CALIFORNIA HIGH-SPEED TRAIN

Program Environmental Impact Report/Environmental Impact Statement

Bay Area to Merced

PALEONTOLOGIC RESOURCES 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

Bay Area to Merced Segment
Paleontologic Resources Technical Evaluation

Prepared by:

C. Bruce Hanson and Jean Durham

for

Parsons, Inc.

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ACRONYMS

APE	AREA OF POTENTIAL EFFECT
AUTHORITY	CALIFORNIA HIGH-SPEED RAIL AUTHORITY
CEQA	CALIFORNIA ENVIRONMENTAL QUALITY ACT
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
LORS	LAWS, ORDINANCES, REGULATIONS, AND STANDARDS
NEPA	NATIONAL ENVIRONMENTAL POLICY ACT
NALMA	NORTH AMERICAN LAND MAMMAL AGE
RPLI	REGIONAL PALEONTOLOGIC LOCALITY INVENTORY, SBCM
RTP	REGIONAL TRANSPORTATION PLAN
SHPO	STATE HISTORIC PRESERVATION OFFICER
SBCM	SAN BERNARDINO COUNTY MUSEUM
SVP	SOCIETY OF VERTEBRATE PALEONTOLOGY
YBP	YEARS BEFORE PRESENT

1.0 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-Los Angeles, Los Angeles-San Diego via the Inland Empire, and Los Angeles-Orange County-San Diego. This Local Area Growth, Development, Planning, Land Use, Socioeconomics, and Environmental Justice Technical Evaluation for the Bay Area-to-Merced 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 (Figure 1.1.2-1). 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)

As with all of the alternatives, the No-Project Alternative will be assessed against the purpose and need topics/objectives for congestion, safety, air pollution, reliability, and travel times.

Figure 1.1.2-1: No-Project Alternative - California Transportation System

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. (Figures 1.2-2 and 1.2-3) 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

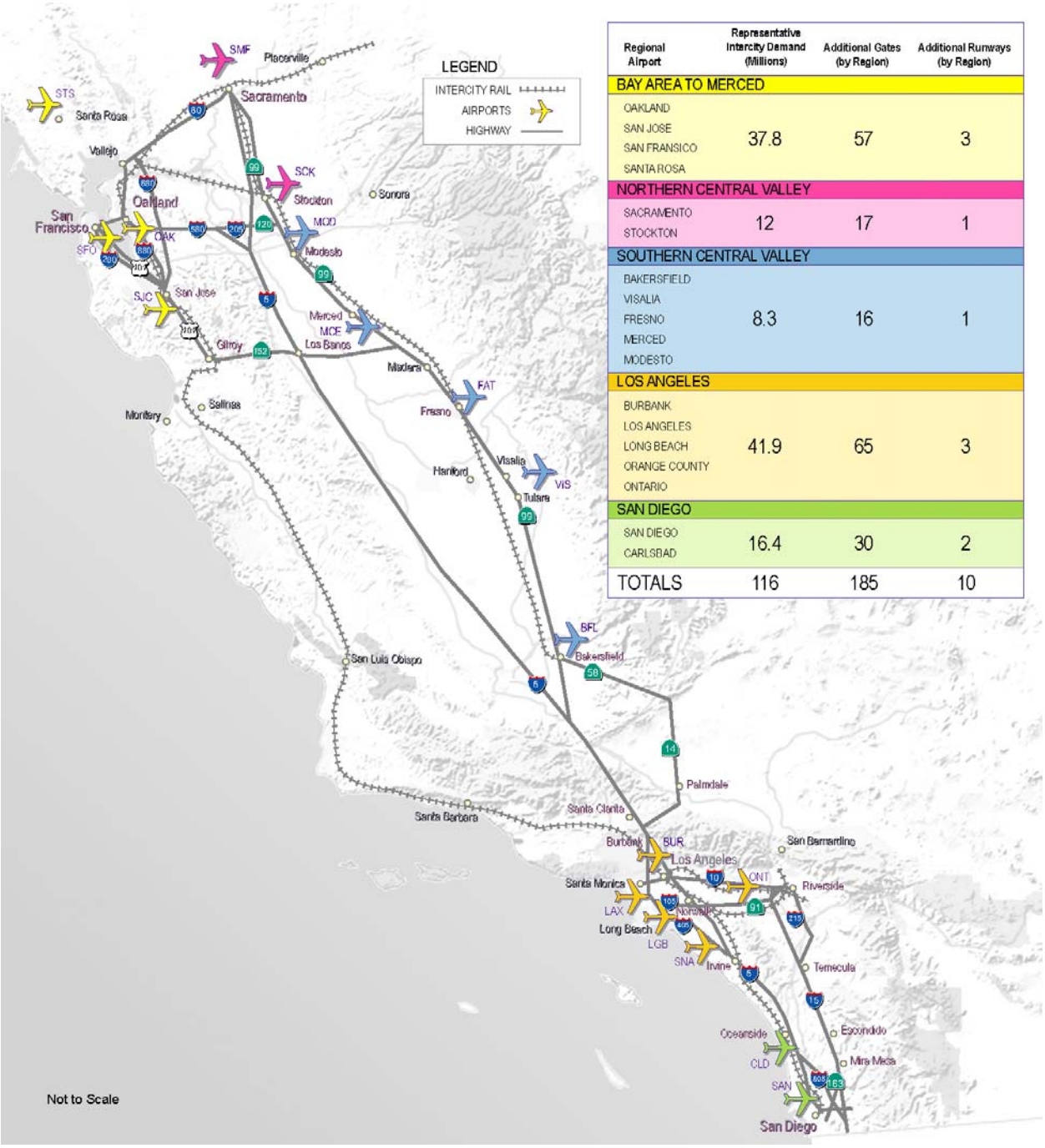
The Authority has defined a statewide high-speed train system capable of speeds in excess of 200 miles per hour (mph) (320 kilometers per hour [km/h]) on dedicated, fully grade-separated tracks, with state-of-the-art safety, signaling, and automated train control systems. State of the art high-speed 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. (Figure 1.2-4)

The High-Speed Train (HST) 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.

Figure 1.1.2-2: Modal Alternative - Highway Component

Figure 1.1.2-3: Modal Alternative - Aviation Component



Regional Airport	Representative Intercity Demand (Millions)	Additional Gates (by Region)	Additional Runways (by Region)
BAY AREA TO MERCED			
OAKLAND SAN JOSE SAN FRANSICO SANTA ROSA	37.8	57	3
NORTHERN CENTRAL VALLEY			
SACRAMENTO STOCKTON	12	17	1
SOUTHERN CENTRAL VALLEY			
BAKERSFIELD VISALIA FRESNO MERCED MODESTO	8.3	16	1
LOS ANGELES			
BURBANK LOS ANGELES LONG BEACH ORANGE COUNTY ONTARIO	41.9	65	3
SAN DIEGO			
SAN DIEGO CARLSBAD	16.4	30	2
TOTALS	116	185	10

Figure 1.1.2-4: High-Speed Alternative - Corridors and Stations for Continued Investigation

2.0 BASELINE/AFFECTED ENVIRONMENT

2.1 STUDY AREA AND AREA OF POTENTIAL EFFECT DEFINED

This report addresses the Bay Area-Merced segment of the statewide HST project. The study area for paleontology in this portion is here defined as the area from which geologic and paleontologic data has been assembled to provide a context for resources along the corridors themselves. The study area is that encompassed by all 15′ USGS topographic quadrangles crossed by the High Speed Train (HST) corridors and alternatives, and the routes of the Modal Alternative. This is broadly bounded between latitudes 36°30′ N and 38°45′ N (about 140 miles), and longitudes 120° W and 122°45′ W (about 150 miles) but includes only 32 of the 88 fifteen-minute quadrangles within this range. More detailed information has been drawn from a still more restricted area; that included in the 7½′ quadrangles crossed by the prospective routes.

The area of potential effect (APE) is more narrowly defined as that area within one mile of the proposed corridors for the HST and the modal alternative, reflecting approximate levels of resolution imposed by the data sources.

2.2 BRIEF GEOLOGIC AND PALEONTOLOGIC BACKGROUND OF REGION

The region spanned by the study area extends from the San Francisco Peninsula northeastward to the Sacramento River and southeastward beyond the San Joaquin River. The diverse terrain along these routes falls within the Coast Ranges and Central Valley geomorphic provinces, and reflects the region's unusually complex geologic history. As the sedimentary rocks which formed during successive geologic intervals often incorporated organic remains, a similarly complex and diverse fossil record exists within the region.

Nearly all of central California west of the Sierras consists of rocks younger than about 160 million years. At about 150 million years ago, a portion of the oceanic tectonic plate became attached to the North American plate, and a new subduction zone appeared farther west, offshore from the present California coastline. This subduction zone, the area marked by a deep trench where the oceanic plate began to dive below the North American continental plate, later became modified along part of its length to form the modern San Andreas Fault zone. As these large-scale events proceeded along the continental margin, successive layers of marine and terrestrial sediments with their included fossils accumulated on the "new" western California fragment of North America. Ongoing tectonic deformation of most of the southwestern portion of the region folded and faulted older rocks causing repeated remodelling of major terrain features which, in turn, governed the accumulation of subsequent sedimentary deposits.

The oldest rocks transected by the HST and Modal Alternative routes were either parts of the former oceanic crust or originated as deposits in the trench between the oceanic and continental plates. Now assigned to the diverse Franciscan Group, these Jurassic to early Tertiary rocks include intrusive and extrusive igneous bodies, with no potential for fossil preservation, as well as marine sedimentary rocks. Franciscan rocks are typically intensely folded and partly metamorphosed in some areas. Having formed in deep-water environments not conducive to life or preservation of remains, even the sedimentary rocks of the Franciscan Group have yielded only extremely rare fossils. Despite the extensive areas of exposure near populated areas, only two specimens representing vertebrate animals have been reported from the Franciscan Group.

While geologic uplift began along the western margin of central California in the late Jurassic Period (about 150 million years ago) and continued through the Cretaceous, much of the modern Coast Range area remained below sea level, but formed a shallow and locally emergent offshore barrier, partially damming a Central Valley sea. In the vicinity of the modern San Francisco Bay, however, this sea apparently remained quite deep during the late Cretaceous, and thick, fine-grained sediments of the Panoche Group here usually preserve few fossils except very small plant fragments. In contrast, exposures along the southernmost portions of the study area reveal slightly younger fossil-bearing sedimentary rocks of the Moreno Formation, documenting a late Cretaceous fauna that included marine turtles and the giant marine reptiles classified as mosasaurs and plesiosaurs. Fragmentary remains of terrestrial dinosaurs have occasionally appeared in the Moreno, apparently washed into the area by submarine currents or floated to sea before decomposition.

Although the Central Valley seaway persisted long after the demise of the dinosaurs and giant marine reptiles at the end of the Cretaceous (about 65 million years ago), within the study area, nearly all geologic records documenting the time of this extinction have either been removed by erosion long ago or covered by younger deposits.

Table 2.2-1: Fossiliferous Geologic Units in Study Area

Period	Epoch	Began (mya)[1]	Major Fossiliferous Units in Study Area (near study area)[1]	# Vertebrate Fossil Localities[2]
QUATERNARY	Holocene ("Recent")	.01	(none)	0
	Pleistocene	1.8	Irvington Gravels, Livermore Gravels, Merced Fm., Santa Clara Fm., Tulare Fm.	69
TERTIARY	Pliocene	5	Tehama Fm., Pinole Tuff.	7
	Miocene	23	San Pablo Fm., Orinda Fm., Siesta Fm., Briones Fm.	132
	Oligocene	33	Markley Sandstone	0
	Eocene	55	Nortonville Shale (Ione Fm., Capay Fm.)	0
	Paleocene	65	(Martinez Fm.)	0
CRETACEOUS		140	Panoche Gp., Quinto Fm., "Chico" Fm., (Moreno Fm.)	5
JURASSIC		195	Franciscan Gp. (fossils v. rare)	2

[1]Abbreviations: Fm. = Formation; Gp. = Group; mya = million years ago.

[2]The numbers of vertebrate fossil localities shown are those found in UCMP records within the study area defined in Section 2.1.

The Tertiary Period, immediately following the Cretaceous, saw repeated incursions and withdrawals of the Central Valley Seaway, leading to preservation of both marine and terrestrial organisms of this age at many sites within the study area.

During the earliest epochs of the Tertiary (Paleocene, Eocene, and Oligocene) sea levels fluctuated but generally shallowed over this period. Though sparsely fossiliferous sedimentary rocks of this age do occur within the study area, only very small exposure areas fall within the APE and these units have not yielded vertebrate fossils.

In contrast, Miocene sedimentary rocks of both marine and non-marine origin appear in many Bay Area locations, and include many more known vertebrate fossil localities in the study area than any other epoch. The Miocene Epoch spans the interval between 23.5 million years ago (mya) and 5.3 mya (Prothero, 1998), but most of the Miocene localities in the study area formed during the latter half of this interval. Combined effects of sea level changes and local tectonic uplift and downwarp caused recurrent changes in the position of the shoreline. In some areas, this produced alternating and intertonguing marine and terrestrial deposits with their included fossils in direct superposition. This superposition allows tie-ins between fossil-based chronological sequences which had been independently constructed for each of the two realms. Meanwhile, sporadic volcanic activity in the Berkeley Hills and just north of the Bay Area produced lava flows and volcanic ash deposits which also became interbedded with the more normal marine and terrestrial sediments. Using radiometric techniques, many of these volcanic deposits can be accurately dated, in terms of millions of years, providing links between an absolute time scale and the relative scales derived from the fossils. (Fossils themselves cannot yield radiometric dates if they are older than about 40,000 years). The unusual coincidence of these factors enhances the scientific value of all Miocene (and many younger) fossils included in rocks of the region.

By the Pliocene epoch, seaways had receded from the Bay area, but volcanic activity continued. Southwest of the Carquinez Straits, exposures of the Pinole Tuff have yielded a diverse mammalian fauna as well as a radiometric date of 5.34 million years (Sarna-Wojcicki, 1976; Evernden et al., 1964), placing the unit virtually at the Mio-Pliocene boundary. To the northeast, a widespread volcanic ash deposit (the Nomlaki Tuff), dated at 3.3 million years, initiated deposition of the Tehama Formation and an even more diverse Pliocene vertebrate faunal record. In the East Bay Hills, a somewhat smaller fossil assemblage has been collected from the Mulholland Formation, but it includes lacustrine vertebrate species and well-preserved fossil leaves, adding important information about the Pliocene environment here.

The Pleistocene epoch is sometimes referred to as the "Ice Age", but central California west of the Sierras remained free of glaciers. Warm periods within the Pleistocene saw climates quite similar to that of today, and geological features suggest that periods of extended drought occurred at times.

The general configuration of Bay Area topography in the early Pleistocene also resembled that of today, although worldwide sea level lowstands during glacial maxima left the area of the modern San Francisco Bay above sea level, apparently on more than one occasion. Other features have since changed as a result of continuing activity of the San Andreas and related faults throughout the Bay Area. Vertebrate fossils incorporated in Pleistocene sediments, especially those near major fault traces, have provided crucial chronologic information about the longer-term history of movements along these faults. Pleistocene deposits, fossiliferous in many areas, underlie all of the larger valleys in the study area, and extend to the lower hillslopes, but they are often blanketed by younger (Holocene) sediments nearer the valley axes. Smaller isolated remnants of once-extensive Pleistocene deposits containing vertebrate fossils also remain in the higher foothills, but may not appear on geologic maps.

Small-scale tectonic tectonic uplift appears to have been responsible for occasional damming of the San Joaquin Valley: Lacustrine deposits such as the Corcoran Formation and parts of the Tulare Formation are important time-marker horizons and locally yield abundant vertebrate fossils, including fish.

Of 237 vertebrate fossil localities identified within the study area, 93 (nearly 40%) are of Pleistocene age.

2.3 DATA SOURCES

Data contributing to this report were assembled from three sources: geologic maps, published geological and paleontological literature, and unpublished museum locality records.

Existing geologic maps provide the information which links the distribution of known fossil localities to the geographic pattern of expectation of additional finds; the relative paleontologic significance of defined subareas within the project area of effects. For the level of detail appropriate to the present study, certain of the 1:250,000– scale series of geologic maps covering the entire state of California are deemed appropriate. Larger-scale maps were also consulted to aid in the integration and visualization of project route information, fossil locality data, and the more detailed geologic data available on the smaller-scale maps. Table 2.3-1 provides a listing of the geologic maps consulted.

Table 2.3-1: Geologic Maps Consulted for This Study

Reference*	Map Scale	Map Name
Chin, J.L., J.R. Morrow, C.R. Ross, and H.E. Clifton, 1993	1:250,000	Geologic Maps of Upper Cenozoic Deposits in Central California
Jennings, C.W., 1977	1:750,000	Geologic Map of California
Jennings, R.W., and R.G. Strand., 1958	1:250,000	Geologic Atlas of California: Santa Cruz
Wagner, D.L., and E.J. Bortugno, 1982.	1:250,000	Geologic Map of the Santa Rosa Quadrangle, California
Wagner, D.L., E.J. Bortugno, and R.D. McJunkin, 1990	1:250,000	Geologic Map of the San Francisco-San Jose Quadrangle, California
Wagner, D.L., C.W. Jennings, T.L. Bedrossian and E.J. Bortugno, 1987	1:250,000	Geologic Map of the Sacramento Quadrangle, California

* See section 6.0 References for complete source information.

There exists no single repository for information about fossil localities throughout California. Exact locations of most fossil localities, especially those yielding vertebrate fossils, are not usually published, even in technical papers describing the fossils or assemblages, in order to protect the localities from unauthorized collecting and consequent loss of scientific information. Geographic data with coverage and accuracy sufficient to assess areal patterns of paleontologic significance must be assembled from unpublished records held by institutions conserving fossil collections and data associated with their geographic sources. The primary source of such data for this report is the University of California Museum of Paleontology in Berkeley (UCMP). Records at this institution extend back to the early 1900s and include data relating to collections formerly housed at the US Geological Survey in Menlo Park. Because if its history, large size of collections, and proximity to most segments of the study area, its records are regarded as most likely to contain any documentation of known fossil sites in the study area. Locations of virtually all recorded vertebrate fossil localities at this institution are documented on large-scale maps (7 ½′ and 15′ topographic quadrangles) in their records collection. The records search revealed nearly 240 vertebrate fossil localities within the defined study area.

Integration of geographic-based data obtained from the geologic maps, fossil locality coordinates, and project corridor locations was accomplished graphically using MicroSoft PowerPoint. Possible locational errors inherent to each of the three data sources and potentially compounded by the data integration methods and varied map projections limit practical resolution to approximately ±1 mile.

2.4 PALEONTOLOGIC SENSITIVITY OF GEOLOGIC UNITS

The mapped geologic units transected by the APE (either the HST corridors or the Modal Alternative corridors) are listed in Table 2.4.1. The table indicates the assessments of low (L), moderate (M), or high (H) sensitivity for each map unit as determined by the criteria presented in section 3.3.2. Assessments are primarily based on the presence or absence of known vertebrate fossil localities within the named units and within the study area. Secondarily, assessments were influenced by the presence of known noteworthy invertebrate localities and by the possible inclusion in the unit of vertebrate localities whose geographic resolution was limited by the available data. In peripheral areas where the locality sample base was limited, some geologic units were assigned moderate sensitivity if the constituent sediments were apparently favorable to fossil preservation. The sensitivity assessments were assigned to all areas underlain by each named unit except where unusual noteworthy occurrences fall close to the APE.

Table 2.4-1: Sensitivity of Geologic Units Within Study Area

Age	Geologic Unit	Sensitivity
Holocene (Recent)	artificial fill, bay fill, younger alluvium	L
	intertidal, channel, levee, basin deposits	L
	alluvial fan, sand deposits	L
	landslide deposits	L
	Patterson alluvium	L
	San Luis Ranch alluvium	L
	Dos Palos alluvium	L
Pleistocene	older alluvium	H
	Los Banos alluvium	H
	Modesto Formation	M
	Riverbank Formation	H
	Irvington Gravels	H
	Tulare Formation	H
Plio-Pleistocene	Plio-Pleistocene continental deposits (undifferentiated)	H
Pliocene	Pinole Tuff	H
Miocene	Contra Costa Group	H
	San Pablo Group	H
	Monterey Formation	L
Oligocene	Markley Sandstone	L
Eocene	Capay Formation	L
	Nortonville Shale	L
Paleocene	Tesla Formation	L
Cretaceous-Tertiary	undifferentiated marine	L
Cretaceous	Great Valley sequence (undifferentiated)	L

Table 2.4-1: Sensitivity of Geologic Units Within Study Area		
	Chico	L
	Berryessa	L
	Pacheco	L/M
	Fransiscan Group undifferentiated	L
	Fransiscan Group ultramafic intrusives, serpentine	L
Jurassic-Cretaceous	"Knoxville Fm."	L

3.0 METHODS FOR PALEONTOLOGIC RESOURCES ANALYSIS

The primary intent of this report is to provide a common basis for comparison of potential impacts among the alternative proposed modes and route segments under consideration. The scale and resolution adopted for the analysis of the paleontologic resources that may be affected are, therefore, gauged to reflect relatively large-scale geographic patterns of significance. These patterns are then compared with and related to the geographic distribution of project corridors. Resolution and accuracy inherent to locality data, geologic maps, and corridor locations limit practical investigation to the levels of resolution of geologic units (as expressed on the 1:250,000 map series) and within one mile of the assumed corridor positions for each of the alternatives.

3.1 DATA COLLECTION

The study area – the area investigated for known paleontologic resources in the vicinity of the proposed corridors – has been defined above as that area encompassed by all 15′ topographic quadrangles crossed by the corridors, with more detailed investigation of the subarea included by similarly situated 7 ½′ quadrangles.

Locality maps corresponding to each of the quadrangles and held in the records at UCMP were examined and the locality numbers of all vertebrate fossil localities on each quadrangle noted. These numbers were then submitted to the Curator of Vertebrate Paleontology at the museum who retrieved electronically stored data associated with each locality number. Retrieved data include locality name, county, latitude, longitude, geologic formation, and storage age. The recorded storage age is the name of the North American Land Mammal Age (NALMA) corresponding to the section within the repository where actual fossils are conserved. The sequential NALMAs are time intervals which collectively comprise the portion of the geologic time scale commonly referenced by vertebrate paleontologists. The Tertiary Period (65 to 1.8 million years ago) is subdivided into six NALMAs.

Known localities for fossil invertebrates and plants were not specifically assembled as these are generally less sensitive, and only "noteworthy" occurrences of these kinds of fossils are regarded as significant under the criteria adopted here. Most of the known invertebrate and plant localities within the study area occur in geologic formations that also yield vertebrate fossils, so would not appreciably alter the distribution of significant resources at the level of resolution employed in this study. The co-occurrence of more than one major category of fossils within a given rock unit, however, enhances the significance of the unit, as each kind of fossil may yield different, or complementary information about the ancient environments represented.

3.2 LEGAL CITATIONS REGARDING THE PROTECTION AND PRESERVATION OF PALEONTOLOGIC RESOURCES

3.2.1 Federal Regulations

Statutes of the United States of America that incorporate provisions for the protection of paleontologic resources include:

Federal Antiquities Act of 1906 (P.L. 59-209, 32 Stat. 225).

> Forbids and establishes criminal sanctions for disturbance of any object of antiquity on Federal land without a permit issued by an authorizing authority.

National Environmental Policy Act of 1969

> (P.L. 91-190, 83 Stat. 852, 42 USC 4321-4327). Mandates policies to "preserve important historic, cultural and natural aspects of our national heritage" (Section 101.b4).

A bill currently before the US Congress would expand and standardize the protection and collecting policy of fossils of all kinds on federal lands, and restrict commercial fossil collecting (S. 546, Senator Akaka 2003). If enacted, this measure may affect management policy relating to paleontological resources in at least some of the project area.

3.2.2 State of California -- Requirements

Fossil remains are a limited, nonrenewable, highly sensitive, scientific resource. In California, these resources are afforded protection against adverse impacts under the authority of the following State of California legislation (California Office of Historic Preservation 1983):

California Environmental Quality Act of 1970

> (13 Public Resources Code, 21000 et seq). Requires public agencies and private interests to identify the potential adverse impacts and/or environmental consequences of their proposed project(s) to any object or site of importance to the scientific annals of California (Division 1, Public Resources Code: 5020.1 [b]).

Guidelines for the Implementation of CEQA (as amended 1 January 1999)

> (CEQA Guidelines Sec. 15064.5). Provides protection for paleontologic resources by requiring that they be identified and mitigated as historical resources under CEQA. The CEQA Guidelines define historical resources broadly to include any object, site, area or place that a lead agency determines to be historically significant. The regulation goes on to provide that generally, a resource shall be considered "historically significant" if it has yielded or may be likely to yield information important in prehistory. Paleontologic resources fall within this broad category, and additionally are included in the CEQA checklist under "Cultural Resources."

Warren-Alquist Act

> (PRC 25000 et seq.). Requires the California Energy Commission to evaluate energy facility siting in unique areas of scientific concern (section 25527).

Public Resources Code, Section 5097.5

(Stats 1965, c. 1136, p. 2792). Prohibits excavation or removal of any "...vertebrate paleontological site...or any other archaeological, paleontological or historical feature, situated on public lands, except with the express permission of the public agency having jurisdiction over such lands." Public lands are defined to include lands owned by or under the jurisdiction of the State of California or any city, county, district, authority or public corporation, or any agency thereof. Defines any unauthorized disturbance or removal of paleontologic, archaeologic and/or historic materials or sites located on public lands as a misdemeanor.

Public Resources Code, Section 30244.

Requires reasonable mitigation of adverse impacts to paleontological resources from development on public land.

3.3 INTERPRETING PALEONTOLOGIC SENSITIVITY

Under both state and federal guidelines for cultural resources (including paleontologic resources), impacts are potentially significant only if the resource being impacted has been determined to be significant. Section V(c) of Appendix G of CEQA makes reference to "unique paleontological resource(s) or site(s) or unique geological feature(s)." No definition of what constitutes a "unique" resource or site is provided. Some interpretation is therefore necessary to provide proper resource protection.

3.3.1 Paleontologic Resources

Fossils and their geologic context together constitute paleontologic resources. Fossils are the remains or traces of organisms of the past, nearly all of which are preserved in sediments or sedimentary rocks. Paleontology, in its broadest sense, is the study of ancient life – biology through time. In practice within North America, this field of science generally excludes studies of prehistoric and modern humans, their cultures, and their technologies, studies falling within the fields of anthropology and archeology. Subdisciplines within paleontology may emphasize anatomy, ecology, or evolution of ancient organisms, or the use of fossils as indicators of geologic time, but all depend ultimately on the discovery and archival preservation of fossils.

The natural preservation of organisms, their parts, or traces as fossils requires the convergence of many independent circumstances: they must be quickly buried after death (or separation of disposable parts, in the case of plants) to avoid destruction by other organisms or weathering; they must be enclosed, sometimes for millions of years, in an environment with a continuously favorable range of chemical conditions and not exposed to extremely high temperatures of pressures; and they must not be re-exposed for long periods to near-surface weathering or erosional forces. On the other hand, their discovery requires that they be naturally exposed at the earth's surface through erosion of the surrounding sediment or rock, or exist within range of human excavations. The net consequences of all these requirements are that accessible fossils are extremely rare compared to the numbers of organisms that once lived on earth, and each fossil is a unique, irreplaceable record of the former existence of a particular organism at a specific place and time.

The past three decades have seen a marked increase in the recognition of paleontological resources as significant and threatened components of our natural environment, offering the only direct evidence of the history and distribution of prehistoric organisms.

3.3.2 Defining Paleontologic Significance and Sensitivity

3.3.2.1 Scientific Importance

The relative importance of a known fossil locality or independently specified area to the science of paleontology depends on a large number of factors whose relative importance may be differently weighted by different investigators, depending on their research interests and subject matter. Research based on fossils may emphasize their use as indicators of geologic time, records of anatomical details of extinct organisms, evidence of the course of evolution, or samples of former ecosystems. However, three general attribute categories contribute to the decision as to whether an area is a "noteworthy" locality: What combined levels of uniqueness, diversity, and quantity of information about past life may be available from the given resource?

Three major categories of fossils are defined by the kinds of organisms they represent: vertebrate animals, invertebrate animals, and plants. Each category requires somewhat different conditions for preservation, though some environments may allow preservation of more than one category of fossils. In general, vertebrate fossils, bones and/or teeth, are much rarer than fossils representing plants or invertebrates, primarily because standing populations of vertebrate animals tend to exist in lower areal densities than the others. Areas known or expected to yield vertebrate fossils are therefore generally assigned greater significance than areas where only invertebrate or plant fossils occur. However, special circumstances associated with certain plant or invertebrate localities may raise their significance to higher levels.

3.3.2.2 BLM criteria

A set of explicit, broadly applicable, and relatively objective criteria for assessment of paleontological significance, compatible with the above considerations, has been developed by the US Bureau of Land Management. These criteria lead to a ranking of geographic areas according to the probability of occurrence and the level of importance of fossils:

"Condition 1: Areas that are known to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils.

Condition 2: Areas with exposures of geologic units or settings that have a high potential to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils. The presence of geologic units from which such fossils have been recovered elsewhere may require further assessment of these same units where they are exposed in the area of consideration.

Condition 3: Areas that are very unlikely to produce vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils based on their surficial geology, igneous or metamorphic rocks, extremely young alluvium, colluvium, aeolian deposits, or the presence of deep soils. Anticipated depth of bedrock will aid in determining if fossiliferous deposits will be potentially uncovered during surface-disturbing activities. " (BLM 1969)

3.3.2.3 Significance vs. Sensitivity

The term "area" is left undefined in the BLM manual. As applied in this report and context, "area" is defined to mean the entire area of exposure or inferred near-surface existence of a given mapped geologic unit.

Areas of geologic units described by Condition 1 above are assigned High sensitivity, those delimited by Condition 2 assigned Moderate sensitivity, and by Condition 3, Low sensitivity. The terms *significant* and *significance* are here reserved to describe the relative importance of *known* localities or level of impacts to the resource. It follows that ground-disturbing activity in areas of High *sensitivity* will more probably

produce *significant* impacts (actual damage to or destruction of *significant* fossils) to paleontologic resources than would result from similar activity in Moderate- or Low-sensitivity areas.

It is also apparent that the extent of impacts expected in linear construction projects depends not only on an overall measure of sensitivity of the segment, but also on the length of the segment.

3.3.2.4 Sensitivity of Corridor Segments

Meaningful comparisons of paleontologic sensitivity and expected impacts among alternative transportation modes and APE corridors requires consideration of the total areas of high- and moderate-sensitivity geologic units affected. These areas are approximately proportional to the cumulative lengths of subsegments in each of the assessment categories, assuming affected corridor widths are comparable throughout.

For some comparative purposes, however, a single overall significance index for each segment, irrespective of length, may be useful. A sensitivity index or weighted average sensitivity applicable to each segment, can be calculated as follows:

Sensitivity index = 100 x (High sensitivity miles + Moderate sensitivity miles/2) / Total miles.

The possible range of this index is zero to 100, a value which would obtain if the entire segment fell on areas of high sensitivity. A sensitivity index of 15 or below is regarded as Low, and above 30 is considered High, with intermediate values assigned Moderate sensitivity. Actual values for HST and modal alternative segments ranged between 0 and 56 (See Table 4.0-1).

3.4 Determinations of Paleontologic Sensitivity of Rock Units

Fossils of all kinds are very unevenly and non-randomly distributed within the rocks comprising the earth's crust. Areas offering higher or lower probability of fossil access and discovery are defined by the geographic distribution of surface exposures of different rock units which have been variously produced, uplifted, distorted, altered, and eroded during the course of geologic history. Delineation of these patterns within a particular geographic area depends on the integration of information from 1) the distribution of previously discovered fossil sites, 2) geologic mapping, and 3) interpretation of local environments which prevailed at and after the time each rock unit originated and which may have been favorable or unfavorable to fossil preservation. For the purpose of this program-level analysis, the first two information categories have been given the greatest weight.

The distribution of previously discovered fossil sites reflects in a general way the underlying concentration of fossils within the area of investigation (the information of present interest), but is equally subject to historical accidents of discovery.

Throughout much of central California, the rocks and older sediment deposits are obscured by a veneer of soil, vegetation, and in populated areas, paving and other man-made structures, precluding discovery of any fossils that may exist just below the surface. While limited natural exposures exist along some creek banks and beach cliffs, human activities that have locally removed this veneer, even to a shallow depth, appear to be responsible for the discovery of most vertebrate fossil localities in the San Francisco Bay area and nearby regions. The most conspicuous features of the distribution of vertebrate fossil localities within the study area are the concentrations of known localities along certain segments of major roadways and railroads in hilly areas: roadcuts provide ideal areas to look for fossils, and were particularly productive before the more recent trend favoring erosion control plantings.

On a broader scale, a marked trend toward lower areal concentrations of fossil localities with distance from Berkeley, the site of the institution that provided the data used in this study, also becomes apparent. More than the underlying distribution of fossils, this trend undoubtedly reflects the history of areal concentration of vertebrate paleontologists, the decreasing concentration of ground-disturbing

human activities with distance away from areas of high population density, and the probability of reporting of finds to the recording institutions by laypersons.

Despite the obvious areal sampling biases associated with the distribution of known fossil localities, previous finds constitute the only concrete evidence that fossils exist within specified geologic units. This information can be generalized over areas not yet adequately exposed for fossil exploration through the use of geologic maps which depict the areal distribution of geologic formations just below the soil, vegetation, and man-made cover. Geologic maps depict the distribution of different rock types throughout their coverage, and provide the basic link between the geographic positions of known fossil localities and predicted likelihood of future finds in other areas.

Most components of the earth's crust and surficial deposits originated in response to one of three categories of processes, leading to the basic classification of rocks as igneous, sedimentary, or metamorphic. With rare exceptions, the high-temperature conditions associated with the formation of igneous rocks (including e.g. granites and basalts) precludes their preservation of organic remains. Metamorphic rocks (e.g. slate, schist, gneiss) may form by alteration of pre-existing sedimentary rocks, but the associated pressures and temperatures required for metamorphism tend to destroy any fossils that may have existed unless the conditions remained below crucial limits.

Sediments, whether unconsolidated or hardened by later geologic processes to form sedimentary rock, include nearly all potential sources of fossils, although not all sediments include fossils. The initial presence and continued preservation of organic remains depend on the physical and biological circumstances at the time and place of deposition, and on subsequent physical and chemical processes affecting the sediments after accumulation, some of which may still destroy the contained organic remains.

Even without the addition of locality data, identification of paleontologically sensitive areas can be initially approximated by delineation of all subareas shown on a geologic map to be underlain by sediments, sedimentary rocks, or very low-grade metamorphic rocks. Sediments deposited in post-Pleistocene ("Recent" or Holocene) time, less than about 9,000 or 10,000 years ago, are less likely to contain fossils of paleontologic interest, and can generally be excluded as non-sensitive, though they may provide only a thin cover over older significant units. Rocks not otherwise excluded may have originated in a broad spectrum of depositional environments, which vary greatly in their potential for fossil preservation. To the extent that known features of a sedimentary rock body can be interpreted in terms of its depositional environment, expectation that it will yield fossils can often be at least qualitatively estimated.

The basic mapped unit of sedimentary rocks is the formation, and is usually assigned a formal name (e.g. Tulare Formation, Pinole Tuff). Formations with related origins may be collectively named as a group (e.g. San Pablo Group, including Neroly Sandstone, Briones Sandstone, and Cierbo Sandstone, all marine Miocene units). These mapped units define the practical resolution level for this report, although local fossil abundance varies considerably within named units. Records of fossil finds, published or unpublished, usually include the name of the geologic formation in which it was found, leading to an initial estimate of the abundance and types of fossils expected in that unit. For purposes of this report, records of fossil localities anywhere within the study area were considered in assessment of the paleontologic sensitivity of each geologic unit mapped within the project boundaries.

3.4.1 Invertebrate Fossils

Marine invertebrate animals with hard skeletal parts (usually shells) tend to be preserved as fossils in relatively large numbers, both because, in life, they are typically numerous and their life environments frequently coincide with environments having high rates of sediment deposition. Invertebrate fossils and sediments or sedimentary rock units in which they are likely to be found are therefore considered to be of relatively low sensitivity.

3.4.2 Vertebrate Fossils

Vertebrate fossils—fossils representing animals with backbones, including mammals, birds, reptiles, and fish— are much less abundantly represented in the fossil record. Furthermore, many specimens from restricted localities may be required for adequate description or identification of each species represented. Because of these factors, vertebrate fossil localities and sediments likely to yield vertebrate fossils are generally understood to be much more sensitive than localities or geologic units likely to contain only invertebrate fossils

3.4.3 Definitions

Literature research and institutional records searches have resulted in the designation of areas within the APE as having high, moderate, or low paleontologic sensitivity. Provisions for mitigation of adverse impacts to significant nonrenewable paleontologic resources present within the boundaries of the APE were based upon these determinations of potential paleontologic sensitivity. The terms "high sensitivity", "moderate sensitivity", and "low sensitivity" are described in Section 3.3.2.

4.0 PALEONTOLOGIC IMPACTS

Potential impacts to paleontologic resources are expected to occur primarily during the construction excavation phase of the project. Additional impacts may result from reduction of visual and physical access to potentially fossiliferous geologic units in areas of permanent installations, landscaping, erosion control measures, and paving. Normal operations are not expected to impact these resources unless maintenance or improvements involve extensive excavation in areas of previously undisturbed sensitive geologic units. Secondary and cumulative impacts due to induced growth may result from the project.

Table 4-1: Detailed Analysis/Comparison − Impacts to Paleontologic Resources, Bay Area to Merced Region

Significance	High (miles)	Mod. (miles)	Low (miles)	Sensitivity Index*	Impact Level
NO-PROJECT ALTERNATIVE					
No-Project	N/A	N/A	N/A	N/A	N/A
MODAL ALTERNATIVE					
Highways					
Merced to San Jose	26	16	87	**27**	MODERATE
San Jose to San Francisco	3	0	41	**8**	LOW
San Jose to Oakland	4	0	36	**11**	LOW
I-580 to I-5 (via I-238)	25	8	19	**56**	HIGH
San Francisco to Sacramento	14	3	62	**20**	MODERATE
HST CORRIDORS AND STATION OPTIONS					
Alignments					
Merced to San Jose					
Corridor 1A via Pacheco Pass and Gilroy					
West End 1A	0	0	22	**0**	NONE
Gilroy Option	2	0	8	**20**	MODERATE
Gilroy Bypass Option	2	0	7	**22**	MODERATE
East End 1A	0	13	45	**21**	MODERATE
Corridor 1B via Atwater and Diablo Range					
Northern Tunnel Option	1	0	29	**2**	LOW
Tunnel Under Park Option	0	1	20	**2**	LOW
Minimize Tunnel Option	0	0	6	**0**	NONE
East End 1B	0	17	1	**47**	HIGH
Caltrain	0	0	17	**0**	NONE

Table 4-1: Detailed Analysis/Comparison − Impacts to Paleontologic Resources, Bay Area to Merced Region

Significance	High (miles)	Mod. (miles)	Low (miles)	Sensitivity Index*	Impact Level
San Jose to San Francisco	0	0	45	**0**	NONE
San Jose to Oakland					
I-880 Option (San Jose to Union City)	7	15	1	**63**	HIGH
Mulford Line Option	1	0	6	**14**	LOW
I-880 Union City to Oakland	7	0	14	**33**	HIGH

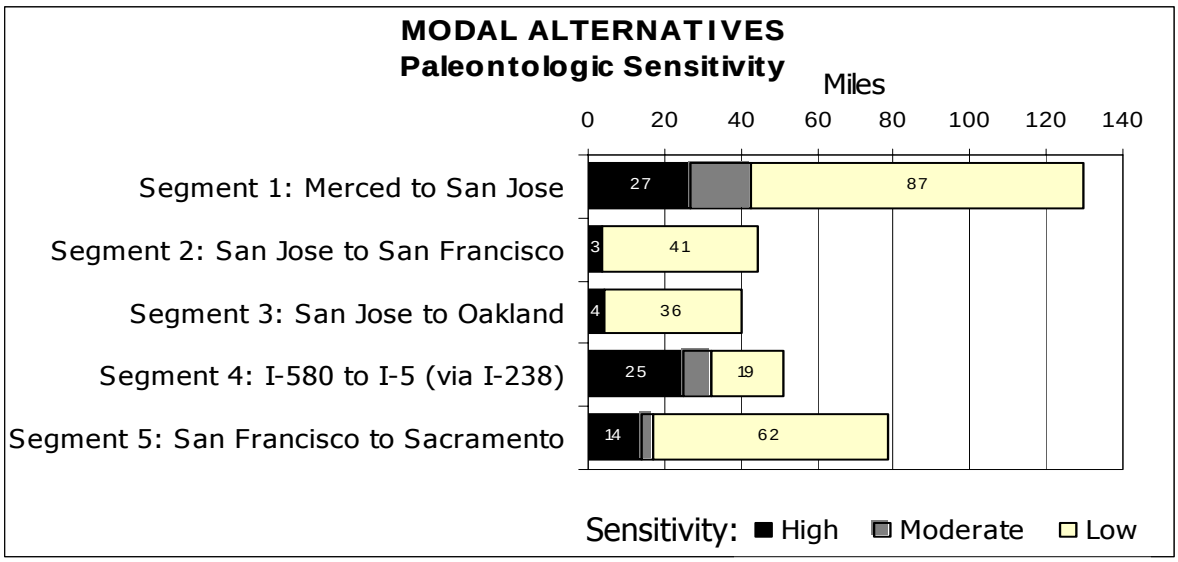
* Sensitivity index = 100 x (High sensitivity miles + Moderate sensitivity miles/2) / Total miles

4.1 NO-PROJECT ALTERNATIVE

The No-Project Alternative includes planned improvements to existing transportation systems which would be required to accommodate the expected transportation needs in the absence of the HST, projected to the year 2020. Such improvement projects in the Bay Area to Merced region would be subject to independent environmental analyses and mitigation under existing LORS, and are not considered in this report.

4.2 MODAL ALTERNATIVE

Figure 4.2-1: Cumulative Lengths of Segments of Assessed Paleontologic Sensitivity Along Modal Alternative Corridors



4.2.1 Highways

The distribution of known vertebrate fossil localities within the study area exhibits marked concentrations in the proximity of existing highway roadcuts. This is undoubtedly due, in large part, to the fact that roadcuts often provide the largest locally available exposures of the fossil-bearing rocks unobscured by soil and vegetation. If the addition of freeway lanes required under the modal alternative involves new excavations to widen existing roadcuts, significant impacts can be expected. Subsequent analyses will be required to determine the extent of impacts due to freeway expansion.

Segment 1: Merced to San Jose

A. SR 152: SR99 to I-5

Quaternary deposits underlie this segment throughout its 44-mile length, but not all are sensitive. Units of high sensitivity underlie both the eastern and western ends, and the moderately sensitive Modesto Formation underlies about 16 miles near the eastern end. Low-sensitivity Holocene valley deposits of unknown depths cover sensitive Pleistocene units in the intervening area.

B. SR 152: I-5 to US101

The eastern end of this 48-mile segment crosses the Pleistocene Los Banos Alluvium (high sensitivity) and passes near at least one known vertebrate fossil locality. Sensitive Pleistocene deposits also occur in two shorter segments nearer the west end. The remainder is underlain by non-sensitive Franciscan rocks and younger alluvium.

C. US 101: SR 152 to Gilroy

This one-mile segment crosses only non-sensitive late Quaternary alluvium.

D. US 101: Gilroy to I-880

High-sensitivity Pleistocene deposits underlie about 1/3 of this 33-mile segment. The remainder crosses younger alluvium and much older serpentine, both of which are non-sensitive.

Segment 2: San Jose to San Francisco

A. US 101: I-880 to Redwood City

This 22-mile segment crosses only non-sensitive late Quaternary alluvium, intertidal deposits, and artificial fill.

B. US 101: Redwood City to SFO

About ¼ of this 14-mile segment crosses high-sensitivity Pleistocene alluvial deposits. Artificial fill covers the surface in the remaining portion.

C. US 101: SFO to San Francisco

This 14-mile portion of the APE crosses artificial fill, Franciscan metasedimentary and ultramafic rocks, and minor late Quaternary alluvium, none of which are sensitive.

Segment 3: San Jose to Oakland

A. I-880: US 101 to Fremont

Less than four miles of this 21-mile segment cross sensitive Pleistocene sediments. Younger Quaternary and intertidal deposits account for the remainder, and are non-sensitive.

B. I-880: Fremont to I-238

Only non-sensitive Holocene deposits underlie this 12-mile segment.

C. I-880: I-238 to I-80

Less than one mile of sensitive Pleistocene alluvium underlies this 14-mile segment.

Segment 4: I-580 to I-5 (via I-238)

A. I-580: I-880 to I-5 (via I-238)

This is the most sensitive portion of the modal alternative corridors, with an overall sensitivity index of 56. Five geologic units of high sensitivity fall along this 49-mile route: the Miocene San Pablo and Contra Costa Groups in the East Bay Hills and Livermore Valley, early Pleistocene Tulare Formation east of Altamont Pass, and Pleistocene alluvium along the lower east flank of the Diablo Range. About 10 miles of the Cretaceous Panoche Formation is ranked at moderate sensitivity: Noteworthy invertebrate marine fossils occur here which apparently document local faunal changes across the Cretaceous/Tertiary boundary. The remaining 15 miles cross non-sensitive Holocene alluvial and fan deposits and generally non-fossiliferous marine Miocene Monterey Formation. About 15 known vertebrate fossil localities occur within two miles of this portion of the APE.

Segment 5: San Francisco to Sacramento

A. I-80: SF to I-880

Nearly all of this segment coincides with the Bay Bridge. The eastern bridge approach crosses non-sensitive Holocene bay mud, while the west end and the Yerba Buena Island segment fall within non-sensitive Franciscan Group rocks. Vertebrate fossils have been recovered from sediments below the bay bottom during earlier bridge construction.

B. I-80: I-880 to I-5

This 77-mile segment passes through roadcuts in the high-sensitivity Contra Costa and San Pablo Groups and within two miles of 13 known vertebrate fossil localities in Contra Costa County between the Hayward Fault, near Richmond, and the Carquinez Straits. Four localities are also recorded within two miles of the APE southwest of the fault in areas mapped as late Quaternary deposits, but these are from excavations into older underlying sediments. Northeast of the Straits, the route crosses short segments of sensitive San Pablo Group and Tehama Formation which includes one roadcut locality. About seven miles of sensitive older Quaternary alluvium also fall along this corridor.

4.3 HIGH SPEED TRAIN ALTERNATIVE

4.3.1 Alignments

Potential net paleontologic impacts for each of the alternative HST corridor segments can be expected to be directly related to the total cumulative length of high- and moderate-sensitivity geologic units crossed by each segment. These cumulative distances are graphically presented in Figure 4.3-1. Data contributing to this figure is given in Table 4-1.

Actual impacts will also be related closely to the placement of major excavations (cuts, tunnels, borrow pits, foundations) relative to the geographic positions of sensitive geologic units and known fossil localities. These factors must be addressed during subsequent analyses.

Segment 1: Merced to San Jose

Corridor 1A via Pacheco Pass and Gilroy
A. West End 1A

This 22-mile segment extends through areas mapped as Franciscan ultramafic rocks and Quaternary terrace and alluvium, all ranking low sensitivity.

B. Gilroy Option

A two-mile segment of this optional corridor passes through Plio-Pleistocene alluvial deposits similar to those which have yielded vertebrate fossils elsewhere and is assigned high sensitivity. The remaining portion falls on non-sensitive lower and upper Cretaceous marine rocks.

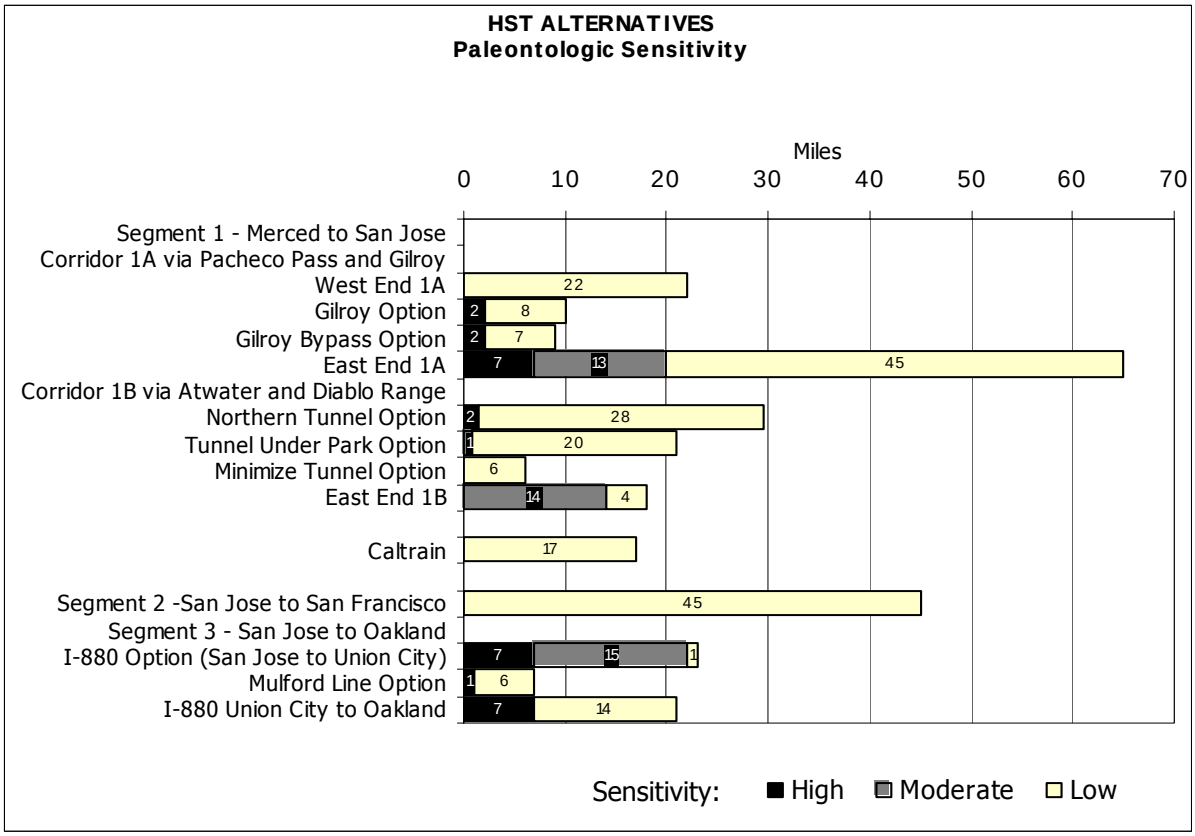
C. Gilroy Bypass Option

As for the Gilroy Option, a two-mile segment of this alternative route passes through Plio-Pleistocene alluvial deposits similar to those which have yielded vertebrate fossils elsewhere and is assigned high sensitivity. The remaining portion falls on non-sensitive lower and upper Cretaceous marine rocks.

D. East End 1A

About seven miles of this corridor, in the vicinity of San Luis Reservoir, crosses the Los Banos Alluvium, a sensitive unit which includes at least one vertebrate fossil locality outside of the APE. The Pacheco and Modesto Formations, totalling 13 miles of the APE in this segment, warrant moderate sensitivity ranking. The remaining 45 miles falls within areas mapped as Franciscan Group, San Luis Ranch Alluvium, Dos Palos Alluvium, and artificial fill, none of which are sensitive.

Figure 4.3-1: Cumulative Lengths of Segments of Assessed Paleontologic Sensitivity Along HST Corridor Alternatives



Corridor 1B via Atwaterand Diablo Range

E. Northern Tunnel Option

Though about 30 miles long, the Northern Tunnel Option crosses only about 1 mile of Los Banos Alluvium and ½ mile of Miocene San Pablo Group, both of high sensitivity. The remainder of the route is underlain by Franciscan ultramafic rocks, Jurassic, Cretaceous, and Paleocene deep marine deposits, coarse Tertiary fan deposits, and Quaternary alluvium, fan, and terrace deposits, none of which appear to warrant more than low sensitivity ranking.

F. Tunnel Under Park Option

Less than one mile of the Tunnel Under Park Option crosses high-sensitivity San Pablo Group sandstone. The remaining 20 miles is underlain by non-sensitive Franciscan rocks, Jurassic and Cretaceous marine Knoxville and Berryessa Formation, and Quaternary alluvial and terrace deposits.

G. Minimize Tunnel Option

This option crosses only low-sensitivity Franciscan rocks.

H. East End 1B

Most of this segment of the Atwater and Diablo Range Corridor is underlain by the Modesto Formation, assessed to have moderate sensitivity. The remaining four miles crosses Holocene and Luis Ranch Alluvium and Dos Palos Alluvium, both of low sensitivity.

Caltrain

I. Caltrain

The segment sharing the Caltrain right-of–way extends across non-sensitive Quaternary alluvium.

Segment 2: San Jose to San Francisco

J. San Jose to San Francisco

Only non-sensitive Franciscan sandstone, Quaternary alluvium, and artificial bay fill underlies this segment.

Segment 3: San Jose to Oakland

K. I-880 Option (San Jose to Union City)

About 1/3 of this segment apparently crosses high-sensitivity older Pleistocene alluvial deposits east of the Hayward Fault. The exact alignment could greatly influence impacts along this reach. Elsewhere, the alignment crosses a 15-mile reach of moderate-sensitivity Pleistocene alluvium and a short segment of Holocene intertidal deposits of low sensitivity

L. Mulford Line Option

This option crosses a shorter (one-mile) stretch of high-sensitivity early Pleistocene alluvium, with the remainder on younger non-sensitive Quaternary alluvium.

M. I-880 Union City to Oakland

About 1/3 of this segment crosses high-sensitivity older Pleistocene alluvial deposits. The remaining 14 miles are underlain by low-sensitivity Quaternary alluvium.

4.3.2 Stations

Specific impacts to paleontologic resources associated with construction of the stations requires additional information not currently available concerning exact locations and subsurface geology.

Many of the station locations are in valley areas with relatively young surficial sediments, but excavations for foundations, pilings, stanchion footings, etc. can be expected to extend to older and, in most cases, more sensitive geologic units.

Additional paleontologic resources assessment would take place at the project level after the station designs are more fully defined.

5.0 REFERENCES

BLM (Bureau of Land Management). 1969. General Procedural Guidance for Paleontological Resource Management. In *Paleontological Resource Management*. BLM Handbook 8270.

Chin, J.L., J.R. Morrow, C.R. Ross, H.E. Clifton, 1993. Geologic maps of upper Cenozoic deposits in central California. US Geological Survey Miscellaneous Investigations Map I-1943. 1:250,000.

Evernden, J. F., D.E. Savage, G.H. Curtis, and G.T James,1964. Potassium-argon dates and the Cenozoic mammalian chronology of North America. American Journal of Science, v. 262, pp. 145-198.

Jennings, C.W., R.G. Strand, and T.H. Rogers. 1977. Geologic Map of California. California Division of Mines and Geology, California Geologic Data Map Series. 1:750,000.

Jennings, R.W., and R.G. Strand, 1958. Geologic Atlas of California: Santa Cruz. Department of Conservation, Division of Mines and Geology, GAM 020. Scale 1:250,000.

Parsons and Geotechnical Consultants, Inc., 2003. California High-Speed Train Program EIR/EIS: Bay Area-Merced Segment Geology and Soils Technical Evaluation. Prepared for: California High-Speed Rail Authority, April 2003.

Prothero, D.R., 1998. The chronological, climatic, and paleogeographic background to North American mammalian evolution. In *Evolution of Tertiary Mammals of North America*, eds. C.M. Janis, K.M. Scott, and L.J. Jacobs, pp. 9-37. Cambridge University Press.

San Bernardino County Museum, 2003. [Draft] California High-Speed Train Program EIR/EIS: Bakersfield-to-Los Angeles Paleontologic Resources Technical Evaluation. Prepared for Applied Earthworks, Inc. and P&D Consultants, Inc., April 23, 2003.

Sarna-Wojcicki, A.M., 1976. Correlation of late Cenozoic tuffs in the central Coast Ranges of California by means of trace- and minor-element chemistry. U.S Geological Survey Professional Paper 972. 30 pp.

Wagner, D.L., and E.J. Bortugno, 1982. Geologic Map of the Santa Rosa Quadrangle, California. Department of Conservation, Division of Mines and Geology, Map No. 2A. Scale 1:250,000.

Wagner, D.L., E.J. Bortugno, and R.D. McJunkin, 1990. Geologic Map of the San Francisco-San Jose Quadrangle, California. Department of Conservation, Division of Mines and Geology, Map No. 5A. Scale 1:250,000.

Wagner, D.L., C.W. Jennings, T.L. Bedrossian and E.J. Bortugno, 1987. Geologic Map of the Sacramento Quadrangle, California. Department of Conservation, Division of Mines and Geology, Map No. 1A. Scale 1:250,000.

6.0 PREPARERS

C. Bruce Hanson **Paleontologic Resource Specialist**	**Master of Science (Paleontology)** (1969), South Dakota School of Mines and Technology, Rapid City, South Dakota. **Bachelor of Science (Geology)** (1967), University of Minnesota, Minneapolis, Minnesota. 30 years of experience as a professional vertebrate paleontologist. • Project Supervision, data collation, and report writing.
Jean B. Durham **Professor of Geology (Ret.)**	**Master of Arts (Paleontology)** (1967), University of California, Berkeley, California. **Bachelor of Arts** (1964), University of California, Berkeley, California. 37 years of experience as a professional paleontologist and geologist. • Data collation