Section 12
Paleontological Resources

This section describes the paleontological resources located in the study area and the potential changes that could occur as a result of implementing the Delta Plan and the project alternatives. It describes the environmental setting, potential environmental impacts, and proposed mitigation measures.

The Delta Plan (the Proposed Project) does not propose implementation any particular physical project; rather it seeks to influence, either through limited policy regulation or through recommendations, other agencies to take certain actions that will lead to achieving the dual goals of Delta ecosystem protection and water supply reliability. Those actions, if taken, could lead to physical changes in the environment. This is described in more detail in part 2.1 of Section 2A, Proposed Project and Alternatives, and in Section 2B, Introduction to Resource Sections.

The types of activities that may occur and that could affect paleontological resources with implementation of Delta Plan-encouraged projects consist of construction work such as earth moving, excavation of fill, importing and exporting fill material, pile driving, dredging, and other ground disturbing activities. These impacts would be associated with water supply reliability, ecosystem restoration, water quality improvement, flood risk reduction, and recreation actions primarily in the Delta and to a lesser extent in areas outside the Delta that use Delta water. Construction-related impacts would be potentially significant (there would be no operations-related impacts), but mitigation is available that could reduce those impacts to less than significant. The Delta Stewardship Council (Council) does not have the authority to require the adoption of mitigation in all cases. Therefore, some construction activities conducted by other agencies on the basis of Delta Plan recommendations (i.e., activities that are not covered actions), may not be mitigated to a less-than-significant level.

12.1 Study Area

The study area is defined as the geographical area in which the majority of potential impacts are expected to occur. Facilities could be constructed, modified, or reoperated in the Delta (the majority), Delta watershed, or areas located outside the Delta that use Delta water. It is unclear where actions would be located. The Delta is the focus of the Delta Plan so the environmental setting for this resource is focused on the legal Delta and Suisun Marsh, although other areas are also covered.

12.2 Regulatory Framework

Appendix D provides an overview of the plans, policies, and regulations relating to paleontological resources within the study area.

12.3 Environmental Setting

This section describes the paleontological resources that could be potentially affected as a result of adopting the Delta Plan or implementing the alternatives.

Paleontological resources, typically called fossils, are the remains of prehistoric plants and animals found in ancient sediments (either unconsolidated or lithified). Fossils are considered nonrenewable scientific and educational resources and are protected by State and federal laws, including the California Environmental Quality Act (CEQA) and the Antiquities Act. Fossils include the bones and teeth of animals, the casts and molds of ancient burrows and animal tracks, and very small remains such as the bones of birds and rodents. They also include plant remains such as logs, prehistoric leaf litter, and seeds. Specimens recovered in the Delta area in the past range from more than 65 million years ago (mya) (such as the shells of marine invertebrates that occupied the Mesozoic seas before this part of California was uplifted and accreted to the North American continent) to less than 200,000 years ago (such as the bones and teeth of extinct Pleistocene megafauna such as the mammoth and giant ground sloth).

12.3.1 Major Sources of Information

Information sources for this section include geological, geomorphic, and sedimentological studies, and data from the UC Berkeley Museum of Paleontology (UCMP) paleontological database collected for the Delta and its surrounding areas. The probability of encountering fossils (paleontological sensitivity) depends on the type of geology at an excavation site; the information below is related to geological resources to the extent necessary to assess the presence of fossils. The geological resources are discussed in Section 11, Geology and Soils.

12.3.2 Delta and Suisun Marsh

12.3.2.1 Physiographic Setting

The Delta includes the northern and lowest portion of the San Joaquin Valley and the southern and lowest portion of the Sacramento Valley, which together contain the axial streams of the Central Valley of California (also known as the Great Valley). The northwest- to southeast-trending Central Valley physiographic province is a geologically long-lived structural trough, approximately 435 miles long and 44 to 56 miles wide (Fenneman 1931). The present-day basin evolved from a late Jurassic to late Cretaceous (85 to170 mya) marine fore-arc basin. During the early Cenozoic, marine sediments continued to accumulate in this basin. Beginning in the middle Tertiary (25 to 30 mya), a change in the relative motion between the Pacific and North American plates resulted in the gradual uplift of the Coast Ranges and the eventual isolation of the basin from the ocean. More recent continental sediments of Miocene and Pliocene age (20 to 2 mya) were derived from the neighboring Coast Ranges and the Sierra Nevada. By the late Pliocene (2 to 3 mya), subaerial depositional conditions prevailed, and Sierra Nevada-derived sediments were deposited in the basin east of the valley axis (Wahrhaftig and Birman 1965).

The region's proximity to the San Andreas Fault Zone results in not only tectonic activity but also local deformation. The Montezuma Hills represent an area of active deformation and a recently upwarped crustal segment (Weber 2005), and the Carquinez Strait itself may have been closed prior to about 0.6 mya as a result of this activity (Lettis and Unruh 1991). Before 0.6 mya, a vast lake or network of lakes and marshes extended more than 200 miles along the floor of the Central Valley, primarily to the south along the axis of the San Joaquin River. The end of this period of lacustrine deposition during the Middle Pleistocene was likely caused by the opening of the Carquinez Strait (Lettis and Unruh 1991), and also coincided with the creation of the geologically "modern" Delta.

12.3.2.2 Geologic and Stratigraphic Setting

The geology of the Delta was considered from the perspective of which geological units are likely to yield scientifically significant fossil remains. Database searches were conducted using the UCMP online search engine (UCMP 2008) to determine which local geological units have yielded fossil remains, the types of fossils recovered, and their integrity (for example, fragmentary remains or entire specimens). Combining the geological literature review with the database search provides an effective means of determining the paleontological sensitivity of sediments and sedimentary rocks.

12.3.2.2.1 Near-surface, Unconsolidated Geologic Units

The unnamed geological units in the Delta and Suisun Marsh, as described in Section 11, Geology and Soils, consist of a variety of facies (distinctive rock units) reflecting different environments of deposition ranging from the clays, silts, and peats of flood basins and marshes to the sands of levee, dune, and river channel deposits. The intent of this section is to present an overview, rather than a comprehensive listing, of these sediments and their relationships to the environment of the Delta and its axial streams. The discussion of sediments younger than that of the Modesto Formation, less than 7,000 before present (B.P.), is brief because these are usually considered too young (middle to late Holocene age) to yield scientifically significant paleontological specimens.

Recent Overburden and Artificial Fill

Recent overburden and artificial fill are commonly determined to have no paleontological sensitivity because there is no potential for these sediments to yield scientifically significant fossils. Recent overburden and artificial fill includes agricultural soils, the sediments of artificially constructed levees, historical flood basin deposits, and the historical "pulse" of outwash sediment from higher elevations resulting not only from hydraulic gold mining in the late 19th century, but also from grazing and agricultural land clearance (Florsheim and Mount 2003). The effects of historical land management practices on sedimentation in the Delta have been pronounced, with many areas displaying 5 to 10 feet of recent sediment immediately below the surface. Other areas immediately outside the Delta on the distal reaches of the alluvial fan plains of the Sierra Nevada and Coast Ranges did not experience this pulse of sedimentation because of their somewhat elevated topographic position.

Quaternary Alluvium (Fan-Delta Sediments)

Although the sedimentary sequence of the Central Valley is commonly thought to be relatively continuous, this is not the case for most of the Delta area. Periodic lowering of sea level occurred in the geologically recent past, resulting in sea level drops of as much as 400 feet during glacial advances over the last 0.7 mya (Bloom 1983). These in turn caused stream entrenchment and hydrographic isolation of the current floodplains (Shlemon 1971). Concurrent with this entrenchment, the Delta system retreated to the west, and the Sierran alluvial fans expanded westward. Conversely, during interglaciations (periods of warmth comparable to today that punctuated late Quaternary glaciations) such as the current Holocene (the last 10,000 years), sea level rose to near present elevations, creating the present Delta system at the terminal reaches of the Sierra Nevada alluvial fans. The overall relationship between sedimentation, sea level rise and fall, and the glacial-interglacial climate cycle, is that the floodplains across this area are interglacial in age, and there is a lack of glacial-age sedimentation (Shlemon 1971). It also means that the Delta is geologically quite young, and formed only within the last 6,000 years (Shlemon and Begg 1975). Florsheim and Mount (2003) estimate pre-disturbance, late Holocene sedimentation rates to be approximately 0.12 inches per year, which would result in approximately 60 feet of sedimentation in 6,000 years.

Levee and Channel Deposits

The bounding alluvial fans, and the fan-delta habitats of their distal reaches generally above the autumnal high-tide line, experienced a different sedimentary history than the Delta, and glacial-age sediments can

be found in those areas at relatively shallow depth (Atwater 1982). Fluvial sedimentation in these areas occurs during overbank floods and from simple river meander after sea level had reached near its present elevation, and before the historic channelization of the Delta (Lettis and Unruh 1991). The detailed mapping of the surficial geology of the fan-delta interface recognizes two units of the Modesto Formation here, as elsewhere (Marchand and Atwater 1979; Atwater 1982). These mapping units consist chiefly of arkosic (quartz-rich) alluvium, chiefly sand, and are thought to represent two periods of glacial outwash from the Sierra Nevada:

- $Qm_{1,}$ Qm_l: Lower member of the Modesto Formation consisting of arkosic alluvium of the contributory river alluvial fans; chiefly sand; probably glacial outwash. Finer-grained facies include the silts and clays of flood-basin deposits.
- $Qm_{2,}$ Qm_u: Upper member of the Modesto Formation also consisting of arkosic alluvium of the alluvial fan of tributary rivers; chiefly sand; probably glacial outwash. Finer-grained facies include the silts and clays of flood-basin deposits. Eolian (wind formed) facies include isolated, relict dune fields on Delta islands and the broad plains of the fan.

Older Alluvium

The Modesto Formation and the older Riverbank Formation are lithologically very similar because the sediments that compose each unit were derived from same rocks in the headwaters of the contributory streams issuing from the Sierra Nevada and were deposited in similar alluvial fan environments. The primary differences between the Modesto and Riverbank formations are age-related; they include the degree of consolidation/cementation, the amount of deformation (tilting and/or folding), and soil development. The older Riverbank Formation has been uplifted in some locations and can be distinguished based on tilted bedding from the flat-lying younger Quaternary alluvium. In other cases, the Riverbank Formation forms higher terraces in an inverted topographic relationship with younger Modesto Formation deposits. However, discrimination of Modesto Formation alluvium from the Riverbank Formation is difficult in many cases. At those places where Modesto alluvium overlies the Riverbank Formation, the contact between the two units is frequently marked by a deeply developed paleosol with a pronounced clay horizon (Atwater 1982).

In much of the Sacramento Valley north of the Delta, the Riverbank Formation is not recognized, although in many places an older alluvial unit occupies a similar topographic and stratigraphic position to the Modesto Formation. This is the Plio-Pleistocene Tehama Formation (Lettis and Unruh 1991). North of Suisun Marsh and the Montezuma Hills on the distal portions of alluvial fans extending south and east from the Coast Ranges, the Tehama Formation also forms terraces topographically inverted above the Modesto Formation. Helley and Harwood (1985) describe this partially lithified alluvial unit as a pale green to gray or tan sandstone and siltstone with lenses of cross-bedded pebble and cobble conglomerate.

The Montezuma Formation is an early Pleistocene alluvial unit exposed by the uplifting of the Montezuma Hills. It is a poorly indurated (relatively soft) unit consisting of orange-weathering, brown, poorly sorted quartz-lithic sand, silt, and pebble gravel. Pebbles include red chert and volcanics. It is mapped nowhere other than the uplift between Suisun Marsh on the west and the Sacramento River channel and Brannon Island on the east (Graymer et al. 1994). Given its apparent age, it must be partly contemporaneous with the Tehama and Tulare formations.

South of Suisun Marsh/Bay and along the southwestern margin of the Delta, an alluvial unit of similar age to the Tehama Formation outcrops at the foot of the Coast Ranges. This is the Plio-Pleistocene Tulare Formation, which occurs below the Riverbank Formation throughout much of the San Joaquin Valley (Lettis and Unruh 1991). Normally lying at depths exceeding 150 feet in the valley, uplift along the margin of the Coast Ranges has brought it to the surface. It is a poorly consolidated, non-marine, gray to maroon siltstone, sandstone, and conglomerate. Near its base, this formation contains tuff correlated with

the Putah Tuff, which has a potassium/argon age of 3.3+0.1 mya (Graymer et al. 1994), while the upper member of the Tulare Formation contains the Corcoran Clay member, dated as early as 0.62 mya.

Estuarine Sediment

Melting of the continental glaciers at the end of the last glacial age led to a marked increase in sea level, and the transgression of estuarine and deltaic environments into what was, until approximately 15,000 B.P., a deeply channeled river system extending through the Carquinez Strait and the Golden Gate to the full-glacial shoreline just west of the present Farallon Islands. Atwater et al. (1977) note that estuarine, and then marine, sedimentation began in San Francisco Bay about 10,000 B.P., and Shlemon (1971) notes the beginning of estuarine habitats in the western portion of the Sacramento–San Joaquin Delta area at about the same time. These authors conclude that, by about 6,000 B.P., habitats that characterize the Delta occupied much of the area. Geographically, estuarine sediments are more common farther west near Suisun Marsh, and the channels and basins are subject to periodic inundation, especially during the equinoctial high tides.

12.3.2.2.2 Bedrock Sedimentary Units

The Sacramento and the San Joaquin rivers are the axial streams of their respective valleys and define the bottom of the Central Valley. However, they are offset far to the west of what would be the geographic centerline of the Central Valley (Lettis and Unruh 1991). The Coast Ranges lie only a few miles to the west of the Delta, and essentially form its western boundary at Carquinez Strait. Conversely, the piedmont of the Sierra Nevada lays tens of miles to the east. Therefore, bedrock units that form the "rim" of the topographic depression encompassing the Delta and Suisun Marsh areas are those of the Coast Ranges, while Sierra Nevadan rocks do not occur in the area, except as clasts in Sierra-derived alluvium comprising the alluvial fans extending to the Delta.

The youngest Neogene sedimentary unit in the area is the Pliocene to Pleistocene Tulare Formation, described above. It reflects terrestrial conditions after the Central Valley had been closed off to the sea. The next-oldest unit reflects near-shore marine conditions. The Neroly Formation is a marine sandstone laid down in an increasingly shallow sea during the mid-Tertiary (late Miocene). With the Tulare Formation, it crops out as the most distal set of ridges and hills on the eastern and northern piedmont of the Coast Ranges, south of Suisun Bay and east of the San Joaquin River's mouth in northeastern Contra Costa County.

The Paleogene and Mesozoic sedimentary units of the eastern and northern margin of the Coast Ranges represent a sequence of increasingly deep ocean basins with increasing age. The Paleocene units are the Eocene Markley and Domingene Formations, and the Paleocene Meganos Formation. These overlie and, in the tectonic setting of the eastern Coast Ranges south of Suisun Bay and west of the lower San Joaquin River, occur farther out into the valley than the marine sandstones, limestones, and shales that compose the Great Valley Sequence. The stratigraphic units that make up the Great Valley Sequence reflect deep-water conditions when this area was an abyssal plain at the bottom of the ocean, some tens of miles west of an arc of volcanic islands that were situated where the Sierra Nevada is now located.

12.3.2.3 Paleontological Sensitivity of Potentially Affected Units

Paleontological sensitivity is a qualitative assessment made by a professional paleontologist accounting for the paleontological potential of the stratigraphic units present, the local geology and geomorphology, and any other local factors that may be germane to fossil preservation and potential yield. According to SVP (1995), "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, ecologic, or stratigraphic data." Sensitivity ratings are described in Table 12-1.

Table 12-1
Paleontological Sensitivity Ratings in Delta Sediments

Rating	Definition
High	Geological formations known to contain paleontological resources that include rare, well-preserved, and/or fossil materials important to ongoing paleoclimatic, paleobiological, and/or evolutionary studies. They have the potential to produce, or have produced vertebrate remains that are the particular research focus of many paleontologists, and also can represent important educational resources.
Moderate	Stratigraphic units that have yielded fossils that are moderately well preserved, are common elsewhere, and/or that are stratigraphically long ranging. This evaluation also can be applied to strata that have an unproven but strong potential to yield fossil remains based on their stratigraphy and/or geomorphologic setting.
Low	Sediment that is relatively recent or that represents a high-energy subaerial depositional environment where fossils are unlikely to be preserved. A low abundance of invertebrate fossil remains or reworked marine shell from other units can occur, but the paleontological sensitivity remains low because they lack the potential to serve as significant scientific or educational purposes. This rating also can be applied to strata that have been extensively sampled but have yielded no megafossils.
Marginal and Zero	Stratigraphic units with marginal potential include pyroclastic flows and soils that might preserve traces or casts of plants or animals. Most igneous rocks, however, have zero (no) paleontological potential. Other stratigraphic units deposited subaerially in a high-energy environment (such as alluvium) also may be assigned a marginal or zero sensitivity rating. Manmade fill is also considered to possess zero paleontological potential.

The paleontological productivity of different stratigraphic units in the study area was based on the number of paleontological records attributed to those units. This determination was made through queries of the UCMP online database (UCMP 2008). In these database searches, invertebrate and microfossil collecting sites were discriminated from the paleobotanical and vertebrate records because there have been many microfossil studies (pollen, radiolaria, diatoms, foraminifera) conducted on Cretaceous and Cenozoic sediments in this area. The associated collection sites are listed in the UCMP database, along with localities where more traditional paleontological "finds" have been made. Many sedimentary exposures that yield microfossils, or isolated invertebrate remains, lack plant or vertebrate megafossils. In addition, many invertebrate and microfossil localities in the UCMP database have no associated catalogued specimens (UCMP 2008). Finally, invertebrate localities include sites where a molluscan fauna has yielded important data and sites where only sponge spicules or echinoderm plates were noted. When microfossil and invertebrate localities are excluded, the resultant number of plant megafossil and vertebrate fossil sites is smaller and more reflective of the paleontological potential of the sedimentary unit.

12.3.2.3.1 Near-surface, Unconsolidated Geologic Units

Recent Overburden and Artificial Fill

Artificial fill and recent overburden, such as agricultural soils, are distributed extensively in the Delta and along its margins. The practice of creating land by placing artificial fill on the gently sloping tidal flats along the margin of San Francisco, San Pablo, and Suisun bays began about the time of the Gold Rush when California's first economic boom created a critical need for development, particularly along the waterfront. Developers used whatever materials were available for fill, including dune sand, alluvium, sediment dredged from the Bay, excavation spoils, quarried rock, and human-made debris—including foundry slag and garbage. Both the thickness and type of fill vary widely over short distances. In other areas of the Delta, fill has been used to create artificial levees and transportation causeways and to "reclaim" agricultural lands. In many cases, fill is indistinguishable from agricultural soils that have been subject to repeated tillage over the last century, and are disturbed usually to a depth of at least 3 to 4 feet.

No intact fossil material is expected in this type of disturbed sediment, and even if fragmentary remains were encountered, they would lack scientific significance because they would not be in stratigraphic context. Lack of stratigraphic context means that the age and geologic setting of the fossil would be uncertain and, without this information, its scientific utility would be compromised. Therefore, recent overburden and artificial fill, including agricultural soils, possess no paleontological sensitivity.

Quaternary Alluvium Including Levee and Channel Deposits (Modesto and Post-Modesto Formation)

As Florsheim and Mount (2003) describe, the substantial lateral variability of Delta environments results in substantial changes in the nature of sediment being deposited in any one area. Prior to historical disturbance, peats, clays, silts, and sands were laid down through the Delta in response to temporal and spatial changes in local environment. Fine-grained facies are indicative of low-energy depositional environments of flood basins, sloughs, and ox-bows. These silts and clays, if laid down under anoxic conditions, would have the greatest potential for paleontological yield. Higher energy sediments of channels and splay deposits are more coarse-grained, but the sands that usually constitute the bulk of this sediment also can be fossiliferous.

Holocene and Late Pleistocene (collectively, Late Quaternary) sediments are distributed in two distinct fashions across the Delta and surrounding area. The Delta consists of middle to Late Holocene sediments alone, to a depth of at least 80 feet below the surface. Material older than about 6,000 B.P. is not expected except at depths greater than 80 feet in the Delta. However, surface exposures of older sediments assigned to the Late Pleistocene, and perhaps early Holocene, Modesto Formation are situated on the surrounding delta-fan areas and up to the first foothills of the Coast Ranges south of Suisun Bay and east of the lower San Joaquin River (Helley and Harwood 1985; Marchand and Atwater 1979). Table 12-2 lists the number of paleontological localities recorded at the UCMP attributed to the Modesto Formation or to undifferentiated sediments of Quaternary age.

Table 12-2
Paleontological Localities Attributed to the Modesto Formation and Undifferentiated Quaternary Alluvium

	Number of Localities	
County	**Invertebrate and Microfossil**	**Paleobotanical and Vertebrate**
Sacramento	3	1
Yolo	1	5
Solano	9	7
Contra Costa	99	45
San Joaquin	2	17
Alameda	54	52

Source: UCMP 2008

Invertebrate and microfossil collecting sites were discriminated from the paleobotanical and vertebrate sites in these record searches, because there have been many microfossil and invertebrate studies (e.g., pollen, radiolaria, diatoms, foraminifera, mollusks) conducted on Cretaceous and Cenozoic sediments in this area, and the collection sites are listed in the UCMP database along with localities where paleontological “finds” have been made

The generally higher numbers of fossil localities in Alameda and Contra Costa County in this summary partly reflect the fact that these counties extend across the Coast Ranges to San Francisco Bay, and therefore encompass many fossiliferous exposures sampled by scientists for decades, and many sites where construction-related excavations have exposed fossils.

Based on these data, undifferentiated Quaternary sediment and sediment assigned to the Modesto Formation possess high paleontological sensitivity. Consideration of the data indicates that most fossil localities are from Late Pleistocene or older contexts, and Recent (Holocene) alluvium possesses low paleontological sensitivity.

Older Alluvium

Depending on the locality and stratigraphic setting, older alluvium in the region immediately surrounding the Delta and Suisun Marsh has been mapped as the Tehama and Montezuma Formations to the north, the Tulare Formation to the south, and the Riverbank Formation to the east and south of the Delta and Suisun Marsh (Table 12-3).

Table 12-3
Paleontological Localities Attributed to the Older Alluvium of the Riverbank, Montezuma, Tulare, and Tehama Formations

	Number of Localities	
County	**Invertebrate and Microfossil**	**Paleobotanical and Vertebrate**
Sacramento	0	6
Yolo	0	13
Solano	0	14
Contra Costa	5	14
San Joaquin	0	1
Alameda	0	3

Source: UCMP 2008

This tabulation of fossil sites found in older alluvium does not include those localities from the Irvington Gravels near Hayward, or the Livermore Gravels, because they are well removed from the Delta and its periphery and have no bearing on the paleontological sensitivity of the area. Older alluvium in the area possesses moderate paleontological sensitivity.

Estuarine Sediment

There are no data that would suggest that Holocene (<10,000 B.P.) estuarine sediment possesses high or moderate paleontological sensitivity. This assessment is partly because recent sediments are traditionally accorded less scrutiny by paleontologists, and also because they seldom yield fossil vertebrate remains. Estuarine muds and peats dating back to the last glacial age have provided a rich source of microfossils for paleoenvironmental studies, but microfossils exist in the uncounted trillions throughout deposits of estuarine mud and peat deposits. Therefore, in spite of the fact that they provide a good environment of preservation, because they are recent in age and because they seldom yield scientifically significant macrofossils, estuarine sediments, including peat, are assigned low paleontological sensitivity

12.3.2.3.2 Bedrock Sedimentary Units

The Tertiary and Mesozoic sedimentary units of the eastern and northern margin of the Coast Ranges south of Suisun Bay, and also exposed in the Potrero Hills just north of Suisun Marsh, represent a sequence of increasingly shallow ocean basins with decreasing age. Some units are largely devoid of fossils, others are quite fossiliferous. There is some correlation between inferred depth at time of deposition and paleontological sensitivity, with sediments from abyssal plains (water depth exceeding 6,000 feet) generally lacking megafossils.

Tertiary Marine Sediments

Prior to the Plio-Pleistocene, sedimentary rocks are marine in origin and include the Miocene Neroly Formation indicating shallowing seas, and the deeper-water sediments of the Eocene Markley and Domengine Formations (Table 12-4). The oldest Cenozoic unit mapped for fossils is the Paleocene Meganos Formation. These sediments encroach onto the Delta area and vicinity of Suisun Marsh only in extreme easterly Contra Costa and Alameda counties, and along the northern margin of Suisun Marsh in Solano County. Other marine rocks occur elsewhere in these counties but they are removed from the Delta margin and the periphery of Suisun Marsh, and are not considered here.

Table 12-4
Paleontological Localities Attributed to Tertiary Marine Sediments of the Neroly, Markley, Domengine, and Meganos Formations

	Number of Localities	
County	**Invertebrate and Microfossil**	**Paleobotanical and Vertebrate**
Sacramento	0	0
Yolo	1	0
Solano	24	1
Contra Costa	188	14
San Joaquin	2	5
Alameda	0	0

Source: UCMP 2008

The Neroly and Markley Formations have yielded megafossils and plant remains, while the Domengine has yielded microfossils and some invertebrates. There are no fossil localities ascribed to the Meganos Formation in the UCMP database for the six counties under consideration here. The Neroly and Markley Formations possess high to moderate paleontological sensitivity depending on location, and the Domengine and Meganos Formations possess low paleontological sensitivity, because they do not appear to yield megafossils of either plants or vertebrates.

Mesozoic Great Valley Sequence

The Mesozoic Great Valley sequence, representing deep-sea sediments laid down during the Jurassic and Cretaceous prior to 65 mya, is often difficult to subdivide into formations because the rocks exhibit few distinguishing characteristics that can be easily applied in the field to other outcrops in other counties (Dickinson and Rich 1972). Therefore, at the scale of this analysis, it would be inappropriate to focus a paleontological record search on the named Great Valley Sequence formations that lie closest to the Delta and Suisun Marsh, since in many areas they are not named. Examination of available mapping indicates that they are all of Cretaceous age, and therefore Jurassic-age localities were excluded from the record review (Table 12-5).

Table 12-5
Paleontological Localities from Cretaceous Marine Sediments of the Great Valley Sequence

	Number of Localities	
County	**Invertebrate and Microfossil**	**Paleobotanical and Vertebrate**
Sacramento	0	0
Yolo	45	1
Solano	45	0

Table 12-5
Paleontological Localities from Cretaceous Marine Sediments of the Great Valley Sequence

	Number of Localities	
County	**Invertebrate and Microfossil**	**Paleobotanical and Vertebrate**
Contra Costa	159	6
San Joaquin	14	0
Alameda	35	5

Source: UCMP 2008

Of the 310 fossil localities recorded for the Cretaceous in the counties encompassing the Delta and Suisun Marsh, fully 96 percent (298) of those are microfossil or invertebrate collection sites. In contrast, only 4 percent (12 sites) are localities where vertebrate or paleobotanical remains have been recovered. The high number of microfossil and invertebrate locality records reflects the degree to which the Great Valley Sequence has been studied, particularly in Contra Costa County. The small number of fossil vertebrate and plant localities reflects the deep-water deposition of much of this marine sequence. At abyssal depths far from the coast, few macroscopic organic remains reach the sea floor and become entombed in sediment quickly enough to be preserved. Because there is low probability that macroscopic fossil remains would be encountered in these Cretaceous rocks, they are assigned low paleontological sensitivity.

12.3.3 Other Areas of California

As described in Section 2A, Proposed Project and Alternatives, facilities could be constructed, modified, or reoperated in the Delta watershed and areas outside of the Delta that use Delta water as well as the Delta; and water use could be modified in the areas outside of the Delta that use Delta water as well as in the Delta. Those areas out of the Delta include a wide range of land uses that range from agricultural, rural residential, suburban, to high-density urban. The discussion of physiographic, geologic, and stratigraphic setting and sensitivity of potentially affected units in Section 12.3.2 for the Delta and Suisun Marsh also applies to the Delta watershed and areas outside the Delta that use Delta water. Paleontological resources may remain in areas that have not been fully developed. Paleontological resources would likely occur throughout the areas at depths below historic soil disturbance. The following descriptions of the conditions present in California throughout geologic history are provided to indicate the geologic setting under which paleontological resources may be identified during project-specific research associated with environmental compliance documentation. Figure 12-1 shows the approximate eras associated with rock formations in California. These eras are described below.

Precambrian Era—Approximately 4.5 Billion to 540 Million Years Ago: Within the study area, sedimentary rocks from the Precambrian and Early Paleozoic are most often found in Southern California. Most rocks of Precambrian age do not contain fossils, although some traces and a few fossils have been found dating to the Proterozoic Eon (between approximately 2.5 billion years ago and 540 mya).

Paleozoic Era—540 Million to 250 Million Years Ago: Deposits from the mid- to late Paleozoic (Cambrian through Devonian periods) are common in the Klamath Mountains and Sierra Nevada provinces. These deposits may contain numerous marine fossils, including corals, ammonites, and brachiopods. Freshwater and marine sedimentary rocks deposited in the late Paleozoic exhibit fossils from both shallow- and deep water deposits, including swamps and estuarine deposits. These formations are found primarily in the northern portion of the study area (Shasta and Butte counties).

Figure 12-1
Distribution of Rock Formations
Source: California Geological Survey 2000 (adapted by MWH)

Mesozoic Era—251 Million to 65.5 Million Years Ago: Uplifting of the Sierra Nevada Province during the Mesozoic Era led to erosion of the mountain range and deposition in the Great Valley Province during this era. Invertebrates, marine reptiles, and a variety of terrestrial flora are represented in the fossil record in Mesozoic rocks throughout California. Uplift of the Coast and Transverse ranges also began in the latter part of the Mesozoic.

Cenozoic Era—65.5 Million Years Ago to Present: Continuing uplift of the Coast and Transverse ranges, fluctuating sea levels, glaciations in the Sierra Nevada, and development of today's lakes and river systems led to deposition of shallow marine, estuarine, freshwater, and terrestrial rocks throughout California. Cenozoic fossil records in these rocks are diverse and include marine, freshwater, and terrestrial flora and fauna. The Pleistocene epoch, known as the "great ice age," began during the Cenozoic approximately 1.8 mya. Mammalian inhabitants of the Pleistocene alluvial fan and floodplain included mammoths, mastodons, horses, camels, ground sloths, and pronghorn antelopes.

12.4 Impacts Analysis of Project and Alternatives

12.4.1 Assessment Methods

The Delta Plan alternatives would not directly result in construction or operation of projects or facilities, and therefore would result in no direct impacts on paleontological resources.

The Delta Plan and its alternatives could encourage the implementation of actions or activities by other agencies to construct and operate facilities or infrastructure that are described in Sections 2A and 2B. Examples of potential actions that could impact paleontological resources include construction of water and wastewater treatment plants; conveyance facilities, including pumping plants; surface water or groundwater storage facilities; ecosystem restoration projects; flood control levees; or recreation facilities. Implementation of these types of actions and construction of these types of facilities could result in impacts on paleontological resources.

The precise magnitude and extent of project-specific paleontological resource-related impacts would depend on the type of action or project being evaluated, its specific location, its total size, and a variety of project- and site-specific factors that are undefined at the time of preparation of this program-level study. Project-specific impacts on paleontological resources would be addressed in project-specific environmental studies conducted by the lead agency at the time the projects are proposed for implementation.

This environmental impact report (EIR) proposes mitigation measures for impacts to paleontological resources. The ability of these measures to reduce these impacts to less-than-significant levels also depends upon project-specific environmental studies; enforceability of these measures depends upon whether the project being proposed is a covered action or not. This is discussed in more detail in Section 12.4.3.6 and in Section 2B, Introduction to Resource Sections.

12.4.2 Threshold of Significance

Based on Appendix G of the State CEQA Guidelines, an impact related to paleontological resources is considered significant if the proposed project would:

- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature

Although CEQA does not specifically define a unique paleontological resource or site, the definition of a unique archaeological resource (section 21083.2) can be applied to a unique paleontological resource or

site and a paleontological resource could be considered a historical resource if it has yielded, or may be likely to yield, information important in prehistory or history under section 15064.5 (a)(3)(D).

The potential for affecting paleontological resources is proportional to the extent and depth of excavations necessary to construct the facilities, especially for actions associated with excavations and other earth-moving activities. Operations and maintenance generally would not affect paleontological resources because these activities do not involve excavations in paleontologically sensitive sediments.

CEQA also does not specifically define a unique geologic feature. However, for purposes of this analysis, a geologic feature could be considered unique if it (County of San Diego 2007):

- Is the best example of its kind locally or regionally;
- Embodies the distinctive characteristics of a geologic principle that is exclusive locally or regionally;
- Provides a key piece of geologic information important in geology or geologic history;
- Is a "type locality" of a geologic feature;
- Is a geologic formation that is exclusive locally or regionally;
- Contains a mineral that is not known to occur elsewhere in the County; or
- Is used repeatedly as a teaching tool.

The following discussion of environmental impacts is limited to those potential impacts that could result from actions or projects the Delta Plan or alternatives could encourage. As individual activities are proposed by other agencies, these individual activities would need to be evaluated in site-specific environmental documents prepared by those agencies.

12.4.3 Proposed Project

12.4.3.1 Reliable Water Supply

As described in Sections 2A and 2B, the Delta Plan does not direct the construction of specific projects, nor would projects be implemented under the direct authority of the Council. However, the Delta Plan seeks to improve water supply reliability by encouraging various actions, which if taken could lead to completion, construction and/or operation of projects that could provide a more reliable water supply. Such projects and their features could include the following:

- Surface water projects (water intakes, treatment and conveyance facilities, reservoirs, hydroelectric facilities)
- Groundwater projects (wells, wellhead treatment, conveyance facilities)
- Ocean desalination projects (water intakes, brine outfalls, treatment and conveyance facilities)
- Recycled wastewater and stormwater projects (treatment and conveyance facilities)
- Water transfers
- Water use efficiency and conservation program implementation

The number and location of all potential projects that would be implemented is not known at this time. However, the Proposed Project specifically names the California Department of Water Resources (DWR) Surface Water Storage Investigation, which includes the North-of-the-Delta Offstream Storage Investigation (aka Sites Reservoir), Los Vaqueros Reservoir Project (Phase 2), and the Upper San Joaquin

River Basin Storage Investigation Plan (aka Temperance Flat Reservoir). It also encourages the update of Bulletin 118 that could lead to improvements in groundwater management and development of related facilities. The bulletin presents a list of 10 recommendations for the management of groundwater but does not result in a specific project the construction or operation of which could affect paleontological resources; therefore, Bulletin 118 is not evaluated in this section.

12.4.3.1.1 Impact 12-1a: Destruction of Paleontological Resources or Unique Geological Features

Construction of treatment plants, surface water and groundwater storage facilities, conveyance facilities (intakes, canals, pipelines, tunnels, siphons, and pumping plants), desalination plants, and groundwater wells could entail extensive excavation and earth moving. Many of these construction activities have the potential to affect previously undisturbed, paleontologically sensitive sediments. These include sediments below 60 feet in depth in the Delta and surrounding areas. Deep excavations that could affect paleontological resources could occur at construction sites for treatment plants, surface water and groundwater storage facilities, conveyance facilities (canals, pipelines, tunnels, siphons, and pumping plants), groundwater wells, and levees. It is unlikely that construction activities would destroy a unique geological feature as defined in Section 12.4.2.

The extent and intensity of effects on paleontological resources in the Delta would depend on the size and placement of water supply facilities. Larger and more numerous facilities, because of their larger development footprint, would be more likely to affect paleontological resources, especially if they required deep excavation. In addition, the placement of in-channel structures has the potential to affect paleontological resources.

Examples of the impacts that could occur from these types of activities were obtained through a review of representative project-specific EIRs that are illustrative of the types of construction-related paleontological impacts associated with water supply reliability projects, These included the Davis-Woodland Water Supply Project (City of Davis 2007), which includes a water intake in the Sacramento River, pumping plants, and conveyance and water treatment facilities; the Huntington Beach Seawater Desalination Project (City of Huntington Beach 2005), and the Carlsbad Precise Development Plan and Desalination Plant Project (City of Carlsbad 2005), both of which illustrate some of the likely short-term paleontological impacts of constructing seawater desalination plants; and the Western Municipal Water District Riverside-Corona Feeder Pipeline Project (WMWD and Reclamation 2011), which includes the installation of a 28-mile-long underground pipeline and groundwater treatment, water storage, and pumping facilities.

The City of Davis evaluated the potential for the project to directly or indirectly destroy a unique paleontological resource and concluded that the impact would be less than significant. The City of Huntington Beach found that the potential impacts on paleontological resources resulting from the construction of a booster pump facility would be less than significant with implementation of a paleontological resource recovery program for Miocene fossils as mitigation. Likewise, the City of Carlsbad found that potential impacts on paleontological resources could result from project grading and excavation and that those impacts could be mitigate to a less-than-significant level through mitigation involving the use of a paleontological monitor at the site during construction. Western Municipal Water District found that installation of an underground water pipeline would not affect paleontological resources.

Construction of surface water storage facilities, such as those considered in the DWR Surface Water Storage Investigation, could include excavation activities that could uncover or destroy paleontological resources. The Los Vaqueros Project, a project named in the Proposed Project, has undergone project-specific environmental review via an environmental impact statement (EIS)/EIR and provides analogous information about the impacts expected from construction and operation of the two other projects, which are similar. In addition, the project-specific EIR for another surface storage project, the Calaveras Dam

Replacement Project (not named in the Delta Plan), also provides analogous information. These surface water storage projects are similar to other, ongoing projects for which environmental evaluations have been conducted. Review of these evaluations provides information helpful to understanding how projects encouraged by the Delta Plan might affect paleontological resources.

The Los Vaqueros Reservoir Expansion Project Draft EIS/EIR (Reclamation et al. 2009) and Calaveras Dam Replacement Project Final EIR (SFPUC 2011) were reviewed to assess effects of facility construction and inundation of land. These documents found that the impacts on paleontological resources were either less than significant or less than significant with mitigation. Specifically, the Los Vaqueros Reservoir Expansion Project EIR found that potential impacts on paleontological resources could result from trenching, grading, and excavation, which would disturb the ground below the surface soil horizon and underlying bedrock, and could intersect and destroy fossil resources within certain sedimentary formations. Those impacts could be mitigated to a less-than-significant level through mitigation involving worker training and monitoring during construction activities and implementation of a salvage plan if paleontological resources are encountered and identified. Similarly, the Calaveras Dam Replacement Project EIR found that potential impacts on paleontological resources could result from construction activities, but that those impacts could be mitigated to a less-than-significant level through mitigation involving worker and foreman training to identify sensitive sites during surveys, monitoring during construction, and implementation of a recovery plan if resources are identified.

The location, number, capacity, operational criteria, and methods and duration of construction activities to support a reliable water supply under the Proposed Project is not clear at this time. Because of the uncertainties underlying this program-level assessment, impacts on paleontological resources in the Delta, Delta watershed, or areas outside the Delta that use Delta water cannot be accurately quantified. The completed EIRs reviewed above suggest that impacts on paleontological resources could be significant in some cases prior to mitigation. However, because of the uncertainty regarding the specifics of the future water supply reliability projects that would be encouraged by the Proposed Project, the potential impacts are considered **significant**. Project-level impacts would be addressed in future site-specific environmental analysis conducted at the time specific projects to support water supply reliability would be proposed by lead agencies.

12.4.3.2 Delta Ecosystem Restoration

As described in Sections 2A and 2B, the Delta Plan does not direct the construction of specific projects, nor would projects be implemented under the direct authority of the Council. However, the Delta Plan seeks to improve the Delta ecosystem by encouraging various actions and projects, which if taken could lead to completion, construction and/or operation of projects that could improve the Delta ecosystem.

Features of such actions and projects that could be implemented as part of efforts to restore the Delta ecosystem include the following:

- Floodplain restoration
- Riparian restoration
- Tidal marsh restoration
- Ecosystem stressor management (e.g., continuation of ongoing programs managing pesticide runoff, water quality, water flows)
- Invasive species management (including removal of invasive vegetation)

The number and location of all potential projects that could be implemented is not known at this time. Five projects or project locations, however, are known to various degrees and are named in the Delta Plan. These are:

- Cache Slough Complex (includes Prospect Island Restoration Project)
- Cosumnes River-Mokelumne River Confluence: North Delta Flood Control and Ecosystem Restoration Project
- Lower San Joaquin River Bypass Proposal
- Suisun Marsh Habitat Management, Preservation, and Restoration Plan (includes Hill Slough Restoration Project)
- Yolo Bypass

Of the projects and actions described above, the North Delta Flood Control and Ecosystem Restoration Project (North Delta Flood Control and Ecosystem Restoration Project EIR) (DWR 2010) and the Suisun Marsh project (Suisun Marsh Habitat Management, Preservation, and Restoration Plan Draft EIS/EIR) (Reclamation et al. 2010) have undergone project-specific environmental review.

The Proposed Project encourages the State Water Resources Control Board to update the Water Quality Control Plan Update for the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary and develop, implement, and enforce updated flow requirements for the Delta and high-priority tributaries in the Delta watershed that are necessary to achieve coequal goals. As described in Section 2A, Proposed Project and Alternatives, these actions likely would result in a more natural flow regime in the Delta and Delta tributaries, and reduced export of water from the Delta. Water users in the areas outside the Delta that use Delta water would likely respond to reduced supplies by constructing facilities to improve water supply reliability and improve water quality. The impacts on paleontological resources associated with these actions would be the same as those described above in Section 12.4.3.1 (Reliable Water Supply) and Section 12.4.3.3 (Water Quality Improvement) below.

In addition to these projects, the policies and recommendations of the Proposed Project include the Delta Conservancy Strategic Plan, the variance for U.S. Army Corps of Engineers' (USACE) Vegetation Policy, and California Department of Fish and Game's Stage Two Actions for Nonnative Invasive Species. These are not expected to directly cause construction activities that would affect paleontological resources.

12.4.3.2.1 Impact 12-1b: Destruction of Paleontological Resources or Unique Geological Features

Construction of the ecosystem restoration projects listed in Section 12.4.3.2 would be similar to the construction-related activities listed for reliable water supply reliability actions (Section 12.4.3.1). Because the mechanism for this impact is ground-disturbing activities, the effects of ecosystem restoration projects related to the disturbance or destruction of paleontological resources would be similar to those described for water supply reliability projects in Section 12.4.3.1.1. It is unlikely that construction activities would destroy a unique geological feature.

While there is uncertainty regarding the specifics of ecosystem restoration projects that would occur, the Proposed Project encourages and/or mentions implementation of restoration in five areas within the Delta. There are ongoing projects that are similar to these restoration projects, the environmental evaluation of which would be comparable to some of the actions/activities that would be expected with the encouraged projects. These ongoing projects include the Suisun Marsh Habitat Management, Preservation, and Restoration Plan (a project named in the Delta Plan) and North Delta Flood Control and Ecosystem Restoration Project. The EIRs for these projects (Reclamation et al. 2010; DWR 2010) did not specifically address paleontological resources.

There is no substantial evidence that this impact would be significant. This conclusion is based on the review of environmental analyses of similar projects and other, pertinent evidence cited in this EIR, and on the inability to identify a reasonably plausible scenario in which a potential significant impact would occur. Ecosystem restoration projects encouraged by the Delta Plan would primarily occur on disturbed soils, and construction of these projects would not include deep excavation below the surface soil horizon, so these projects would be unlikely to intersect and destroy paleontological resources. It is therefore concluded that this impact would likely be **less than significant**. Future project-specific analyses may develop adequate information to arrive at a different conclusion; however, for purposes of this program-level analysis, there is no available information to indicate that another finding is warranted or supported by substantial evidence.

12.4.3.3 Water Quality Improvement

As described in Sections 2A and 2B, the Delta Plan does not direct the construction of specific projects, nor would projects be implemented under the direct authority of the Council. However, the Delta Plan seeks to improve water quality by encouraging various actions and projects, which if taken could lead to completion, construction, and/or operation of projects that could improve water quality.

Features of such actions and projects that could be implemented as part of efforts to improve water quality include the following:

- Water treatment plants (construction and operation)
- Pipelines (construction and maintenance)
- Wastewater treatment plants (construction and operation)
- Stormwater treatment (construction and operation)
- Agricultural runoff treatment (construction and operation)

The number and location of all potential actions and projects that could be implemented is not known at this time. Various projects, however, are known to some degree and are named in the Delta Plan. These are:

- North Bay Aqueduct Alternative Intake Project
- Central Valley Drinking Water Policy
- Central Valley Pesticide Total Maximum Daily Load and Basin Plan Amendment for diazinon and chlorpyrifos (regulatory processes, research, and monitoring)
- Central Valley Pesticide Total Maximum Daily Load and Basin Plan Amendment for pyrethroids (regulatory processes, research, and monitoring)
- Total Maximum Daily Load and Basin Plan Amendments for selenium and methylmercury (regulatory processes, research, and monitoring)
- Water Quality Control Plan Update for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (water flow objectives update)
- State Water Resources Control Board/Central Valley Regional Water Quality Control Board Strategic Workplan
- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)

Of these named projects/actions, only the North Bay Aqueduct Project and the CV-SALTS effort would involve facilities the construction of which could have impacts on paleontological resources.

12.4.3.3.1 Impact 12-1c: Destruction of Paleontological Resources or Unique Geological Features

Construction of the water quality improvement actions/projects listed in Section 12.4.3.3 would be similar to the construction-related activities listed for reliable water supply reliability actions (Section 12.4.3.1). Because the mechanism for this impact is ground-disturbing activities, the effects of water quality improvement projects related to the disturbance or destruction of paleontological resources would be similar to those described for the other project categories above. It is unlikely that construction activities would destroy a unique geological feature as defined in Section 12.4.2.

As with the categories of actions already discussed, it is unclear at this time how implementation of the Proposed Project would lead to specific constructed projects, including the location, number, methods, and duration of these projects. However, the Delta Plan encourages implementation of the North Bay Aqueduct Alternative Intake Project and the CV-SALTS effort. The new North Bay Alternative Intake Structure serves the purpose of meeting CV-SALTS and water discharge requirements. The new alternative intake structure would be located on the Sacramento River in a rural area of Sacramento or Yolo County, and the new pipeline would extend from the new intake structure to the existing North Bay Regional Water Treatment Plant. The CV-SALTS program could result in the construction of new wastewater treatment facilities.

Documents reviewed as examples of potential impacts include the EIR for the Davis-Woodland Water Supply Project (City of Davis 2007), which includes a water intake in the Sacramento River, pumping plants, and conveyance and water treatment facilities similar to the North Bay Alternative Intake Structure; and the Grassland Bypass Project EIS/EIR (Reclamation and San Luis & Delta-Mendota Water Authority 2008). The Grassland Bypass Project EIS/EIR did not assess the impacts on paleontological resources. The Davis-Woodland Water Supply Project EIR analysis found that the impacts on paleontological resources were less than significant with mitigation. Specifically, the Davis-Woodland EIR found that paleontological resources could be affected during excavation activities during construction, which could potentially disturb unknown, buried paleontological resources, but that these impacts could be mitigated to a less-than-significant level through a mitigation approach that also fulfills section 106 of the National Historic Preservation Act discussed in Section 10.4.3.6.1. No impact would occur due to project operation.

The location, number, capacity, operational criteria, and methods and duration of construction activities to support water quality improvement under the Proposed Project are not clear at this time. Because of the uncertainties underlying this program-level assessment, impacts on paleontological resources in the Delta, Delta watershed, or areas outside the Delta that use Delta water cannot be accurately quantified. The completed EIRs reviewed above suggest that impacts on paleontological resources could be significant in some cases prior to mitigation. Project-level impacts would be addressed in future site-specific environmental analysis conducted at the time specific projects to support water quality improvement would be proposed by lead agencies. However, because of the uncertainty regarding the specifics of the future water quality improvement projects that would be encouraged by the Proposed Project, the potential impacts are considered **significant**.

12.4.3.4 Flood Risk Reduction

As described in Sections 2A and 2B, the Delta Plan does not direct the construction of specific projects, nor would projects be implemented under the direct authority of the Council. However, the Delta Plan seeks to reduce the risk of floods in the Delta by encouraging various actions that, if taken, could lead to completion, construction, and/or operation of projects that could reduce flood risks in the Delta. Such projects and their features could include the following:

- Setback levees
- Floodplain expansion
- Levee maintenance

- Levee modification
- Dredging
- Stockpiling of rock for flood emergencies
- Subsidence reversal
- Reservoir reoperation

The number and location of all potential projects that would be implemented are not known at this time. Two possible projects, however, are known to some degree and are named in the Delta Plan: the Sacramento Deep Water Ship Channel and Stockton Deep Water Ship Channel Dredging (the United States Army Corps of Engineer's *Delta Dredged Sediment Long-Term Management Strategy* included in Appendix C, Attachment C-7 of this EIR) and the DWR Framework for Investments in Delta Flood Management. The DWR Framework for Investments in Delta Flood Management is a program, and that is not an activity that would generate paleontological resources; therefore, it is not evaluated in this section.

12.4.3.4.1 Impact 12-1d: Destruction of Paleontological Resources or Unique Geological Features

Construction of flood risk reduction actions/projects listed in Section 12.4.3.4 would be similar to the construction-related activities listed for reliable water supply reliability actions (Section 12.4.3.1). In some cases, the construction activities involved with levee modification could include deep excavation below the surface soil horizon. Specifically, levee modification could involve the construction of cut-off walls extending up to 100 feet below the ground surface. Because the mechanism for this impact is ground-disturbing activities, the effects of flood risk reduction projects related to the disturbance or destruction of paleontological resources would be similar to those described for the reliable water supply reliability actions above. It is unlikely that construction activities would destroy a unique geological feature as defined in Section 12.4.2.

Neither of the EIR for the Sacramento Deep Water Ship Channel and Stockton Deep Water Ship Channel (USACE and Port of West Sacramento 2011) nor the EIR for the North Delta Flood Control and Ecosystem Restoration Project (DWR 2010) analyzed potential impacts on paleontological resources.

However, construction of flood risk reduction projects would likely involve ground-disturbing activities at a similar depth and extent as the water supply reliability actions described in Section 12.4.3.1, and therefore could cause similar significant effects. Accordingly, the potential impacts are considered **significant**. Project-level impacts would be addressed in future site-specific environmental analysis conducted at the time specific flood risk reduction projects are proposed by lead agencies.

12.4.3.5 Protection and Enhancement of Delta as an Evolving Place

As described in Sections 2A and 2B, the Delta Plan does not direct the construction of specific projects, nor would projects be implemented under the direct authority of the Council. However, the Delta Plan seeks to protect and enhance the Delta as an evolving place by encouraging various actions and projects that, if taken, could lead to completion, construction, and/or operation of associated projects. Features of such actions could include the following:

- Gateways, bike lanes, parks, trails, and marinas and facilities to support wildlife viewing, angling, and hunting opportunities
- Additional retail and restaurants in legacy towns to support tourism

The number and location of all potential projects that would be implemented are not known at this time. However, four possible projects are known to some degree and are named in the Delta Plan: new State parks at Barker Slough, at Elkhorn Basin, and in the southern Delta and the Economic Sustainability Plan. There are no project-specific environmental evaluations of the three park projects. Implementation of the Economic Sustainability Plan is not an activity that would generate paleontological impacts.

12.4.3.5.1 Impact 12-1e: Destruction of Paleontological Resources or Unique Geological Features

Because the mechanism for this impact is ground-disturbing activities, the effects of Delta-as-a-place projects related to the disturbance or destruction of paleontological resources would be similar to those described for the other ground-disturbing project above. It is unlikely that construction activities would destroy a unique geological feature as defined in Section 12.4.2.

The types and locations of specific projects that would be implemented to protect and enhance the Delta as an evolving place are not currently known. However, the Delta Plan encourages implementation of new parks at Barker Slough, Elkhorn Basin, and the southern Delta. None of these projects progressed to the point of having completed environmental documentation. To illustrate the types of impacts that could occur, the EIRs for two similar park projects with completed environmental documents were reviewed: the EIR for the Bidwell–Sacramento River State Park Habitat Restoration and Outdoor Recreation Facilities Development Project (The Nature Conservancy and the California Department of Parks and Recreation 2008) and the Draft Program-level EIR for the San Luis Rey River Park Master Plan (San Diego County Department of Parks and Recreation 2008). The EIR for the Bidwell–Sacramento River State Park Habitat Restoration and Outdoor Recreation Facilities Development Project determined that because the rock formations within 8 to 10 feet of the soil surface were composed of deposits that are less than 10,000 years old, ground-disturbing project activities would not affect paleontological resources. The Draft EIR for the San Luis Rey River Park Master Plan came to the same conclusion for similar reasons.

There is no substantial evidence that this impact would be significant. This conclusion is based on the review of environmental analyses of similar projects and other, pertinent evidence cited in this EIR, and on the inability to identify a reasonably plausible scenario in which a potential significant impact would occur. It is therefore concluded that this impact would likely be **less than significant**. Future project-specific analyses may develop adequate information to arrive at a different conclusion; however, for purposes of this program-level analysis, there is no available information to indicate that another finding is warranted or supported by substantial evidence.

12.4.3.6 Mitigation Measures

Any covered action that would have significant environmental impacts related to the impacts listed above shall incorporate the following features and/or requirements that are applicable to the proposed action.

With regard to covered actions implemented under the Delta Plan, these mitigation measures will reduce the impacts of the proposed action. Project-level analysis by the agency proposing the covered action will determine whether the measures are sufficient to reduce those impacts to a less-than-significant level. Generally speaking, these measures are considered standard, and impacts would be reduced to a less-than-significant level after mitigation, if implemented.

With regard to actions taken by other agencies on the basis of Delta Plan recommendations (i.e., activities that are not covered actions), the implementation and enforcement of these measures would be within the responsibility and jurisdiction of public agencies other than the Council. Those agencies can and should adopt these measures as part of their approval of such actions, but the Council does not have the authority to require their adoption. Therefore, significant impacts of noncovered actions could remain **significant and unavoidable**.

How mitigation measures in this EIR relate to covered and noncovered actions is discussed in more detail in Section 2B, Introduction to Resource Sections.

12.4.3.6.1 Mitigation Measure 12-1

The following mitigation measure would reduce the effects of Impacts 12-1a, 12-1c, and 12-1d.

- During the project-level analysis, a Paleontological Resources Monitoring and Recovery Plan (PRMRP) shall be developed and implemented for all actions. The PRMRP shall include protocols for paleontological resources monitoring in those areas where sediment with moderate to high paleontological sensitivity would be affected by construction-related excavations. The PRMRP also shall set forth the following procedures:
  - Confirming the paleontological sensitivity (high, moderate, or low) of the areas to be impacted through review of project-level geological and geotechnical data
  - Determining the qualifications of the paleontologist as established by the Society of Vertebrate Paleontology (SVP 1991, 1995, 1996)
  - The assessment and recovery of discovered fossil resources
  - The preparation and curation of fossil finds

The PRMRP would provide guidelines for the establishment of a yearly or biannual monitoring program led by a qualified paleontologist to determine the extent of fossiliferous sediment being exposed and affected by erosion, and determine whether paleontological resources are being lost. If loss of scientifically significant paleontological resources can be documented, then a recovery program should be implemented.

Implementation of Mitigation Measures 12-1 has the ability to reduce impacts associated with projects to a less-than-significant level in all foreseeable cases if implemented, as evidenced (by analogy) by the reference EIRs/EISs mentioned above in the impact analysis. However, because the Council cannot guarantee mitigation implementation in all cases (particularly for noncovered actions), potential paleontological resource impacts are considered **significant and unavoidable.**

12.4.4 No Project Alternative

As described in Section 2A, Proposed Project and Alternatives, the No Project Alternative is based on the continuation of existing plans and policies and the continued operation of existing facilities into the future. Several ongoing projects have been identified as part of the No Project Alternative. The list of projects included in the No Project Alternative is presented in Table 2-2.

The significance of paleontological impacts is associated with ground disturbance and the potential for ground-disturbing projects to occur without adoption of the Delta Plan. With the No Project Alternative, project construction at the seven specific project sites is expected to be completed within the next 2-5 years. To the extent that the specific projects require ground disturbance, construction of these facilities could have significant paleontological impacts.

With the No Project Alternative, the Delta Plan would not be in place to encourage various other projects to move forward. To the extent that the absence of the Delta Plan prevents those projects from moving forward, there could be fewer occurrences of construction-related paleontological impacts. Because paleontological impacts are related to the location of projects in areas with moderate or high potential for paleontological resources, the No Project Alternative could result in significant construction-related paleontological impacts like those of the Proposed Project.

Although the No Project Alternative is expected to have paleontological impacts **less than** the Proposed Project, the potential impact on paleontological resources of projects that are implemented could still be **significant**.

12.4.5 Alternative 1A

With Alternative 1A, the construction and operation of surface water projects (water intakes, treatment and conveyance facilities, and reservoirs) would be the same as under the Proposed Project. As described in Section 2A, Proposed Project and Alternatives, there would be fewer groundwater projects (wells, wellhead treatment, conveyance facilities), ocean desalination projects, and recycled wastewater and stormwater projects (treatment and conveyance facilities) compared with the Proposed Project. Water transfers and water use efficiency and conservation programs would be reduced relative to the Proposed Project, but these activities would not be expected to impact paleontological resources.

Projects to restore the Delta ecosystem would be reduced in comparison to the Proposed Project. Implementation of flow objectives would not be expected to impact paleontological resources. Ecosystem stressor management activities and invasive species management (including removal of invasive vegetation) would be the same as described for the Proposed Project.

Projects and actions to improve water quality would be the same as under the Proposed Project. Flood risk reduction projects also would be the same as under the Proposed Project, except that levee maintenance and modification on levees that protect agricultural land would receive less emphasis and levees that protect water supply corridors and urban areas would receive more emphasis. This difference would result in an overall reduction in these levee modification activities. Projects to protect and enhance the Delta as an evolving place would be the same as under the Proposed Project.

12.4.5.1.1 Impact 12-1: Destruction of Paleontological Resources or Unique Geological Features

The same type of permanent impacts on paleontological resources would occur under Alternative 1A as described under the Proposed Project in Sections 12.4.3.1.1 (water supply), 12.4.3.2.1 (Delta ecosystem restoration), 12.4.3.3.1 (water quality), and 12.4.3.5.1 (Delta enhancement). Flood risk reduction projects described in Section 12.4.3.4.1, including construction of levees in the Delta, may be less likely under Alternative 1A because of more stringent levee investment criteria than under the Proposed Project. Because fewer levee projects would occur as part of this alternative compared to the Proposed Project, there would be a smaller area of ground disturbance and therefore a reduced likelihood that paleontological resources would be encountered.

Under Alternative 1A, there would also be fewer occurrences of water supply projects resulting in significant impacts to paleontological resources and smaller areas of ground disturbance that could reduce overall impacts compared to the Proposed Project. Overall, the number of occurrences of significant impacts related to paleontological resources under Alternative 1A would be **less than** under the Proposed Project.

As compared to existing conditions, the impacts related to paleontological resources under Alternative 1A would be **significant**.

12.4.5.2 Mitigation Measures

Mitigation measures for Alternative 1A would be the same as those described in Section 12.4.3.6.1 (Mitigation Measure 12-1) for the Proposed Project. Because it is not known whether the mitigation measure listed above would reduce Impact 12-1 to a less-than-significant level for Alternative 1A, these potential impacts are considered **significant and unavoidable.**

12.4.6 Alternative 1B

With Alternative 1B, the construction and operation of surface water projects (water intakes, treatment and conveyance facilities, and reservoirs) would be the same as under the Proposed Project. As described in Section 2A, Proposed Project and Alternatives, there would be fewer groundwater projects (wells,

wellhead treatment, conveyance facilities), recycled wastewater and stormwater projects (treatment and conveyance facilities). There would be no impacts to paleontological resources attributable to water transfers and water use efficiency and conservation programs. There would be no ocean desalination projects.

Projects to restore the Delta ecosystem would be reduced in extent relative to the Proposed Project and would not emphasize restoration of floodplains in the lower San Joaquin River. Implementation of flow objectives, ecosystem stressor management activities, and invasive species management would not be expected to require ground-disturbing activities that could affect paleontological resources.

Water quality improvement projects, including water treatment plants, conveyance facilities, and wells and wellhead treatment facilities would be less emphasized relative to the Proposed Project, and greater emphasis would be placed on the construction and operation of wastewater treatment and recycle facilities, and municipal stormwater treatment facilities.

Flood risk reduction would place greater emphasis on levee modification/maintenance and dredging than the Proposed Project, but there would be no construction of setback levees or subsidence reversal projects. Floodplain expansion projects would be fewer or less extensive. Actions to protect and enhance the Delta as an evolving place would be consistent with the Economic Sustainability Plan, but the locations for new parks, as encouraged by the Proposed Project, would not be emphasized.

12.4.6.1.1 Impact 12-1: Destruction of Paleontological Resources or Unique Geological Features

The same type of impacts on paleontological resources would occur under Alternative 1B as described under the Proposed Project. Under Alternative 1B, there would be fewer occurrences of certain projects (e.g., groundwater, ecosystem restoration, and water quality improvement projects) resulting in significant impacts to paleontological resources and smaller areas of ground disturbance, which could reduce overall impacts compared to the Proposed Project. The increased emphasis on levee modification and the potential for construction of cut-off walls involving deep excavation, however, could result in greater impacts than the Proposed Project. Overall, the number of occurrences of significant impacts related to paleontological resources under Alternative 1B would be approximately the **same as** under the Proposed Project.

As compared to existing conditions, the impacts related to paleontological resources under Alternative 1B would be **significant**.

12.4.6.2 Mitigation Measures

Mitigation measures for Alternative 1B would be the same as those described in Section 12.4.3.6.1 (Mitigation Measure 12-1), for the Proposed Project. Because it is not known whether the mitigation measure listed above would reduce Impact 12-1 to a less-than-significant level for Alternative 1B, these potential impacts are considered **significant and unavoidable.**

12.4.7 Alternative 2

As described in Section 2A, Proposed Project and Alternatives, Alternative 2 would place greater emphasis on groundwater, ocean desalination, and recycled water projects and less emphasis on surface water projects. Greater emphasis also would be placed on water transfers and water use efficiency and conservation programs, but these activities would not be expected to impact paleontological resources that would exceed any of the thresholds of significance. The surface storage reservoirs considered under the DWR Surface Water Storage Investigation would not be encouraged; instead, surface storage at a new facility in the Tulare Basin would be emphasized.

Ecosystem restoration projects similar to but less extensive than those encouraged by the Proposed Project, would be emphasized. Alternative 2 would also emphasize the development of flow objectives

that take into consideration updated flow criteria that support a more natural flow regime, water rights, and greater protection of the public trust resources, none of which would impact paleontological resources.

The number of actions to improve water quality would be similar to or greater than those under the Proposed Project, especially the treatment of wastewater and agricultural runoff. Actions to reduce flood risk under Alternative 2 would emphasize floodplain expansion and reservoir reoperation rather than levee construction and modification. The actions to protect and enhance the Delta as an evolving place would be the same as under the Proposed Project.

12.4.7.1.1 Impact 12-1: Destruction of Paleontological Resources or Unique Geological Features

The same types of impacts on paleontological resources would occur under Alternative 2 as were described for the Proposed Project. The reduced emphasis on surface water supply, ecosystem restoration, and levee projects under Alternative 2 could result in fewer ground-disturbing construction activities that have the potential to affect paleontological resources.

Overall, the number of occurrences of significant impacts related to paleontological resources under Alternative 2 would be **less than** under the Proposed Project.

As compared to existing conditions, the impacts related to paleontological resources under Alternative 2 would be **significant**.

12.4.7.2 Mitigation Measures

Mitigation measures for Alternative 2 would be the same as those described in Section 12.4.3.6.1 (Mitigation Measure 12-1) for the Proposed Project. Because it is not known whether the mitigation measure listed above would reduce Impact 12-1 to a less-than-significant level for Alternative 2, these potential impacts are considered **significant and unavoidable.**

12.4.8 Alternative 3

As described in Section 2A, Proposed Project and Alternatives, the water supply reliability projects and actions under Alternative 3 would be similar to those of the Proposed Project, although there would be less emphasis on surface water projects. Ecosystem restoration (floodplain restoration, riparian restoration, tidal marsh restoration, and floodplain expansion) would be reduced compared to the Proposed Project, and restoration on publicly owned lands, especially in Suisun Marsh and the Yolo Bypass, would be emphasized. There would be more stressor management actions (e.g., programs for water quality, water flows) and more management for nonnative invasive species. Water quality improvements would be the same as for the Proposed Project.

Actions under Alternative 3 to reduce flood risk would not include setback levees or subsidence reversal but would result in greater levee modification/maintenance and dredging relative to the Proposed Project. Reservoir reoperation and materials stockpiling would be the same as for the Proposed Project, as would activities to protect and enhance the Delta as an evolving place.

12.4.8.1.1 Impact 12-1: Destruction of Paleontological Resources or Unique Geological Features

The same types of impacts on paleontological resources would occur under Alternative 3 as described under the Proposed Project; however, there would be fewer large ground-disturbing projects that could impact paleontological resources and smaller areas of ground disturbance, which could reduce overall impacts compared to the Proposed Project. Greater levee modification/maintenance and dredging activities could lead to more construction involving deep excavation, increasing the overall impacts compared to the Proposed Project. Overall, the number of occurrences of significant impacts related to

paleontological resources under Alternative 3 would be approximately the **same as** under the Proposed Project.

As compared to existing conditions, the impacts related to paleontological resources under Alternative 1A would be **significant**.

12.4.8.2 Mitigation Measures

Mitigation measures for Alternative 3 would be the same as those described in Sections 12.4.3.6.1 (Mitigation Measure 10-1) for the Proposed Project. Because it is not known whether the mitigation measure listed above would reduce Impact 12-1 to a less-than-significant level for Alternative 3, these potential impacts are considered **significant and unavoidable.**

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