province. This province is comprised primarily of Mesozoic and early Cenozoic granitic and metamorphic rock units with deeply incised, alluviated valleys. Extensive crushing and rotation of these rock units occurs in the region where the SAFZ joins the Garlock Fault Zone near Tejon Pass, owing to its complex geologic structure. In contrast, the Great Valley Province consists of a comparatively stable deeply alleviated trough between the Sierra Nevada Mountains to the east and the Coast Ranges to the west, representing some of the least seismically active portions of California's landscape. Like the Great Valley, the Mojave Province is represented by deep sedimentation of alluvial deposits resulting from erosion of the adjacent mountainous terrain. The Mojave Desert region is, however, unique to these other adjoining provinces in that it represents the western extent of the Basin and Range continental province characterized by north-south trending, extensional terrain represented by normal faulting from the eastern Sierra Nevada Mountains to Utah and Colorado.

2.2.2 Topography

Topography along the HST alignments is shown on Plate 2. Broad, alluvial basins occupy both ends of the alignment represented by the San Fernando Valley to the south and the San Joaquin Valley at the north. These two valleys are separated by rugged, mountainous terrain of the San Gabriel and

Tehachapi Mountains. Elevations in the San Fernando Valley along the westerly I-5 alignment range from 39m to 400m above mean sea level (msl) and ultimately reach elevations of about 500m± at the north end of the alignments near Bakersfield. The highest point of this alignment is Tejon Pass at about 1,263m above msl. The easterly SR14-SR58 alignment climbs out of the San Fernando Valley along SR14 to the Mojave Desert where it reaches an elevation of about 400m± while passing through the crest of the San Gabriel Mountains at about 990m±. This alignment continues through gentle terrain of the Mojave Desert until it reaches Mojave and climbs along SR58 over the Tehachapi Mountains to Bakersfield reaching a maximum elevation of 1,460m± at Tehachapi Pass.

2.2.3 Geologic Materials

Geologic earth units along the study area are shown on Plate 3 (Jennings, 1977, 1991). This map was used in its GIS (Geographic Information System) format for much of the project analysis involving earth units. The project setting geologically consists of fluvial and basin deposits in the low-lying, valley areas and older, lithified rock units in the elevated topographic terrain of the San Gabriel and Tehachapi Mountains. Surficial deposits in the valley areas consist of alluvium and floodplain deposits, and are frequently bounded at the base of hillsides by older alluvial deposits representing remnants from previous drainage environments. Bedrock units in the mountainous terrain include predominantly Mesozoic plutonic rocks and Tertiary sedimentary formations. Characteristics of each of these units where they occur along the alignment are discussed in greater detail in the following sections. In addition to the Jennings (1977) geologic mapping, the 2-degree geologic map sheets (Jennings, 1969) at a scale of 1:250,000 were used to evaluate the proposed tunnel alignments and are also discussed later.

2.2.4 Groundwater

Groundwater is addressed here in a very preliminary and regional manner. No attempt was made to contour or discern groundwater levels throughout the project area. However, groundwater generally occurs in three distinct regions throughout the study area. Relatively uniform, unconfined aquifers and associated water tables are expected in the two valleys at either end of the alignments, including the San Fernando Valley to the south and the San Joaquin Valley to the north. Groundwater in these basins are routinely pumped for domestic and agricultural purposes and subject to long-term changes in water levels due to overdraft and recharge conditions. A portion of the SR14-SR58 alignment traverses a portion of the margin of the Mojave Desert that is similarly a broad alluvial basin and subject to the same conditions. Groundwater in the mountainous regions between these points represented by the San Gabriel and Tehachapi Mountains is highly variable, controlled by fracture permeability in rock units and local alluviated valleys that are relatively restricted in their extent. Further information on groundwater is contained in the Technical Evaluation for Hydrology and Groundwater

2.2.5 Oil and Gas Fields

Oil and gas maps produced by the CGS for the DOG (Division of Oil and Gas) and have been digitized into GIS layers for the entire state (DOG, 2001), as shown on Plate 5. Oil and gas fields exploit subsurface deposits of hydrocarbons trapped within permeable zones along faults and within upwarped or domed geologic structures. These oilfields generally occur in three main areas including the southern San Joaquin Basin, the Ventura Basin that extends as far east as the Santa Clarita Valley, and the Los Angeles Basin. Sources of information for both mineral resources and oil/gas resources were available through the California Geological Survey. Maps and publications are available through their website.

The major issue associated with oil, gas, and geothermal resources is the exclusion of future resource availability caused by the placement of facilities (railroad track, roadways, parking areas). Additionally, subsurface oil and gas deposits could impact tunnel construction and lining design, as well as operational considerations. Potential impacts on oil, gas, or geothermal resource availability were evaluated based on a comparison of known resource location versus facility location. Potential resources were identified

from published resource maps produced by the *California Department of Conservation - Division of Oil, Gas, and Geothermal Resources (CDC 2001a, CDC2001b)*.

2.2.6 Mineral Resources

Mineral resources have been mapped by the USGS for eleven of the western states and digitized in GIS format, as shown on Plate 6 (Frank, 1999). This mapping shows sand and gravel and clay deposits in the San Fernando and San Joaquin Valleys and metallic ore deposits within the San Gabriel and Tehachapi Mountains. Metallic deposits consist of gold, mercury, iron ore, and copper bodies. Gold is restricted largely to the Mojave – Tehachapi area in the northeastern portion of the project. Some gypsum is mined in the southeastern portion of the San Gabriel Mountains project area. Gypsum occurs within the marine sedimentary deposits and is often associated with hydrocarbon degradation

2.2.7 Potentially Unstable Slopes/Land sliding

Slope instability can require stabilization planning, design, and construction costs and, if not adequately characterized and mitigated during construction, can cause severe damage to surface and near-surface improvements. Typically, site-specific studies are undertaken to address subsurface conditions and perform quantitative analysis of slope stability and design of mitigation measures where necessary. Since this evaluation precedes the availability of a design, a more general approach was taken. Each of the geologic formations mapped by Jennings (1977, 1991) and depicted on Plate 3 were assigned a formational rating for slope stability (low meaning relatively stable formational characteristics relative to potential for slope failure). The potentially unstable formations were then compared to the Digital Elevation Model (DEM) that has been queried for slope areas flatter than and steeper than 33% slope gradient. For purposes of this project, the criteria for mapping potentially unstable slopes was all areas in which slope gradients exceed 33% and are not underlain by rock units having high strength characteristics (i.e. low instability ratings). A 200-foot wide buffer zone around these potentially unstable areas was created to take into consideration other site improvements that may be influenced as well. The extents of potentially unstable slopes meeting these criteria within the project area are shown on Plate 11. Since statewide maps showing existing landslides were not available, they were not used in our analysis.

2.2.8 Difficult Excavation Areas

Difficult excavation areas have been addressed relative to surface excavation characteristics and tunneling methods. Surface excavation (i.e. earthwork) methods differ significantly from deeper tunneling methods such as a Tunnel Boring Machine (TBM). Whereas hard rock at the surface may be difficult to excavate for bulldozers and other heavy earthmoving equipment, tunneling methods typically prefer these conditions. Conversely, fractures and faults result in crushed rock along which groundwater is prevalent and is difficult to excavate using tunneling methods and yet the preferred conditions for surface excavation methods. For this reason, we have used rock hardness characteristics for portions of the alignment in which aerial and at-grade track is proposed and fault zone information for areas where tunneling is proposed. Each of the geologic formations mapped by Jennings (1977, 1991) and depicted in Plate 3 were assigned a formational rating for hardness and thus excavatability using surface methods. Faults also shown on Plate 3 which include both Quaternary faults and pre-Quaternary fault were digitized into zones identified as difficult to excavate using tunneling methods. These areas are shown on Plate 12 it should be noted however first some hard rock formations may contain rock that is too hard to tunnel using a TBM and may require mining and blasting.

2.3 SOILS

Soil units mapped by the USDA National Resource Conservation Service (NRCS) provide information only for near-surface conditions. Plate 4 shows the distribution of the mapped soil units in relationship to the proposed alignments and station alternatives. These maps were prepared by the USDA on the basis of

shallow (maximum 6.5 feet deep) hand auger borings or test pits. The distribution of these soil units is highly variable along the alignments.

2.3.1 Corrosive Soils

Soils can contain low pH and/or high sulfate concentrations that can adversely influence proposed surface and subsurface improvements. Low pH soils can severely deteriorate buried metal pipelines and other metallic improvements. High sulfate content soils can deteriorate concrete and prevent complete curing of concrete, reducing its strength considerably. These soil units generally coincide with saline soils such as playas and evaporite deposits that may occur within the project area. Generalized extent of these areas can be mapped using pH and resistivity properties contained in soil parameter tables and used in conjunction with this soil unit GIS layer. This can be performed at a later stage in the project when a more refined project plan and design are available.

2.3.2 Erosion

Soils can contain very little fine-grained soil fraction and may be low in density, rendering them more susceptible to erosion when exposed to high velocity flow of water or severe wind conditions. These soil units generally coincide with permeable and low-density soils such as young alluvium and other surficial deposits that may occur within the project area. Generalized extent of these areas can be mapped using USCS (Unified Soil Classification System) symbols describing the composition of soils and erodibility values contained in the soil parameter tables used in conjunction with this soil unit GIS layer. This can be performed at a later stage in the project when a more refined project plan and design are available.

2.3.3 Shrink-swell

Soils can contain high concentrations of clay that are susceptible to shrink and swell when wetted or allowed to dry. Severe shrinkage or swelling can damage adjacent and overlying foundations and other surface improvements. These soil units generally coincide either with broad floodplain sediments that tend to be more clayey due to their distance of transport and also occur as a result of weathering of the surface of other geologic units as soil profiles. These conditions may occur within the project area. Generalized extent of these areas can be mapped using USCS symbols and plasticity and liquid limit values contained in the soil parameter tables used in conjunction with this soil unit GIS layer. This can be performed at a later stage in the project when a more refined project plan and design are available.

2.4 SEISMIC HAZARDS

Three primary seismic hazards occur as a result of the presence of faults capable of generating earthquakes, including ground rupture potential, strong ground motion, and liquefaction and other seismically-related ground movements or deformation. Ground rupture occurs when the fault ruptures at depth and movement along the fault propagates to the ground surface. Ground motion occurs when faults rupture at depth where pressures are high and result in earthquakes. Liquefaction and other ground deformation are the result of ground motions where localized subsurface earth unit conditions are susceptible to collapse or flow. Each of these hazards is described more thoroughly below along with a description of their potential occurrence.

2.4.1 Regional Faulting and Historic Seismicity

Faulting is prevalent throughout California, resulting in its intense seismicity when compared to other parts of the country. Faulting within the study area has been evaluated on the basis of the most recent known age of faulting, and recency of activity. Three sources were compiled to evaluate faulting including the Fault Activity Map of California (Jennings, 1994), Alquist-Priolo (AP) Earthquake Fault Zones of California (CGS, 2002), and fault source information used by the California Department of

Transportation (Mualchin, 1996). These sources were used to compile Plate 7, Quaternary Faults and Alquist-Priolo Earthquake Fault Zones. It should be noted that faults mapped by Mualchin were useful in that GIS layers contain valuable fault names and parameters but are mapped irrespective of recency of movement. AP mapping represents those zones where the California Geologic Survey (CGS) considers faults to be present, requiring further site-specific fault studies and recommendations prior to development. These zones generally include faults with known movement within the past 10,000 years (i.e. Holocene).

California is a seismically active region when compared to other parts of the country. The Bakersfield to Los Angeles segment study area occurs within a region of widespread faulting and folding, much of which has occurred during recent geologic time. As a result, seismicity within this segment study area is relatively frequent and often results in moderate to large earthquakes, as shown on Plate 11.

2.4.2 Ground Rupture Potential

The potential for ground rupture is typically estimated based upon the presence of faults with known displacement during recent geologic time. California generally categorizes a fault as capable of future movement if there is evidence that the fault has moved within the past 10,000 years (i.e. Holocene) and defines this category of faults as “Active”. Faults with movement within the past 1.6 million years (i.e. Quaternary) and no known Holocene displacement are considered moderately capable of rupture and are categorized as “Potentially Active”. Faults older than 1.6 million years are treated with the least concern and are called “Inactive”. Essential or critical facilities to human health and safety are required to recognize the potential for ground rupture on or immediately adjacent to both Active and Potentially Active Faults. For purposes of this project, Quaternary fault crossing zones are defined as areas where Quaternary faults transect any portion of the alignment including a 200-foot buffer allowing for other improvements associated with the project and still influenced by ground rupture potential. These areas are shown on Plate 7. The potential magnitude of displacement, and direction of displacement are outlined (from north to south) on Table 2.4-1 on the following page.

2.4.3 Ground Motion Potential

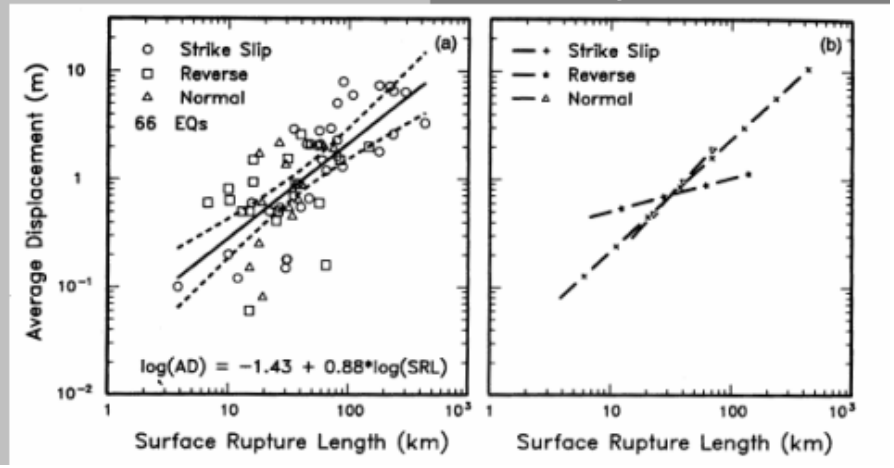
The future potential for seismicity within the project area will be controlled by the behavior of faults within and adjacent to this region. The CGS and USGS have generated maps that indicate potential seismic ground motions (USGS, CGS, 1996). These maps are the result of running computer models that consider the fault recency of movement and slip rate as well as documented (historic) seismicity defining future ground motions on the basis of probability of occurrence. Generally speaking, this model relates each of the recognized faults considered capable of generating earthquakes during the near future and decreases, or attenuates, the ground shaking with distance away from the fault. The probability of occurrence is provided in three probability scenarios including the Design Basis Event (10% probability of exceedance in 50 years), the Upper Bound Event (10% probability of exceedance in 100 years), and the Maximum Conceivable Event (10% probability of exceedance in 250 years). The State requires that essential and critical public facilities be designed to mitigate against catastrophic failure based on the Upper Bound Event, or UBE. For purposes of this project, areas of potentially strong ground motion have been defined as areas where peak horizontal earthquake ground motion accelerations may exceed 40% (i.e. 0.40) g. The aerial extent of the project within these strong ground motion zones is shown on Plate 9.

Table 2.4-1

References: Peterson et al, 1996, PROBABILISTIC SEISMIC HAZARD ASSESSMENT FOR THE STATE OF CALIFORNIA, CGS OFR 96-08, and Frankel et al, 1996, PROBABILISTIC SEISMIC HAZARD ASSESSMENT FOR THE STATE OF CALIFORNIA, USGS OFR 96-706

Fault Name	Fault Type	Sense of Movement (1)	Dip Angle	Length (km)	Slip Rate (mm/yr)	Mmax (2)	Characteristic Rate (events/yr)	Return Interval (years) (3)	Downdip Width (km) (4)	Slip Rate Reference	Displacement (in meters): Slip-Rate-Based (8)	Displacement (in meters): Empirically-Based (9)
Elysian Park	B	r	20NE	-	-	6.7	-	-	-	-	*Same as Hollywood*	
Hollywood	B	ll-r-o	70 N	17	1.00	6.4	0.00160	626	14	Dolan, 1995	0.6	2.0
Verdugo	B	r	45 NE	29	0.50	6.7	0.00062	1608	18	Weber, 2980	0.8	3.0
San Fernando	B	r	45 N	18	2.00	6.7	0.00100	1000	18	Crook, 1987	2.0	2.0
Santa Susana	B	r	55 N	27	5.00	6.6	0.00727	138	16	Yeats, 1997	0.7	3.0
San Gabriel	B	rl-ss	90	72	1.00	7.0	0.00079	1264	13	Yeats, 1994	1.3	5.0
San Andreas (Mojave Segment) (6)	A	rl-ss	90	99	30.00	7.1	0.00182	550	12		16.5	7.0
San Andreeas (Carrizo Segment) (7)	A	rl-ss	90	145	34.00	7.2	-	-	12		*Same as Mojave Segment*	10.0
Garlock West	B	ll-ss	90	10	6.00	7.1	0.00100	1000	12		6.0	0.8
Pleito	B	r	20 S	44	2.00	7.2	0.00142	706	38	Hall, 1984	1.4	2.0
White Wolf	B	r-ll-o	60 S	67	2.00	7.2	0.00119	839	21	Thatcher, 1981	1.7	4.0
Wheeler Ridge	B	r	45S	-	-	7	-	-	-		*Same as Pleito*	
Oilfield	-	-	-	-	-	-	-	-	-		*Same as White Wolf*	
Kern Front	-	-	-	-	-	-	-	-	-		*Same as White Wolf*	
Great Valley Segment 5	B	r	15 W	28	1.5	6.5	0.00200	501	10	Wakabayashi, 1994	0.8	3.0
San Joaquin South	-	-	-	-	-	-	-	-	-		*Same as Great Valley*	
San Joaquin North	-	-	-	-	-	-	-	-	-		*Same as Great Valley*	

(1) Sense of displacement: ss = strike slip, r = reverse, n = normal, rl = right lateral, ll = left lateral, and o = oblique
(2) Maximum moment magnitude calculated from relationships (rupture area) derived by Wells and Coppersmith (1984).
(3) R.I. = recurrence interval.
(4) Down-dip width = (rupture bottom minus rupture top) divided by sine of dip angle.
(5) San Andreas - San Bernardino Segment defined by Lat/Long between -117.53/34.31 to -116.48/33.92
(6) San Andreas - Mojave Segment defined by Lat/Long between -118.50/34.70 to -117.53/34.31
(7) San Andreas - Carrizo Segment defined by Lat/Long between -119.86/35.31 to -118.50/34.70
(8) Displacement computed by slip rate (mm/yr) x RI
(9) Maximum displacement versus rupture length (Wells & Coppersmith, 1994)



2.4.4 Liquefaction and Seismically Ground Induced Deformation

Liquefaction is a seismic-induced soil condition in which loose, saturated, granular (i.e. sandy) soils behave like a fluid when subjected to high-intensity ground shaking. Liquefaction occurs when three general conditions exist: 1) shallow groundwater, 2) low-density sandy soils, and 3) high-intensity ground motion. Although liquefaction has occurred in areas where fine-grained soils exist, studies have demonstrated that the most severe and most common liquefaction occurs in areas of granular soils. Effects of liquefaction on level ground include sand boils, settlement, and bearing capacity failures below structural foundations. Groundwater contours for the entire project study areas was not available with reasonable accuracy that would be beneficial to this preliminary evaluation. Therefore, in the absence of this information and for purposes of this project, all areas were assumed potentially underlain by shallow groundwater. This allowed mapping of the aerial extent of potentially liquefiable zones by including areas where ground motions exceed 30% (i.e. 0.30) g but excluding areas mapped as underlain by rock. Areas of the project meeting this criteria have been mapped on Plate 10.

2.4.5 Tsunami and Seiche

Tsunamis are oceanic waves that are generated by earthquakes, submarine volcanic eruptions, or large submarine landslides. The waves are generally formed in groups that may have very long wavelengths (several to more than 100 miles), but only a few feet high. As a tsunami enters shallow water near coastlines, the wave velocity diminishes and the wave height increases. If the trough of the wave reaches land first, the arrival of a tsunami is preceded by a recession of coastal waters; if the crest of the wave reaches land first, there would be a rise in water level. The large waves that follow can crest at heights of more than 50 feet and strike with devastating force.

The potential for tsunami influence on the subject project was evaluated by comparing the nearest portion of any of the alternatives alignments and/or stations. For the Bakersfield to Los Angeles segment, the closest design element to the nearest shoreline is more than 25 km at it's southern extent at Union Station. Therefore, the potential influence of tsunami on this project is considered low to nil.

A seiche is a standing wave condition whereby large bodies of water when subjected to seismic accelerations can generate significant waves that overtop the basin boundaries. Large bodies of water within or near the Bakersfield to Los Angeles segment of the project alternatives include:

Van Norman Reservoir
Castaic Lake
Pyramid Lake
Castac Lake

These reservoirs are owned, operated, and maintained by various State and Federal agencies such as the US Army Corps of Engineers, US Bureau of Reclamation, and Department of Water Resources. These jurisdictional agencies perform regular facility conditions and design reviews relative to seismic, hydrologic, and geotechnical performance given current state of the practice. These dam and reservoir reviews include the analysis of seiche impacts and result in retrofitting where necessary. In view of these requirements, these reservoirs are not expected to adversely influence the proposed project alternatives.

3 METHODOLOGY FOR GEOLOGY AND SOILS

The proposed HST and Modal Alternative were evaluated by comparing conditions and/or potential impacts including seismic hazards, active fault crossings, potentially unstable slopes, difficult excavation areas, potential gas migration from oil and/or gas fields, and mineral resources. Criteria for geographic delineation of these potential hazards and/or conditions are described in previous sections. Soil conditions have been described previously in Baseline/Affected Environment (Section 2.0) but are not included in the methodology. These conditions include expansive soils (i.e. shrink-swell potential), erosion, and corrosivity. These conditions are proposed to be addressed in Subsequent Analysis Requirements, as outlined in Section 5.0 and are not considered to be significant impact to the preliminary planning and environmental analysis of the project alternatives. Similarly, tsunamis and seiche are discussed in section 2.4.5 but were not considered significant to the project and were not included in our ranking methodology. The methodology used to compare alternative project alternatives, alignments, and stations are outlined below. The results of these comparisons are summarized later in Section 4.0

3.1 SEISMIC HAZARDS

Seismic hazards have been evaluated by combining the influences of strong ground motion and liquefaction potential. These potential hazards are discussed previously in Sections 2.4.3 and 2.4.4. Strong ground motion zones have been defined previously as areas where horizontal peak ground accelerations may exceed 50% (i.e. 0.50) g. The aerial extent of the project within these strong ground motion zones is shown on Plate 12. Liquefaction potential has been previously defined as those areas where ground motions exceed 30% (i.e. 0.30) g but excluding areas mapped as underlain by rock. Those areas are shown on Plate 12. In order to compare alternative projects (i.e. Modal versus HST), alignments, and stations, a ranking system was developed. This ranking system consists of the combination of the percentage of portions of the alignment within the strong ground motion zones or potentially liquefiable zones. Overlapping liquefaction/ground motion hazards are not considered duplicative in that they do not require unique mitigation effort. Stations were compared by determining whether any portion of the proposed station occurs within the ground rupture zone and a yes or no ranking, or:

Alignments - % in Strong Ground Motion Zone or in Potentially Liquefiable Zones
Stations – Presence of any Part within either Zone: Yes / No

Results of calculations using this methodology are contained in Section 4.0 (Operations and Construction Impacts)

3.2 ACTIVE FAULT CROSSINGS

Ground rupture hazard has been evaluated by mapping any portion of the proposed project alignments and/or stations that occur within 200 feet of faults with known Quaternary movement. These potential hazards are discussed previously in Sections 2.4.2. The aerial extent of the project within these active fault zones is shown on Plate 6. In order to compare alternative projects (i.e. Modal versus HST), alignments, and stations, a ranking system was developed. Any fault crossings were counted for each of the tabulated segments for comparison. This ranking system consists of the number of fault crossings within any portion of the alignment and a yes or no rating for stations, or:

Alignments - Number of Active Fault Crossings
Stations – Presence of any Part within Zone: Yes / No

Results of calculations using this methodology are contained in Section 4.0 (Operations and Construction Impacts)

3.3 SLOPE STABILITY

Potentially unstable slope areas have been defined previously in Section 2.5 as areas where slopes are steeper than 33% slope gradient but are not underlain by strong geologic rock formations. A 200-foot wide buffer zone was added to consider the influences of other improvements. These areas are shown on Plate 14. In order to compare alternative projects (i.e. Modal versus HST), alignments, and stations, a ranking system was developed in which the percentage of alignment within the potentially unstable zones are computed and compared. Stations were compared by determining whether any portion of the proposed station occurs within the potentially unstable slope areas with the 200-foot buffer and a yes or no ranking, or:

Alignments - % within Potentially Unstable Zones
Stations – Presence of any Part within 200-foot Buffer Zone: Yes / No

Results of calculations using this methodology are contained in Section 4.0 (Operations and Construction Impacts)

3.4 DIFFICULT EXCAVATION

Difficult excavation zones have been identified using both geologic formation characteristics as well as the existence of faults of any age, as described previously in Section 2.6. These areas are shown on Plate 12. These zones consist of fault zones that may influence subsurface tunneling methods and also hard rock zones that may influence surface excavation methods. It should be noted that some hard rock formations may contain rock that is too hard to tunnel using TBM and may require mining and blasting. In order to compare alternative projects (i.e. Modal versus HST), alignments, and stations, a ranking system was developed in which the percentage of alignment within the areas of difficult excavation applied to the corresponding track profile (i.e. at-grade/aerial versus tunnel) was computed and compared. Single fault crossings were assumed to be 200 meters wide. Stations were evaluated by determining the presence of any part of the facility within the zone and a yes or no rating, or:

Alignment - % Surface Segments in Hard Rock plus % Tunnel Segments within Fault Zones
Stations – Presence of any Part within either Zone: Yes / No

Proposed tunnels along the I-5 corridor through the San Gabriel Mountains required additional information for assessment of tunneling conditions. In addition to the methodology expressed above, geologic cross-sections were prepared to estimate the subsurface conditions along these key tunnel segments using Jennings' 1997 earth units and structures along with Jennings' 1994 faults. Geologic maps were prepared along these alignments using these data plus the 1:250,000 scale geologic map sheets by the CGS (Strand, 1969). Plates 13 – 16 show these conditions excluding Strand's 1969 mapping which was not available in GIS format for all four-selected tunnel segments, including:

- Grapevine Peak Tunnel (Geologic Cross-Section A-A')
- Castac Lake Tunnel (Geologic Cross-Section B-B')
- Pyramid Lake Tunnel (Geologic Cross-Section C-C')
- Santa Clarita Tunnel (Geologic Cross-Section D-D')

Results of calculations using this methodology are contained in Section 4.0 (Operations and Construction Impacts)

3.5 OIL AND GAS FIELDS

Areas of potential gas migration and the potential loss of valuable resources associated with the presence of known oil and gas fields are discussed previously in Section 2.4 and are distributed as shown on Plate 5. In order to compare alternative projects (i.e. Modal versus HST), alignments, and stations, a ranking system was developed in which the percentage of alignment within these oil and gas field areas were compared. Stations were compared by determining whether any portion of the proposed station occurs within the mapped oil and gas field areas as a yes or no ranking, or:

Alignments - % within Mapped Oil and Gas Fields
Stations – Presence of any Part within either Fields: Yes / No

Results of calculations using this methodology are contained in Section 4.0 (Operations and Construction Impacts)

3.6 MINERAL RESOURCES

The major issue associated with mineral resources is the exclusion or restriction of current or future extraction due to facility (railroad track, roadways, parking areas) location. Potential impacts on mineral extraction were evaluated based on a comparison of known resource location versus facility location. Areas of potential mineral resources are shown on Plate 6 and criteria for identification are discussed previously in Section 2.5. In order to compare alternative projects (i.e. Modal versus HST), alignments, and stations, a ranking system was developed in which the number of occurrences of mined mineral resources are compared for alignments. Stations were compared by determining whether any portion of the proposed station occurs within the mapped resources as a yes or no rating, or:

Alignments - # of Mapped Resources within 200-feet
Stations – Presence of Resources within 200-feet of any Part of Proposed Facilities

Results of calculations using this methodology are contained in Section 4.0 (Operations and Construction Impacts)

4 POTENTIAL GEOLOGICAL IMPACTS

For the Soils and Geology technical report, impacts are described for both construction and operations. Construction impacts are those having the potential to be encountered during construction or mitigated during construction – such as difficult excavation, or soil densification for liquefiable soils. Operational impacts are those which may need to be mitigated or inspected through the life of the project – such as creeping faults or slopes.

4.1 OPERATIONS

4.1.1 Impacts

Potential impacts are summarized for the High-Speed Train and Modal Alternatives in the attached Impact Analysis Tables. Ranking of each alignment project alternative is shown on Tables 3 and 4. The numerical rankings using the methodology described in Section 3.0 were used to develop low medium and high ratings for each alternative in Table 1. Six potential impacts were considered, including seismic hazards, active fault crossings, slope stability, difficult excavation, oil and gas fields, and mineral resources. Each of these potential impacts is discussed in conjunction with the proposed project alternative in the following sections.

4.1.1.1 No-Project Alternative

The No-Project Alternative does not require any additional operations and is therefore not considered unique to the Modal Alternative. Potential impacts for the Modal Alternative (below) are thus considered applicable to this alternative as well.

4.1.1.2 Modal Alternatives

The Modal Alternative includes improvement of existing highways and airports and was evaluated as summarized in the attached Impact Analysis Tables. Potential impacts to the operation of these improvements are summarized in the following sections.

4.1.1.2.1 Seismic Hazards

Seismic hazards include strong ground motion due to earthquakes and liquefaction and other seismically induced ground deformation. Strong ground motion and/or liquefaction or other seismically induced ground deformation during a major earthquake may influence the operation of roads and airports in the following respects:

- Potential risk to public safety due to automobile accidents caused by ground motion during strong earthquakes
- Potential risk to public safety due to collapse or toppling of facilities during strong earthquakes

All of the modal alignments and airports are located in areas of potentially strong ground motion and to a lesser extent, liquefaction, the Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.1.1.2.2 Active Fault Crossings

Several active faults occur within the project areas and may influence the operation of the roads and airports in the following respect:

- Potential risk to public safety due to damage to highway or airport by ground rupture along active faults

With the exception of the segment of I-5 from Burbank to LA Union Station, all modal alternatives are intersected by at least one fault crossing. Approximately seven active faults cross the segment of I-5 that extends between SR-99 and SR-14, including the Garlock and San Andreas Faults. The segment of SR-14 between Palmdale and I-5 has approximately five active fault crossings including the San Andreas. The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.1.1.2.3 Slope Stability

Several potentially unstable slopes and/or formations where proposed cut slopes or retention structures may require stabilization occur within the project areas, as shown on Plate 11, and may influence the operation of the roads or airports in the following respect:

- Potential risk to public safety and operation of roads and airports due to failure of natural and/or construction cuts slopes or retention structures

Segments that cross the Tehachapi Mountains and the San Gabriel Mountains have areas of potentially unstable slopes, including the I-5 alternative between SR-99 and SR-14, SR-14 between Palmdale and I-5, and SR-58/11 between SR-99 and Palmdale. The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.1.1.2.4 Difficult Excavation

Several areas where hard rock may be difficult to excavate at the surface or fault and fracture zones exist at depth along proposed tunnel alignments occur within the project areas, as shown by Plate 12. This condition is not anticipated to influence operations. Difficult excavation is addressed in Construction Impacts (Section 4.2).

4.1.1.2.5 Oil and Gas Fields

The potential for subsurface migration of oil and gas is not considered a potential impact to the proposed Modal Alternative since subsurface facilities are not typical to this style of infrastructure design.

4.1.1.2.6 Mineral Resources

Mineral resources were not identified along the proposed Modal Alternative. Therefore this condition is not expected to impact the operation of the Modal Alternative.

4.1.1.3 High-Speed Train Alternative

Alternative alignments and stations were evaluated and are summarized in the attached Impact Analysis Tables. Potential impacts to the operation of the High Speed Train (HST) are summarized in the following sections.

4.1.1.3.1 Seismic Hazards

Seismic hazards include strong ground motion due to earthquakes and liquefaction and other seismically induced ground movement. Areas of potential strong ground motion and/or liquefaction or other seismically induced ground deformation during a major earthquake are shown on Plates 9 and 10, respectively. Strong ground motion and/or liquefaction or other seismically induced ground deformation during a major earthquake may influence the operation of the HST in the following respects:

- Potential risk to public safety and interruption of service due to derailment by strong ground motion during strong earthquakes
- Potential risk to public safety due to collapse of facilities during strong earthquakes

Although the majority of all of the HST alternative alignments and stations are located in areas of potentially strong ground motion and to a lesser extent, liquefaction, the Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.1.1.3.2 Active Fault Crossings

Several active faults occur within the project area as shown on Plate 7, which depicts Quaternary Faults and Alquist Priolo Fault Zones. Six faults intersect the I-5 Tehachapi corridor, which extend from Wheeler Ridge to San Fernando and seven faults cross the Soledad Canyon Corridor. Other alternatives with at least one fault crossing include the SR-58 Corridor, the Wheeler Ridge Corridor, the Union Avenue Corridor, the Metrolink/UPRR: Sylmar Station to Metrolink, Metrolink/UPRR: Over I-5 and SR-110, Metrolink/UPRR: Glendale, and the existing south LA Union Station. Fault parameters are shown on Table 2.4-1. Active fault crossings may influence the operation of the HST in the following respect:

- Potential risk to public safety and interruption of service due to derailment and damaged facilities by ground rupture along active faults

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.1.1.3.3 Slope Stability

Several potentially unstable slopes and/or formations where proposed cut slopes or retention structures may require stabilization occur within the project areas and may influence the operation of the HST, as shown by Plate 11. Particularly, the Soledad Canyon Corridor which crosses the San Gabriel Mountain; the I-5 Tehachapi corridor which crosses the Tehachapi Mountains and the Liebre Mountains; and the I-5 Silver Lake Option which traverses the Santa Monica Mountains. Potentially unstable slopes may influence the operation of the HST in the following respect:

- Potential risk to public safety and interruption of service due to failure of natural and/or constructed cut slopes or retention structures

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.1.1.3.4 Difficult Excavation

Several areas where hard rock may be difficult to excavate at the surface or fault and fracture zones exist at depth along proposed tunnel alignments occur within the project areas, as shown by Plate 12. This condition is not anticipated to influence operations. Difficult excavation is addressed in Construction Impacts (Section 4.2).

Table 4.1-1
Detail Table
Bakersfield to Los Angeles

	Seismic Hazards (%)	Active Fault Crossings (#)	Slope Stability (%)	Difficult Excavation (%)	Oil and Gas Fields (%)	Mineral Resources (#)
No-Build						
Modal Alternative						
Highways						
I-5: SR-99 to SR-14	100	7	6	37	8	0
I-5: SR-14 to I-405	100	1	0	0	0	0
I-5: SR-405 to Burbank	100	3	0	0	1	0
I-5: Burbank to LAUS	100	0	0	0	0	0
SR-58/11: SR-99 to Palmdale	68	4	2	9	4	0
SR-14: Palmdale to I-5	100	5	3	38	6	0
Airports						
Burbank	100	1	0	0	0	0
High Speed Rail						
Alignments						
Wheeler Ridge Corridor	68	1	0	0	17	0
Union Avenue Corridor	78	1	0	0	22	0
Metrolink/UPPR: Sylmar Station to Metrolink	100	1	0	0	0	0
Metrolink/UPPR: Sylmar Station Siding	100	1	0	0	0	0
Metrolink/UPPR: Sylmar Station North	100	0	0	0	0	0
SR-58 Corridor	80	3	0	55	0	0
South Connection	100	0	0	0	6	0
Soledad Canyon Corridor	100	7	3	45	9	0
Metrolink/UPPR: Under I-5 and SR-110	100	0	0	0	0	0
Metrolink/UPPR: Over I-5 and SR-110	100	0	0	0	0	0
Metrolink/UPPR: Over and Under I-5 and SR-110	100	0	0	0	0	0
Metrolink/UPPR: Glendale	100	1	0	0	0	0
LAUS: South Siding	100	0	0	0	0	0
LAUS: East Bank Siding	100	0	0	0	0	0
LAUS: East Bank North	100	0	0	0	0	0
I-5: Tehachapi Corridor	100	6	8	23	5	0
I-5: Silverlake Aerial / Cut and Cover Option	100	0	12	0	0	0
I-5: Glendale	100	1	0	0	0	0
LAUS: Existing South	100	0	0	0	67	0
LAUS: Existing Siding	100	0	0	0	0	0
LAUS: Existing East	100	0	0	0	32	0
East Connection	100	0	0	0	0	0
I-5: Burbank Downtown Siding	100	0	0	0	0	0
Metrolink/UPPR: Burbank Downtown Siding	100	0	0	0	0	0
Burbank Downtown Siding	100	0	0	0	0	0
Burbank Airport Siding	100	0	0	0	0	0
Antelope Valley Corridor	70	0	0	0	0	0
Burbank Airport to Downtown	100	0	0	0	0	0
Maintenance Yard	100	0	0	0	0	0
Palmdale Siding	100	0	0	0	0	0
Stations						
Burbank Airport Station	100	0	0	0	0	0
Union Station East	100	0	0	0	0	0
Union Station South	100	0	0	0	0	0
Burbank Downtown Station	100	0	0	0	0	0
Sylmar Station	100	0	0	0	0	0
Palmdale Station	100	0	0	0	0	0
Los Angeles Union Station	100	0	0	0	0	0

4.1.1.3.5 Oil and Gas Fields

Areas where potential for subsurface migration of oil and gas may influence the operation and/or construction of the HST are shown on Plate 5. Several oil fields are located in the Bakersfield, Wheeler Ridge and San Fernando Areas, as well as the Los Angeles area. The Union Avenue, Kernsumner, North Tejon, Wheeler Ridge, and Tejon Fields are intersected by the Wheeler Ridge Corridor Alignment. The Tejon, Honor Rancho, Castaic Junction, Lyon Canyon and Newhall fields are intersected by the I-5 Tehachapi Alignment. The LAUS Existing East and Existing South Alignments as well as the South Connection intersect the Union Station Field. The Soledad Canyon Alignment intersects the Plecerita and Newhall Fields. The potential for subsurface migration of oil and may influence the operation of the HST in the following respects:

- Migration of potentially explosive and or toxic gases into subsurface facilities such as tunnels.
- Access to the fields may be impacted.

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.1.1.3.6 Mineral Resources

Mineral resources were not identified along the proposed HST alignment and/or stations. Therefore this condition is not expected to impact the operation of the HST.

4.1.1.4 High-Speed Train Alternative

Impact: Potential risk to public safety and interruption of service due to derailment by strong ground motion during strong earthquakes

The potential for derailment of the HST during a peak event cannot likely be mitigated by designing a track-wheel system that could withstand the potential ground motions in most of the project area. This holds true for most train systems throughout California. Although strong ground motion cannot be predicted accurately, the science of seismology and the ability to estimate the location and magnitude of these events continues to improve and early warning systems that monitor precursory activity have grown in effectiveness. A network of strong motion instruments has been installed throughout California and additional monitoring stations are proposed. This ground motion data can be used to temporarily shut down the HST operations. The HST system would then be inspected due to ground motion and/or ground deformation and then returned to service when appropriate. This level of seismic protection is used for most public rapid transit systems and has been proven effective.

Impact: Potential risk to public safety due to collapse or toppling of facilities during strong earthquakes

The potential for collapse or toppling of superstructures due to strong ground motion (including seismically induced ground deformation) is routinely mitigated by designing structures to withstand the estimated ground motions. Ground motions estimated during this analysis considered Upper Bound Earthquake (UBE) accelerations as required for essential or critical facilities in California and should be used for future seismic design of the project.

Impact: Potential risk to public safety and interruption of service due to derailment by ground rupture along active faults

The potential for ground rupture along active faults is one of the few geologic hazards that is rarely mitigated. However, the effects of the ground rupture along faults can be estimated in location and

magnitude, and to some extent direction of displacement. The HST alternative has been modified in mountain crossing areas where tunnels are required to avoid crossing known, or mapped active faults within the tunnel. Similar to mitigation of ground motion during peak seismic events discussed above, these events can be predicted to some extent based on precursory seismic activity that can be used to limit operation of the HST during these high probability periods.

Impact: Potential risk to public safety and interruption of service due to failure of natural and/or construction cuts slopes or retention structures

Failure of adjacent natural slopes and/or construction cut slopes or retention structures is typically mitigated by geotechnical review of proposed earthwork and foundation excavation plans and profiles. Based on this review, recommendations are provided for slope reinforcement and protection, as needed. These recommendations are incorporated into construction plans and notes and geotechnical review during construction is performed to verify that no new, unanticipated conditions are encountered and to verify the proper incorporation of recommendations during construction.

Impact: Migration of potentially explosive and/or toxic gases into subsurface facilities such as tunnels

Areas where potential migration of hazardous gases due to the presence of oil fields, gas fields, or other potential sources of hazardous gases can be mitigated by installation of impermeable subsurface barriers and/or relief wells. Active monitoring systems and alarms would be required in underground facilities. The effectiveness of these systems can be monitored by installing and monitoring gas probes and other gas detection systems.

4.2 CONSTRUCTION

4.2.1 Impacts

Potential impacts are summarized for the High-Speed Train and Modal Alternatives in the attached Impact Analysis Tables. Six potential impacts were considered, including seismic hazards, active fault crossings, slope stability, difficult excavation, oil and gas fields, and mineral resources. Each of these potential impacts is discussed in conjunction with the proposed project alternative in the following sections.

4.2.1.1 No-Project Alternative

The No-Project Alternative does not require any additional construction and is therefore considered the same as Modal Alternative. Potential impacts for the Modal Alternative in Section 5.6.3 below are thus considered applicable to this alternative.

4.2.1.2 Modal Alternatives

The Modal Alternative includes improvement of existing highways, rail lines and airports and was evaluated as summarized in the attached Impact Analysis Tables. Potential impacts to the construction of these improvements are summarized in the following sections.

4.2.1.2.1 Seismic Hazards

Seismic hazards include ground motion due to strong earthquakes and liquefaction and other seismically induced ground deformation. Strong ground motion and/or liquefaction or other seismically induced ground deformation during a major earthquake may influence the operation of roads and airports in the following respects:

- Potential risk to worker safety and interruption of construction due to automobile accidents caused by strong ground motion during strong earthquakes
- Potential risk to worker safety due to collapse or toppling of partially constructed facilities during strong earthquakes

Although the majority of all of the modal alignments and airports are located in areas of potentially strong ground motion and to a lesser extent, liquefaction, the Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.2.2 Active Fault Crossings

Several active faults occur within the project areas and may influence the construction of the modal alternatives in the following respect:

- Potential risk to worker safety and interruption of construction due to ground rupture along active faults

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.2.3 Slope Stability

Several potentially unstable slopes and/or formations where proposed cut slopes or retention structures may require stabilization occur within the project areas and may influence the construction of modal facilities in the following respect:

- Potential risk to worker safety and interruption of construction due to failure of natural and/or construction cuts slopes or retention structures

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.2.4 Difficult Excavation

There are several areas where hard rock may be difficult to excavate at the surface within the modal alternative project areas and may influence construction in the respect:

- Cost and duration of surface excavations during construction

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.2.5 Oil and Gas Fields

No impact on Modal as described in 4.1.3.5

4.2.1.2.6 Mineral Resources

Mineral resources were not identified along the proposed Modal Alternative. Therefore this condition is not expected to impact the construction of the Modal Alternative

4.2.1.3 High-Speed Train Alternative

Alternative alignments and stations were evaluated and are summarized in the attached Impact Analysis Tables. Potential impacts to the operation of the High Speed Train (HST) are summarized in the following sections.

4.2.1.3.1 Seismic Hazards

Seismic hazards include strong ground motion due to earthquakes and liquefaction and other seismically induced ground deformation. Strong ground motion and/or liquefaction or other seismically induced ground deformation during a major earthquake may influence the construction of the HST in the following respects:

- Potential risk to worker safety and interruption of construction by strong ground motion during strong earthquakes
- Potential risk to worker safety due to collapse or toppling of partially constructed facilities during strong earthquakes

Although the majority of all of the HST alternative alignments and stations are located in areas of potentially strong ground motion and to a lesser extent, liquefaction, the Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.3.2 Active Fault Crossings

Several active faults occur within the project area as shown on Plate 7, which depicts Quaternary Faults and Alquist Priolo Fault Zones. Six faults intersect the I-5 Tehachapi corridor, which extend from Wheeler Ridge to San Fernando and seven faults cross the Soledad Canyon Corridor. Other alternatives with at least one fault crossing include the SR-58 Corridor, the Wheeler Ridge Corridor, the Union Avenue Corridor, the Metrolink/UPRR: Sylmar Station to Metrolink, Metrolink/UPRR: Over I-5 and SR-110, Metrolink/UPRR: Glendale, and the existing south LA Union Station. Fault parameters are shown on Table 2.4-1. Several active faults occur within the project areas and may influence the construction of the HST in the following respect:

- Potential risk to worker safety due to ground rupture along active faults

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.3.3 Slope Stability

Several potentially unstable slopes and/or formations where proposed cut slopes or retention structures may require stabilization occur within the project areas and may influence the construction of the HST, as shown by Plate 11. Particularly, the Soledad Canyon Corridor which crosses the San Gabriel Mountain; the I-5 Tehachapi corridor which crosses the Tehachapi Mountains and the Liebre Mountains; and the I-5 Silver Lake Option which traverses the Santa Monica Mountains. Potentially unstable slopes and/or formations that may require stabilization occur within the project areas and may influence the construction of the HST in the following respect:

- Potential risk to worker safety and due to failure of natural and/or temporary construction cuts slopes

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.3.4 Difficult Excavation

Several areas where hard rock may be difficult to excavate at the surface or fault and fracture zones exist at depth along proposed tunnel alignments occur within the project areas. As shown on Plate 12, areas of difficult excavation are depicted along the SR-58 Corridor, the Soledad Canyon Corridor, and the I-5 Tehachapi Corridor, particularly where the alternatives cross the San Gabriel Mountains and the Tehachapi Mountains. This condition may influence the project construction in the following respects:

- Cost and duration of surface excavation (especially tunnel portals) during construction
- Cost and duration of tunneling along proposed tunnel segments.

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.3.5 Oil and Gas Fields

Areas where potential for subsurface migration of oil and gas may influence the operation and/or construction of the HST are shown on Plate 5. Several oil fields are located in the Bakersfield, Wheeler Ridge and San Fernando Areas, as well as the Los Angeles area. The Union Avenue, Kernsumner, North Tejon, Wheeler Ridge, and Tejon Fields are intersected by the Wheeler Ridge Corridor Alignment. The Tejon, Honor Rancho, Castaic Junction, Lyon Canyon and Newhall fields are intersected by the I-5 Tehachapi Alignment. The LAUS Existing East and Existing South Alignments as well as the South Connection intersect the Union Station Field. The Soledad Canyon Alignment intersects the Plecerita and Newhall Fields. The potential for subsurface migration of oil and gas may influence the construction of the HST in the following respects:

- Migration of potentially explosive and/or toxic gases into subsurface facilities such as tunnels

The Impact Analysis Tables provide a relative comparison of the degree of impact on each alternative.

4.2.1.3.6 Mineral Resources

Mineral resources were not identified along the proposed HST alignment and/or stations. Therefore this condition is not expected to impact the construction of the HST.

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6 PREPARERS

This screening level evaluation of geology, soils, and seismic condition and impacts has been performed by the following individuals:

Bruce R. Hilton, R.G., C.E.G. #2212, Senior Engineering Geologist, Kleinfelder, Inc. – Sacramento

Role in Project: Project Engineering Geologist for LA-Bakersfield and Bakersfield-Sacramento HST Segments

Richard M. Stauber: Senior Geotechnical Engineer, Kleinfelder, Inc. – Sacramento

Role in Project: Project Geotechnical Engineer for LA-Bakersfield and Bakersfield-Sacramento HST Segments