SUBSECTION 8.16

Paleontological Resources

8.16 Paleontological Resources

8.16.1 Introduction

Paleontological resources (fossils—the remains of prehistoric plants and animals) are important scientific and educational resources because of their use in (1) documenting the presence and evolutionary history of particular groups of now extinct organisms, (2) reconstructing the environments in which these organisms lived, and (3) in determining the relative ages of the strata in which they occur and the geologic events that resulted in the deposition of the sediments that formed these strata. This subsection summarizes the potential environmental impacts on paleontological resources that may result from construction of the San Francisco Electric Reliability Project (SFERP).

8.16.2 Laws, Ordinances, Regulations, and Standards

Paleontological resources are non-renewable scientific and educational resources and are protected by several federal and state statutes (California Office of Historic Preservation, 1983; see also Marshall, 1976, West, 1991, Fisk and Spencer, 1994, and Gastaldo, 1999), most notably by the 1906 Federal Antiquities Act and other subsequent federal legislation and policies and by the State of California's environmental regulations (California Environmental Quality Act [CEQA], Section 15064.5). Professional standards for the assessment and mitigation of adverse impacts on paleontological resources have been established by the Society of Vertebrate Paleontology (1995, 1996). Design and construction of the proposed SFERP will be conducted in accordance with all laws, ordinances, regulations, and standards (LORS) applicable to paleontological resources. Federal, State, County, and City LORS applicable to paleontological resources are summarized in Table 8.16-1 and discussed briefly below, along with Society of Vertebrate Paleontology (SVP) professional standards.

TABLE 8.16-1
LORS Applicable to Paleontological Resources

LORS	Applicability	Reference	Project Conformity
Antiquities Act of 1906	Protects paleontological resources on federal lands	Section 8.16.2.1	Yes
Public Resources Code, Sections 5097.5/5097.9	Protects paleontological resources on publicly owned lands in the State of California	Section 8.16.2.2	Yes
CEQA, Appendix G	Requires that impacts to paleontological resources be assessed and mitigated on all discretionary projects, public and private	Section 8.16.2.2	Yes

8.16.2.1 Federal LORS

Federal protection for significant paleontological resources would only apply to the SFERP if any construction or other related project impacts occur on federally owned or federally managed lands. Federal legislative protection for paleontological resources stems primarily from the Antiquities Act of 1906 (PL 59-209; 16 United States Code 431 et seq.; 34 Stat. 225), which calls for protection of historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest on federal lands. Since the SFERP site is not on federally owned or managed land, federal LORS do not apply to this project.

8.16.2.2 State LORS

The California Energy Commission (CEC) environmental review process under the Warren-Alquist Act is considered functionally equivalent to that of the California Environmental Quality Act (CEQA; Public Resources Code Sections 21000 et seq.). CEQA requires that public agencies and private interests identify the potential environmental consequences of their proposed projects on any object or site of significance to the scientific annals of California (Division I, California Public Resources Code Section 5020.1 [b]). Guidelines for the Implementation of CEQA (Public Resources Code Sections 15000 et seq.) define procedures, types of activities, persons, and public agencies required to comply with CEQA. Appendix G in Section 15023 provides an Environmental Checklist of questions that a lead agency should address if relevant to a project's environmental impacts. One of the questions to be answered in the Environmental Checklist (Section 15023, Appendix G, Section V, part c) is the following: "Would the project directly or indirectly destroy a unique paleontological resource or site…?"

Although CEQA does not define what is "a unique paleontological resource or site," Section 21083.2 defines "unique archaeological resources" as "…any archaeological artifact, object, or site about which it can be clearly demonstrated that, without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

1. [It] contains information needed to answer important scientific research questions and that there is a demonstrable public interest in that information.
2. It has a special and particular quality such as being the oldest of its type or the best available example of its type.
3. [It] is directly associated with a scientifically recognized important prehistoric or historic event."

With only slight modification, this definition of "unique archaeological resources" is equally applicable to recognizing "a unique paleontological resource or site." Additional guidance is provided in CEQA Section 15064.5 (a)(3)(D), which indicates "generally, a resource shall be considered historically significant if it has yielded, or may be likely to yield, information important in prehistory or history."

Section XVII, part a, of the CEQA Environmental Checklist asks a second question equally applicable to paleontological resources: "Does the project have the potential to eliminate important examples of the major periods of California history or pre-history?" Fossils are important examples of the major periods of California prehistory. To be in compliance with CEQA, environmental impact assessments, statements, and reports must answer both these questions in the Environmental Checklist. If the answer to either question is *yes* or *possibly*, a mitigation and monitoring plan must be designed and implemented to protect significant paleontological resources.

The CEQA lead agency having jurisdiction over a project is responsible to ensure that paleontological resources are protected in compliance with CEQA and other applicable statutes. The lead agency with the responsibility to ensure that fossils are protected during construction of the proposed SFERP is the CEC. California Public Resources Code Section 21081.6, entitled Mitigation Monitoring Compliance and Reporting, requires that the CEQA lead agency demonstrate project compliance with mitigation measures developed during the environmental impact review process.

Other state requirements for paleontological resource management are in California Public Resources Code Chapter 1.7, Section 5097.5 (Stats. 1965, c. 1136, p. 2792), entitled Archaeological, Paleontological, and Historical Sites. This statute defines any unauthorized disturbance or removal of a fossil site or fossil remains on public land as a misdemeanor and specifies that state agencies may undertake surveys, excavations, or other operations as necessary on state lands to preserve or record paleontological resources. This statute would apply to the proposed SFERP since construction or other related project impacts would occur on publicly owned or managed lands.

8.16.2.3 County and City LORS

California Planning and Zoning Law requires each county and city jurisdiction to adopt a comprehensive, long-term general plan for its development. The general plan is a policy document designed to give long range guidance to those making decisions affecting the future character of the planning area. It represents the official statement of the community's physical development as well as its environmental goals. The general plan also acts to clarify and articulate the relationship and intentions of local government to the rights and expectations of the general public, property owners, and prospective investors. Through its general plan, the local jurisdiction can inform these groups of its goals, policies, and development standards; thereby communicating what must be done to meet the objectives of the general plan.

The current general plan for City and County of San Francisco (CCSF) (2000) contains no specific requirements, regulations, ordinances, conditions, standards, goals, or objectives designed to mitigate the negative impacts of development on paleontological resources. However, the general plan does contain the following general statement in Policy 1.4: "Assure that all new development meets strict environmental quality standards…." In explaining this policy, the general plan states: "In reviewing all proposed development for probable environmental impact, careful attention should be paid to upholding high environmental quality standards." In addition, the Environmental Protection section of the Central Waterfront chapter of the general plan states in Objective 7: "Assure that the land resources in San Francisco are used in ways that both respect and preserve the natural values of the land and serve the best interests of all the City's citizens." San Francisco general plan Policy 7.1 states, "Features of a…geological…nature are also important criteria [in determining the value of land] as open space. These natural values of land should be respected." The Preservation Element of the San Francisco general plan presents a comprehensive set of policies for the preservation of San Francisco's cultural resources and defines cultural resources to "include…objects…which are historically or archaeologically significant, or significant in our…scientific…or cultural annals." This section of the General Plan establishes as a goal: "Protect Cultural Resources. Preserve significant cultural resources." Under CEQA, paleontological resources are included as significant cultural resources.

8.16.2.4 Professional Standards

To assist in the compliance with applicable laws, the SVP, an international scientific organization of professional vertebrate paleontologists, has established standard guidelines (SVP, 1995; 1996) that outline acceptable professional practices in the conduct of paleontological resource assessments and surveys; monitoring and mitigation; data and fossil recovery; sampling procedures; and specimen preparation, identification, analysis, and museum curation. The SVP's standard guidelines were approved by a consensus of professional paleontologists and are a commonly used standard against which paleontological monitoring and mitigation programs are evaluated. Most professional paleontologists in the United States adhere closely to the SVP's assessment, mitigation, and monitoring requirements as specifically spelled out in these standard guidelines. Many regulatory agencies, including the CEC, have either formally or informally adopted the SVP's standard guidelines for the mitigation of construction-related adverse impacts on paleontological resources, including federal (FERC, USFS, BLM, NPS, etc.), state (CEC, CPUC, Caltrans, etc.), and many county and city agencies. Briefly, SVP guidelines require that each project have literature and museum archival reviews, a field survey, and, if there is a high potential for disturbing significant fossils during project construction, a mitigation plan that includes monitoring by a qualified paleontologist to salvage fossils encountered, identification of salvaged fossils, determination of their significance, and placement of curated fossil specimens into a permanent public museum collection (such as the designated California State repository for fossils, the University of California Museum of Paleontology at Berkeley).

8.16.3 Setting

8.16.3.1 Geographic Location

The site proposed for construction of the SFERP is located on a parcel within the existing Potrero Power Plant (Potrero PP), in the City of San Francisco. San Francisco Bay (Bay), which forms the eastern boundary of the City, also forms the eastern boundary of the Potrero PP site. The Bay fills a north-northwest-trending structural depression in the central Coast Ranges and lies between the San Andreas Fault to the southwest and the Hayward Fault to the northeast. The center of the SFERP site is located at approximately 37°45′24″ N. latitude and 122°23′00″ W. longitude in T. 2 S., R. 5 W. This township has never been surveyed into sections because it was part of an original Spanish land grant. The SFERP site is adjoined on the south by 23rd Street, on the north by Humboldt Street, and on the west by the PG&E Portrero Substation located on Illinois Street.

To provide a source of cooling water for the SFERP, the San Francisco combined sewer system will be intercepted at a collection station near the east end of Marin Street where it dead ends at the Caltrain tracks. At this location a diversion/control structure and pump station will be built and effluent will be conveyed via an underground pipeline to a water treatment facility to be located on the southern boundary of the SFERP site, adjacent to 23rd Street. A portion of the approximately one-mile-long effluent pipeline will be buried within existing streets and a portion will be located within an existing underground collection box.

All the proposed SFERP facilities will be located within either the southernmost portion of the U. S. Geological Survey (USGS) San Francisco North or the northernmost portion of the San Francisco South 7.5′ (1:24,000-scale) standard topographic maps.

The City of San Francisco is located in the northern portion of the San Francisco Peninsula, which consists of north-northwest oriented ridges comprising the western portion of the Coast Ranges Physiographic Province (Fenneman, 1931; Jahns, 1954). The Coast Ranges Physiographic Province is located between the Great Valley Physiographic Province on the east and the Pacific Ocean on the west.

The general project area is located along the gently sloping western shore of the Bay. The site proposed for SFERP is located between the low rolling hills of the San Francisco Peninsula to the west and, on the east, by the Bay itself. Although the modern Bay shoreline is immediately adjacent to the Potrero PP site on the east, in 1857 tidal marshlands actually extended into the southwestern portion of the project site (Nichols and Wright, 1971; Helley and Miller, 1992). The area surrounding the SFERP site is completely urbanized (Stinson et al., 1986), with ever increasing industrial development. The general location of the proposed SFERP facilities is shown on Figure 2-1 and confidential Figure 8.16-1 (filed confidentially under separate cover).

The project area consists of a bedrock high surrounded by a gently sloping alluvial fan and flood plain with an average elevation of only about 26 feet above mean sea level. A few small but prominent rocky hills surround the SFERP site. The largest of these surrounding hills is to the southwest and named Bernal Heights; the hills near the project area to the west and south are named Potrero Hill and Hunters Point, respectively. Streams draining these hills (particularly Islais Creek and tributaries) have built an alluvial fan that forms the broad, gently sloping surface on which the proposed SFERP is to be built.

The low alluvial fans surrounding San Francisco Bay have frequently been referred to as part of the bay plain (see for instance Robinson, 1956). Welch (1981) used the bay plain to refer to all that area extending from the foothills of the adjacent highlands to the tidal flats of the Bay. However, the bay plain was first defined by Finlayson et al. (1967) as that area surrounding San Francisco Bay, having an elevation between lower low tide and higher high tide. In other words, the bay plain as defined by Finlayson et al. (1967) is intertidal and distinct from adjacent areas of higher relief that are not directly affected by tides. Rather than attempt to make an arbitrary distinction between the bay plain and alluvial fan based on a nearly imperceptible change in slope, the distinction can easily be made based on modern tidal influence alone. Helley et al. (1979) applied the name flatlands to areas surrounding San Francisco Bay with a slope less than 15 percent. However, rather than adopt the inappropriate name *flatland* for a gently sloping surface (Helley et al., 1979) or use the often misused term bay plain, the term alluvial fan is used for that area that lies between the Bay tidal flats (bay plain sensu stricto) and the bedrock adjacent hills.

8.16.3.2 Regional Geologic Setting

The general geology of the San Francisco area has been described in some detail by Lawson (1895, 1914), Crandall (1907), Louderback (1939, 1951), Taliaferro (1941, 1951), U. S. Army Corps of Engineers (USACE) (1963), Treasher (1963), Trask and Rolston (1951), Goldman (1967, 1969a), Finlayson et al. (1967), Finlayson et al. (1968), Schlocker (1968, 1974), Helley et al. (1979), Wahrhaftig and Sloan (1989), and Wahrhaftig et al. (1993), among others. The information in these and other published reports form the basis of the following discussion. Individual publications are incorporated into this report and referenced where appropriate.

The geology in the vicinity of the proposed project facilities has been geologically mapped by numerous workers, including Wahrhaftig et al. (1993; 1:1,000,000 scale); Jennings (1977; 1:750,000 scale); Jenkins (1938; 1:500,000 scale); Schlocker (1971, 1:500,000 scale); Jennings and Burnett (1961, 1:250,000 scale), Finlayson et al. (1967; 1:125,000 scale); and Helley et al. (1979; 1:125,000 scale). Larger scale mapping of the project site is provided by Lawson (1914; 1:62,500 scale), Brabb and Pampeyan (1972; 1:62,500 scale), Lajoie et al. (1974; 1:62,500 scale), Lawson (1908; 1:40,000 scale), Schlocker et al. (1958; 1:24,000 scale), Schlocker (1961, 1974; 1:24,000 scale), Bonilla (1964, 1971; 1:24,000 scale), and Radbruch and Schlocker (1:12,000 scale). The site-specific geology of the SFERP site, water pipeline route, and immediate vicinity will be considered separately below.

The geology of the San Francisco Peninsula is poorly known, owing in large part to its structural and stratigraphic complexities and also to a lack of exposures. Large portions of the area are covered by water, surficial deposits, artificial fill, and man-made structures. In general, the geology of the San Francisco Peninsula consists of bedrock hills surrounding small, narrow valleys filled with unconsolidated deposits. The aspects of geology pertinent to this report are the types, distribution, and ages of rocks and sediments immediately underlying the project area and their probability of producing fossils during project construction.

Geological materials in the general vicinity of the SFERP site can be divided into two distinct units: bedrock composed of Jurassic, Cretaceous, and Tertiary age sandstone, siltstone, shale, chert, greenstone, and serpentinite named the Franciscan Complex (Franciscan Formation of some reports); and much younger, unconsolidated, sedimentary deposits that range in age from Pleistocene to Recent and which have been variously subdivided and named by geologists. Formal formation names have been applied to the Pleistocene to Recent sedimentary sequence by some authors (see for instance Lawson, 1914). However, most geologists working in the San Francisco Bay area still prefer to use informal designations, such as “older bay mud,” “sand deposits,” and “younger bay mud.” The geographic extent and limiting geologic ages of these informal stratigraphic units are still uncertain.

The geologic history of the San Francisco area is still imperfectly known. Considerable difficulty in interpreting the geologic history is due to the fact that many of the deposits have limited local extent and their time relations cannot be determined by either tracing their lateral continuity or determining their relative superposition. In addition, not all units contain age-diagnostic fossils. The result is that, even after years of study by geologists and paleontologists, any statement of the geologic history of the San Francisco Bay region must still be looked upon as incomplete. Our understanding has not dramatically improved since Savage (1951) stated, “Many stratigraphic problems still exist in this area despite the fact that these problems have at times received the attention of competent geologists and paleontologists.” New excavations have the potential to yield important new information, new fossils, or other field evidence, which may add to, confirm, or require modification of previous interpretations. This new information has the potential to also provide a more complete and accurate understanding of both the geological and biological history of the area.

8.16.3.3 Resource Inventory Methods

To develop a baseline paleontological resource inventory of the SFERP site, water pipeline route, and surrounding area and to assess the potential paleontological productivity of each stratigraphic unit present, the published as well as available unpublished geologic and paleontologic literature was searched and stratigraphic and paleontologic inventories were compiled, synthesized, and evaluated (see below). These tasks are in compliance with CEC (2000) and Society of Vertebrate Paleontology (SVP, 1995) guidelines for assessing the importance of paleontological resources in areas of potential environmental impact. In addition, to obtain further information for this assessment, a field survey of the SFERP site and surrounding area was conducted on 25 February 2004 by Dr. Lanny H. Fisk, Ph.D., R.G. Dr. Fisk was also present during geotechnical drilling to determine what rocks and sediments underlie the SFERP site. These geotechnical borings helped determine the subsurface distribution of stratigraphic units and further evaluate their potential for producing scientifically important paleontological resources.

8.16.3.3.1 Stratigraphic Inventory. Geologic maps and reports covering the bedrock and surficial geology of the project site, water pipeline route, and vicinity were reviewed to determine the exposed and subsurface stratigraphic units, to assess the potential paleontological productivity of each stratigraphic unit, and to delineate their respective areal distribution in the project area. The SFERP site and vicinity is thoroughly urbanized with concrete, asphalt, or buildings covering nearly the entire surface area. The only rock outcrops are serpentinite exposed at the north-central edge of the SFERP property. No disturbed or undisturbed native sediments exist at the surface within or near the proposed location of the SFERP.

8.16.3.3.2 Paleontological Resource Inventory. Published and unpublished geological and paleontological literature (including previous environmental impact assessment documents and paleontological resource impact mitigation program final reports) were reviewed to document the number and locations of previously recorded fossil sites from rock units exposed in and near the project site and the types of fossil remains each rock unit has produced. The literature review was supplemented by an archival record search of the University of California Museum of Paleontology (UCMP) in Berkeley, California, looking for additional information regarding the occurrence of fossil sites and remains in and near the site proposed for project construction.

8.16.3.4 Resource Inventory Results

8.16.3.4.1 Stratigraphic Inventory. Large scale geologic mapping of the SFERP site and vicinity has been provided by Lawson (1914; 1:62,500 scale), Brabb and Pampeyan (1972; 1:62,500 scale), Lajoie et al. (1974; 1:62,500 scale), Lawson (1908; 1:40,000 scale), Schlocker et al. (1958; 1:24,000 scale), Schlocker (1961, 1974; 1:24,000 scale), Bonilla (1964, 1971; 1:24,000 scale), and Radbruch and Schlocker (1958, 1:12,000 scale). Unfortunately, in these geologic maps, geologists have not consistently used the formally named formations of Lawson (1914), nor have they consistently used the same map units. As a result of different geological map units being used, considerable interpretation is required to compare these information sources and determine stratigraphic relations and relative ages of the individual map units.

Instead of using formally named and lithologically and chronologically distinct geologic formations, many geologists working in the San Francisco area have used map units that reflect depositional processes or facies. Although they are facies subdivisions of alluvial fan and intertidal bay deposits, these map units are shown on geologic maps with distinct contact lines when actually contacts between map units are gradational, with alluvial fans grading into alluvial plains, which grade imperceptibly into bay muds. These mapped boundaries may represent the best possible estimate of facies distribution; however, they have limited utility in determining stratigraphic superposition, relative age, or potential for producing significant paleontological resources. In addition, using facies subdivisions makes it more difficult to compare descriptions of fossil sites, which typically use formally named stratigraphic units rather than facies.

For these reasons, in this discussion the report uses the formally named stratigraphic units of Lawson (1914), which have been found to be generally applicable to the area (Trask and Rolston, 1951; Mitchell, 1963), despite the fact that many current engineering geologists and hydrogeologists still prefer to use informal stratigraphic units such as *older bay mud* and *younger bay mud*. In their work on sedimentary deposits underlying San Francisco Bay, Treasher (1963) and Goldman (1967) correlated their informal *older bay mud* with the San Antonio Formation of Lawson (1914) and their *younger bay mud* with Lawson's *Bay mud*. Lawson considered his *Bay mud* and *salt-marsh deposits* to be equivalent to sediments he named the Temescal Formation (see also Trask and Rolston, 1951). A correlation chart comparing the formal stratigraphic units of Lawson (1914) with the numerous facies map units used by many USGS geologists is provided in Table 8.16-2 below. Quite simply, as used in this report, the Temescal Formation of Lawson (1914) is the equivalent of Holocene and latest Pleistocene map units; Lawson's Merritt Sand is equivalent to the slightly older marine and continental sand deposits of various authors; and Lawson's San Antonio Formation is equivalent to even older Pleistocene map units, including the Colma Formation of Schlocker et al. (1958) and Schlocker (1974).

TABLE 8.16-2
Tentative Correlation of Quaternary Stratigraphic Units Exposed on San Francisco Bay Area Alluvial Fans and Bay Plains.

Formal Map Units of Lawson (1914)	Equivalent Informal Map Units
Temescal Formation	Alluvium (Qal), sedimentary deposits undifferentiated (Qu), bay mud (Qm), beach deposits (Qb), dune sand (Qd), sand dune and beach deposits (Qs), slope debris and ravine fill (Qsr), younger alluvial fan deposits (Qyf), younger (inner) alluvial fan deposits (Qyr), younger (outer) alluvial fan deposits (Qyfo), basin deposits (Qb), colluvium (Qcl), younger fluvial deposits (Qyfo), interfluvial basin deposits (Qb), alluvial fan and fluvial deposits (Qhaf), levee deposits (Qhl), floodplain deposits (Qhfp), floodbasin deposits (Qhb), floodbasin deposits (salt-affected) (Qhbs), and estuary deposits (Bay mud) (Qhbm)
Merritt Sand	Sand deposits stratigraphically between younger and older bay mud
San Antonio Formation	Older alluvial fan deposits (Qof), alluvial fan deposits (Qpaf), older mud (Qom), coarse-grained older alluvial fan and stream terrace deposits (Qof), fine-grained older basin and alluvial fan deposits (Qob), Colma Formation (Qc), and marine terrace deposits (Qmt)

This simplified subdivision of the alluvial fan and bay mud deposits used in this report appears to be defensible not only on the bases of stratigraphic superposition, topographic expression, and the presence or absence of deformation, but also on the basis of fossil content. From his survey of vertebrate faunas from the non-marine Quaternary deposits of the San Francisco Bay region, Savage (1951) concluded that only two divisions could be recognized. He named the earlier Pleistocene fauna the Irvingtonian North American Land Mammal Age and the later Pleistocene and Holocene fauna the Rancholabrean North American Land Mammal Age. As used in this report, the older San Antonio Formation is believed to be entirely Irvingtonian in age and the younger Merritt Sand and Temescal Formation are entirely Rancholabrean in age.

Deformed gravels with interbedded sand and clay in the San Francisco area here referred to the San Antonio Formation have yielded an abundant Middle Pleistocene Irvingtonian fauna (Savage, 1951; Wahrhaftig et al., 1963; Jefferson, 1991a; 1991b). These fossiliferous deposits were called the Irvington Gravels by Savage (1951), a name which was accepted as a formal designation by Hall (1958) and Christensen (1987). The Irvington Gravels are distinctly folded and the strata dip as much as 20° to 25° (Savage 1951, Louderback 1951, Hall 1958). Unconformably overlying the Irvington Gravels are comparatively flat-lying layers of younger alluvium. From my assessment of the stratigraphy and paleontology of the San Francisco Bay area, it appears that Savage’s (1951) Irvington Gravels may be the coarse-grained, proximal alluvial fan deposits of the San Antonio Formation and the overlying, undeformed layers of younger alluvium the equivalent of the Rancholabrean-age Merritt Sand and/or Temescal Formation.

Lawson’s (1914) Alameda Formation does not crop out in the immediate vicinity of the proposed project (Bonilla, 1971; Schlocker, 1974; Brabb and Pampeyan, 1972), and, thus, is not considered further in this discussion. Sedimentary rocks of Tertiary age, which might be expected to underlie the Quaternary-age San Antonio Formation, are also not known to occur within the vicinity of the SFERP site.

8.16.3.4.2 Site Geology. The SFERP site and vicinity is located within the “Hunters Point Shear Zone” (Schlocker, 1974), a Jurassic-age fault zone that trends northwestward across the San Francisco Peninsula. This fault zone has been repeatedly reactivated and deformed by translational movement along the San Andreas Fault system (Wakabayashi, 1992). Movement along this fault zone over time has resulted in rocks being intensely fractured and sheared. Similar major shear zones are found throughout the Bay area. The Hunters Point Shear Zone is over one mile wide and contains a melange of various rock –types, but is characterized by the metamorphic rock serpentinite (Schlocker, 1974).

As mapped by Lawson (1914; 1:62,500 scale), Brabb and Pampeyan (1972; 1:62,500 scale), Lajoie et al. (1974; 1:62,500 scale), Schlocker et al. (1958; 1:24,000 scale), Bonilla (1971; 1:24,000 scale), Schlocker (1974; 1:24,000 scale), and Radbruch and Schlocker (1958; 1:12,000 scale), both the site proposed for SFERP construction and the proposed route of the water pipeline are located primarily on artificial fill overlying either rocks of the Franciscan Complex or late Pleistocene to Holocene alluvium of the Temescal Formation. In the subsurface, the Temescal Formation overlies in sequence the Merritt Sand, San Antonio Formation, and Franciscan Complex. Each of these stratigraphic units will be individually discussed below, from oldest to youngest.

8.16.3.4.3 Franciscan Complex. Bedrock in the vicinity of the SFERP site is composed of sandstone, shale, siltstone, and volcanic rocks, with lesser amounts of conglomerate, limestone, radiolarian chert, greenstone, schist, and serpentinite, named the Franciscan Complex (also known as the Franciscan Formation, Franciscan Series, Franciscan Group, and Franciscan melange). The Franciscan Complex is an unnatural or artificial assemblage of variably deformed and metamorphosed rock units that formed in a subduction zone at the western edge of the North American Plate (Hamilton, 1969; Page, 1981; Wakabayashi, 1992). Franciscan lithologies are predominantly sedimentary rocks with subordinate volcanic rocks that are believed to represent trench fill and volcanic islands, respectively. Although they are uncommon, fossils have been very important in unraveling the ages, depositional environments, and tectonic history of these Franciscan Complex rocks. Major unanswered questions and heated controversy regarding the history of the Franciscan Complex remain (Wakabayashi, 1992).

Within the Franciscan Complex are numerous fault-bounded blocks, each with a distinctive lithology, age, metamorphic grade, and structure, that have been termed tectonostratigraphic terranes (Blake et al., 1982). The San Francisco Peninsula is composed of several coherent tectonostratigraphic terranes separated by major fault zones. The northwest-southeast trending Hunters Point Shear Zone separates the Alcatraz Terrane to the northeast from the Marin Headlands Terrane to the southwest. The Alcatraz Terrane is composed primarily of early Cretaceous-age sandstones and shales, while the Marin Headlands Terrane contains late Cretaceous-age volcanic rocks (metamorphosed to greenstone) and banded radiolarian cherts. The ages of rocks in the Alcatraz and Marin Headland Terranes is based on fossils (Blake et al. 1982; Wakabayashi, 1992). The predominant rock type found within the Hunters Point Shear Zone is serpentinite, with occasional tectonic blocks of sandstones and shales of the Alcatraz Terrane.

Lawson (1895) first named these rocks the Franciscan Series and then later (Lawson, 1914) used the name Franciscan Group. He designated San Francisco as the type area, stating that “the Franciscan group was named from San Francisco, where it occurs in extensive exposures….” Lawson (1895) originally divided the Franciscan Series/Group into five formations. However, after 60 years of further study, Schlocker (1974) considered these formations obsolete and suggested that they be abandoned. Schlocker (1974) and many earlier workers used the name Franciscan Formation. However, because the stratigraphy of Franciscan-age rocks is not at all simple, most geologists now working in the San Francisco area prefer to use the term Franciscan Complex for this complex assemblage of dissimilar rocks.

Ages of Franciscan Complex rocks vary from place to place (Fox, 1983). Based primarily on fossil evidence, rocks in the sequence have been dated as Jurassic, Cretaceous, and Tertiary. On the San Francisco Peninsula, Franciscan Complex sedimentary facies of the Alcatraz and Marin Headlands Terranes are Cretaceous in age (Schlocker, 1974).

According to Spaulding (2000), Franciscan Complex bedrock occurs at depths less than 5 feet below the ground surface in the western half of the Potrero PP site. However, to the east and closer to the waterfront, serpentinite occurs at depths up to 85 feet below ground surface. Excavations for construction of the SFERP proposed to be built in the southwestern corner of the Potrero PP site would impact Franciscan Complex rocks.

Unconformably overlying the Franciscan Complex basement rocks in the proposed project area are estuarine sediments of Pleistocene age often informally referred to as “older bay mud” and formally known as the San Antonio Formation.

San Antonio Formation. The oldest sediments overlying the Franciscan Complex basement rocks are here referred to the San Antonio Formation. Lawson (1914) applied the name San Antonio Formation to alluvial deposits older than and immediately underlying the Merritt Sand. Strata comprising the San Antonio Formation have been deformed by frequent tectonic activity and are often recognizable from the overlying Merritt Sand and Temescal Formation by their non-flat-lying attitude (Savage, 1951). This older stratigraphic unit is also more consolidated or cemented and, therefore, often has a distinct topographic expression. Lawson (1914) stated that since its deposition, the San Antonio Formation has been thoroughly dissected and terraced. Thus, as San Antonio Formation deposits were exposed by lowering of sea level and tectonic uplift, streams cut below the surface, leaving many remnants preserved as topographic highs (Robinson, 1956). In the time period separating deposition of sediments now referred to as the San Antonio and Temescal Formations, coarser sediments named the Merritt Sand and Colma Formation were deposited.

Many areas on the San Francisco Peninsula have alternated between being submerged beneath the Bay and being dry land in response to glacially controlled fluctuations of sea level and tectonic uplift. Depending on whether they were deposited during a high or low sea level stand, sediments of the San Antonio Formation were deposited in environments varying from estuarine and intertidal mud flats to swamps and slow flowing streams.

The San Antonio Formation is probably early to late Pleistocene in age (Louderback, 1951). Stirton (1939) described an early Pleistocene fossil fauna from gravels exposed near Irvington, on the eastern side of the San Francisco Bay. Later, Savage (1951) named this site the type locality for the Irvingtonian North American Land Mammal Age (NALMA). Lithologically similar sediments of the San Antonio Formation that occur elsewhere in the San Francisco Bay area have also yielded Irvingtonian-age land mammal fossils and, therefore, are probably age-equivalent.

Sediments of the San Antonio Formation are not known to underlie the SFERP site, and even if they were to exist, they would be at a depth greater than 35 feet. Thus, it is unlikely that they would be impacted except in the deepest excavations during SFERP construction. These “older bay muds” could be encountered during deep augering for the placement of concrete piers or support piles in the southwestern corner of the proposed SFERP site.

Merritt Sand. Trask and Rolston (1951) named the sand below “younger bay mud” the Merritt Sand. In their study of Quaternary sediments in the Islais Creek Basin (which includes the SFERP site), Radbruch and Schlocker (1958) simply designated equivalent deposits “the sand layer” but did correlate it with the Merritt Sand. Where not eroded away during the sea-level low stand following deposition, the Merritt Sand separates deposits of the San Antonio and Temescal Formations. On the east side of San Francisco Bay, Radbruch (1957) showed that the marine type Merritt Sand grades into and interfingers with alluvial-fan deposits of the Temescal Formation. Schlocker et al. (1958) named equivalent sands exposed on the San Francisco Peninsula the Colma Formation, while clearly stating that at least the marine portion of the Colma was “correlated with the Merritt Sand.” Since the Merritt Sand was named first and, therefore, has precedence, this report uses the Merritt

Sand as the formal name for the predominantly sandy deposits that unconformably overlie sediments of the San Antonio Formation. Although it may grade into and even locally interfinger with sediments of the overlying Temescal Formation (Radbruch 1957), both in outcrop and in the subsurface "this sand layer" is a distinctive stratigraphic unit (Radbruch and Schlocker, 1958).

The Merritt Sand found in the vicinity of the SFERP site is a complex of Pleistocene marine and coastal sediments, including some interbedded gravel, silt, and clay beds. The environment of deposition of Merritt Sand deposits varies greatly over short distances. Depending on whether they were deposited during high or low sea-level, the environment in which they were deposited could vary from offshore marine, estuarine, lagoonal, beach, paludal (swamp), lacustrine (lake), fluvial (stream), flood plain, to dunes (Lawson, 1895; Martin, 1916; Schlocker, 1974). The Merritt Sand was encountered in a geotechnical borehole in the southwestern corner of the SFERP site, and, thus, could be impacted by deep augering for the placement of concrete piers or support piles in this vicinity.

Temescal Formation. Late Pleistocene and Holocene age younger alluvium in the San Francisco Bay area was named the Temescal Formation by Lawson (1914), who included within this formation alluvial deposits younger than and overlying the Merritt Sand. These younger alluvial deposits developed in part from the erosion and redeposition of older alluvium. The principal differences between the younger and older alluvium are stratigraphic position (separated by the Merritt Sand), lithologic components, degree of consolidation, topographic expression, attitude (tilted versus flat-lying), and fossil content. According to Savage (1951), sediments in the San Francisco Bay area containing latest Pleistocene and Holocene fossil faunas can often be distinguished from the older Pleistocene deposits because they are relatively flat-lying, while, in contrast, the older sediments containing early Pleistocene fossil faunas are often slightly tilted. This criterion has also been helpful to others in distinguishing older alluvium from younger alluvium (see Taliaferro, 1951; Hall, 1958; and Helley et al., 1972). According to Taliaferro (1951), the tilting of early Pleistocene sediments is a direct result of the mid-Pleistocene orogeny (but see Christensen [1987] for a contrary view).

Like sediments referred to as the "older bay mud" or San Antonio Formation, depending on whether they were deposited during high or low sea level, the depositional environment of Temescal Formation sediments varies from estuarine to swamp to stream.

The age range for sediments referred to the Temescal Formation is late Pleistocene to Recent. Kvenvolden (1962) reported radiocarbon dates on samples collected 11 to 20 feet below the surface ranging from about 6,000 to 8,000 years before present. Story et al. (1966) reported radiocarbon ages ranged from 2,500 to 7,500 years for samples collected between 2 and 50 feet below the surface. Schlocker (1974) expressed the opinion that sediments here referred to the Temescal Formation were deposited after the Wisconsin Glaciation about 14,000 years ago, when sea level began to rise with the melting of glacial ice.

Geotechnical investigations reveal that sediments referable to the Temescal Formation underlie artificial fill at a depth below about 20 feet in the southwest corner of the SFERP site. Thus, this stratigraphic unit could be impacted by excavations for the SFERP proposed to be built in this corner of the site. Augering for concrete piles or support piers in this area could impact sediments of the Temescal Formation.

As mapped by Schlocker (1974; 1:24,000 scale), Bonilla (1971; 1:24,000 scale), and Radbruch and Schlocker (1958; 1:12,000 scale), the route of the water pipeline traverses sediments referable to the Temescal Formation. Thus, this stratigraphic unit could also be impacted by trenching for burial of the water pipeline.

Artificial Fill. Artificial fill is extensive along the margins of San Francisco Bay. The practice of creating land by dumping artificial fill on the gently sloping tidal flats along the eastern margin of the San Francisco Peninsula began about the time of the Gold Rush, when San Francisco became a booming center of growth and needed room to expand, particularly along the waterfront. Over time, more than 3 square miles of the most valuable land in San Francisco originated in this way (Schlocker, 1974). For fill, developers used whatever materials were available, including dune sand, alluvium, sediment dredged from the Bay, spoils from excavations, solid rock from quarries, and man-made debris, including foundry slag and garbage. Both the thickness and type of fill vary widely over short distances.

Artificial fill of varying depth underlies the entire Potrero PP site (Spaulding, 2000). Geotechnical borehole logs indicate that fill thickens from west to east. It is as shallow as 1 foot in the northern part of the SFERP site and as deep as 20 feet in the southeastern part. In the vicinity of the site proposed for SFERP construction, artificial fill unconformably overlies either serpentine bedrock or bay mud referable to the Temescal Formation.

8.16.3.4.4 Paleontological Resource Inventory. An inventory of the paleontological resources of the stratigraphic units in or near the proposed project site is presented below and the paleontological importance of these resources is assessed. The literature review and UCMP archival search conducted for this inventory documented no previously recorded fossil sites within the very limited footprint of the SFERP site. However, each of the stratigraphic units that could possibly be impacted by construction of the SFERP facilities has produced significant and scientifically important fossils in the San Francisco area. Fossil sites were documented as occurring near the proposed SFERP. These known fossils and localities are briefly described below starting with those from the oldest stratigraphic unit.

Franciscan Complex. Low-grade metamorphic rocks of the Franciscan Complex have produced highly significant fossils at numerous localities in the past. Schlocker (1974) referred to the "scarcity of fossils" in rocks of the Franciscan Complex and even wrote: "fossils are almost nonexistent." Yet, in the same publication he also emphasized the importance of fossils in unraveling the ages, depositional environments, and tectonic history of the Franciscan Complex. Schlocker et al. (1958) reported a Cretaceous ammonite found in shales of the Alcatraz Terrane within northeastern San Francisco. Schlocker (1974) also referred to fossil plant remains in Franciscan rocks, although usually with such terms as "carbonaceous matter," "lignitic material," "large carbonaceous particles and layers," "large abundant paper-thin flakes of coaly material…," or "carbon having relict plant-cell structures." Lastly, Schlocker (1974) reported "curved thin shells…that resemble chitinous parts of arthropods and tiny shark's teeth." The latter are the only reported vertebrate fossils from the Franciscan Complex.

Fossils have also been reported in Franciscan rocks by many other geologists and paleontologists. As the name implies, radiolarian chert beds in the Franciscan Complex produce radiolarian microfossils important as biostratigraphic markers. Fossil radiolaria were first described from Franciscan rocks by Hinde (1894) and later by Riedel and

Schlocker (1956). Schlocker (1974) wrote: “In some chert beds fossils are so crowded that they touch each other.” Limestone nodules and concretions in Franciscan shales often also contain abundant radiolaria (Schlocker, 1974). Fossil foraminifera have also been reported from Franciscan limestone (Kupper, 1956). Fossil gastropods (snails) and pelecypods (clams) have also been reported from a locality on Alcatraz Island and elsewhere by Gabb (1869), Stewart (1930, Anderson (1938), and Ghent (1963). Plant microfossils (pollen and spores) and marine algal cysts of dinoflagellates have also been reported from Franciscan shales (Evitt and Pierce, 1975; Damassa, 1979a, 1979b; Blake et al. 1984). The latter were instrumental in determining that some rocks included in the Franciscan Complex are as young as early Tertiary.

Locally, the Franciscan Complex contains a melange of various rock-types that vary irregularly over short distances (Schlocker, 1974). Likewise the metamorphic grade varies in intensity from place to place (Schlocker, 1974). Geotechnical boreholes on the Potrero PP site indicate that the predominant rock type in the Franciscan Complex is serpentinite (Spaulding, 2000). However, on the northeast slopes of Potrero Hill, less than 0.5 mile west of the SFERP site but still within the Hunters Point Shear Zone, the Franciscan Complex consists of low metamorphic grade sedimentary rocks referred to as “sandstone and shale” by Radbruch and Schlocker (1958) and as “sandstone” by Schlocker (1974). During the field survey for this assessment, an outcrop of nonfossiliferous, arkosic sandstone was discovered on 20th Street between Pennsylvania and Mississippi Streets, approximately 0.5 mile west of the SFERP site.

San Antonio Formation. Fossils from the San Antonio Formation are early Pleistocene in age and equivalent to those reported from the Irvington Gravels. The mammals collected from these units include mammoths, musk oxen, horses, peccaries, camels, deer, elk, pronghorns, ground sloths, saber-tooth cats, dire wolves, coyotes, foxes, gophers, mice, and squirrels (Peabody, 1945; Savage, 1951; Stirton, 1951; Louderback, 1951; Hall, 1958).

When naming the San Antonio Formation, Lawson (1914) noted that this unit contained bones of extinct vertebrates, including ground sloth, bison, mammoth, mastodon, horse, camels, and large carnivores. Savage (1951) questioned the exact stratigraphic position from which some of these specimens were obtained. Helley et al. (1972) also noted that the older alluvial fan deposits (San Antonio Formation of this report) locally contain concentrations of continental vertebrate and invertebrate fossils, and that their older mud map unit (also included in the San Antonio Formation) contained continental vertebrate fossils, freshwater invertebrate fossils, and plant remains.

Stirton (1939) described an early Pleistocene fauna from gravels exposed along the scarp of the Hayward Fault near Irvington, on the eastern side of the San Francisco Bay. Later, Savage (1951) named this site the type locality for the Irvingtonian NALMA. Lithologically similar and probably age-equivalent gravels occur elsewhere in the San Francisco Bay area. These gravels have also yielded Irvingtonian-age land mammal fossils (for instance UCMP localities V-6322, V-3602, V-3604, and V-3605) and are probably correlative with the Irvington Gravels.

Merritt Sand. Quaternary sediments referred to as the Merritt Sand or the equivalent Colma Formation have produced significant marine and terrestrial fossils in the past. Rodda and Baghai (1993) reported bones and teeth of mammoths and bison from sediments they referred to the Colma Formation. Fossil diatoms and pollen were also recovered from this site. A leg bone of a ground sloth had been previously recovered from a shallow well in this same vicinity (Winslow, 1876; Stock, 1925; Hay, 1927). Savage (1951) listed other vertebrate fossil localities in the San Francisco Bay region to which he assigned an “undifferentiated Pleistocene” age. Some or all of these additional vertebrate fossils may also be referable to the Merritt Sand. Schlocker (1974) reported fossil plant remains and a peat layer at the top of his Colma Formation. The latter he thought might represent a paleosol—“an old soil that developed in or near local marshes or lakes.” The Merritt Sand has also produced marine megafossils, marine and nonmarine diatoms, and sponge spicules (Schlocker, 1974). During excavations for the Broadway Tunnel, a fossil “tree” was discovered and identified by paleobotanist Roland W. Brown as a juniper or red cedar, probably Juniperus californica (Schlocker, 1974). Wood from this tree was radiocarbon dated at greater than 30,000 years before present. Fossil mollusk shell fragments were observed in a core from a depth of approximately 30 feet in the Merritt Sand in a geotechnical borehole in the southwestern corner of the SFERP site.

Temescal Formation. An abundance of Pleistocene and Holocene fossils have been reported from sediments referable to the Temescal Formation in the San Francisco area. Hay (1927) listed numerous discoveries made between 1873 and 1927. Peabody (1945) added to this list. Surveys of Quaternary land mammal fossils in the San Francisco Bay area have been made by Stirton (1939, 1951), Hay (1927), Savage (1951), Lundelius et al. (1983), and Jefferson (1991b), and surveys of Quaternary birds, reptiles, and amphibians have been made by Miller and DeMay (1953) and Jefferson (1991a).

The Temescal Formation has yielded fossil remains of petrified wood; shells of clams and oysters; and the bones and/or teeth of bony fishes, amphibians, reptiles, birds, and a diversity of extinct land mammals, including ground sloths, mammoths, mastodonts, deer, moose, horses, camels, and bison (Hay, 1927; Stock, 1925; Miller and Peabody, 1941; Savage, 1951; Jefferson, 1991b; UCMP records). These fossils from the Temescal Formation are late Pleistocene to Holocene (Rancholabrean NALMA) in age. The age of these Rancholabrean faunas is based on the presence of fossil Bison and many mammalian species that are inhabitants of the same area today.

Fossils recovered from Temescal Formation sediments at sites in the area around San Francisco Bay include microfossils useful in paleoenvironmental reconstructions (radiolaria, foraminifera, sponge spicules, coccoliths, diatoms, dinoflagellates, pollen, and spores), marine invertebrates (gastropods, pelecypods, and bryzoa), and both marine and terrestrial mammals (Atwater et al., 1977). Schlocker (1974) has also reported fossil plant remains from Temescal-equivalent sediments he referred to as “Bay mud and clay.” Bonilla (1971) reported fossil shells and plant remains from “Bay mud” here referred to the Temescal Formation.

A number of previously recorded fossil sites in the Temescal Formation are reported as having been uncovered by earth moving associated with previous construction projects (Radbruch and Schlocker, 1958; Jefferson, 1991a, 1991b, Rodda and Baghai, 1993; UCMP records) including the Bay Bridge, Bay Shore Southern Pacific Tunnel, Twin Peaks Tunnel, construction of an office building on Pacific Street, and construction of the Southeast Sewage Treatment Plant (now known as the Southeast Water Pollution Control Plant).

Remains of land mammals have been found at a number of localities in younger alluvial deposits referable to the Temescal Formation (Louderback, 1951; Savage, 1951; Stirton, 1951; Jefferson, 1991b). Jefferson (1991a; 1991b) compiled a database of California Late Pleistocene (Rancholabrean) vertebrate fossils from published records, technical reports, unpublished manuscripts, information from colleagues, and inspection of museum paleontological collections at over 40 public and private institutions. He listed 10 individual sites in San Francisco County and 16 in adjacent San Mateo County that have yielded Rancholabrean vertebrate fossils, including several UCMP localities. Most, if not all, of these fossil sites would presumably be referable to the Temescal Formation as used in this report. In addition to UCMP localities, Jefferson (1991a; 1991b) listed in this area Rancholabrean-age vertebrate fossil localities of the California Academy of Science Museum (formerly the Golden Gate Memorial Museum), Academy of Natural Sciences Museum in Philadelphia, Field Museum of Natural History in Chicago, U. S. Geological Survey in Denver, U. S. National Museum in Washington, and Yale Peabody Museum.

The most common vertebrate fossils reported from Rancholabrean-age alluvial sediments in the San Francisco Bay area are the remains of extinct mammoths, bison, and horses. Radbruch and Schlocker (1958), Story et al. (1966), Goldman (1969b), and Helley et al. (1972) have noted that the Temescal Formation equivalent sediments locally also contain marine and freshwater invertebrate fossils (sponges, gastropods [snails], and pelecypods [clams and oysters]), diatoms, and plant remains.

The age of Temescal Formation deposits apparently extends from latest Pleistocene to the Holocene. Lawson (1914) referred to the Temescal Formation as entirely Holocene in age, but Louderback (1951) believed that the bulk of the younger alluvium was Pleistocene in age. Based on the presence of fossil bison, Savage (1951) referred the younger alluvium to the Rancholabrean NALMA, which spans the boundary between late Pleistocene and early Holocene.

UCMP vertebrate fossil locality V-65243, known as the Twin Peaks Tunnel site, located approximately 2.7 miles (4.3 kms) northwest of the SFERP site, produced Rancholabrean land mammal fossils from Temescal Formation sediments. In the vicinity of the Islais Creek Channel 0.5 mile south of the SFERP site, UCMP locality V-3410 yielded a Rancholabrean-age fossil fauna from sediments equivalent to the Temescal Formation. Radbruch and Schlocker (1958) also reported the recovery of fossils from borings in the Islais Creek area from bay sediments which they correlated with the Temescal Formation. Radbruch and Schlocker (1958) also reported the discovery of fossil plant remains and mollusk fossils in an excavation at the Southeast Sewage Treatment Plant (now known as the Southeast Water Pollution Control Plant). Two localities in South San Francisco (UCMP localities V-6203 and V-6319) have also produced Rancholabrean faunas, including bison and elk or moose. During construction of the San Francisco-Oakland Bay Bridge, part of a jaw of a bison with several teeth, bones and teeth of horses, and a mammoth tooth were collected from sediments considered to be late Pleistocene (Louderback 1951, Savage 1951) and probably equivalent to the Temescal Formation. These localities are now referred to as UCMP localities V-34011 and V-69186. Several additional Rancholabrean fossil faunas are located further from the SFERP site. Abundant fossil mollusk shells were observed in cores of younger bay mud from depths of approximately 20 and 25 feet in a geotechnical borehole in the southwestern corner of the SFERP site.

Artificial Fill. No fossils have been recorded from artificial fill in the San Francisco Bay area. However, since artificial fill includes sediments from the older formations discussed above, it is highly likely that such fossils exist. Such fossils would have been transported from their original source and would be lacking stratigraphic context and provenance. Therefore, they would have only limited scientific and educational value. An unconsolidated sand containing mollusk shell fragments was observed in cores from depths of approximately 10 and 15 feet in a geotechnical borehole in the south-central portion of the SFERP site. This sand was underlain by deposits of foundry slag, charcoal, and ash, clearly demonstrating that the shell-bearing sand is artificial fill.

8.16.4 Impacts

The potential environmental impacts on paleontological resources from construction and operation of the SFERP are presented in the following subsections.

8.16.4.1 Discussion of Impacts

8.16.4.1.1 Paleontological Resource Significance Criteria. In its standard guidelines for assessment and mitigation of adverse impacts to paleontological resources, the SVP (1995) established three categories of sensitivity for paleontological resources: high, low and undetermined. The paleontological importance or sensitivity of a stratigraphic unit reflects (1) its potential paleontological productivity (and thus sensitivity), and 2) the scientific significance of the fossils it has produced. Thus, the potential paleontological productivity of a stratigraphic unit exposed in a project area is based on the abundance of fossil specimens and/or previously recorded fossil sites in exposures of the unit in and near that project site. The underlying assumption of this assessment method is that exposures of a stratigraphic unit are most likely to yield fossil remains in quantity (and quality) similar to those previously recorded from that unit in and near the project site.

An individual fossil specimen is considered scientifically important and significant if it is (1) identifiable, (2) complete, (3) well preserved, (4) age diagnostic, (5) useful in paleoenvironmental reconstruction, (6) a type or topotypic specimen, (7) a member of a rare species, (8) a species that is part of a diverse assemblage, and/or 9) a skeletal element different from, or a specimen more complete than, those now available for that species (SVP, 1995). For example, identifiable land mammal fossils are considered scientifically important because of their potential use in providing very accurate age determinations and paleoenvironmental reconstructions for the sediments in which they occur. Moreover, vertebrate remains are comparatively rare in the fossil record. Although fossil plants are usually considered of lesser importance because they are less helpful in age determination, they are actually more sensitive indicators of their environment and, thus, as sedentary organisms, more valuable than mobile mammals for paleoenvironmental reconstructions. For marine sediments, invertebrate fossils, including microfossils, are scientifically important for the same reasons that land mammal and/or land plant fossils are valuable in terrestrial deposits. The value or importance of different fossil groups varies depending on the age and depositional environment of the stratigraphic unit that contains the fossils.

The following tasks were completed to establish the paleontological importance and sensitivity of each stratigraphic unit exposed in or near the project site:

- The potential paleontological productivity of each rock unit was assessed, based on the abundance of fossil remains and/or previously recorded and newly documented fossil sites it contains in and/or near the project site.
- The scientific importance of fossil remains recorded from a stratigraphic unit exposed in the project site was assessed.
- The paleontological importance of a rock unit was assessed, based on its documented and/or potential fossil content in the project site and surrounding area.

This method of paleontological resource assessment is the most appropriate because discrete levels of paleontological importance can be delineated on a topographic or geologic map.

Under SVP (1995) standard guidelines, stratigraphic units in which fossils have been previously found are deemed to have a high sensitivity and a high potential to produce additional fossils. In areas of high sensitivity, full-time monitoring by a professionally trained paleontologist is recommended during any project ground disturbance. Stratigraphic units that are not sedimentary in origin or that have not been known to produce fossils in the past are deemed to have low or undetermined sensitivity and monitoring is usually not recommended nor needed during project construction in these units. Stratigraphic units that have not had any previous paleontological resource surveys or fossil finds are deemed undetermined until surveys and mapping are done to determine their sensitivity. After reconnaissance surveys, observation of exposed strata, and possibly subsurface testing, a qualified paleontologist can usually determine whether the stratigraphic unit should be categorized as having high, low, or undetermined sensitivity; that is, whether there is a high, low, or undetermined potential to encounter fossil resources during construction. In keeping with the significance criteria of the SVP (1995), all vertebrate fossils are categorized as being of significant scientific value and all stratigraphic units in which vertebrate fossils have previously been found have high sensitivity. According to SVP (1995) standard guidelines, sensitivity comprises both (a) the potential for yielding abundant or significant vertebrate fossils or for yielding a few significant fossils, large or small, vertebrate, invertebrate, or botanical, and (b) the importance of recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, or stratigraphic data.

Using the criteria of the SVP (1995) above, the significance of the potential adverse impacts of earth moving on the paleontological resources of each stratigraphic unit exposed in and near the SFERP site was assessed. This assessment reflects the paleontological importance/impact sensitivity of the stratigraphic unit, which, in turn, reflects the potential for fossil remains and fossil sites being encountered during earth moving. However, it should be noted that any impact on a fossil site or a fossil-bearing rock unit during construction would be considered highly significant, regardless of the previously determined paleontological importance of the rock unit in which the site or fossiliferous layer occurs. For example, grading in an area underlain by a rock unit with low sensitivity would have only a low potential to disturb fossil remains (i. e., the rock unit would have low sensitivity to adverse impacts). However, the loss of any fossil remains from that rock unit would be a highly significant impact.

8.16.4.2 Paleontological Resource Impact Assessment

The significance of potential adverse impacts of SFERP project-related earth moving on the paleontological resources of the stratigraphic units likely to be disturbed at the project site is presented in this section.

8.16.4.2.1 Franciscan Complex. The predominant rock type found in Franciscan Complex rocks of the Hunters Point Shear Zone is serpentinite, although sedimentary rocks resembling those of the Alcatraz Terrane have been previously identified on Potrero Hill immediate west of the project area (Schlocker, 1974). Serpentinite is a metamorphic rock believed to have formed from either ultramafic igneous rocks or sediments high in manganese and iron and low in silica. Even though the original parent material may have been sediments, they have been subjected to high pressures and temperatures either prior to or during intrusion along fault zones. Metamorphism resulting from these high pressures and temperatures would have destroyed any fossils present. Therefore, the serpentinite basement rock in the project area is considered to have no sensitivity. However, because there is a possibility that excavations may encounter blocks of fossil-bearing sedimentary rocks such as those present on the northeast slopes of Potrero Hill less than 0.5 mile west of the SFERP site (Schlocker, 1974), overall the Franciscan Complex is still considered to have low sensitivity.

Sedimentary rocks of the Franciscan Complex have in the past produced very significant fossils, which have been important for understanding the age, depositional environments, and tectonic history of rocks in the San Francisco area. Although no previously reported fossils are known to directly underlie the proposed SFERP site, the presence of sedimentary rocks on Potrero Hill, less than 0.5 mile west of the SFERP site, suggests that there is a potential for similar rocks being uncovered during SFERP construction-related excavations. Therefore, using SVP (1995) criteria, rocks of the Franciscan Complex (not including the serpentinite) have a low sensitivity to impacts from SFERP construction. Additional fossil remains discovered in rocks of the Franciscan Complex during SFERP construction could be scientifically important and significant.

8.16.4.2.2 San Antonio Formation. A number of fossil localities are known from the San Antonio Formation in the San Francisco region, although no previously reported fossils are known to occur in this formation within one-mile of the proposed SFERP site. Nonetheless, using SVP (1995) criteria the San Antonio Formation has high sensitivity. There is only a low potential for similar scientifically important fossil remains being discovered in the deepest excavations at the proposed SFERP site. Additional fossil remains discovered in sediments of the San Antonio Formation during SFERP construction could be scientifically important and significant.

8.16.4.2.3 Merritt Sand. The Merritt Sand has produced significant fossils at numerous previously recorded fossil localities in the San Francisco Bay area, including in a geotechnical borehole at the SFERP site. The presence of these fossil sites suggests that the Merritt Sand has the potential to produce additional similar fossil remains during deep excavations at the proposed SFERP site. Therefore, the Merritt Sand possesses high sensitivity. Additional identifiable fossil remains recovered from the Merritt Sand during SFERP construction could be significant and scientifically important.

8.16.4.2.4 Temescal Formation. Sediments referable to the Temescal Formation have produced numerous significant plant, invertebrate, and vertebrate fossils at numerous previously recorded fossil sites. Several previously recorded fossil localities are found near the proposed SFERP site, including sites containing vertebrate fossils approximately 0.5 mile south of the SFERP site and less than 0.5 mile east of the water pipeline route. In addition, abundant fossil mollusks were observed in sediments of the Temescal Formation cored in a borehole in the southwestern corner of the SFERP site. The presence of these previously recorded fossil sites in sediments of the Temescal Formation suggests that there is a high potential for additional similar fossil remains to be uncovered by excavations for SFERP construction. Therefore, using SVP (1995) criteria, the Temescal Formation has high sensitivity to impacts from construction. Additional fossil remains discovered in sediments of the Temescal Formation during SFERP construction could be scientifically important and significant.

8.16.4.2.5 Artificial Fill. Although artificial fill may contain fossils transported from its source, those fossils would be lacking stratigraphic context and provenance and, therefore, would have only limited scientific and educational value. There is concurrence among paleontologists and land managers that fossils not in situ, that is those that have been removed from their initial stratigraphic context and that cannot be confidently related to a particular stratigraphic unit, are not scientifically significant. This is due to the fact that, in the absence of stratigraphic, and therefore chronologic and geologic context, a fossil cannot be used to effectively address important scientific research questions. Therefore, artificial fill possesses a low sensitivity to impacts from construction.

8.16.4.3 Summary of Paleontological Resource Assessment

Potential adverse impacts on paleontological resources resulting from construction of the proposed SFERP are summarized in this section. Potential impacts on paleontological resources resulting from construction can be divided into construction-related impacts and impacts related to plant operation. No impacts on paleontological resources are expected to occur from the continuing operation of the SFERP. However, construction-related impacts to paleontological resources could occur as a result of numerous ground disturbing or earth-moving activities during construction. These impacts could be either direct or indirect. Direct impacts would result from grading, excavations for foundations, and augering for concrete pilings at the SFERP site, trenching for burial of the water pipeline, and any other earth-moving activity that disturbed previously undisturbed fossiliferous sediments. Although earth moving associated with construction would be a comparatively short-term activity, the loss of fossil remains, unrecorded fossil sites, associated specimen data and corresponding geologic and geographic site data, and the fossil-bearing strata would be a long-term environmental impact.

Site grading is not expected to result in significant adverse impacts to paleontological resources, as the ground surface in the area is already relatively flat, is covered by artificial fill, and has already been disturbed by previous construction activities. Neither are the support facilities, such as temporary construction offices, proposed laydown area(s), and parking areas, expected to have a significant adverse impact on paleontological resources, as they also would be located on ground previously disturbed and will involve no significant new ground disturbance. However, excavations deeper than the artificial fill at the SFERP site could disturb potentially fossiliferous sediments of the Franciscan Complex, San Antonio Formation, Merritt Sand, and Temescal Formation, all of which have produced significant fossils elsewhere. Deep augering for the placement of concrete piers or foundation piles for SFERP facilities and trenching for burial of the water pipeline could also disturb sediments of the Franciscan Complex, San Antonio Formation, Merritt Sand, and Temescal Formation. In conclusion, project-related ground-disturbing and earth-moving activities could potentially have adverse impacts on significant paleontological resources in any of the sediments and rocks present underlying the proposed SFERP site. However, although each of the stratigraphic units that could be impacted by construction are potentially fossiliferous and any fossils discovered could be significant and scientifically important, the overall probability of earth moving related to SFERP construction having adverse impacts to non-renewable paleontological resources is considered to be low.

8.16.5 Mitigation

8.16.5.1 Environmental Checklist

The Guidelines for the Implementation of CEQA (Public Resources Code Sections 15000 et seq.) include as one of the questions to be answered in the Environmental Checklist (Section 15023, Appendix G, Section XIV, Part a) the following: "Would the project directly or indirectly destroy a unique paleontological resource or site…?" Because of potential adverse impacts on significant paleontological resources resulting from SFERP construction, mitigation measures are necessary.

8.16.5.2 Proposed Mitigation Measures

This section describes applicant-proposed mitigation measures that would be implemented to reduce potential adverse impacts to significant paleontological resources resulting from SFERP construction. These proposed paleontological resource impact mitigation measures would reduce to an insignificant level the direct, indirect, and cumulative adverse environmental impacts on paleontological resources that might result from project construction. The mitigation measures proposed below are in compliance with CEC environmental guidelines (CEC, 2000) and with SVP standard guidelines for mitigating adverse construction-related impacts on paleontological resources (SVP, 1995; 1996).

8.16.5.2.1 Paleontological Monitoring. Prior to construction, a qualified paleontologist will be retained to both design and implement a monitoring and mitigation program. During construction, earth moving construction activities will be monitored where these activities will potentially disturb previously undisturbed sediment. Monitoring will not be conducted in areas where the ground has been previously disturbed, in areas of artificial fill, in areas immediately underlain by serpentinite, or in areas where exposed sediment will be buried, but not otherwise disturbed.

8.16.5.2.2 Paleontological Resource Monitoring and Mitigation Plan. The paleontological resource monitoring and mitigation plan (PRMMP) will include a description of where and when construction monitoring will be required; emergency discovery procedures; sampling and data recovery, if needed; preparation, identification, analysis, and museum curation of any fossil specimens and data recovered; preconstruction coordination; and reporting.

This monitoring and mitigation plan will be consistent with Society of Vertebrate Paleontology standard guidelines for the mitigation of construction-related adverse impacts on paleontological resources (SVP, 1995), as well as the requirements of the designated museum repository for any fossils collected, the University of California Museum of Paleontology at Berkeley.

Scientific recovery, preparation, identification, determination of significance, and curation into a public museum is considered by most land management agencies and by the SVP (1995) to adequately mitigate impacts to paleontological resources in most circumstances. Therefore, the implementation of these mitigation measures would reduce the potentially significant adverse environmental impact of project-related ground disturbance and earth moving on paleontological resources to an insignificant level by allowing for the recovery of fossil remains and associated specimen data and corresponding geologic and geographic site data that otherwise would be lost to earth moving and to unauthorized fossil collecting. With a well designed and implemented paleontological resource monitoring and mitigation plan, project construction could actually result in beneficial impacts on paleontological resources through the possible discovery of fossil remains that would not have been exposed without project construction and, therefore, would not have been available for study. The identification and analysis of fossil remains discovered as part of project construction could help answer important questions regarding the geographic distribution, stratigraphic position, tectonic history, and age of fossiliferous sediments in the San Francisco area.

8.16.5.2.3 Construction Personnel Education. Prior to start of construction, construction personnel involved with earth-moving activities will be informed that fossils may be encountered, on the appearance of fossils, and on proper notification procedures. This worker training will be prepared and presented by a qualified paleontologist.

8.16.5.3 Significant Unavoidable Adverse Impacts

Because potential impacts on paleontological resources resulting from SFERP construction can be mitigated to an insignificant level, the proposed project would not cause significant unavoidable adverse impacts as defined by CEQA.

8.16.5.4 Cumulative Impacts

Disturbance or destruction of paleontological resources during project excavation have the potential to contribute to cumulative impacts. Impacts from this and other projects that may take place in the reasonably foreseeable future could cumulatively result in significant, adverse impacts to paleontological resources. These impacts would include the destruction of nonrenewable paleontological resources as a consequence of disturbance by earth-moving, and the consequent loss of their scientific data and educational potential.

However, if paleontological resources are encountered during project-related ground disturbance, the potential cumulative impacts would be low, as long as the mitigation measures proposed above were fully implemented to recover the resources, they are identified, their significance is determined, a written report is prepared, and they are curated into a public museum. When properly implemented, the mitigation measures proposed above would effectively recover the value to science of any significant fossils discovered during SFERP project construction. Thus, the proposed project would not cause or contribute to significant cumulative impacts to paleontological resources.

8.16.6 Involved Agencies and Agency Contacts

There are no state or local agencies having specific jurisdiction over paleontological resources. The CEQA lead agency having specific responsibility to ensure that paleontological resources are protected in compliance with CEQA and other applicable statutes during construction of the SFERP is the CEC. California Public Resources Code Section 21081.6, entitled Mitigation Monitoring Compliance and Reporting, requires that the CEQA lead agency demonstrate project compliance with mitigation measures developed during the environmental impact review process.

8.16.7 Permits Required and Permit Schedule

No state or local agency requires a paleontological collecting permit to allow for the recovery of fossil remains discovered as a result of construction-related earth moving on private or public lands, except for federal lands. Removal of paleontological resources from federal lands requires a Cultural Resource Use Permit from the Bureau of Land Management. However, since no federal lands are involved in this project, no permits will be required.

8.16.8 References

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