Appendix 18A

Archaeological Resources Sensitivity Assessment

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This appendix provides the following information in support of Chapter 18, *Cultural Resources*:

- An overview of the sensitivity of the study area for previously unidentified and buried prehistoric and historic archaeological resources, and;
- A table of identified resources that intersect with typical conveyance footprints to show the number and kind of identified resources that occur in the study area, as these resources provide factual indication of the nature of additional resources that are likely to be encountered but which have not yet been identified.

It should be noted that this appendix does not describe the particular identified resources that will be affected by the alternatives under consideration. This appendix instead considers the relationship of sensitive soil formations and identified sites against typical conveyance footprints to demonstrate the overall sensitivity of the area where conveyance would be constructed for previously unidentified archaeological resources. Although the model used for this analysis is based on well-established relationships between to the timing of human occupation of the North American continent and landform age, it has not been formally field tested.

18A.1 Landscape Sensitivity for Prehistoric Archaeological Resources

This analysis describes the physical processes such as sediment accumulation and erosion that interact with archaeological sites in the Delta Region. An overview of these processes is necessary to understand the sensitivity of the study area for unidentified and buried archaeological resources. Landform and physical processes play a fundamental role in the creation, preservation, burial, and ultimate discovery of archaeological sites in the region (Meyer and Rosenthal 1997; Rosenthal and Meyer 2004a; Rosenthal, et al. 2007). This is due in large part to the area's ample rainfall and associated runoff creating conditions amenable to erosive and burial sequences that destroy archaeological sites on the one hand, and preserve them on the other. In the latter case burial has the unfortunate effect of making sites very difficult to find, making archaeological research and cultural resource management all the more difficult, for obvious reasons. Because different landscapes, landforms, and locations have differential probabilities of: (1) ever being used by humans; (2) preserving archaeological remains; and (3) containing buried archaeological sites, it has been repeatedly shown that assessing the sensitivity of different areas to the presence of buried archaeological sites has utility both for research and management (Meyer and Dalldorf 2004; Rosenthal and Meyer 2004b). This initial analysis thus assesses the study area for the possible presence of buried archaeological sites using relevant geoarchaeological data sets (i.e., landform, soils, and settlement pattern data).

Although existing archaeological sites are used as a bench-mark for assessing the overall landscape sensitivity, it is important to note that the results of the CHRIS records searches reflect only available information on already documented cultural resources. The vast majority of the Delta has never been subjected to intensive archaeological inventory. Accordingly, presently unrecorded cultural resources undoubtedly exist in the area. In addition, most archaeological surveys in California consist of surface pedestrian inventories that typically cannot provide detailed information on the potential existence of subsurface resources, even in areas where ground surface visibility is good, such as freshly plowed agricultural fields.

For this discussion, ICF archaeologists defined the archaeologically sensitive areas of the BDCP alternatives by analyzing and synthesizing previous research, soils, and examining the project alternatives. This analysis was facilitated by GIS, which allows data from multiple sources to be easily related geospatially. Existing shapefile data and other site records were georeferenced and digitized into a GIS. Detailed predictive modeling, however, is best accomplished in smaller geographic regions, where the number of relevant variables can be reduced. This study offers a gross assessment of the potential for previously unidentified and buried sites, in order to determine if the action alternatives are likely to result in effects on such resources. Accordingly this study is not meant to serve as a robust predictive model, but instead offers a tool for impact analysis by providing facts demonstrating why additional previously unidentified resources are likely to occur and may be affected.

18A.1.1 Geological History of the Delta Region

Surface soils formed in the Sacramento–San Joaquin Delta (Delta) as the result of geologic processes over approximately the past 7,000 years, but the depositional history of the region goes back further still—some 20,000 years—with the melting of Pleistocene glaciers and associated sea level rise. As the continental ice sheets began to melt, the world's seas rose rapidly, causing flooding of dry land in the Delta and San Francisco Bay.

These processes produced landward accumulation of sediment behind the bedrock barrier at the Carquinez Strait, forming marshlands comprising approximately 100 islands that were surrounded by hundreds of miles of channels (Weir 1950). Generally, mineral soils formed near the channels during flood conditions and organic soils formed on marsh island interiors as plant residues accumulated faster than they could decompose. Between 7,000 and 4,000 Before Present (BP), sediment deposition outpaced sea level rise and totaled about five meters (16.4 feet) of soil accumulation. Due to this rapid accumulation, the Delta was a vast marsh and floodplain, under which peat soils developed to a thickness of up to 30 feet in many areas (Weir 1950), with a thickness of approximately 55 feet in the vicinity of Sherman Island (Real and Knudsen 2009).

The historical Delta evolved at the inland margin of the San Francisco Bay Estuary as two overlapping geomorphic units. The Sacramento River Delta comprises about 30% of the total area and was influenced by the interaction of rising sea level and river floods that created channels, natural levees, and marsh plains. During large river flood events, silts and sands were deposited adjacent to the river channel, forming natural levees above the marsh plain. In contrast, the larger San Joaquin River Delta—located in the central and southern portions of the Delta and having relatively small flood flows and low sediment supply—formed as an extensive, unleveed freshwater tidal marsh dominated by tidal flows and organic soil (peat and muck) accretion (Atwater and Belknap 1980). Because the San Joaquin River Delta had less well-defined levees, sediments were deposited more uniformly across the floodplain during high water, creating an extensive tule marsh with many small branching tributary channels. As a result of the differential amounts of inorganic sediment supply, the peats and mucks of the San Joaquin River Delta grade northward into peaty mud and then into mud toward the natural levees and flood basins of the Sacramento River Delta (Atwater and Belknap 1980).

Management of Delta soils for agriculture and flood control over the past 100 years caused dramatic changes to soils and the overall landscape. The Delta today is a highly modified system of artificial levees and dredged waterways that were constructed to control flooding and to support farming and urban development on approximately 57 reclaimed islands (Ingebritsen et al. 2000). The peat soils have been largely drained, resulting in oxidation of organic matter and subsequent large-scale land subsidence on Delta islands.

18A.1.1.1 Geoarchaeology and Buried Sites

One of the main utilities of geoarchaeological investigation is identifying archaeological sites buried by depositional processes, natural or cultural. Because buried sites typically lack visible features or artifacts indicating their presence to a field observer, they are often not identified during surface survey (Bettis 1992). This issue is partially resolved by assessing the probability of discovering buried sites in different parts of a study area (McManamon 1984; Nance 1983). The ability to locate buried sites ultimately depends on a number of factors, particularly the presence of depositional or stable landforms and/or appropriate soils.

The principle operating behind geoarchaeological sensitivity assessments is that buried archaeological sites are the result of geophysical process specific to particular landforms as much as they are of human behavior (Waters 1992). This means landforms play a fundamental role in site preservation, burial, and discovery. Put simply, landform (and other affiliated characteristics like soils, geologic substrate, and climate) determines to a large degree whether and when an archaeological site is buried. This principle takes on particular significance when it comes to reconstructing prehistoric behaviors, past settlement and subsistence patterns, and, of particular relevance to the current investigation, assessing and managing hard-to-find and buried sites in areas where substantial ground disturbing activities are planned. In the first case, geomorphic processes (erosion, fluvial transport, burial, etc.) can move, disturb, or bury artifacts, in some cases leading to pronounced misreading of the archaeological record (e.g., Kellogg 1995; Reinhardt 1993; Will and Clark 1996). Geomorphic processes can also result in patterned deposits that resemble cultural ones, also leading to potential misinterpretation of archaeological materials (Hallet 1990).

It is important to realize that the archaeological record is a product of both cultural and geologic factors. Where and when people engage in activities and leave behind artifacts is a cultural phenomenon. Once a site is abandoned, however, whether or not it is preserved and becomes part of the archaeological record is a geologic phenomenon. This aspect of preservation is especially important in valleys, where stream erosion regularly removes older deposits. Equally important in assessing the archaeological record is the potential for younger deposits to bury sites and prevent their detection. These two processes, erosion and soil accumulation, are the primary geological processes that interact with archaeological deposits in the Delta.

18A.1.1.2 Prehistoric Archaeological Sensitivity Assessment

The potential for buried archaeological deposits and archaeological sensitivity within the study area was determined based on map distribution of different Quaternary-aged (originating in the last 2 million years) landforms, as depicted in Figure 18A-1. Four categories of buried site potential were identified: Very High, High, Moderate, and Low. Pleistocene-aged (between 2 million and 10,000 years ago) and early Holocene (within the last 10,000 years) deposits are considered to be very low in archaeological sensitivity, as are peat and muck (due to the rapid and constant inundation by water). Therefore, the middle Holocene is generally considered as moderately sensitive, and later Holocene as

High to Very High, depending on other factors such as known archaeological sites and major water sources. Table 18A-1 presents the archaeological sensitivity of soils. These factors were used to provide a gross means of ranking different portions of the study area as depicted in Figure 18A-1.

Table 18A-1. Buried Site Potential of Different Landforms

Potential Category	Landform
Low	Early Holocene Fans and Floodplains; Pre-Pleistocene through Latest Pleistocene Hillslopes, Fans and Floodplains; Peat and Muck
Moderate	Middle Holocene Fans and Floodplains
High	Late Holocene Fans and Floodplains
Very High	Latest Holocene Fans and Floodplains

The overall sensitivity ranking depicted in Figure 18A-1 was generated by a review of the various specific geological formations crossed by the action alternatives. Of these landforms, six are highly sensitive for containing undocumented prehistoric sites and human remains (Table 18A-2). All are Holocene (originating within the last 10,000 years) alluvium, with the exception of eolian deposits. These are included due to the rapidly shifting structure of the deposits and the known resources found on the banks of the river systems. Relatively stable eolian deposits also contain landforms that are sensitive for archaeological sites and human remains, such as the sand deposits colloquially referred to as "piper sand mounds."

Table 18A-2. Buried Site Potential of Different Landforms

Landform	Buried Site Potential
Outside Survey Area	N/A
Dredge soils post 1900 (Qds)	Low
Montezuma Formation – Pleistocene (Qmz)	Low
Peat and Muck – Holocene (Qmz)	Low
Tertiary and Cretaceous Bedrock (TKb)	Low
Tehama Foundation (Pt)	Low
Alluvial Sand Deposits (Pt)	Low
Upper Jurassic-Lower Cretaceous (Kju)	Low
Capay Formation (Ec)	Low
Lake Deposits (QI)	Low
Markley Sandstone (Emk)	Low
Martinez Foundation (Pmz)	Low
Nortonville Shale (En)	Low
Older Alluvium (Qo)	Low
Alluvial Fans from Glaciated Basins – Modesto Formation (Qm)	Moderate
Basin Deposits (Qb)	Moderate
Dos Palos Alluvium (Qdp)	Moderate
Alluvium of Supratidal Floodplains – Holocene (Ql, Qb, Qfp)	High
Eolian Deposits – Pleistocene (Qe, Qm2e, Qoe)	High
Alluvium (Q)	High
Montezuma Formation (Qmz)	High
Alluvial Fans and Terraces from Unglaciated Drainage Basins (Qup, Qop, Qom, Qcr, Qoa, Qya, Qia, Qomc, Qch)	Very High
Alluvial Fans from Glaciated Basins – Riverbank Formation (Qr, Qro, Qry)	Very High

18A.1.1.3 Conclusions Regarding Sensitivity for Prehistoric Archaeological Sites

Within the project area in general, Quaternary deposits include Holocene fluvial and alluvial material derived from surrounding slopes and major waterways. Both banks and terraces along natural river courses (e.g., the Sacramento, San Joaquin, and Mokelumne rivers) are considered likely settings for encountering surface and subsurface traces of early Native American habitation and activities. In acknowledging the results of previous research in central California (Rosenthal and Meyer 2004a), we recognize that buried archaeological deposits are not distributed randomly throughout the landscape, but occur in specific geoenvironmental settings. For example, fans and floodplains consistently contain buried archaeological deposits, indicating some relationship between these landforms and past settlement activities. Ideally, predictions about where buried archaeological sites are located would take into account a number of characteristics related to the past distribution of important subsistence resources (i.e., distance to water) and other environmental factors (e.g., aspect, ecotone, slope) that may have made a specific location more favorable for occupation than another.

Identified sites are often large, complex sites recorded in Sacramento County, and some have been the subject of extensive archaeological research over that last seven or eight decades. For alternatives that would convey water through a western canal, prehistoric sites are recorded mostly in the area of Bethel Island, Oakley, and Brentwood. These sites include large sand mound sites and midden/habitation sites, both of which typically contain rich burial complexes. These identified sites, however, do not reflect the likely density of cultural resources because surveys have not been conducted for most of the right-of-way for this conveyance option. Many of the sites were studied as part of levee improvement projects and private development. Areas where few formal environmental studies have been conducted are likely to contain archaeological resources. In addition, a pedestrian survey will often be insufficient to identify these resources because of the possibility of buried soils, especially in areas depicted as High or Very High sensitivity.

Based on the broad patterns presented here, the highest potential for archaeological sites in the study area occurs within Holocene Alluvium in general, and Alluvial Fans and Terraces specifically. Table 18A-3 summarizes identified prehistoric sites that overlap with typical conveyance footprints for the action alternatives.

Collectively, the presence of numerous recorded prehistoric resources, and the presence of landforms that are sensitive for additional unidentified resources, suggests that the action alternatives will disturb both additional resources that can be identified through inventory, and buried resources that cannot be feasibly identified. Where human activity formed archaeological sites on landforms that have now been buried, feasible surface inventory and subsurface sampling through excavation may not reveal such resources.

Table 18A-3. Prehistoric Sites Occurring on or Near Typical Conveyance Footprints (All Alternatives Combined)

P-Number	Trinomial	Detail	County
P-34-000025	CA-SAC-025	midden/mound	Sacramento
P-34-000330	CA-SAC-1165	artifact scatter	Sacramento
P-34-000128	CA-SAC-1367	midden/mound	Sacramento County
P-34-000128	CA-SAC-155	midden/mound	Sacramento County
P-34-000330	CA-SAC-1569	artifact scatter	Sacramento
P-34-000276	CA-SAC-249	midden/mound	Sacramento County
P-34-000330	CA-SAC-357	artifact scatter	Sacramento
P-34-000074	CA-SAC-47	artifact scatter	Sacramento
P-34-000128	CA-SAC-559	midden/mound	Sacramento County
P-34-000083	CA-SAC-56	midden/mound	Sacramento County
P-34-000086	CA-SAC-59	midden/mound	Sacramento County
P-34-000087	CA-SAC-60	midden/mound	Sacramento County
P-34-000088	CA-SAC-61	midden/mound	Sacramento County
P-34-000330	CA-SAC-761	artifact scatter	Sacramento
P-34-000128	CA-SAC-963	midden/mound	Sacramento County
P-07-000070	CA-CCO-128	midden/mound	Contra Costa County
P-07-000072	CA-CCO-130	midden/mound	Contra Costa County
P-07-000085	CA-CCO-143	refuse scatter	Contra Costa County
P-07-000086	CA-CCO-144	Blank site record	Contra Costa County
P-07-000413	CA-CCO-653	midden/mound	Contra Costa County
P-07-000721	CA-CCO-368	midden/mound	Contra Costa County
P-07-002650	CA-CCO-767	midden/mound	Contra Costa County
P-34-000025	CA-SAC-025	midden/mound	Sacramento
P-34-000083	CA-SAC-056	midden/mound	Sacramento County
P-34-000086	CA-SAC-059	midden/mound	Sacramento County
P-34-000087	CA-SAC-060	midden/mound	Sacramento County
P-34-000088	CA-SAC-061	midden/mound	Sacramento County
P-34-000089	CA-SAC-062	midden/mound	Sacramento County
P-34-000215	CA-SAC-188	midden/mound	Sacramento County
P-34-000336	CA-SAC-309	baked clay	Sacramento County
P-34-000355	CA-SAC-328	midden/mound	Sacramento County
P-34-000422	CA-SAC-395	midden/mound	Sacramento County
P-39-000204	CA-SJO-068	midden/mound	San Joaquin
P-39-000247	CA-SJO-115	mound	San Joaquin
P-39-000260	CA-SJO-142	midden/mound	San Joaquin
P-39-000261	CA-SJO-143	Blank site record	San Joaquin
P-39-000262	CA-SJO-144	Blank site record	San Joaquin
P-39-000263	CA-SJO-145	midden/mound	San Joaquin
P-39-000264	CA-SJO-146	Blank site record	San Joaquin

18A.1.2 Historical Archaeological Sensitivity

Because historic-era archaeological deposits formed more recently, their interaction with local geological processes is not as complex as are those of prehistoric sites. While such sites may be eroded or buried during the historic era during short-term geological processes, an overview of the presence of identified sites provides one means of assessing the sensitivity of the study area. Numerous historic-era archaeological sites have been documented in the Delta and surrounding vicinity. Table 18A-4 shows which identified sites overlap with typical conveyance footprints under consideration. While few historic archaeological sites have been previously identified in the direct footprint of the alignments, survey efforts that would reveal these resources have not been completed at this time. Because historic-era archaeological sites are known to occur in the Delta, the project area should be considered sensitive for historical archaeology. Special attention should be paid to areas of known historic occupation and use where activities may have occurred that could have created buried and subsurface deposits such as trash and borrow pits, privies, and buried foundations and/or structural remains. Attention should also be paid to waterways where previously unidentified submerged historic-era resources may exist, such as shipwrecks that may be associated with the intense navigation and commerce that occurred in the Delta region during the historic era. Collectively, the number of identified sites and the intensity of historic-era activity indicate that the study area is sensitive for additional historic-era archaeological resources that may be affected by the action alternatives.

The majority of the previously identified historic-era archaeological resources in the Delta consist of those associated with Euro-American occupation. Refuse deposits may be the most visible evidence remaining of a former residence area, particularly where an associated building left little imprint on the land. Some of these solitary recorded refuse deposits, therefore, may be linked with adjacent homes or businesses, and these connections often cannot be determined without additional archaeological testing and documentary research. Historic commercial sites—such as hotels, bars, and garages—also regularly produced considerable refuse; however none have been identified in the project area as containing known archaeological deposits. Abandoned farms and ranches are also common structural remains that have the potential to contain archaeological deposits. Farm and ranch sites typically include evidence of corrals, pens, refuse, barns, houses, and outbuildings. Although not as likely in this area of the Delta, there may also be some evidence of mining activities in the area, including associated mining equipment and tailings. Equipment associated with the creation of the Delta, dredging, shipping and travel along the Delta waterways, and activities associated with industry in and along the Delta waters may also be encountered. Isolated deposits of artifacts also commonly appear near old roads or levees, particularly in rural areas where methods of trash disposal were left up to the individual households until relatively recent times. The potential to encounter materials in the area, especially those associated with farming and ranching activities, remains high.

Table 18A-4. Historic-Era Archaeological Sites Occurring on or Near Typical Conveyance Footprints (All Alternatives Combined)

Number	Trinomial	Detail	County
P-39-000330	CA-SJO-216H	Historic	Foundation
P-39-000331	CA-SJO-217H	Historic	Foundation
P-57-000182	CA-YOL-165H	Historic	Foundation
P-39-000333	CA-SJO-219H	Historic	Foundation
P-39-000335	CA-SJO-221H	Historic	Foundation
P-39-000336	CA-SJO-222H	Historic	Foundation

The presence of these identified resources suggests that the project area is sensitive for additional, yet-unidentified historic-era archaeological deposits. In addition, because of the erosive and rapidly accumulating nature of alluvial soils as described above, it is possible that buried historic-era archaeological sites may exist which could be damaged or exposed during construction, even after inventory has been conducted. While subsurface testing may reveal such resources, the distribution of such resources in relation to the large geographic areas involved reduces the probability that subsurface inventory will reveal all sites and allow their protection prior to construction.

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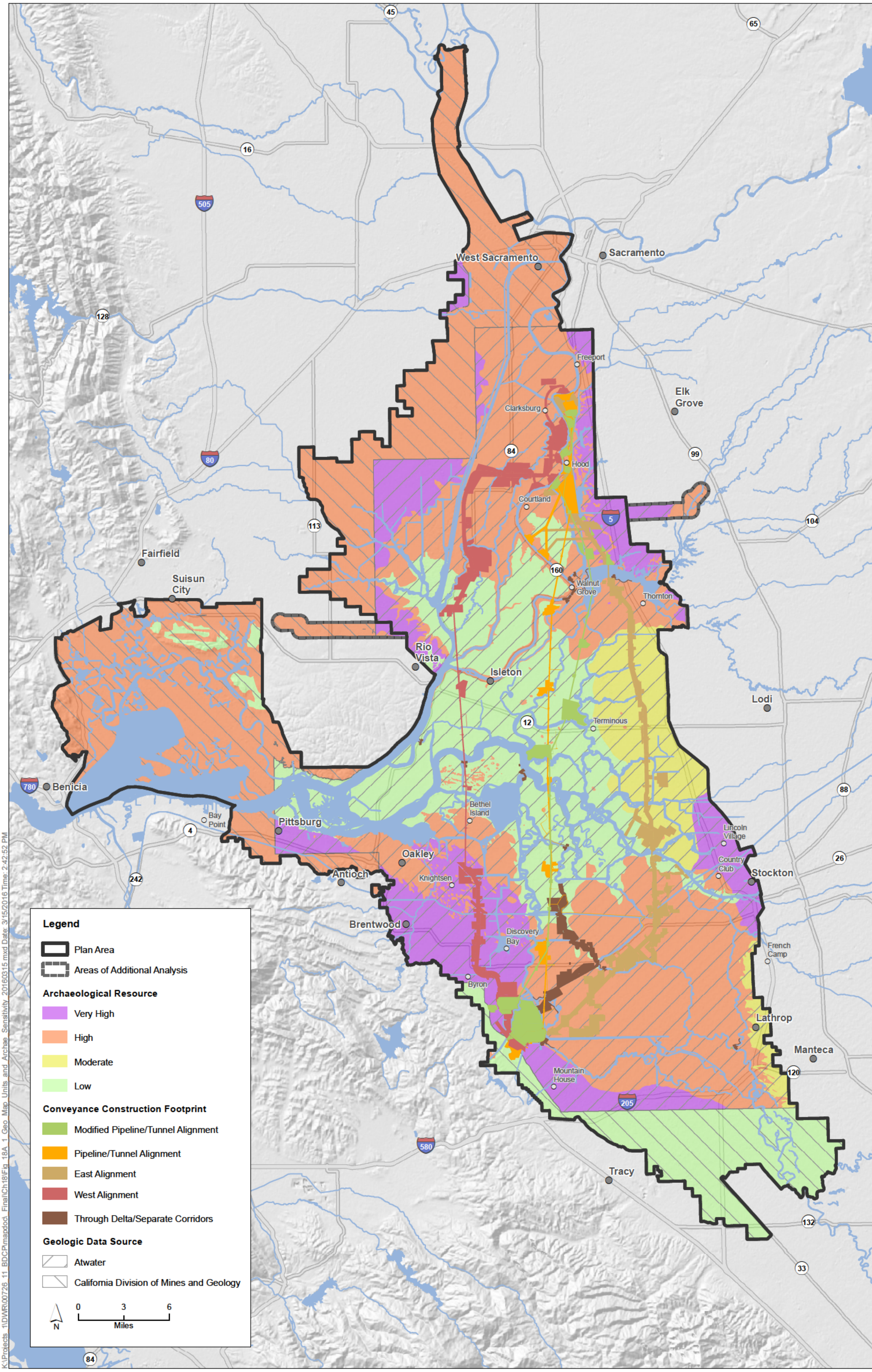

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Sources: Plan Area, ICF 2012; Constructability (Rev 10b), DHCCP DWR 2012; Constructability (Rev 3b), DHCCP DWR 2012; Constructability (Rev 2b), DHCCP DWR 2013; Soils, California Division of Mines and Geology - San Francisco - San Jose Quadrangle (Wagner e. al 1991); Sacramento Quadrangle (Wagner et. al 1981); Santa Rosa Quadrangle (Wagner and Bortugno 1982), Atwater 1982

Figure 18A-1
Geological Map Units and Archaeological Sensitivity