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# 8.16 Paleontological Resources

## 8.16.1 Introduction

Paleontological resources (fossils) are the remains or traces of prehistoric animals and plants. Fossils 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) determining the relative ages of the strata in which they occur and of the geologic events that resulted in the deposition of the sediments that formed these strata and in their subsequent deformation.

This section summarizes the potential environmental impacts on paleontological resources that may result from construction of the CPP. Section 8.16.2 lists the federal and state LORS and the professional standards that protect paleontological resources. Section 8.16.3 describes the existing environment that could be affected by the proposed project. Section 8.16.4 describes the potential impacts on paleontological resources resulting from construction and operation of the proposed project. The cumulative impacts to paleontological resources are discussed in Section 8.16.5. Proposed mitigation measures to reduce potential adverse impacts to paleontological resources are discussed in Section 8.16.6. The involved agencies and agency contacts are provided in Section 8.16.7. Section 8.16.8 discusses the status of permits required and permit schedule. Section 8.16.9 lists the references used in preparing this section.

## 8.16.2 Laws, Ordinances, Regulations, and Standards

Paleontological resources are classified as non-renewable scientific resources and are protected by several federal and state statutes (California Office of Historic Preservation, 1983; Marshall, 1976; Fisk and Spencer, 1994), most notably by the 1906 Federal Antiquities Act and other subsequent federal legislation and policies and by the State of California's environmental regulations (CEQA, Section 15064.5). Professional standards for assessment and mitigation of adverse impacts on paleontological resources have been established by the Society of Vertebrate Paleontology (SVP) (1995, 1996). Design, construction, and operation of the proposed project, including ancillary facilities, will be conducted in accordance with LORS applicable to paleontological resources. Federal and state LORS applicable to paleontological resources are summarized in Table 8.16-1 and discussed briefly below, together with SVP professional standards.

**TABLE 8.16-1**
LORS Applicable to Paleontological Resources

| Project LORS | Applicability | AFC Conformance Section | Conformity |
|---|---|---|---|
| Antiquities Act of 1906 | Protects paleontological resources on federal lands | Section 8.16.6 | Yes |
| CEQA | Fossil remains may be encountered by earth-moving | Section 8.16.6 | Yes |
| Public Resources Code Sections 5097.5/5097.9 | Would apply only if some project land were acquired by the State of California | | Yes |

### 8.16.2.1 Federal

Federal protection for significant paleontological resources would apply to the project if any construction or other related project impacts occurred on federally owned or managed lands. Federal legislative protection for paleontological resources stems 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 land.

### 8.16.2.2 State

The 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 15000 et seq.) with respect to paleontological resources. Guidelines for the Implementation of CEQA, as amended March 29, 1999 (Title 14, Chapter 3, California Code of Regulations: 15000 *et seq*.) define procedures, types of activities, persons, and public agencies required to comply with CEQA, and include as one of the questions to be answered in the Environmental Checklist (Section 15023, Appendix G, Section XIV, Part a) the following: "*Will the proposed project disturb paleontological resources?*"

Other state requirements for paleontological resources management are in Public Resources Code Chapter 1.7, Section 5097.5, Archaeological, Paleontological, and Historical Sites. This statute specifies that state agencies may undertake surveys, excavations, or other operations as necessary on state lands to preserve or record paleontological resources and defines any unauthorized disturbance or removal of a fossil site or remains on public land as a misdemeanor. It would apply to the proposed project only if the state or a state agency were to obtain ownership of project lands during the term of the project license.

### 8.16.2.3 County

Sacramento County does not have mitigation requirements that specifically address potential adverse impacts to paleontological resources.

### 8.16.2.4 Professional Standards

The SVP 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 curation. Most practicing professional paleontologists in the nation adhere closely to the SVP's assessment, mitigation, and monitoring requirements as specifically provided in its standard guidelines. Most California state regulatory agencies accept the SVP standard guidelines as a measure of professional practice.

## 8.16.3 Affected Environment

### 8.16.3.1 Geographic Location

The site proposed for construction of the proposed plant is at the District's existing Rancho Seco Plant in southeastern Sacramento County, approximately 25 miles south-southeast of Sacramento, California. The approximate location is 38° latitude 20' 20" N, 121° longitude 07' 20" W, in south-central Section 29, T. 6 N., R. 8 E. The site is located on the eastern edge of the Sacramento Valley, along the westernmost foothills of the Sierra Nevada, and just north of the geographic center of the state of California. The Sacramento Valley comprises roughly the northern third of the major north-northwest oriented synclinorium called either Valle Grande (Clark, 1929), Great Valley (Fenneman, 1931; Hackel, 1966), Central Valley (Jahns, 1954), Great Central Valley (Piper et al., 1939; Davis et al., 1957), or California Trough (Piper et al., 1939). The Central Valley Physiographic Province is located between the Sierra Nevada Physiographic Province on the east and the Coast Ranges Physiographic Province on the west. The general project area is bounded on the west by the floodplain of the Sacramento River and on the east by a gently inclined alluvial fan, which heads in the Sierra Nevada. Most of the project area is rural rangeland with relatively sparse native grass cover, but with increasing development of grape vineyards. The proposed project is located in the U. S. Geological Survey Clay and Goose Creek 7.5-minute (1:24,000 scale) Quadrangles.

### 8.16.3.2 Regional Geologic Setting

The geology in the vicinity of the proposed project site has been mapped or described by numerous workers, including Bryan (1923); Gale et al. (1938); Piper et al. (1939); Olmsted and Davis (1961); Strand and Koenig (1965); Hansen and Begg (1970); Bartow and Marchand (1979); Marchand and Allwardt (1981); and Wagner et al. (1981). Surficial geologic mapping of the project site and vicinity has been provided at a scale of 1:1,000,000 by Wahrhaftig et al. (1993); at a scale of 1:500,000 by Jenkins (1938); at a scale of 1:250,000 by Olmsted and Davis (1961), Strand and Koenig (1965), and Wagner et al. (1981); at a scale of 1:100,000 by the California Department of Water Resources (1973); at a scale of 1:63,360 by Gale et al. (1938); and at a scale of 1:62,500 by Bartow and Marchand (1979). No 1:24,000-scale geologic maps are currently available for this area. The information in geologic maps and other published and unpublished reports form the basis of the following discussion. Individual maps and publications are incorporated into this AFC and referenced where appropriate. The site-specific geology of the CPP site is discussed in Section 8.16.3.6. The aspects of geology pertinent to this AFC are the types, distribution, and age of sediments immediately underlying the project area and their probability of producing fossils during project construction.

The east side of the Central Valley is a nearly continuous series of coalescing alluvial fans, with their apices located where streams drain the west slope of the Sierra Nevada. These low relief alluvial fans form a continuous belt between the dissected uplands of the Sierra Nevada and the nearly flat surface of the valley bottom. They are composed of undeformed to slightly deformed alluvial deposits laid down primarily during Plio-Pleistocene time by the streams that drain the adjacent uplands of the Sierra Nevada. Each alluvial fan consists of a mass of coarse to fine rock debris that splays outward from the mouth of its primary stream channel onto the valley floor as a fan-like deposit of well-sorted sand and gravel encased in a matrix of finer sediments, chiefly poorly sorted fine sand, and silt deposited away from the stream channels on the alluvial plain. Our current interpretations and understanding of the alluvial deposits of major Sierran rivers lies in Arkley’s (1962, 1964) studies of the Merced, Tuolumne, and Stanislaus River fans, Janda’s (1966; Janda and Croft, 1965) study of alluvium of the upper San Joaquin River, Shlemon’s (1967) study of the American River fan, and Atwater’s (1980) studies of the Mokelumne River fan.

The alluvial deposits accumulated on Central Valley alluvial fans consist of medium- to fine-grained sediment eroded from the Tertiary and older volcanic, plutonic, and metamorphic rocks in the mountains to the east (Clark, 1964). The alluvial fan deposits grade west- and southwest-ward through gradually decreasing grain sizes from coarse pebble to cobble gravel at the Sierra Nevada foothills to clay-rich silt on the Sacramento and San Joaquin River flood plains. The gravel, sand, and silt that compose these alluvial fans have in the past produced abundant fossils, primarily large land mammals such as mammoths, mastodons, camels, bison, and horses. These paleontological resources are discussed below.

In the project vicinity, an alluvial fan has been created by rock debris deposited by the Cosumnes River, Laguna Creek, and adjacent smaller streams, all of which drain off the foothills of the Sierra Nevada Range. Geological materials composing the Cosumnes River alluvial fan have been subdivided into stratigraphic units differently by different geologists.

The task of subdividing alluvial fan deposits into formal stratigraphic units is complicated by that fact that alluvial sediments are often lithologically similar. Davis and Hall (1959) addressed this problem by stating:

> "*An important problem in attempting to differentiate geologic units in alluvial areas is that the sediments often are derived from a common source and are deposited in similar environments. All or nearly all of the alluvium of the east side of the San Joaquin Valley is derived from granitic and associated rocks of the Sierra Nevada which lie to the east. Thus, the formations offer no textural or lithologic basis for subdivision. Nevertheless, the use of the topographic expression of the units in conjunction with the development of their soils makes it possible to define formations.*"

In the project vicinity, sediments composing the Cosumnes River alluvial fan have been divided into four stratigraphic units, from youngest to oldest:

- Weakly cemented siltstone, sandstone, and conglomerate of the Pliocene Laguna Formation exposed only on the upper alluvial fan
- Coarser but otherwise similar sediments of the Early Pleistocene Turlock Lake Formation
- A slightly younger and less consolidated, sedimentary sequence mapped as Middle Pleistocene to Early Holocene Riverbank Formation, Modesto Formation, or "Modesto/Riverbank formations undivided"
- The Turlock Lake and Laguna Formation on the lower portion of the alluvial fan. Each of these stratigraphic units has yielded fossil remains at previously recorded fossil localities within the Central Valley

The Pliocene age Laguna Formation includes the oldest alluvium within the Cosumnes River alluvial fan, but is not easily distinguished from younger alluvial deposits that overlay this unit. The principal differences between the younger and older alluvial sediments are stratigraphic position, degree of consolidation, topographic expression, attitude (tilted versus flat-lying), and fossil content. According to Savage (1951), sediments in the greater San Francisco Bay area containing Late Pleistocene and Holocene fossil faunas can often be distinguished from Pliocene and older Pleistocene sediments by their relatively flat-lying attitude, while, in contrast, the older sediments containing Pliocene (Blancan North American Land Mammal Age (NALMA)) and Early to Middle Pleistocene (Irvingtonian NALMA) fossil faunas are often slightly tilted. This criterion has also been helpful to others in distinguishing older alluvium from younger alluvium (see for instance, Taliaferro, 1951; Davis et al., 1957; Hall, 1958; and Helley et al., 1972).

On the Cosumnes River alluvial fan, the Turlock Lake Formation has a discontinuous distribution. It is represented primarily by gravel to cobble-size clasts in a coarse sand matrix originally named the "Arroyo Seco Gravel" by Piper et al. (1939). The Turlock Lake Formation typically forms a thin gravel veneer overlying the Laguna Formation on what has been interpreted as a pediment surface by most geologists working in the area. Since this unit is not present at the proposed project site and will not be impacted by project construction, it will not be discussed further in this section.

The Quaternary alluvium of the Cosumnes River alluvial fan assigned to the Riverbank and Modesto Formations is lithologically indistinct from the underlying Laguna Formation, but can be distinguished from it by stratigraphic position, degree of cementation and therefore topographic expression, amount of deformation, and age. The Laguna Formation is believed to be Pliocene to possibly Early Pleistocene in age, while the age of the Riverbank Formation is probably Middle to Late Pleistocene, and the Modesto Formation is Late Pleistocene to possibly Early Holocene in age. Strata comprising both the Laguna Formation and Riverbank Formation have been deformed by tectonic activity related to uplift of the Sierra Nevada and can often be recognized from the overlying Modesto Formation by their non-flat-lying attitude. Because of its greater cementation, the older stratigraphic units also often have a distinct topographic expression. As Plio-Pleistocene uplift of the Sierra Nevada occurred, it left exposed alluvial sediments of the Laguna and Riverbank Formations. As streams cut through these older deposits, remnants were preserved as topographic highs capped by gravels of the Turlock Lake Formation and with valleys filled with Modesto Formation.

### 8.16.3.3 Resource Inventory Methods

To develop a baseline paleontological resource inventory of the proposed project site and surrounding area and to assess the potential paleontological productivity of each stratigraphic unit present, the published and available unpublished geological and paleontological literature was reviewed; and stratigraphic and paleontologic inventories were compiled, synthesized, and evaluated (see below). These methods are consistent with CEC (2000) and SVP (1995) guidelines for assessing the importance of paleontological resources in areas of potential environmental effect. No subsurface exploration was conducted for this assessment. Stratigraphy was observed in numerous road cuts, railroad cuts, and stream banks during site surveys on July 14 and July 28, 2001.

Geologic maps and reports covering the bedrock and surficial geology of the project site and vicinity were reviewed to determine the exposed and subsurface rock units, to assess the potential paleontological productivity of each rock unit, and to delineate their respective areal distribution in the project area. In addition, available soil surveys and aerial photographs of the area were examined to aid in determining the areal distribution of distinctive sediment and soil types.

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 were evaluated based on published and unpublished geological and paleontological literature (including previous environmental impact assessment documents and paleontological resource impact mitigation program final reports). The literature review was supplemented by archival searches conducted at the University of California Museum of Paleontology (UCMP) in Berkeley, California, for additional information regarding the occurrence of fossil sites and remains in and near the project site.

Field surveys, which included a visual inspection of exposures of potentially fossiliferous strata in the project area, were conducted to document the presence of sediments suitable for containing fossil remains and the presence of any previously unrecorded fossil sites. The field surveys for this assessment were conducted on July 14 and July 28, 2001 by Lanny H. Fisk, Ph.D, RG, senior paleontologist with PaleoResource Consultants (PRC).

#### 8.16.3.4 Qualifications of Surveyor of Paleontological Resources

This paleontological resources inventory and impact assessment was prepared by Dr. Lanny H. Fisk, a California registered geologist, senior paleontologist, and a principal of PRC. It meets all CEC requirements (CEC, 2000), regulations, and the standard measures for mitigating adverse construction-related environmental impacts on significant paleontological resources established by the Society of Vertebrate Paleontology (SVP, 1995, 1996).

#### 8.16.3.5 Paleontological Resource Assessment Criteria

A paleontological resource can be significant if:

- It provides important information on the evolutionary trends among organisms, relating living organisms to extinct organisms.
- It provides important information regarding development of biological communities or interaction between botanical and zoological biota.
- It demonstrates unusual circumstances in biotic history.
- It is in short supply and in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and is not found in other geographic localities.

Under CEQA guidelines, (PRC 15064.5 (a) (2)), public agencies must treat all historical and cultural resources as significant unless the preponderance of evidence demonstrates that they are not historically or culturally significant. In keeping with significance criteria of the SVP (1995), all vertebrate fossils are categorized as having significant scientific value.

The SVP, in common with other environmental disciplines such as archeology and biology (specifically in regard to listed species), considers any fossil specimen significant, unless demonstrated otherwise, and, therefore, protected by environmental statutes. This position is held because vertebrate fossils are uncommon and only rarely will a fossil locality yield a statistically significant number of specimens representing the same species. In fact, vertebrate fossils are so uncommon that, in most cases, each fossil specimen found will provide additional important information about the characteristics or distribution of the species it represents.

A stratigraphic unit (such as a formation, member, or bed) known to contain significant fossils is considered to be "sensitive" to adverse impacts if there is a high probability that earth-moving or ground-disturbing activities in that rock unit will either disturb or destroy fossil remains. This definition of sensitivity differs fundamentally from that for archeological resources:

> *"It is very important to make the distinction between archaeologic resource sites and paleontologic resource sites when defining sensitivity. Archaeologic site boundaries define the limit of the extent of the resource. Paleontologic sites, however, serve as indicators that the sedimentary unit or formation in which they are found is fossiliferous. The boundaries of an entire fossiliferous formation, therefore, define the limits of paleontologic sensitivity in a given region"* (SVP, 1991).

This distinction between archeological and paleontological sites is important. Most archeological sites have a surface expression that allow for their geographic location. Fossils, on the other hand, are an integral component of the rock unit below the ground surface, and, therefore, are not observable unless exposed by erosion or human activity. Thus, a paleontologist cannot know either the quality or quantity of fossils present before the rock unit is exposed as a result of natural erosion processes or earth-moving activities. The paleontologist can only make conclusions on sensitivity to impact based upon what fossils have been found in the rock unit in the past, along with a judgment on whether or not the depositional environment of the sediments that compose the rock unit was likely to result in the burial and preservation of fossils.

Fossils are seldom uniformly distributed within a rock unit. Most of a rock unit may lack fossils, but at other locations within the same rock unit concentrations of fossils may exist. Even within a fossiliferous portion of the rock unit, fossils may occur in local concentrations. For example, Shipman (1977, 1981) excavated a fossiliferous site using a three dimensional grid and removed blocks of matrix of a consistent size. The site chosen was known prior to excavation to be richly fossiliferous, yet only 17 percent of the blocks actually contained fossils. These studies demonstrate the physical basis for the difficulty in predicting the location and quantity of fossils in advance of project-related ground disturbance.

Since it is unfortunately not possible to determine where fossils are located without actually disturbing a rock unit, monitoring of excavation by an experienced paleontologist during construction increases the probability that fossils will be discovered and preserved. Preconstruction mitigation measures such as surface prospecting and collecting will not prevent adverse impacts on fossils because many sites will be unknown in advance due to an absence of fossils at the surface.

The non-uniform distribution of fossils within a rock unit is essentially universal and many paleontological resource assessment and mitigation reports conducted in support of environmental impact documents and mitigation plan summary reports document similar findings (see for instance Lander, 1989, 1993; Reynolds, 1987, 1990; Spencer, 1990; Fisk et al., 1994; and references cited therein). In fact, most fossil sites recorded in reports of impact mitigation (where construction monitoring has been implemented) had no previous surface expression. Because the presence or location of fossils within a rock unit cannot be known without exposure resulting from erosion or excavation, under SVP (1991, 1995) standard guidelines, an entire rock unit is assigned the same level of sensitivity based on recorded fossil occurrences.

Using SVP (1991, 1995) criteria, the paleontological importance or sensitivity (high, low, or undetermined) of each rock unit exposed in a project site or surrounding area is the measure most amenable to assessing the significance of paleontological resources because the areal distribution of each rock unit can be delineated on a topographic or geologic map. The paleontological importance of a stratigraphic unit reflects: (1) its potential paleontological productivity (and thus sensitivity), and (2) the scientific significance of the fossils it has produced. This method of paleontological resources assessment is the most appropriate because discrete levels of paleontological importance can be delineated on a topographic or geologic map.

The potential paleontological productivity of a stratigraphic unit exposed in a project area is based on the abundance/densities of fossil specimens and/or previously recorded fossil sites in exposures of the unit in and near a project site. The underlying assumption of this assessment method is that exposures of a stratigraphic unit in a project site are most likely to yield fossil remains both in quantity and density similar to those previously recorded from that stratigraphic unit in and near the project site.

An individual fossil specimen is considered scientifically important if it is:

- Identifiable
- Complete
- Well preserved
- Age diagnostic
- Useful in paleoenvironmental reconstruction
- A type or topotypic specimen
- A member of a rare species
- A species that is part of a diverse assemblage
- A skeletal element different from, or a specimen more complete than, those now available for that species

Identifiable land mammal fossils are considered scientifically important because of their potential use in providing 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 animals for paleoenvironmental reconstructions. For marine sediments, invertebrate and marine algal 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 density 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 area surrounding the project site.

#### 8.16.3.5.1 Categories of Sensitivity

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.

***High Sensitivity.*** Stratigraphic units in which fossils have been previously found have a high potential to produce additional fossils and are, therefore, considered to be highly sensitive. In areas of high sensitivity, full-time monitoring is recommended during any project-related ground disturbance.

***Low Sensitivity.*** Stratigraphic units that are not sedimentary in origin or that have not been known to produce fossils in the past are considered to have low sensitivity. Monitoring is usually not recommended nor needed during project construction through a stratigraphic unit with low sensitivity.

***Undetermined Sensitivity.*** Stratigraphic units that have not had any previous paleontological resource surveys or any fossil finds are considered to have undetermined sensitivity. After reconnaissance surveys, observation of artificial exposures (such as road cuts) and natural exposures (such as stream banks), and possible subsurface testing (such as augering or trenching), an experienced, professional paleontologist can often determine whether the stratigraphic unit should be categorized as having high or low sensitivity.

In keeping with the significance criteria of the SVP (1995), all vertebrate fossils are categorized as having significant scientific value and all stratigraphic units in which vertebrate fossils have previously been found have high sensitivity.

### 8.16.3.6 Resource Inventory Results

**Stratigraphic Inventory.** Regional geologic mapping of the District's proposed project site and vicinity has been provided by Wahrhaftig et al. (1993; 1:1,000,000 scale), Jenkins (1938; 1:500,000 scale), Strand and Koenig (1965; 1:250,000 scale), and Wagner et al. (1981, 1:250,000 scale). Larger scale mapping of the project site has been provided by California Department of Water Resources (1973; 1:100,000 scale), Gale et al. (1938; 1:63,360 scale), and Bartow and Marchand (1979; 1:62,500 scale). Unfortunately, in their geologic maps of the Late Cenozoic deposits of the project area, geologists have not always used formally named stratigraphic units, nor have they consistently used the same map units.

Gale et al. (1938, 1:63,360 scale) and Piper et al. (1939) published the first detailed map and descriptions of Quaternary sediments in southeastern Sacramento County. They named the Pliocene strata the Laguna Formation and the Pleistocene strata the Victor Formation. Davis and Hall (1959) subdivided Pleistocene sediments equivalent to the Victor Formation into the Turlock Lake, Riverbank, and Modesto formations, from oldest to youngest. These formation names were later extended into Sacramento County by Shlemon (1967, 1971). Later, Marchand and Allwardt (1981) proposed that the name “Victor Formation” be abandoned and that the Turlock Lake, Riverbank, and Modesto formations be accepted as uniform stratigraphic nomenclature for Quaternary deposits in the area; their recommendations have been followed by most later workers (see for instance Helley and Harwood, 1985) and are followed in this AFC.

Strand and Koenig (1965, 1:250,000 scale) mapped the area in the vicinity of the proposed project as “Plio-Pleistocene non-marine” with Holocene “fan deposits” along stream valleys. The California Department of Water Resources (1973, 1:100,000 scale) mapped the area as Laguna Formation overlain by “Arroyo Seco Gravels” (now considered part of the Turlock Lake Formation), with unnamed Quaternary alluvium along stream valleys. Wagner et al. (1981, 1:250,000 scale) mapped the area as Laguna Formation with “Modesto-Riverbank formations undivided” along stream valleys. Finally, in their more detailed geologic mapping, Bartow and Marchand (1979, 1:62,500 scale) showed that the project site and surrounding hills are underlain by Laguna Formation and they subdivided the Quaternary alluvium into the Riverbank Formation and Modesto Formation.

Bartow and Marchand’s (1979) interpretation of the geology at the project site is supported by soil surveys (Weir, 1950; Cole et al., 1954). Soil maps of the project site indicate significant changes in soil types corresponding to changes in the underlying geology. For instance, soils over most of the project property have been mapped as “Pentz-Redding gravelly loam” (Weir, 1950) or “Redding gravelly loam” (Cole et al., 1954), except for a narrow band along both sides of the unnamed stream at the northeast edge of the project site, which was mapped by both Weir (1950) and Cole et al. (1954) as “Bear Creek gravelly loam.” Cole et al. (1954) stated that “Bear Creek gravelly loam” soils developed on flood plains and recent alluvial fans and was derived chiefly from the older Redding Series soils. Cole et al. (1954) wrote: “*At depths ranging from 30 inches to more than 6 feet, this material* [soil referred to as Bear Creek gravelly loam] *normally rests on a somewhat consolidated formation similar to that underlying the Redding soils*.” These soil descriptions support the interpretation that soils referred to the Redding (or Pentz-Redding) gravelly loam formed on older alluvium of the Laguna and Riverbank Formations, while soils referred to the Bear Creek gravelly loam formed on younger alluvium of the Modesto Formation. Thus, the geologic map of Bartow and Marchand (1979) and the soil maps of both Weir (1950) and Cole et al. (1954) are in excellent agreement that the project site is underlain by sediments of the Laguna, Riverbank, and Modesto formations.

An additional line of evidence in support of this interpretation comes from geomorphology. Aerial photos clearly show that the surface of most of the project area is covered by “mima mound microrelief” (Cole et al., 1954), also known as “hummocky microrelief” (Cole et al., 1954; Harradine, 1963), and “hogwallow microrelief” (Weir, 1950). Mima mounds (also known as prairie mounds, pimple mounds, and locally as hog wallows) are enigmatic and controversial geomorphic features consisting of small dome-like mounds of earth forming a more-or-less evenly spaced pattern over the surface. Individual mounds typically range in size from 10 to 20 feet in diameter and from 2 to 6 feet in height. Each mound is composed of loose sediment surrounded by and separated from adjacent mounds by rock or gravel. The genesis of mima mounds is a controversial subject; numerous and diverse explanations have been proposed for their formation. Popular interpretations of their origin range from mounds of soil formed around ancient colonial rodent burrows, to mounds left after erosion of ice-wedged soils on the margins of permafrost polygons on patterned ground, to preservational features left at sites of evenly spaced plants such as sagebrush that during their life time preserved the mound of loose soil from erosion. In the Central Valley of California, Page et al. (1977) noted that mima mounds occur in soils formed on older sediments, such as the Pliocene Laguna Formation and Middle Pleistocene Riverbank Formation, but do not occur in soils on Late Pleistocene or Holocene sediments, such as the Modesto Formation. Thus, the presence of mima mounds over most of the project site, except for a narrow band along the unnamed creek, supports the interpretation that the stratigraphic unit underlying the mima mounds is not as young as the Modesto Formation, while the stratigraphic unit along the unnamed creek in the valley bottom is the Modesto Formation.

Fortunately, the difficulty in assigning a name to a stratigraphic unit does not affect its potential for producing significant paleontological resources. It only makes it more difficult to compare descriptions of fossil sites, which typically use either formally named stratigraphic units (formations and members) or NALMA, such as Blancan, Irvingtonian, or Rancholabrean.

#### *8.16.3.6.1 Site Geology*

Detailed geologic mapping by Bartow and Marchand (1979, 1:62,500 scale) indicates that the project site is underlain by continental deposits of the Laguna Formation of Pliocene age, Riverbank Formation of Middle Pleistocene age, and Modesto Formation of Late Pleistocene age. Sediments of all three formations have yielded fossilized remains of extinct species of continental vertebrates at numerous previously recorded fossil sites in the Central Valley (Fisk, 2000).

Starting from the southwest corner of the proposed site and going toward the northeast, there is a gently sloping surface consisting of first Laguna Formation, then Riverbank Formation, and finally Modesto Formation in the floodplain of the unnamed stream that borders the property. Each younger formation overlaps and forms a relatively thin sedimentary deposit over the next older formation. Thus, where the Riverbank or Modesto Formation is present at the surface of the project site, the older Laguna Formation may still be encountered in deep excavations.

#### *8.16.3.6.2 Laguna Formation*

The Laguna Formation was named by Piper et al. (1939), who designated the type section one mile northeast of Clay. This location is only 1.25 miles northwest of the proposed project site (see Figure 8.16-1, filed confidentially under separate cover). The Laguna Formation is composed of interbedded and poorly sorted, reddish-brown siltstone and sandstone with lenses of pebble to cobble conglomerate. Locally these sediments are well cemented with calcareous and/or hematite cements, but in other nearby locations they are only slightly cemented. These beds are primarily fluvial (stream) deposits, but lacustrine (lake) beds are not uncommon. The Laguna formation is Pliocene in age based on stratigraphic superposition and age-diagnostic fossils.

#### *8.16.3.6.3 Riverbank Formation*

The Riverbank Formation was first named by Davis and Hall (1959), who designated a type section along the south bluff of the Stanislaus River within the City of Riverbank. This formation consists of weakly consolidated reddish-brown siltstones, sandstones, and pebble conglomerates with a few thin intervals of brick-red claystone. Marchand and Allwardt (1981) placed the age of the Riverbank Formation between 130,000 and 450,000 years BP, Middle Pleistocene.

#### *8.16.3.6.4 Modesto Formation*

The Late Pleistocene Modesto Formation was first named by Davis and Hall (1959), who designated a type section along the south bluff of the Tuolumne River at the south edge of the City of Modesto. The Modesto Formation is composed of interbedded, largely unconsolidated, and poorly sorted, brownish sandstone and siltstone with lesser amounts of pebble to cobble conglomerate. These beds are primarily fluvial deposits and are believed to represent the depositional cycle between two major glacial stages in the Sierra Nevada (Davis and Hall, 1959; Hall, 1960; Marchand and Allwardt, 1981). Marchand and Allwardt (1981) gave the age of the Modesto Formation between about 12,000 and 42,400 years BP, Late Pleistocene.

### 8.16.3.7 Paleontological Resource Inventory

An inventory of the paleontologic resources of each rock unit exposed at 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 actual project site. However, a number of fossil sites were documented as occurring in sediments of the Laguna, Riverbank, and Modesto formations in other exposures of these formations. In addition, fossil remains were found at several previously unrecorded fossil sites during the field survey of the proposed project site and vicinity conducted for this assessment.

Numerous vertebrate fossil localities have been reported from sediments referable to the Laguna, Riverbank, and Modesto formations in the general vicinity of the proposed site. Surveys of Pliocene and Quaternary land mammal fossils have been made by Merriam (1915a, 1915b, 1917), 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). Mammalian fossils have been the most helpful in determining the relative age of alluvial fan sedimentary deposits (Louderback, 1951; Savage, 1951).

#### *8.16.3.7.1 Laguna Formation*

The Laguna Formation has yielded fossil remains at numerous sites in the Central Valley. These remains include petrified wood and the bones and teeth of a diversity of extinct land mammals. Hay (1927) reported teeth and bones of mammoths, bones of horses, and a tooth of a camel from sediments that Piper et al. (1939) interpreted as probably equivalent to the Laguna Formation. Piper et al. (1939) also reported a horse tooth from a site 4 miles northeast of Galt in Laguna Formation sediments. During a field survey of prospective fossiliferous sediments near the project site on July 14 and July 28, 2001, weathered bones of small land mammals, silicified wood, burrow casts, and root casts were found in the Laguna Formation in road cuts along the entrance road to the Rancho Seco Plant, the road to Rancho Seco Park, and along Clay East Road (see confidential Figure 8.16-1). All of these localities are within one mile of the proposed project site.

In summary, sediments referable to the Laguna Formation have yielded scientifically significant fossils in the past and several previously unrecorded fossil localities were found less than one mile from the proposed project site. Although no fossils are known to directly underlie the proposed project site, the presence of fossil sites in the Laguna Formation within one mile of the proposed project site suggests that there is a high potential for fossil remains to be uncovered by excavations at the proposed site. Because this unit in the past has produced significant fossils, under SVP (1995) criteria, the Laguna Formation is judged to have high sensitivity. Additional identifiable fossil remains recovered from the Laguna Formation during project construction would be scientifically important and significant.

#### *8.16.3.7.2 Riverbank Formation*

Fossil vertebrates have been previously reported from Riverbank Formation sediments near their type area (Garber, 1989; Jefferson, 1991b) and at numerous other scattered locations (Fisk and Lander, 1999; Lander, 1999). Fossils previously reported from the Riverbank Formation include clams, fish, turtles, frogs, snakes, birds (including geese), bison, mammoths, mastodons, ground sloths, camels, horses, deer, dire wolves, coyotes, rabbits, rodents, and land plant remains (including wood, leaves, and seeds) (see compilation in Fisk, 2001). Marchand and Allwardt (1981) have reported additional unidentified bones and petrified wood. A Pleistocene horse (*Equus*) tooth was collected from approximately 1.2 miles west of Herald in sediments of the Riverbank Formation (UCMP locality V-3524). These fossil remains from the Riverbank Formation are scientifically highly significant because the taxa they represent previously had been unreported or only very rarely reported from the fossil record of California. Moreover, continental vertebrate remains are comparatively rare in the fossil record. In addition, paleontological data derived from a study of the fossil remains, in conjunction with geologic (particularly geochronologic, sedimentologic, and paleomagnetic) evidence, have been significant in documenting the origin and age of the Riverbank Formation and in reconstructing the Pleistocene geologic history of the Sacramento Valley and Sierra Nevada.

Since fossil vertebrates have been previously reported from this formation and since depositional conditions appear to be favorable for the preservation of fossils, the Riverbank Formation is judged to have high sensitivity. There is a high probability of adverse impacts on paleontological resources resulting from ground disturbance during construction of the proposed plant in sediments of the Riverbank Formation.

#### *8.16.3.7.3 Modesto Formation*

Fossil vertebrates of Rancholabrean land-mammal age and fossil wood have previously been reported from sediments of the Modesto Formation near its type area (Garber, 1989; Jefferson, 1991b; Marchand and Allwardt, 1981) and at numerous other scattered locations along the east side of the Central Valley (Fisk and Lander, 1999; Lander, 1999). Jefferson (1991a, 1991b) compiled a data base of California Pleistocene (primarily Rancholabrean NALMA) 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 seven sites in Sacramento County that yielded Rancholabrean vertebrate fossils, including several UCMP localities. Some, if not all, these fossil sites would presumably be referable to the Modesto Formation. The mammals previously collected from this stratigraphic unit include mammoths, bison, horses, camels, ground sloths, and various rodents (Jefferson, 1991b; UCMP records). The age of these Late Pleistocene Rancholabrean faunas is primarily based on the presence of *Bison*, along with many mammalian species that are inhabitants of the same area today. Since it is likely that additional significant paleontological resources will be found in sediments of the Modesto Formation, this stratigraphic unit has high sensitivity for paleontological resources.

#### *8.16.3.7.4 Summary*

Although no fossils are known to directly underlie the proposed project site, the presence of fossil sites in alluvial deposits of the Laguna, Riverbank, and Modesto formation elsewhere suggests that there is a high potential for additional similar fossil remains to be uncovered by excavations in these formations during project construction. Under SVP (1995) criteria, all three formations have a high sensitivity for producing additional paleontological resources. Identifiable fossil remains recovered from any or all three formations during project construction would be scientifically important and significant.

Identifiable fossil remains recovered during project construction could represent new taxa or new fossil records for the area, for the state of California, or for a formation. They could also represent geographic or temporal range extensions. Moreover, discovered fossil remains could make it possible to more accurately determine the age, paleoclimate, and depositional environment of the sediments from which they are recovered. Finally, fossil remains recovered during project construction could provide a more comprehensive documentation of the diversity of animal and plant life that once existed in Sacramento County and could result in a more accurate reconstruction of the geologic history of the Central Valley and Sierra Nevada.

## 8.16.4 Environmental Consequences

Potential impacts on paleontological resources resulting from construction of the proposed project can be divided into construction-related impacts and operation-related impacts. Construction-related impacts to paleontological resources primarily involve terrain modification (excavations and drainage diversion measures). Paleontologic resources, including an undetermined number of fossil remains and unrecorded fossil sites; associated specimen data and corresponding geologic and geographic site data; and the fossil-bearing strata, could be adversely affected by (i. e., would be sensitive to) ground disturbance and earth moving associated with construction of the project. Direct impacts would result from vegetation clearing, grading of roads and the generating facility site, trenching for pipelines, augering for foundations for electrical towers or poles, and any other earth-moving activity that disturbs or buries previously undisturbed fossiliferous sediments, making those sediments and their paleontologic resources unavailable for future scientific investigation. The potential environmental effects from construction and operation of the project on paleontological resources are presented in the following subsections.

### 8.16.4.1 Potential Impacts from Project Construction

The proposed project site is located on Pliocene, Pleistocene, and Holocene-age alluvial deposits of the fossiliferous Laguna, Riverbank, and Modesto formations. The planned site clearing, grading, and deeper excavation at the site are expected to result in significant adverse impacts to paleontological resources. In addition, the construction of supporting facilities, such as temporary construction offices, laydown area, and parking areas, have potential to cause adverse impacts on significant paleontological resources, as they also will involve significant new ground disturbance. Likewise, deeper excavations at the plant site for foundations for turbines, trenching for the natural gas pipeline, the water supply pipeline, and electrical transmission line would disturb Pliocene, Pleistocene, and Holocene alluvium that contains vertebrate fossils elsewhere. Thus, any project-related ground disturbance could have adverse impacts on significant paleontological resources.

### 8.16.4.2 Potential Impacts from Project Operation

No impacts on paleontological resources are expected to occur from the continuing operation of the project or any of its related facilities.

## 8.16.5 Cumulative Impacts

If the project were to encounter paleontological finds during construction, the potential cumulative effect would be low, as long as mitigative measures were implemented to recover the resources. The mitigative measures proposed in Section 8.16.6 would effectively recover the value to science of significant fossils recovered.

## 8.16.6 Mitigation Measures

This section describes proposed mitigation measures that will be implemented to reduce potential adverse impacts to significant paleontological resources resulting from project construction. Mitigation measures are necessary because of potential adverse impacts of project construction on significant paleontological resources within the Laguna, Riverbank, and Modesto formations. The proposed paleontologic resource impact mitigation program would reduce, to an insignificant level, the direct, indirect, and cumulative adverse environmental impacts on paleontologic resources that could result from project construction. The mitigation measures proposed below for the project are consistent with CEC environmental guidelines (CEC, 2000) and with SVP standard guidelines for mitigating adverse construction-related impacts on paleontologic resources (SVP 1995, 1996).

Prior to construction, a qualified paleontologist will be retained to both design a monitoring and mitigation program and implement the program during project-related earth-moving activities at the generating facility site, for deep boring for electrical transmission towers, and for construction of the water and natural gas pipelines, and for all other project-related ground disturbance. The paleontological resource monitoring and mitigation program will include construction monitoring; emergency discovery procedures; sampling and data recovery, if needed; museum storage of any specimen and data recovered; preconstruction coordination; and reporting. Prior to the start of construction, the paleontologist will conduct a field survey of exposures of sensitive stratigraphic units within the construction site that will be disturbed. Earth-moving construction activities will be monitored where this activity will disturb previously undisturbed sediment. Monitoring will not be conducted in areas where the ground has been previously disturbed or in areas where exposed sediment will be buried, but not otherwise disturbed.

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

Implementation of these mitigation measures will reduce the potentially significant adverse environmental impact of ground disturbance and earth-moving on paleontological resources of the proposed project site 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 might 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 effects on paleontological resources through the recovery of fossil remains that would not have been exposed without project construction and, therefore, would not have been available for study. The recovery of fossil remains as part of project construction could help answer important questions regarding the geographic distribution, stratigraphic position, and age of fossiliferous sediments in the project area.

## 8.16.7 Involved Agencies and Agency Contacts

There are no state or local agencies having specific jurisdiction over paleontological resources.

## 8.16.8 Permits Required and Permit Schedule

No state or county agency requires a paleontological collecting permit to allow for the recovery of fossil remains discovered as a result of construction-related earth moving on state or private land in a project site.

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**FIGURE 8.16-1**
**Confidential Paleontological Figure**