# Chapter 10
# Soils

## 10.1 Environmental Setting/Affected Environment

This section provides information on soils in the study area (the area in which impacts may occur) which is limited to the Plan Area (the area covered by the BDCP). This includes portions of the Sacramento–San Joaquin Delta (Delta), Suisun Marsh, and Yolo Bypass. See Chapter 1, *Introduction*, for a detailed description of the Plan Area. The Plan Area was selected for the geographic scope of the analysis because all soil-related effects and constraints are restricted to the immediate location of the potential effect. Land outside of the Plan Area were not considered because there are no structures being proposed and because changed operations at upstream and within the water user service areas do not increase potential adverse effects on soils in those areas. The information is based largely on Natural Resources Conservation Service (NRCS) (formerly Soil Conservation Service) soil surveys for the seven counties in the Plan Area and the online Soil Survey Geographic (SSURGO) database. Other sources include California Department of Water Resources (DWR) and U.S. Geological Survey publications, academic technical reports and publications, and county and city general plans.

This section describes soil characteristics in the study area (Plan Area) with respect to the following.

- Soil associations.
- Soil chemical and physical characteristics.
- Soil suitability/limitations for various uses.
- Land subsidence resulting from biological oxidation of organic carbon in peat soil.

Other chapters that contain information related to soils are listed below.

- Soil resources, as they pertain to agricultural land use and important farmlands mapped by the Farmland Mapping and Monitoring Program (FMMP), are discussed in Chapter 13, *Land Use.*
- Soil resources, as they pertain to crop production (including potential salinization caused by irrigation), are discussed in Chapter 14, *Agricultural Resources*.
- Geotechnical properties of soils, as they pertain to soil stability, levee stability, and liquefaction, are described in Chapter 6, *Surface Water*, and Chapter 9, *Geology and Seismicity*.
- Carbon dioxide ($CO_2$) flux to the atmosphere from oxidation of organic matter in peat soil is discussed in Chapter 29*, Climate Change*, and Chapter 22, *Air Quality and Greenhouse Gas Emissions*.
- Water quality concerns and regulatory implications associated with soil erosion and sedimentation are summarized in this chapter, but are more thoroughly discussed in Chapter 8, *Water Quality*.
- Land subsidence from groundwater extraction and geologic causes is described in Chapter 7, *Groundwater*, and Chapter 9, *Geology and Seismicity*.

This chapter does not describe the soil setting or potential project effects in the State Water Project (SWP) and Central Valley Project (CVP) Export Service Areas Region (Export Service Areas Region) or in the areas upstream of the Delta. As appropriate, this topic is addressed in Chapter 30, *Growth Inducement*.

The setting information for soils, except where otherwise noted, is derived from the soils appendix that was included in the conceptual engineering reports (CERs) prepared for the BDCP.

- Conceptual Engineering Report—Isolated Conveyance Facility—All Tunnel Option (California Department of Water Resources 2010a).
- Conceptual Engineering Report—Isolated Conveyance Facility—Pipeline/Tunnel Option—Addendum (California Department of Water Resources 2010b).
- Conceptual Engineering Report—Isolated Conveyance Facility—East Option (California Department of Water Resources 2009a).
- Conceptual Engineering Report—Isolated Conveyance Facility—East Option—Addendum (California Department of Water Resources 2010c).
- Conceptual Engineering Report—Isolated Conveyance Facility—West Option (California Department of Water Resources 2009b).
- Conceptual Engineering Report—Isolated Conveyance Facility—West Option—Addendum (California Department of Water Resources 2010d).
- Option Description Report—Separate Corridors Option (California Department of Water Resources 2010e).

## 10.1.1 Potential Environmental Effects Area

The study area (the area in which impacts may occur) evaluated for potential effects on soil is the Plan Area (the area covered by the BDCP) and includes portions of Sacramento, Yolo, Solano, San Joaquin, Contra Costa, and Alameda Counties and the cities of Sacramento, Isleton, West Sacramento, Rio Vista, and Antioch, which lie within the Plan Area.

### 10.1.1.1 Soil Associations

Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. Areas are not considered to have soil if the surface is permanently covered by water too deep (typically more than 8.2 feet) for the growth of rooted plants. The lower boundary that separates soil from the nonsoil underneath is most difficult to define. Soil consists of horizons near the Earth's surface that, in contrast to the underlying parent material, have been altered by the interactions of climate, relief, and living organisms over time. Commonly, soil grades at its lower boundary to hard rock or to earthy materials virtually devoid of animals, roots, or other marks of biological activity.

Soil formed in the Delta as the result of geologic processes over approximately the past 7,000 years. 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 soil formed near the channels during flood conditions and organic soil formed on marsh island interiors as plant residues accumulated faster than they could decompose. Prior to the mid-1800s, the Delta was a vast marsh and floodplain, under which peat soil 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).

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

Soils continue to be a key resource in the Delta (Delta Protection Commission 1993) and have physical and chemical characteristics that qualify many areas as prime farmland (see Chapter 14, *Agricultural Resources*). The growing season, drainage, and available moisture in many Delta soils provide an excellent medium for growing a wide variety of crops. The soils also continue to support important wetland ecosystems in the Delta and Suisun Marsh.

Because the study area is large, the soils are best described at a landscape scale, rather than at a detailed scale. NRCS maps soils at a landscape scale by mapping soil associations. Soil associations are groupings of individual soils that occur together in the landscape and are typically named after the two or three dominant soil series. For example, the dominant soil components in the Gazwell-Rindge soil association in Sacramento County are the Gazwell and Rindge soil series. Soil associations cover broad areas that have a distinctive pattern of soils, relief, and drainage. Figure 10-1 shows the soil associations in the Plan Area within each county (Soil Conservation Service 1966, 1972, 1977a, 1977b, 1988, 1992, 1993). This generalized soil map is useful for comparing the suitability of large areas for general land use purposes. Larger scale maps showing the individual soil map units that comprise each association are often used for evaluating soil suitability on a site-specific scale (e.g., selecting a building site). Appendix 10A, *Soil Associations*, identifies the individual map units that comprise each association.

Soils within the Plan Area can be generally grouped based on relationships with the following physiographic settings. The geographic context of these relationships is described below.

- Basin, delta, and Suisun Marsh.
- Basin rims.
- Floodplains and stream terraces.
- Valley fill, alluvial fans, and low terraces.
- Uplands and high terraces.

## Basin, Delta, and Suisun Marsh Soils

Basin and delta soils occupy the lowest elevations and are often protected by levees (Soil Conservation Service 1992, 1993). Most of these low-lying soils contain substantial organic matter and are classified as peats or mucks (Soil Conservation Service 1992, 1993); Figure 10-2 shows the percent organic matter content of the upper 5 feet of soils in the Plan Area. Examples of organic soil associations in the Delta include the Gazwell-Rindge association in Sacramento County, the Rindge-Kingile-Ryde and Peltier-Egbert associations in San Joaquin County, and the Rindge-Kingile and Joice-Reyes associations in Contra Costa County.

Peat soils contain large accumulations of partially decomposed plant material. In muck soils, plant material is decomposed to a greater degree than in peat soils. In the Delta, unaltered peat soils are characterized as having two layers: one relatively thin layer with plant material derived from tule, and an underlying deeper layer of plant material derived from reed, primarily *Phragmites communis* (Weir 1950). Peat soils are grouped in the soil order Histosols. By definition, Histosols contain more than 18% organic carbon if the mineral fraction of the soil contains at least 60% clay, or more than 12% organic carbon if no clay is present (Buol et al. 1980:315-317). Histosols are further classified into suborders according to level of decomposition in the subsurface. Fibrists (i.e., peat) exhibit relatively minor decomposition, with fibric material dominant in the subsurface; Hemists are moderately decomposed with hemic organic material in the subsurface; and Saprists (i.e., muck) are the most decomposed, with sapric material in the subsurface (Buol et al. 1980: 315-317). Soil series representing organic soils from those closest to a natural state, to those most altered (and possessing the highest to lowest organic matter content), are Venice, Staten, Egbert, and Roberts, respectively (California Department of Water Resources 2007). Soils with less organic matter may have been drained earlier than others (California Department of Water Resources 2007).

The thickness of the organic soils is greatest on islands of the central Delta. Figure 10-3 shows the total thickness of the organic soils[1], which extends well below the 5-foot depth typically described in NRCS soil surveys. The areas with the thickest organic soils include southern Grand, southern Tyler, southern Brannan, Twitchell, northern and southern Sherman, Venice, Medford, and western Bouldin Islands in Sacramento and San Joaquin Counties (Delta Protection Commission 1993). The Suisun Marsh has the largest contiguous area of highly organic soils, with poorly drained muck and peat soils in salt marshes, such as the Joice-Suisun association. In addition to being very deep, peat soils are also poorly drained and may have a high water table. They have a high water-holding capacity. These soils have good fertility, with 2–3.5% nitrogen; therefore, they make excellent agricultural soils when drained (Delta Protection Commission 1993).

Soils along the margin of the Delta contain more mineral material and less organic material than those in the central Delta. Mineral soils that occur in the Delta are typically fine textured with poor drainage (e.g., the Clear Lake association in Sacramento County, the Sacramento association in Yolo County, and the Sacramento-Omni association in Contra Costa County [Figure 10-1]). These soils also may be calcareous with high salinity and a high sodium content (e.g., the Willows-Pescadero association in Yolo and San Joaquin Counties [Figure 10-1]). Soils in the Yolo Bypass are primarily those of the Capay-Sacramento association and are moderately well-drained to poorly drained silty clay loams to clays, as shown in Figure 10-1 (Soil Conservation Service 1972).

The topsoil layer ranges between 20 and 60 inches thick.

### Basin Rim Soils

Basin rim soils are found along the rims (edges) of basins. Soils in this physiographic setting are mineral soils that are poorly drained to well-drained, and have fine textures in their surface horizons. Some areas contain soils with a claypan layer in the subsurface. For example, the Marcuse-Solano-Pescadero association in Contra Costa County contains very poorly drained to somewhat poorly drained clays, loams, and clay loams (Figure 10-1). A cemented hardpan can occur at depths of 40–60 inches in Hollenbeck soils in San Joaquin County (Figure 10-1). Dierssen soils in

[1] The original source of this figure (California Department of Water Resources 2007) does not define "organic soils", but is assumed to be those soil materials with a minimum of 15% organic matter content.

western Sacramento County have a sandy clay loam texture at the surface, a calcareous clay subsoil, and a hardpan at a depth of 20–45 inches (Figure 10-1) and also can have a perched water table at a depth of 6–36 inches in winter and early spring (Soil Conservation Service 1993).

The topsoil layer of the soils in this physiographic setting generally ranges between 5 and 14 inches thick.

## Floodplain and Stream Terrace Soils

Floodplain and stream terrace soils are mineral soils located adjacent to major rivers and other streams, and may be associated with landward sediment accumulations behind natural levees. Soils are stratified, with relatively poor drainage and fine textures. Examples include Sailboat-Scribner-Cosumnes and Egbert-Valpac associations adjacent to the Sacramento River, and the Columbia-Cosumnes association adjacent to the Cosumnes River and other streams in Sacramento County (Figure 10-1). The Merritt-Grangeville-Columbia and Columbia-Vina-Coyote Creek associations in San Joaquin County (Figure 10-1) are additional examples.

The topsoil layer of the soils in this physiographic setting generally ranges between 8 and 20 inches thick.

## Valley Fill, Alluvial Fan, and Low Terrace Soils

Valley fill, alluvial fan, and low terrace soils are typically very deep with variable texture and ability to transmit water. Alluvial fan soils range from somewhat poorly drained fine sandy loams and silty clay loams (e.g., the Sycamore-Tyndall association in Yolo County) to well-drained silt loams and silty clay loams (e.g., the Yolo-Brentwood association in Yolo County). Soils on low terraces include the San Joaquin association in Sacramento County and San Joaquin-Bruella and Madera soils in San Joaquin County, which are moderately well-drained with a claypan subsoil and have a cemented hardpan at a depth of 20–40 inches (Soil Conservation Service 1992, 1993). A perched water table may be present (e.g., the Capay-Sycamore-Brentwood association in Contra Costa County [Soil Conservation Service 1977a]), or a high water table may sometimes be present as the result of irrigation (e.g., the Capay association on interfan basins of San Joaquin County [Soil Conservation Service 1992]). Delhi soils have sandy textures on dunes and are very deep and somewhat excessively drained (e.g., the Delhi-Veritas-Tinnin association on dunes, alluvial fans, and low fan terraces in San Joaquin County, and the Delhi association in Contra Costa County [Soil Conservation Service 1992, 1977a]).

The topsoil layer of the soils in this physiographic setting generally ranges between 6 and 26 inches thick.

## Upland and High Terrace Soils

Upland and high terrace soils in general are well-drained and range in texture from loams to clays. These soils primarily formed in material weathered from sandstone, shale, and siltstone, and can occur on dissected terraces (e.g., Altamont-Diablo association in Solano and Alameda Counties) (Figure 10-1) or on mountainous uplands (Dibble-Los Osos and Millsholm associations in Solano County [Soil Conservation Service 1977b]). Erosion by surface water flows may be a hazard where slopes are steep. The subsoil may be slowly permeable (e.g., Corning-Hillgate association in Yolo County) (Figure 10-1), or a cemented hardpan may be present at depth (Redding-Yellowlark soils in San Joaquin County) (Figure 10-1).

The topsoil layer of the soils in this physiographic setting generally ranges between 7 and 30 inches thick, with the thicker A horizons always occurring among the soils that are clay throughout the profile.

#### 10.1.1.2 Soil Physical and Chemical Properties

Soil physical and chemical characteristics affect the way a soil "behaves" under specific land uses. These characteristics are especially important for engineering considerations. Suitability and limitation ratings for various engineering uses are identified in Appendix 10B, *NRCS Soil Suitability Ratings*. Relevant soil physical and chemical properties described in this section are expansiveness (i.e., shrink-swell potential) and erodibility by water and wind. Physical and chemical properties of soils in the Plan Area are detailed in Appendix 10C, *Soil Chemical and Physical Properties*, and are described in the following sections. Other soil properties shown in Appendix 10C but not discussed below include those properties that are important for evaluation of soil suitability for agriculture, including Storie Index, Land Capability Classification, and Prime Farmland soils. A discussion of these characteristics, which are relevant to agricultural use, is provided in Chapter 13, *Land Use*, and Chapter 14, *Agricultural Resources*.

##### Expansive Soils (Shrink-Swell Potential)

Expansive soils increase in volume when wet and shrink in volume when dry. The degree of expansiveness, or shrink-swell potential, depends on the type and amount of clay content in the soil. The highest shrink-swell potential exists in soils with high amounts of smectitic clays. Expansiveness can be characterized by measuring a soil's linear extensibility percentage (LEP), which is the change in length of an unconfined soil clod as moisture content is decreased from a moist to a dry state, reported as a percentage (Natural Resources Conservation Service 2010a). See Appendix 10C for the LEP of the soil map units for the upper 5 feet of the soil profile. Table 10-1 shows the shrink-swell soil classes based on LEP.

**Table 10-1. Shrink-Swell Soil Classes Based on Linear Extensibility Percentage**

| Shrink-Swell Class | LEP |
|---|---|
| Low | <3 |
| Moderate | 3–6 |
| High | 6–9 |
| Very High | ≥9 |

Source: Natural Resources Conservation Service 2010b.
Note: LEP = linear extensibility percentage

Figure 10-4 shows the LEP classes for the upper 5 feet of soil material. The LEP of soil materials below approximately 5 feet is not rated. Where one soil layer in the soil profile has a different LEP than other layers, the layer with the highest LEP is shown on the figure. Areas of the Plan Area with the highest soil shrink-swell potential include large portions of the northern and southwestern parts of the Delta, the Yolo Bypass, and areas within Suisun Marsh (Figure 10-4). Soils with the lowest shrink-swell potential occur in the central and southeastern parts of the Delta.

## Water Erodibility

Water erosion results when raindrop impact detaches soil particles and flowing water removes and transports soil material. Sheet erosion removes soil from an area in a fairly uniform manner without development of discrete channels. Rill erosion removes soil through the cutting of many small but discrete channels where runoff concentrates. Gully erosion occurs when water cuts down into the soil along the line of flow, and the cut channels are deep enough that they cannot be obliterated through tillage. Soil loss through sheet and rill erosion can be predicted through models, such as the Revised Universal Soil Loss Equation (RUSLE). RUSLE predicts soil loss based on numerous factors, including rainfall erosivity, soil erodibility (defined below), slope length and steepness, vegetative cover, and management practices (Natural Resources Conservation Service 2010b).

Appendix 10C includes soil erodibility factors for each soil map unit in the Plan Area. The soil erodibility factor (Kw) is a relative index of the susceptibility of a bare, cultivated soil to particle detachment and transport by raindrop impact and runoff, but does not reflect the influence of slope on potential erosion rates. Therefore, the erosion hazard may be low in a level area with soils that have a high Kw value. Experimentally measured Kw values vary from 0.02 to 0.69, with the higher end of the range representing soils with greater susceptibility to particle detachment and transport. Clayey and sandy soils have low Kw values because the soil particles are resistant to detachment from raindrop impact (clayey soils) or because of their higher infiltration capacity (sandy soils). Loamy soils have moderate Kw values. Silty soils are the most susceptible to water erosion, with high Kw values (Michigan State University 2002).

Figure 10-5 provides water erosion hazard ratings for the surface layer of soils in the Plan Area (Natural Resources Conservation Service 2010a). *Erosion hazard* refers to the degree to which a soil will be subject to accelerated erosion rates when the land surface is disturbed. Erosion hazard is primarily controlled by the soil erodibility factor and the steepness of the slope. The soil survey hazard ratings shown in Figure 10-5 are based on sheet or rill erosion in areas outside of roads and trail areas, where 50–75% of the land surface has been exposed by ground-disturbing activities[2]. Hazard ratings range from "slight," which indicates that erosion is unlikely under ordinary climatic conditions, to "very severe," which indicates that significant erosion is expected, loss of soil productivity, and offsite damage are likely, and erosion-control measures are costly and generally impractical (Natural Resources Conservation Service 2010a). The ratings show the relative water erosion hazard that would exist during construction or other ground-disturbing activities. The water erosion hazard ratings are based on the dominant soil present, although other, minor soil components also may be present within the map unit. Because of the level to nearly level slopes, water erosion hazard is rated as slight throughout most of the Plan Area; in more sloping areas, the water erosion hazard ranges from moderate to very severe.

## Soil Erodibility by Wind

Soil erodibility by wind is related to soil texture, organic matter content, calcium carbonate content, rock fragment content, mineralogy, and moisture content. NRCS assigns soil map units to one of eight wind erodibility groups (WEGs) based on susceptibility to blowing (Natural Resources Conservation

[2] For the purpose of this analysis, the erosion hazard rating for areas of Histosols and mucky mineral soils was modified from that provided in the SSURGO database to compensate for the influence of high organic matter content on the rating. The Histosols and mucky mineral soils in the Plan Area typically have a very low Kw value (i.e., 0.02). This low soil erodibility, combined with level to nearly level slopes, results in a slight erosion hazard in such areas; this characterization is consistent with the manuscript versions of the county soil survey reports.

Service 2010b): 1, 2, 3, 4, 4L, 5, 6, 7, and 8. The WEGs assume that the soil that has been cultivated or is bare. The organic soils of the Suisun Marsh and the central Delta have a high susceptibility to wind erosion, as indicated by their classification in WEGs 1 through 3. Figure 10-6 shows the WEG of the surface layer of the soils in the Plan Area (CPA).

#### 10.1.1.3 Soil Suitability and Use Limitation Ratings

Physical and chemical properties of soils are used by NRCS to determine suitability for various uses, such as for agriculture, levee construction, urban development, or marsh wildlife habitat. Suitability and limitation ratings for soil use in embankments, dikes, and levees; shallow excavations; and corrosivity are identified in Appendix 10B, *NRCS Soil Suitability Ratings* (Natural Resources Conservation Service 2010b).

##### Use Limitations for Embankments, Dikes, and Levees

Construction of embankments, dikes, and levees requires soil material that is resistant to seepage, piping, and erosion and that has favorable compaction characteristics. Soils with limited suitability for construction of embankments and levees include those with high organic matter content, high stone content, elevated sodium, high shrink-swell potential, and high gypsum (calcium sulfate) content (Natural Resources Conservation Service 2010b).

Soil use limitation ratings of slightly limited, somewhat limited, limited, and very limited, are provided in Appendix 10B for each soil map unit. The rating is given for the whole soil, from the surface to a depth of about 5 feet, based on the assumption that soil horizons will be mixed in loading, dumping, and spreading. The ratings do not indicate the suitability of the undisturbed soil for supporting the embankment. Soil properties to a depth greater than the embankment height have an effect on the performance and safety of the embankment (e.g., low-density silts and clays in the supporting foundation generally have excessive settlement and low strength); therefore, geotechnical studies must generally be made to evaluate suitability as load-bearing surfaces. Nearly all soil units in the Plan Area have some restrictions associated with use for embankments, dikes, or levees, and the suitability of most soil types for these features is very limited (Appendix 10B).

##### Use Limitations for Shallow Excavations

Shallow excavations are trenches or holes dug in the soil to a maximum depth of 5 or 6 feet for construction of pipelines, sewer lines, telephone and power transmission lines, basements, and open ditches. These excavations are most commonly made by trenching machines or backhoes. Use limitation ratings are defined as slight, somewhat limited, limited, and very limited based on the soil properties that influence ease of excavation and resistance to sloughing. Restrictive properties adversely influence the ease of digging, filling, and compacting, and include shallow depth to bedrock or cemented pan and presence of large stones. Presence of a seasonally high water table and flooding may restrict the period when excavations can be made. Slope influences the ease of using machinery and accessibility. Soil texture and depth to water table influence the resistance of soil walls to sloughing (Natural Resources Conservation Service 2010b).

Use limitations for shallow excavations in the Plan Area are predominantly a result of caving potential of clay soils, slopes greater than 15%, soil saturation less than 2.5 feet in depth, and presence of high organic matter content to a depth of 20 inches below ground surface (Natural Resources Conservation Service 2010b). Nearly all soil map units in the Plan Area have some restrictions associated with shallow excavations, and many soil map units have a rating of very limited (Appendix 10B).

## 10.1.1.4 Risk of Corrosion to Uncoated Steel

Uncoated steel corrodes when soil-induced electrochemical or chemical actions convert iron from steel into its respective ions and cause the uncoated steel to dissolve or weaken (Natural Resources Conservation Service 2010b). The rate of deterioration of uncoated steel is controlled by soil moisture content, soil texture, acidity, and soluble salt content. The Soil Survey Handbook provides three classes of corrosion risk to uncoated steel (low, medium, and high), and the NRCS guidance for estimating corrosion risk is shown in Table 10-2.

**Table 10-2. Guidance for Estimating Corrosion Risk to Uncoated Steel[a]**

| | Limits | | |
|---|---|---|---|
| Property | Low | Moderate | High |
| Drainage Class and Texture | Excessively drained coarse textured or well-drained, coarse to medium textured soils; or moderately well-drained coarse textured, soils; or somewhat poorly drained, coarse textured soils | Well-drained, moderately fine textured soils; or moderately well-drained, medium textured soils; or somewhat poorly drained, moderately coarse textured soils; or very poorly drained soils with stable high water table | Well-drained, fine textured or stratified soils; or moderately well-drained, fine and moderately fine textured or stratified soils; or somewhat poorly drained, medium to fine textured or stratified soils; or poorly drained soils with fluctuating water table |
| Total Acidity (milliequivalents per 100 grams)[b] | <8 | 8–12 | ≥12 |
| Resistivity at Saturation (ohms per centimeter)[c] | ≥5,000 | 2,000–5,000 | <2,000 |
| Conductivity of Saturated Extract (millimhos per centimeter)[d] | <0.3 | 0.3–0.8 | ≥0.8 |

Source: Natural Resources Conservation Service 2010b.

[a] Based on data in the publication *Underground Corrosion,* Table 99, p. 167, Circular 579, U.S. Department of Commerce, National Bureau of Standards.

[b] Total acidity is roughly equal to extractable acidity (as determined by Soil Survey Laboratories Method 6Hla, Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004).

[c] Roughly equivalent to resistivity of fine- and medium-textured soils measured at saturation (Method 8E1, Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November, Natural Resources Conservation Service 2004). Resistivity at saturation for coarse-textured soil is generally lower than when obtained at field capacity and may cause the soil to be placed in a higher corrosion class.

[d] Method 8Ala, Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004. The relationship between resistivity of a saturated soil paste (Method 8E1) and electrical conductivity of the saturation extract (Method 8A1a), is influenced by variations in the saturation percentage, salinity, and conductivity of the soil minerals. These two measurements generally correspond closely enough to place a soil in one corrosion class. (For reference, 1 millimho per centimeter = 1 deciseimen per meter.)

In the Plan Area, most soil units are expected to have a high potential to cause corrosion to uncoated steel (Figure 10-7 and Appendix 10B).

#### 10.1.1.5 Risk of Corrosion to Concrete

Corrosion to concrete results from a chemical reaction between a base (the concrete) and a weak acid (the soil solution). Construction activities may need to use special types of cement when local soils have a high risk of corrosion (Natural Resources Conservation Service 2010b). The rate of concrete deterioration depends on soil texture and acidity, the amount of sodium, or magnesium sulfate and calcium sulfate (gypsum) present in the soil. In particular, soils containing gypsum generally require a special cement to reduce risk of corrosion. The NRCS Soil Survey Handbook classifies risk of corrosion to concrete as low, moderate, or high, in accordance with the guidelines provided in Table 10-3.

**Table 10-3. Soil Classification for Risk of Corrosion to Concrete**

| | Limits[a] | | |
|---|---|---|---|
| Property | Low | Moderate | High |
| Texture and Reaction | Sandy and organic soils with pH >6.5 or medium and fine textured soils with pH >6.0 | Sandy and organic soils with pH 5.5 to 6.5 or medium and fine textured soils with pH 5.0 to 6.0 | Sandy and organic soils with pH<5.5 or medium and fine textured soils with pH <5.0 |
| Sodium and/or Magnesium Sulfate (ppm) | <1,000 | 1,000–7,000 | >7,000 |
| Sodium Chloride (ppm) | <2,000 | 2,000–10,000 | >10,000 |

Source: Natural Resources Conservation Service 2010b.

Notes: pH = measure of acidity or alkalinity; ppm = part(s) per million

[a] Based on data in *National Handbook of Conservation Practices*, Standard 606, Subsurface Drain, Natural Resources Conservation Service 1980.

ppm = parts per million

In the Plan Area, most soil units are expected to have a low to moderate potential to cause corrosion to concrete (Figure 10-8).

### 10.1.2 Land Subsidence

Land subsidence is a gradual settling or sudden sinking of the earth's surface resulting from subsurface movement of earth materials (Galloway et al. 2000). Although subsidence can have various causes, such as aquifer compaction, drainage of organic soils, underground mining, extraction of oil and natural gas, natural compaction, tectonic movement (changes resulting from movements in the Earth's crust), and sinkholes, the primary cause in the Delta is decomposition of organic carbon in the peat soils. This section summarizes the scientific and technical literature on land subsidence in the Delta.

#### 10.1.2.1 History

For more than 7,000 years, a balance existed between sediment influx to the Delta, production of organic sediment in the Delta, and export of sediment to San Francisco Bay. During this time, marsh conditions were supported. Much of the area was covered with dense stands of tule (*Scirpus lacustris*), with riparian plant species occupying higher stream banks (natural levees) where mineral soils were present (Weir 1950). The land elevation was at or near sea level, and the land surface was inundated at high tide and when flood conditions were present. Equilibrium conditions promoted the development of peat soils to depths of up to approximately 30 feet in some areas (Weir 1950).

This equilibrium was first disrupted when large volumes of sediment influx occurred from hydraulic mining in the mid-1800s, then by subsequent reclamation of Delta tule marsh islands that took place from the late 1800s through about 1930 (Weir 1950). With passage of the Swamp and Overflow Act of 1850 (when title of lands in the Delta passed from federal to state control), the marshlands began to be drained for conversion to agricultural use. Levees were constructed around Delta islands to exclude floods and tidal overflow. Much of the construction material was channel sediment excavated by a clamshell dredge. Following levee construction, tule marshes on island interiors began to die and were burned, drainage ditches were constructed at the perimeter of levees, and pumps were installed to transfer drainage water from the island interiors into the adjacent waterways (Weir 1950). The land was cultivated when it was dry enough for plowing.

The ages of Delta islands are related to the date they were reclaimed. For example, Lower Jones Tract was drained and put into cultivation in 1902, cultivation on Bacon Island began in 1915, and Mildred Island was first farmed in 1921. Most of the Delta was in cultivation in 1922, when land subsidence was first investigated (Weir 1950). The Delta's present form dates to the 1930s, when approximately 100 islands and tracts had been drained and more than 1,000 miles of levees had been constructed (Ingebritsen et al. 2000).

#### 10.1.2.2 Causes of Subsidence

The primary cause of land subsidence in the Delta has been attributed to microbial decomposition of peat soils (Ingebritsen et al. 2000; Deverel and Rojstaczer 1996). Waterlogged soils contain little oxygen, which is necessary for microbial decomposition of organic matter. Under anaerobic conditions, organic matter from plant materials accumulates faster than it can decompose. When the Delta islands were drained, the formerly saturated soils became oxygen rich and conditions favored microbial oxidation. When organic carbon is oxidized from peat soils, it is emitted as $CO_2$ gas to the atmosphere, thereby reducing the soil carbon pool and soil volume (Deverel and Rojstaczer 1996). The agricultural cultivation of the Delta's peat soils has, over time, contributed to the subsidence of most Delta islands, particularly in the West and Central Delta. Prior to agricultural development, the soil was waterlogged and anaerobic (oxygen-poor). Organic carbon accumulated faster than it could decompose. Drainage for agriculture led to aerobic (oxygen-rich) conditions that favor rapid microbial oxidation of the carbon in the peat soil. Most of the carbon loss is emitted as carbon dioxide gas to the atmosphere (Deverel and Rojstaczer 1996).

Other processes that may be contributing to land subsidence in the Delta are discussed below.

- Anaerobic decomposition of peat soils. Although anaerobic decomposition is considered a minor contributor to subsidence, some studies from the 1960s found that considerable decomposition occurred immediately below the groundwater table and accelerated with cycles of soil wetting and drying (Delta Protection Commission 1993).
- Soil compaction caused by consolidation and farm equipment. Shrinkage, consolidation, and compaction are responsible for the initial subsidence, specifically within about the first 3 years

after the water table is lowered. After this, a degree of stability is reached and subsidence declines to a steady rate, primarily because of oxidation (Natural Resources Conservation Service 2010b).

- Soil shrinkage. Organic soils shrink up to 50% in volume when dried; when undecomposed peat soils are exposed to the atmosphere, they will shrink upon drying (Delta Protection Commission 1993).
- Burning. This practice was common between 1900 and 1950, and was used to add nutrients to the soil, expose fresh peat, and control weeds and disease. Burning was especially common during World War II, when potatoes and sugar beets, crops with a high potassium requirement, were most in demand. Each burning event could result in loss of 3–5 inches of soil, and fields were typically burned every 3–5 years (Weir 1950). Burning has not been performed routinely since the 1960s.
- Wind erosion. Wind erosion was estimated to result in the removal of 0.25–0.5 inch of topsoil per year. Peat soils have a low bulk density (often less than 1 gram per cubic centimeter before decomposition). During cultivation, clouds of dust surround tractors unless the soil is moist. If bare soils are exposed when fields are not being cropped, such as occurred historically on asparagus fields in the springtime, large amounts of soil can be lost to wind erosion (Weir 1950).
- Dissolution of organic matter. This process is estimated to account for only about 1% of observed subsidence (Deverel and Rojstaczer 1996).
- Water, oil, and gas extraction. Water and gas extraction are not important factors in land subsidence in the Delta (Rojstaczer et al. 1991). Although slight groundwater-induced subsidence may occur during the summer months, elevations rebound during the winter months. On the other hand, groundwater extraction has historically resulted in substantial subsidence in the San Joaquin Valley outside of the Delta, and reduced imported water deliveries could lead to increased groundwater reliance and renewed subsidence in these areas (Ingebritsen et al. 2000).

#### 10.1.2.3 Rates of Subsidence and Current Conditions

The rate of decomposition of organic soils is related to temperature and moisture conditions (Buol et al. 1980). The microbial activity that drives the oxidation of peat soils approximately doubles with a 10-degree increase in soil temperature. However, the rate of $CO_2$ loss is reduced when soils are wet and contain little oxygen (Deverel and Rojstaczer 1996). Therefore, activities that increase oxygen in the subsurface (e.g., construction of underdrains to improve drainage) lead to decomposition of peat soils, and the rate of decomposition increases during warmer times of the year.

Historical subsidence rates in the Delta have been found to strongly correlate with the organic matter content of the soil and the age of the reclaimed island (Rojstaczer and Deverel 1995). In 1948, Lower Jones Tract, Mildred Island, and Bacon Island were all between 10 and 11 feet below sea level and were continuing to subside at the rate of 3–4 inches per year. Rojstaczer and Deverel (1995) quoted sources that suggest historical subsidence rates ranged from 1.8 to 4.6 inches per year, with higher rates associated with areas in the central Delta. Ingebritsen et al. (2000) indicated that long-term average rates of subsidence are 1–3 inches per year.

Rojstaczer and Deverel (1993) and Mount and Twiss (2005) also showed that subsidence rates on Lower Jones Tract, Mildred Island, and Bacon Island have slowed with time.

Deverel and Rojstaczer (1996) found that, while a certain amount of subsidence was caused by seasonal fluctuation in water table elevations, subsidence due primarily to biological oxidation of peat soils on three islands (Jersey Island, Orwood Tract, and Sherman Island) occurred at a rate of 0.27 inch per year, 0.32 inch per year, and 0.18 inch per year, respectively, in the 1990s. Dissolved organic carbon flux contributed less than 1% of the measured subsidence. Flux of dissolved organic carbon was greater and pH was lower in drainage waters when water table levels were seasonally located in soil layers containing highly decomposed organic matter.

Geographically, the soils within the centers of Delta islands typically have greater organic matter content than those near the margins close to levees. Consequently, the center areas also experience greater subsidence, and the land surface tends toward a saucer shape with the lowest elevation at island centers. Approximately 100 years following drainage of the Delta islands, many are 10–25 feet below sea level. Figure 10-9 shows the existing generalized elevations throughout most of the Plan Area. Areas that are at elevations lower than -5 feet can be assumed to have subsided.

Drainage ditches now maintain the water table at about 2.5–5 feet below the land surface. With continuing subsidence, however, ditches must be deepened periodically to keep the water table below the crop root zone.

Some recent estimates, including those developed as part of the DWR's Delta Risk Management Strategy, predict that 3–4 feet of additional subsidence will occur in the central portion of the Delta by 2050 (California Department of Water Resources 2007).

### 10.1.2.4 Consequences of Land Subsidence

Land subsidence has direct or indirect consequences on land use, water supply and quality, and other operations and uses of the Delta. These consequences are discussed in this section.

#### Levee Instability

As land subsides, the difference in water surface elevation between channels and the island interior becomes greater. This hydraulic head difference between the water surface of the channels and the island interiors increases hydrostatic forces on levees, which decreases levee stability and contributes to seepage through and under levees (Mount and Twiss 2005). Furthermore, as the land subsides, the shallow groundwater level becomes nearer to the ground surface, and drainage ditches along the toe of the levee must be deepened to ensure that the water table remains below the crop root zone. This practice decreases levee stability by reducing lateral support to levee foundations, which also leads to increased risk of levee failure. Many of the Delta islands have experienced levee breaches. Levee instability is described more thoroughly in Chapter 6, *Surface Water*.

#### Infrastructure Damage

In addition to levees, subsidence can damage infrastructural improvements such as pipelines, roads, railroads, canals, bridges, utility tower foundations, storm drains, and sanitary sewers, as well as public and private buildings and water, oil, and gas well casings. These effects can be particularly acute in areas of differential subsidence, in which the amount of ground level lowering varies over short distances.

#### Water Supply Disruption

Levee instability because of subsidence could disrupt the water source for more than two-thirds of California's population. The presence of the western Delta islands is believed to inhibit the migration of the salinity interface between the San Francisco Bay and the Delta. Were these islands to experience a levee breach and become inundated, water in the southern Delta might become too saline to use as drinking water (Ingebritsen et al. 2000). Effects related to salinity and water quality are discussed in Chapter 8, *Water Quality*.

### Greenhouse Gas Emissions and Climate Change

On a global scale, soil organic carbon lost by oxidation and combustion can significantly contribute to the amount of $CO_2$ in the atmosphere. Worldwide annual input of carbon to the atmosphere from agricultural drainage of organic soils may be as much as 6% of that produced by fossil fuel combustion; the Delta has been estimated to contribute 2 million tons of carbon per year to the atmosphere through oxidation of peat soils (Rojstaczer and Deverel 1993). Increased carbon in the Earth's atmosphere has been tied to increased concentrations of greenhouse gases and global climate change (California Department of Water Resources 2005). Greenhouse gas emissions and global climate change are discussed in Chapter 29, *Climate Change* and Chapter 22, *Air Quality and Greenhouse Gas Emissions*.

### Water Quality Degradation

Land subsidence can indirectly affect water quality by reducing levee integrity and increasing the risk of breaches. The present configuration of Delta islands may help ensure salinity intrusion does not increase salinity levels in Delta waterways, which would potentially reduce suitability of these waters for various uses, including drinking water supply and agricultural water supply. Although not a major cause of subsidence, dissolution of peat soils contributes dissolved organic carbon in drainage waters, which further reduces water quality. Water quality is discussed in Chapter 8, *Water Quality*.

### Soil Productivity Degradation

As the land surface subsides, the plant root zone becomes nearer to the shallow groundwater level. This is of particular significance in areas that are close to or below sea level, such as the organic soils of the Delta. A shallow water table can cause saturation of the root zone, making a soil less productive and limiting the types of crops that can be grown. The effects of subsidence on crop production and types are further discussed in Chapter 14, *Agricultural Resources*.

# 10.2 Regulatory Setting

This section describes federal and state codes, plans, policies, regulations, and laws and regional or local plans, policies, regulations, and ordinances that pertain to soil resources. The focus of this section is on laws and regulations related to soil hazards. The codes, plans, policies, regulations, and ordinances discussed below inform minimum design and construction requirements for some aspects of the BDCP water conveyance facility (CM1) and the other conservation measures (CM2–CM22). These act as performance standards for engineers and construction contractors and their implementation is considered an environmental commitment of the agencies implementing the BDCP. This commitment is discussed further in Appendix 3B, *Environmental Commitments*.

## 10.2.1 Federal Plans, Policies, and Regulations

Federal laws and regulations that are relevant to soils include the portions of the Clean Water Act (CWA) and implementing regulations that establish requirements for stormwater discharges from construction sites. As noted, these laws and regulations are thoroughly described in Chapter 8, *Water*

*Quality*. However, because they are related to activities applicable to soil resources, such as excavation and grading, they are summarized in this section.

#### 10.2.1.1 Clean Water Act Section 402, National Pollutant Discharge Elimination System Program: Storm Water Permitting

In November 1990, the U.S. Environmental Protection Agency (EPA) established regulations to mainly address construction related run-off and sedimentation into streams that established stormwater permit requirements for specific categories of industries, including construction (Phase I Rule). Under Phase I, a stormwater permit was required for construction projects that disturbed 5 or more acres of land, and for large Municipal Separate Storm Sewer Systems (MS4s). In December 1999, EPA promulgated regulations (Phase II Rule) that expanded the National Pollutant Discharge Elimination System (NPDES) to require a stormwater discharge permit for construction activities with a disturbance area of 1–5 acres and for small MS4s. In California, EPA has delegated responsibility for CWA implementation to the State Water Resources Control Board (State Water Board).

### 10.2.2 State Plans, Policies, and Regulations

#### 10.2.2.1 Porter-Cologne Water Pollution Control Act

The Porter-Cologne Water Pollution Control Act (Porter-Cologne Act) (California Water Code, Division 7) is the state law governing water quality in California. Under the Porter-Cologne Act, responsibilities for coordination and control of water quality are assigned to the State Water Board and nine Regional Water Quality Control Boards (Regional Boards). The Delta and Suisun Marsh are in the jurisdictions of the Central Valley Regional Board and the San Francisco Bay Regional Board, respectively. These Regional Boards are responsible for ensuring that construction activities comply with the state general permit regulating construction activities (discussed below).

#### 10.2.2.2 National Pollutant Discharge Elimination System General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities

In 2009, the State Water Board adopted the General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities, State Water Board Order No. 2009-0009-DWQ (General Permit), which regulates stormwater discharges from construction sites that involve 1 acre or more of disturbed area. Coverage under the General Permit is obtained by submitting permit registration documents to the State Water Board, which include a risk level assessment and a site-specific stormwater pollution prevention plan (SWPPP) that identifies an effective combination of erosion control, sediment control, and non-stormwater best management practices (BMPs). The General Permit requires that the SWPPP define a program of regular inspections of the BMPs and in some cases sampling of water quality parameters. Bay Delta Conservation Plan (BDCP) construction activities would require coverage under the General Permit.

#### 10.2.2.3 Municipal Separate Storm Sewer Systems Permits

The Phase I Rule required that large MS4s obtain a stormwater discharge permit, and the Phase II Rule expands the requirement to small MS4s. Generally, Phase I MS4s are covered by individual permits while Phase II MS4s are covered by a general permit. In the Plan Area, individual MS4 permits have been issued for several municipal jurisdictions, which are identified in Chapter 8, *Water Quality*. Phase I and II MS4 permits require permittees to develop and implement stormwater management plans that include provisions for reducing pollutant discharges from construction activities. Local jurisdictions are responsible for enforcement of those provisions. Future BDCP construction activities would need to implement soil erosion and sediment control measures that are consistent with municipal stormwater management plan requirements.

#### 10.2.2.4 Nonpoint Source Implementation and Enforcement Policy

The state's Nonpoint Source Implementation and Enforcement Policy describes how its nonpoint source (NPS) plan is to be implemented and enforced, in compliance with Section 319 of the CWA, Coastal Zone Act Reauthorization Amendments, and the Porter-Cologne Act. In contrast to point source pollution that enters water bodies from discrete conveyances, NPS pollution enters water bodies from diffuse sources, such as land runoff, seepage, or hydrologic modification. NPS pollution is controlled through implementation of management measures. The NPS program contains recommended management measures for developing areas and construction sites, as well as wetland and riparian areas. Requirements for soil erosion and sediment controls to prevent NPS sediment discharges to waterways may be incorporated into permits issued by the San Francisco Bay Conservation and Development Commission (BCDC) or other regulatory entities.

#### 10.2.2.5 McAteer-Petris Act

BCDC was permanently established by the McAteer-Petris Act of 1969, which gave the agency jurisdiction over certain activities in San Francisco Bay and portions of Suisun Marsh below the 10-foot contour line (including islands, levees, and grasslands), and any creeks or streams that flow into the bay. BCDC's authority includes issuing permits for dredging, grading, or construction, and repair or remodeling of structures within areas in the agency's jurisdiction.

#### 10.2.2.6 Suisun Marsh Preservation Act of 1977 and Suisun Marsh Protection Plan (1976)

The Suisun Marsh Preservation Act of 1977 adopted and called for the implementation of the Suisun Marsh Protection Plan (San Francisco Bay Conservation and Development Commission 1976). BCDC is the state agency designated to administer the plan, certify consistency of local protection programs with the plan, hear appeals on local governmental decisions affecting Suisun Marsh, and decide what developments should be permitted within the primary management zone. The objectives of the plan, developed in coordination with the California Department of Fish and Wildlife (DFW), are to preserve and enhance the quality and diversity of the Suisun Marsh aquatic and wildlife habitats, and to ensure retention of upland areas adjacent to the Suisun Marsh in uses compatible with its protection (San Francisco Bay Conservation and Development Commission 1976). BDCP activities in the Suisun Marsh that may be regulated under the Suisun Marsh Preservation Act include dredging, reduction of agricultural land by flooding of islands, and erosion control measures. If restoration activities are conducted in the Suisun Marsh in areas under BCDC jurisdiction, a permit from that agency would include measures to control soil erosion and sedimentation.

#### 10.2.2.7 California Building Code

California's minimum standards for structural design and construction are provided in the California Building Code (CBC) (California Code of Regulations [CCR], Title 24). The CBC provides standards for various aspects of construction, including excavation, grading, and fill. It provides requirements for classifying soils and identifying corrective actions when soil properties (e.g., expansive and corrosive soils) could lead to structural damage. BDCP water conveyance facility and restoration component construction activities would require conforming with the CBC.

## 10.2.3 Regional and Local Plans, Policies, and Regulations

### 10.2.3.1 General Plans, Ordinances, and Codes

Cities and counties have developed ordinances, policies, and other regulatory mechanisms for controlling pollutant discharges in construction site runoff, including grading and erosion control ordinances and drainage and land leveling ordinances. Development and implementation of local control measures, including adoption of ordinances, are generally requirements of MS4 permits issued by Regional Boards. An application for a grading permit typically includes vicinity and site maps, a grading plan, and an engineered erosion, sediment, and runoff control plan. Local permits are generally required for construction activities, and construction projects must conform to local drainage and erosion control policies and ordinances.

Certain county general plans that cover the Plan Area also contain policies to conserve topsoil or soil *as a resource*, without regard to its agricultural suitability or prime farmland status. Relevant provisions of these county general plans are outlined below.

#### Contra Costa County General Plan

A comprehensive update to the *Contra Costa County General Plan* was adopted on January 18, 2005, to guide future growth, development, and resource conservation through 2020 (Contra Costa County 2005). Amendments to the general plan occurred in 1996 and 2005 to reflect changes to the land use map and the incorporation of the City of Oakley, and the Housing Element was updated in 2009 (Contra Costa County 2010).

Relevant goals of the Contra Costa County General Plan (Contra Costa County 2010) pertaining to soils as a resource are listed below.

- **Goal 8-P:** To encourage the conservation of soil resources to protect their long-term productivity and economic value.
- **Goal 8-Q:** To promote and encourage soil management practices that maintain the productivity of soil resources.

The following policy pertaining to soils as a resource appears in the general plan.

  - **Policy 8-63:** The County shall protect soil resources within its boundaries.

#### Sacramento County General Plan

The *Sacramento County General Plan*, amended on November 9, 2011, provides for growth and development in the unincorporated area through 2050.

Relevant policies of the Sacramento County General Plan (County of Sacramento 2011) pertaining to soils as a resource are listed below.

- **Policy AG-28:** The County shall actively encourage conservation of soil resources.

- **Policy CO-57:** In areas where top soil mining is permitted, it shall be done so as to maintain the long term.

## Solano County General Plan

The *Solano County General Plan* was adopted on August 5, 2008. The Agriculture and Resources Elements of the general plan address conservation of agricultural land. The general plan is the guide for both land development and conservation in the unincorporated portions of the county and contains the policy framework necessary to fulfill the community's vision for Solano County in 2030.

Relevant policies of the Solano County General Plan (Solano County 2008) pertaining to soils as a resource are listed below.

#### Agriculture Element

- **Policy AG.I-22:** Promote sustainable agricultural activities and practices that support and enhance the natural environment. These activities should minimize impacts on soil quality and erosion potential, water quantity and quality, energy use, air quality, and natural habitats. Sustainable agricultural practices should be addressed in the County's proposed Climate Action Plan to address climate change effects.

#### Sacramento-San Joaquin Delta Policies

- **Policy RS.P-21:** Preserve and protect the natural resources of the Delta including soils and riparian habitat. Lands managed primarily for wildlife habitat should be managed to provide inter-related habitats.

## Yolo County General Plan

The *Yolo County 2030 Countywide General Plan* was adopted on November 10, 2009, and provides for growth and development in the unincorporated area through 2030. The general objective of the general plan is to guide decision making in the unincorporated areas in the county toward the most desirable future possible and to identify efficient urbanization with the preservation of productive farm resources and open space amenities (County of Yolo 2009). Among all the county general plans within the Primary Zone of the Delta, Yolo County contains the most specific policies relating to protection of soils as a resource.

Relevant policies and actions of the Yolo County general plan (County of Yolo 2009) pertaining to soils as a resource are listed below.

#### Conservation and Open Space Element

The following policies that pertain to soils as a resource appear in the conservation and open space element of the general plan.

- **Policy CO-2.14:** Ensure no net loss of oak woodlands, alkali sinks, rare soils, vernal pools or geological substrates that support rare endemic species, with the following exception. The limited loss of blue oak woodland and grasslands may be acceptable, where the fragmentation of large forests exceeding 10 acres is avoided, and where losses are mitigated.

- **Policy CO-3.5:** Preserve and protect the County's unique geologic and physical features, which include geologic or soil "type localities", and formations or outcrops of special interest.

The following action pertaining to soils as a resource appears in the conservation and open space element of the general plan.

- **Action CO-A54:** The County's unique geologic or physical features, which include geologic or soil "type localities" and formations or outcrops of special interest, shall be researched, inventoried, mapped, and data added to the County GIS database.

#### Agriculture & Economic Development Element

The following policy pertaining to soils as a resource appears in the agriculture and economic development element of the general plan.

  - **Policy AG-2.6:** Work with appropriate local, State and federal agencies to conserve, study, and improve soils. Promote participation in programs that reduce soil erosion and increase soil productivity.

# 10.3 Environmental Consequences

This section describes potential direct (both temporary and permanent) and indirect effects on soils that would result with implementation of each alternative. Note that the discussion in this chapter separates each of the alternatives' proposed features into three categories; *physical/structural components* and *operations*, both of which are evaluated at the project level; and *restoration actions*, which are evaluated at the programmatic level. Broadly, the types of effects that are evaluated are listed below.

- Accelerated soil erosion from water and wind.
- Loss of topsoil as a resource caused by excavation, overcovering, and inundation.
- Land subsidence due to biological oxidation of peat soils.
- Effects of corrosive, expansive, and compressible soils.

Potential adverse effects that are triggered by a seismic event (either earthquake-induced or construction-related) are assessed in Chapter 9, *Geology and Seismicity*. Potential effects of irrigation-induced salt loading to soils are assessed in Chapter 14, *Agricultural Resources*. Potential effects of eroded soil (i.e., sediment) reaching receiving waters are assessed in Chapter 8, *Water Quality*.

Soil-related effects would be restricted to the Plan Area and would be associated primarily with the footprint of the proposed conveyance facilities and restoration areas. Because all conveyance and restoration activities related to the alternatives would be in the Plan Area, soils in the Upstream of the Delta Region and SWP/CVP Export Service Areas would not be affected by proposed construction, operation, maintenance, or restoration activities. Therefore, this section does not evaluate effects on soils in those geographic areas.

Additionally, nine of the proposed conservation measures related to reducing other stressors (listed below and described in detail in Chapter 3, *Description of the Alternatives*), which would be implemented under all action alternatives, are not anticipated to result in any meaningful effects on soils in the Plan Area because the actions implemented under these conservation measures would not have a bearing on soils, nor would they be expected to result in any direct or indirect, permanent or substantial temporary changes in soil conditions. Accordingly, these measures are not addressed further in this effects analysis.

- Methylmercury Management (Conservation Measure [CM]12)
- Nonnative Aquatic Vegetation Control (CM13)
- Stockton Deep Water Ship Channel Dissolved Oxygen Levels (CM14)
- Predator Control (CM15)
- Nonphysical Fish Barriers (CM16)
- Illegal Harvest Reduction (CM17)
- Recreational Users Invasive Species Program (CM20)
- Nonproject Diversions (CM21)
- Avoidance and Minimization Measures (CM22)

### 10.3.1 Methods for Analysis

This section describes the methods used to evaluate soil-related hazards and potential effects of the alternatives in the Plan Area and the potential for the elements of the alternatives to increase human health risk and loss of property or other associated risks. These effects would be associated with construction activities, the footprint of disturbance from new facilities, and operation of the alternatives. Lands outside of the Plan Area were not considered because there are no structures being proposed and because changed operations upstream and within the water user service areas do not increase soil hazards in those areas. Both quantitative and qualitative methods were used to evaluate these effects, depending on the availability of data. Conservation and restoration activities were evaluated on a programmatic level using qualitative methods to identify potential soil-related effects.

The impact analysis for soils was performed using information on near-surface soils (i.e., the upper 5 feet) and maps of peat thickness, soil organic matter content, and topography. The emphasis in the impact analysis was to identify where soils could be adversely affected by erosion or by excavation, overcovering, or inundation. The impact analysis also focused on identifying those soil characteristics that could pose a potentially serious threat to the integrity of structures. The analysis determines whether these conditions and associated risks can be reduced to an acceptable level by conformity with existing codes and standards, and by the application of accepted, proven engineering design and construction practices. A range of specific design and construction approaches are normally available to address a specific soil condition. For example, the potential for expansive soils to affect structural integrity could be controlled by use of soil lime treatment, a post-tensioned foundation, or other measure. Irrespective of the engineering approach to be used, the same stability criteria must be met to comply with code and standard requirements. Design solutions would be guided by relevant building codes and state and federal standards for foundations, earthworks, and other project facilities.

The following description of the site evaluation and design process is intended to clarify how site-specific hazard conditions are identified and eventually fully addressed through data collection, analysis and compliance with existing design and construction requirements.

As the BDCP and its various conservation measures were developed by DWR in anticipation of agency and public review through the NEPA/CEQA process, the agency compiled information on the geotechnical characteristics of the near-surface soils for the project alternatives. This soil information has been compiled under the supervision of professional engineers and documented in the project's geotechnical data reports (California Department of Water Resources 2010f, 2010g, 2011) and conceptual engineering reports (CERs) (California Department of Water Resources 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2010e). The latter reports are not final, site-specific design-level reports but instead describe project alternative construction feasibility by identifying site conditions and constraints.

The NEPA/CEQA analysis for the project alternatives includes review of soil survey data, the geotechnical data reports, and CERs as well as other information to determine if potential adverse effects caused by soil hazards can be overcome by applying accepted and proven engineering design and construction practices.

The effects of soil hazards would be substantial if the risk of potential loss, injury or death cannot be addressed by an engineering solution. Significance thresholds do not require the elimination of the potential for structural damage from a construction site's soil conditions. Rather, the criteria require evaluation of whether site conditions can be overcome through engineering design solutions that reduce the substantial risk of people and structures to loss, injury or death. The codes and design standards ensure that foundations, earthwork, and other facilities are designed and constructed such that, while they may sustain damage caused by a soil hazards, the substantial risk of loss, injury or death due to structural failure or collapse is reduced to an acceptable level. The NEPA/CEQA evaluation determines whether conformity with existing federal, state, and local standards, guidelines, codes, ordinances, and other regulations and application of accepted and proven engineering design and construction practices would reduce the substantial risk of people and structures to loss, injury or death to acceptable level.

Design-level detail will not be fully developed until after the NEPA/CEQA process is complete. After NEPA/CEQA document certification and project approval, the final design will be developed, which will require additional geotechnical studies to identify additional site-specific conditions that the final engineering design will meet. These soil investigations will characterize, log, and test soils on a site-specific basis to determine their load-bearing capacity, shrink-swell capacity, corrosivity, and other parameters. The soil investigations and the recommendations that are derived from them will be presented in a geotechnical report by a California registered civil engineer or a California certified engineering geologist. The report will be prepared according to *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (California Geological Survey 2008) and reviewed and approved by the BDCP proponents.

This final design would meet the guidelines and standards included in Appendix 3B, *Environmental Commitments*, for all the project components. In the present case, these components include aspects of the canals, pipelines, intake structures, levees, temporary and permanent access roads, borrow areas, and spoil storage sites.

Based on the final geotechnical report and code and standards requirements, the final design of levees, foundations, and related engineering structures will be developed by a California registered civil engineer or a California certified engineering geologist with participation and review by DWR, and in some cases county building departments, to ensure that design standards are met. The design and construction specifications would then be incorporated into the construction contract for implementation. During project construction, new or unanticipated soil conditions may be found that are different from those described in the detailed, site-specific geotechnical report that guides the final design. Under these circumstances, the soil condition will be evaluated and an appropriate method to meet the design specification will be determined by the project engineer and approved by DWR.

### 10.3.1.1 Impact Mechanisms

#### Accelerated Water and Wind Erosion

Soil disturbance (e.g., grading, excavating, tunneling, borrow material excavating, and stockpiling) during construction can lead to soil loss from water and wind erosion unless adequate management practices are implemented to control erosion and sediment transport.

#### Loss of Topsoil

Loss of topsoil as a resource can be caused by excavation, overcovering, or inundation. The condition (quality) and productivity of the topsoil can be degraded as a result of construction activities, such as compaction.

#### Subsidence and Compressibility

Soil subsidence could result from a variety of factors, but primarily from oxidation of soil organic matter and primarily only in high organic matter content soils (i.e., peats and mucks). Subsidence can cause damage or failure of structures, utilities, and levees.

Soil compression/settlement can occur when the soil is under load. Structures constructed on soils with poor load bearing capability can be damaged or fail when part or all of the structure settles under load. Utilities connecting to the subsided or settled facilities can also be damaged.

#### Soil Expansion and Contraction

Soils with a high content of expansive clay are subject to shrinking and swelling with seasonal changes in moisture content. Clay soils below the depth of the permanent water table are not subject to shrinking and swelling. Soil expansion and contraction can cause damage or failure of foundations, utilities, and pavements.

#### Soil Corrosion

Soil may corrode uncoated steel; the hazard of corrosion is controlled by soil water content, texture, acidity, and content of soluble salts. Soil may also corrode concrete; the hazard of corrosion is controlled by soil texture, acidity, and the amount of sodium or magnesium sulfate and sodium chloride present in the soil. Corrosion can cause failure of pipelines and other in-ground utilities, culverts, foundations, footings, and other facilities containing concrete and steel in contact with the soil.

### 10.3.1.2 Construction Activity Effects

The analysis of soil-related effects during construction is related to wind and water erosion hazard.

NRCS soil survey and geographic information system (GIS) data (i.e., SSURGO data [Natural Resources Conservation Service 2010a]) for each county in the Plan Area were used to identify and map variations in the soil's water and wind erosion hazard.

Because planned restoration activities are programmatic in nature, this analysis took a programmatic approach to addressing impacts on soils at the ROAs. Soils in the ROAs were evaluated to determine their susceptibility to wind and water erosion during grading and other types of ground disturbance that would be expected during restoration construction activities.

#### 10.3.1.3 Facility Effects

The analysis methods for soil-related effects on facilities are based on the following.

##### Soil Expansion and Corrosion

NRCS soil surveys and GIS data (i.e., SSURGO data [Natural Resources Conservation Service 2010a]) for each county in the Plan Area were used to identify and map variations in shrink-swell potential and in corrosivity to concrete and uncoated steel. This information was used to identify areas where such soils could adversely affect public safety and the structural integrity of proposed facilities, and consequently, where specific design measures for facilities would need to be implemented to avoid these effects.

##### Subsidence Potential

GIS and NRCS SSURGO data on the organic matter content of the near-surface soils, a map of the thickness of peat soils, and an elevation map were used to identify areas that are subject to continued subsidence.

##### Soil Compressibility

Soil compressibility/load bearing capability was assessed using NRCS soil surveys and GIS data (i.e., SSURGO data [Natural Resources Conservation Service 2010a]) for each county in the Plan Area.

#### 10.3.1.4 Operational Component Effects

The potential effect on channel bank scour from changes in flow regimes was evaluated by reviewing the current and expected operations channel flow rates.

The analysis of channel bank scour effects for the operational components relied mostly on the results from Chapter 6, *Surface Water*—in particular, the expected change in channel flow rates (feet per second). Soil erosion hazard as shown in Figure 10-5 was not used in the analysis because no data are available to describe the erodibility of the soils that could be affected by the operational components (i.e., those soils along channel banks). The soils along the channel banks may consist of fill material (from levees) and may be partly or fully protected by riprap; these conditions make the NRCS data on erosion hazard not applicable to assessing the hazard of channel bank erosion, because the NRCS soil mapping upon which erosion hazard is based does not account for the local soil characteristics and bank protection measures that may be present along the channel banks.

### 10.3.2 Determination of Effects

Effects on soils were considered adverse under NEPA and significant under CEQA if implementation of an alternative would result in any of the following.

- Cause substantial soil erosion.
    - For purposes of this analysis, “substantial soil erosion” would occur when effluent monitoring indicates that the daily average turbidity of site runoff exceeds 250 nephelometric turbidity units (NTUs). This measurement is in accordance with Construction General Permit (CGP) numeric action level requirements under site-specific SWPPPs. Regarding wind-caused erosion, Sacramento Metropolitan Air Quality Management Districts’ CEQA guidelines require fugitive dust control practices related to the potential for creating wind-borne dust. The best

management practices outlined include suspending excavation, grading, and/or demolition activity when wind speeds exceed 20 mph. (These guidelines are sufficient to address dust control requirements of all the air quality management districts in the Plan Area.) Accordingly, continuing those activities when wind speed exceeds 20 mph would constitute an adverse effect with respect to wind erosion. (Neither substantial water erosion nor wind erosion effects are likely to occur because BDCP proponents would comply with all CGP, SWPPP, air quality management district, and other permit requirements to stop work or adjust BMPs to remain within applicable thresholds.)

- Cause a substantial loss of topsoil.
  - For purposes of this analysis, "substantial loss of topsoil" would be caused by activities that would overcover, inundate, or remove topsoil such that the loss is irreversible, for example, by paving over it.
- Subject people, structures, or property to soil instability caused by soil subsidence.
  - For purposes of this analysis, an adverse effect (NEPA) or significant impact (CEQA) would exist if project construction or operation created an increased likelihood for the potential for loss, injury or death related to soil instability caused by soil subsidence which cannot be offset by an engineering solution that reduces the risk to people and structures to an acceptable level. "Engineering solution" means conformity with all applicable government and professional standards, codes, ordinances, and regulations for site assessment, design and construction practices, including the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, CBC, and U.S. Army Corps of Engineers (USACE) Design and Construction of Levees (see Section 10.3.1.1, *Impact Mechanisms*).
- Create substantial risks to life or property as a result of being located on expansive, corrosive, and compressible soil (as defined in Table 18-1-B of the Uniform Building Code [1994]).
  - For purposes of this analysis, an adverse effect (NEPA) or significant impact (CEQA) would exist if project construction or operation created an increased likelihood for the potential for loss, injury or death related to location on expansive, corrosive, and compressible soils which cannot be offset by an engineering solution that reduces the risk to people and structures to an acceptable level. "Engineering solution" means conformity with all applicable government and professional standards, codes, ordinances, and regulations for site assessment, design and construction practices, including the DWR Interim Levee Design Criteria for Urban and Urbanizing Area State Federal Project Levees; USACE Engineering and Design—Earthquake Design and Evaluation for Civil Works Projects; USACE Design and Construction of Levees; American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures; and CBC requirements (see Section 10.3.1.1, *Impact Mechanisms*).
- Be located on a geologic unit or soil that is unstable or that would become unstable as a result of the project and potentially result in an onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse.
  - For purposes of this analysis, any "geologic unit or soil that is unstable or would become unstable" would be those identified as such in Appendix 10B, *NRCS Soil Suitability Ratings,* which provides suitability and limitation ratings by the Natural Resources Conservation Service for various engineering uses. This chapter primarily addresses risks due to subsidence. Other causes of instability induced by earthquake or construction are assessed in Chapter 9, *Geology and Seismicity*. An adverse effect (NEPA) or significant impact (CEQA) would exist if the

potential for loss, injury or death related to soil instability cannot be offset by an engineering solution that reduces the risk to people and structures to an acceptable level. "Engineering solution" means conformity with all applicable government and professional standards, codes, ordinances, and regulations for site assessment, design and construction practices, including the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, CBC, and USACE Design and Construction of Levees (see Section 10.3.1.1, *Impact Mechanisms*).

- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems in areas where sewers are not available for the disposal of wastewater.

The effects criteria described above are carried forward for analysis in this chapter with the exception of the criteria related to soils capable of adequately supporting the use of septic tanks or alternative wastewater disposal systems. While pumping plants would include permanent restroom facilities, which would be equipped with a sanitary gravity drainage leading to a wastewater holding tank, effects are not anticipated to result from the facilities that would be constructed for the project because these facilities would be minor (constructed to serve only small operations and maintenance crews). Additionally, such facilities would require proper testing and permits from regulatory agencies, which would reduce any adverse environmental effects to less than significant.

### 10.3.2.1 Compatibility with Plans and Policies

Constructing the proposed water conveyance facility (CM1) and implementing CM2–CM22 could potentially result in incompatibilities with plans and policies related to soils. Section 10.2, *Regulatory Setting*, provides an overview of federal, state, regional and agency-specific plans and policies applicable to public services and utilities. This section summarizes ways in which BDCP is compatible or incompatible with those plans and policies. Potential incompatibilities with local plans or policies, or with those not binding on the state or federal governments, do not necessarily translate into adverse environmental effects under NEPA or CEQA. Even where an incompatibility "on paper" exists, it does not by itself constitute an adverse physical effect on the environment, but rather may indicate the potential for a proposed activity to have a physical effect on the environment. The relationship between plans, policies, and regulations and impacts on the physical environment is discussed in Chapter 13, *Land Use*, Section 13.2.3.

The construction and operation of all BDCP alternatives would comply with all regulations related to construction run-off and sedimentation, such as Section 402 of the Clean Water Act and Porter-Cologne Water Pollution Control Act. Both of these are enforced by the State Water Board. As discussed below, BDCP will seek General Permits for Storm Water Discharges Associated with Construction and Land Disturbance Activities in accordance with State Water Board Order No. 2009-0009-DWQ. In order to obtain a General Permit from the State Water Board, the BDCP proponents must submit a risk level assessment and a SWPPP, which will include many of the BMPs required to further the aims of various state and regional policies and plans.

## 10.3.3 Effects and Mitigation Approaches

### 10.3.3.1 No Action Alternative

The No Action Alternative is the future condition at the year 2060 that would occur if none of the action alternatives was approved and if no change from current management direction or the level of management intensity occurred. The No Action Alternative includes projects and programs with defined management or operational plans, including facilities under construction as of February 13, 2009, because those actions would be consistent with the continuation of existing management direction or level of management for plans, policies, and operations by the BDCP proponents and other agencies. The No Action Alternative assumptions also include projects and programs that received approvals and permits in 2009 to remain consistent with existing management direction. A complete list and description of programs and plans considered under the No Action Alternative is provided in Appendix 3D, *Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions*. Under the No Action Alternative, the condition of soils would continue largely as they have under Existing Conditions.

### Accelerated Soil Erosion

Under the No Action Alternative, it is anticipated that current rates of water and wind erosion would continue in the future. Currently, erosion (primarily wind erosion) is largely a result of agricultural practices. Additionally, accelerated water and wind erosion could take place in the Delta and statewide as a result of implementation of numerous levee stabilization, dredge spoil disposal, and habitat restoration projects. However, federal, state, and local regulations, codes, and permitting programs would continue to require implementation of measures to prevent nonagricultural accelerated erosion and sediment transport associated with construction.

### Loss of Topsoil

The loss of topsoil as a result of excavation, overcovering, and inundation would continue in the Delta and statewide under the No Action Alternative as a result of numerous land development and habitat restoration projects. The land development projects would tend to cause loss of topsoil as a result of excavation and overcovering, particularly by foundations, pavements, and other impervious surfaces. Such losses of topsoil are effectively irreversible. In contrast, the loss of topsoil associated with habitat restoration projects typically results from overcovering, such as placement of dredge spoils in subsided areas, and inundation, such as the introduction of seasonal or perennial water into nonwetland environments to establish seasonal wetlands or freshwater or tidal marshes. In this latter scenario, the topsoil is effectively "lost" for as long as the area is inundated, but would remain available for cropping or for livestock grazing if water management changes in the future. Finally, most dredging projects have a spoil disposal/placement component, typically on land (as opposed to in water). The disposal would therefore entail overcovering of and effective loss of topsoil.

### Subsidence

Land subsidence in the Delta and the Suisun Marsh would continue to varying degrees under the No Action Alternative. Ingebritsen et al. (2000) indicated that long-term average rates of subsidence in the Delta are 1–3 inches per year. It is anticipated that this rate of subsidence would continue. Ongoing subsidence would result from biological oxidation of organic soils, thereby continuing to threaten levee stability, which in turn affects water quality and water supply because levee failure could cause saline water to enter the Delta. However, the rate of subsidence in the future may be slower than the current rate as the organic soils become more consolidated over time.

Several projects are now underway that would have a beneficial effect on subsidence, some with the explicit goal of controlling or reversing subsidence. These entail inundating areas underlain by peat soils to restore or create tidal marsh habitat. The inundation would tend to reduce biological oxidation rates of the soil organic matter. Depending on the vegetation type, soil organic matter would accumulate over time in the restored marsh habitats, thereby raising the elevation of the area. Although these projects would tend to control or reverse subsidence only on the islands at which they are implemented, they would benefit the Delta as a whole by promoting the "blocking" effect of Delta islands on sea water intrusion in the Delta. The subsidence control/reversal projects would therefore help to maintain water quality and water supply in the Delta in the event of widespread levee failure.

## Soil Expansion, Corrosion, and Compression

Ongoing and reasonably foreseeable future projects in the Plan Area are likely to encounter expansive, corrosive, and compressible soils. However, federal and state design guidelines and building codes would continue to require that the facilities constructed as part of these projects incorporate design measures to avoid the adverse effects of such soils.

## Ongoing Plans, Policies, and Programs

The programs, plans, and projects included under the No Action Alternative are summarized in Table 10-4, along with their anticipated effects on soils.

**Table 10-4. Effects on Soils from the Plans, Policies, and Programs for the No Action Alternative**

| Agency | Program/Project | Status | Description of Program/Project | Effects on Soils |
|---|---|---|---|---|
| California Department of Water Resources | Mayberry Farms Subsidence Reversal and Carbon Sequestration Project | Completed October 2010 | Permanently flooded a 308-acre parcel of DWR owned land (Hunting Club leased) and restored 274 acres of palustrine emergent wetlands within Sherman Island to create permanent wetlands and to monitor waterfowl, water quality, and greenhouse gases. | Reduced subsidence over approximately 308 acres and inundation of topsoil over approximately 274 acres. |
| DWR | Dutch Slough Tidal Marsh Restoration Project | Planning phase | Wetland and upland habitat restoration in area used for agriculture. | Inundation and overcovering (by dredge spoils) of topsoil over much of 1,166-acre site. |
| Freeport Regional Water Authority and Bureau of Reclamation | Freeport Regional Water Project | Completed late 2010 | Project included an intake/ pumping plant near Freeport on the Sacramento River and a conveyance structure to transport water through Sacramento County to the Folsom South Canal. | Loss of approximately 50–70 acres of topsoil from excavation and overcovering. |
| Reclamation District 2093 | Liberty Island Conservation Bank | Completed 2011 | This project included restoration of inaccessible, flood prone land to wildlife habitat. | Inundation of approximately 186 acres of topsoil. |
| City of Stockton | Delta Water Supply Project (Phase 1) | Currently under construction | This project consists of a new intake structure and pumping station adjacent to the San Joaquin River; a water treatment plant along Lower Sacramento Road; and water pipelines along Eight Mile, Davis, and Lower Sacramento Roads. | Loss of 106 acres of topsoil from excavation and overcovering. |

| Agency | Program/Project | Status | Description of Program/Project | Effects on Soils |
|---|---|---|---|---|
| DWR | Delta Levees Flood Protection Program | Ongoing | Levee rehabilitation projects in the Delta. | Unknown but probably small acreage of overcovering of topsoil. |
| USACE | Suisun Channel (Slough) Operations and Maintenance Project | Ongoing | Maintenance dredging of an entrance channel in Suisun Bay, with turning basin. | Unknown acreage of overcovering of topsoil from dredge material disposal. |
| DWR | Central Valley Flood Management Planning Program | Planning phase | Among other management actions, involves levee raising and construction of new levees for flood control purposes. | Unknown acreage of overcovering of topsoil from levee earthwork. |
| Bureau of Reclamation | Delta-Mendota Canal/California Aqueduct Intertie | Anticipated completion by 2012. | The purpose of the intertie is to better coordinate water delivery operations between the California Aqueduct (state) and the Delta-Mendota Canal (federal) and to provide better pumping capacity for the Jones Pumping Plant. New project facilities include a pipeline and pumping plant. | Loss of approximately 2 acres of topsoil from excavation and overcovering. |
| California Department of Water Resources | North Delta Flood Control and Ecosystem Restoration Project | Final EIR certified and Notice of Determination filed in 2010. | Project is intended to improve flood management and provide ecosystem benefits in the North Delta area through actions such as construction of setback levees and configuration of flood bypass areas to create quality habitat for species of concern. These actions are focused on McCormack-Williamson Tract and Staten Island. The purpose of the Project is to implement flood control improvements in a manner that benefits aquatic and terrestrial habitats, species, and ecological processes. | Unknown but probably significant acreage of overcovering of topsoil from tidal inundation, excavation and overcovering. |
| NMFS/ USFWS | 2008 and 2009 Biological Opinion | Ongoing | The Biological Opinions issued by NMFS and USFWS establish certain RPAs and RPMs to be implemented. Some of the RPAs require habitat restoration which may require changes to existing levees and channel improvements. | RPAs requiring habitat restoration may result in up to 8,000 acres of inundated topsoil and potential overcovering of topsoil from levee earthwork. |

In total, the plans and programs would result in the loss of at least 3,618 acres of topsoil from overcovering or inundation. Because of the amount of topsoil that would be lost under the No Action alternative, these plans, policies, and programs would be deemed to have direct and adverse effects on topsoil loss in the Delta.

Subsidence would be controlled or reversed on approximately 308 acres, resulting in a beneficial effect.

***CEQA Conclusion*:** In total, the plans and programs under the No Action Alternative (see Table 10-4 and Appendix 3D, *Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative*

*Impact Conditions*) would result in the loss of at least 3,618 acres of topsoil from overcovering or inundation between the present and 2060. This would constitute a significant impact. Subsidence would be controlled or reversed on approximately 308 acres, resulting in a beneficial impact.

### 10.3.3.2 Alternative 1A—Dual Conveyance with Pipeline/Tunnel and Intakes 1–5 (15,000 cfs; Operational Scenario A)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Construction of water conveyance facilities would involve vegetation removal, constructing building pads and levees, excavation, overexcavation for facility foundations, surface grading, trenching, road construction, spoil and reusable tunnel material (RTM) storage, soil stockpiling, and other activities over approximately 7,500 acres during the course of constructing the facilities. Vegetation would be removed (via grubbing and clearing) and grading and other earthwork would be conducted at the intakes, pumping plants, the intermediate forebay, the Byron Tract Forebay, canal and gates between the Byron Tract Forebay tunnel shafts and the approach canal to the Banks Pumping Plant, borrow areas, RTM and spoil storage areas, setback and transition levees, sedimentation basins, solids handling facilities, transition structures, surge shafts and towers, substations, transmission line footings, access roads, concrete batch plants, fuel stations, bridge abutments, barge unloading facilities, and laydown areas. Some of the work would be conducted in agriculture areas that are fallow at the time. Some of the earthwork activities may also result in steepening of slopes and soil compaction, particularly for the embankments constructed for the intermediate forebay and the Byron Tract Forebay. These conditions tend to result in increased runoff rates, degradation of soil structure, and reduced soil infiltration capacity, all of which could cause accelerated erosion, resulting in loss of topsoil.

***Water Erosion***

The excavation, grading, and other soil disturbances described above that are conducted in gently sloping to level areas, such as the interiors of Delta islands, are expected to experience little or no accelerated water erosion because of the lack of runoff energy to entrain and transport soil particles. Any soil that is eroded within island interiors would tend to remain on the island, provided that existing or project levees are in place to serve as barriers from keeping the eroded soil (i.e., sediment) from entering receiving waters.

In contrast, graded and otherwise disturbed tops and sideslopes of existing and project levees and embankments are of greater concern for accelerated water erosion because of their steep gradients. Although soil eroded from the landside of levees would be deposited on the island interiors, soil eroded from the disturbed top and water side of levees could reach adjoining waterways. Soil eroded from natural slopes in upland environments could also reach receiving waters.

***Wind Erosion***

Most of the primary work areas that would involve extensive soil disturbance (i.e., staging areas, borrow areas, and intakes) within the Alternative 1A footprint are underlain by soils with a moderate or high susceptibility to wind erosion (Natural Resources Conservation Service 2010a) (Figure 10-6). Of the primary areas that would be disturbed, only the proposed borrow/spoil area southwest of Clifton Court Forebay and the Byron Tract Forebay generally have a low wind erosion hazard.

Construction activities (e.g., excavation, filling, grading, and vehicle traffic on unimproved roads) that could lead to accelerated wind erosion are generally the same as those for water erosion. These activities may result in vegetation removal and degradation of soil structure, both of which would make the soil much more subject to wind erosion. Removal of vegetation cover and grading increase exposure to wind at the surface and obliterate the binding effect of plant roots on soil aggregates. These effects make the soil particles much more subject to entrainment by wind. However, most of the areas that would be extensively disturbed by construction activities are already routinely disturbed by agricultural activities, such from disking and harrowing. These activities would be associated with construction of the pumping plants, the intermediate forebay, most of the Byron Tract Forebay, borrow areas, RTM and spoil storage areas, sedimentation basins, solids handling facilities, substations, access roads, concrete batch plants, and laydown areas. Consequently, with the exception of loading and transporting of soil material to storage areas, the disturbance that would result from constructing the conveyance facilities in many areas would not substantially depart from the existing condition, provided that the length of time that the soil is left exposed during the year does not change compared to that associated with agricultural operations. Because the SWPPPs prepared for the various components of the project will be required to prescribe ongoing best management practices to control wind erosion (such as temporary seeding), the amount of time that the soil would be exposed during construction should not significantly differ from the existing condition.

Unlike water erosion, the potential adverse effects of wind erosion are generally not dependent on slope gradient and location relative to levees or water. Without proper management, the wind-eroded soil particles can be transported great distances.

Excavation of soil from borrow areas and transport of soil material to spoil storage areas would potentially subject soils to wind erosion. It is likely that approximately 8 million cubic yards of peat soil material would be disposed of as spoils; this material would be especially susceptible to wind erosion while being loaded onto trucks, transported, unloaded, and distributed.

***NEPA Effects:*** These potential effects could be substantial because they could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Many SWPPPs and erosion control plans are expected to be prepared for the project, with a given SWPPP and erosion control plan prepared for an individual component (e.g., one intake) or groups of component (e.g., all the intakes), depending on the manner in which the work is contracted. DWR would be responsible for preparing and implementing a SWPPP and erosion control plan as portions of the construction are contracted out and applications are made to the State Water Board for coverage under a General Permit.

The General Permit requires that SWPPPs be prepared by a Qualified SWPPP Developer (QSD) and implemented under the supervision of a Qualified SWPPP Practitioner (QSP). As part of the procedure to gain coverage under the General Permit, the QSD would determine the Risk Level (1, 2, or 3) of the project site, which involves an evaluation of the site's *Sediment Risk* and *Receiving Water Risk*. *Sediment Risk* is based on the tons per acre per year of sediment that the site could generate in the absence of erosion and sediment control BMPs. *Receiving Water Risk* is an assessment of whether the project site is in a sediment-sensitive watershed, such as those designated by the State Water Board as being impaired for sediment under Clean Water Act section 303(d). Much of the northern half of the Plan Area is in a sediment-sensitive watershed; such areas would likely be Risk Level 2. The remaining areas, generally southwest of the San Joaquin River, are not in a sediment-sensitive watershed.

The results of the Risk Level determination partly drive the contents of the SWPPP. In accordance with the General Permit, the SWPPP would describe site topographic, soil, and hydrologic characteristics; construction activities and a project construction schedule; construction materials to be used and other potential sources of pollutants at the project site; potential non-stormwater discharges (e.g., trench dewatering); erosion and sediment control, non-stormwater, and "housekeeping" BMPs to be implemented; a BMP implementation schedule; a site and BMP inspection schedule; and ongoing personnel training requirements. The SWPPPs would also specify the forms and records that must be uploaded to the State Water Board's online Stormwater Multiple Application and Report Tracking System (SMARTS), such as quarterly non-stormwater inspection and annual compliance reports. In those parts of the Plan Area that are determined to be Risk Level 2 or 3, water sampling for pH and turbidity would be required; the SWPPP would specify sampling locations and schedule, sample collection and analysis procedures, and recordkeeping and reporting protocols.

The QSD for the SWPPPs would prescribe BMPs that are tailored to site conditions and project component characteristics. Partly because the potential adverse effect on receiving waters depends on location of a work area relative to a waterway, the BMPs would be site-specific, such that those applied to level island-interior sites (e.g., RTM storage areas) would be different than those applied to water-side levee conditions (e.g., intakes).

All SWPPPs, irrespective of the site and project characteristics, are likely to contain the following BMPs.

- Preservation of existing vegetation.
- Perimeter control.
- Fiber roll and/or silt fence sediment barriers.
- Watering to control dust entrainment.
- Tracking control and "housekeeping" measures for equipment refueling and maintenance.
- Solid waste management.

Most sites would require temporary and permanent seeding and mulching. Sites that involve disturbance or construction of steep slopes may require installation of erosion control blankets or rock slope protection (e.g., setback levees at intakes). Turbidity curtains would be required for in-water work. Excavations that will require dewatering (such as for underground utilities and footings) will require proper storage of the water, such as land application or filtration. Soil and material stockpiles (such as for borrow material) would require perimeter protection and covering or watering to control wind erosion. Concrete washout facilities would be established to prevent surface and ground water contamination. Such BMPs, if properly installed and maintained, would ensure compliance with the pH and turbidity level requirements defined by the General Permit.

The QSP would be responsible for day-to-day implementation of the SWPPP, including BMP inspections, maintenance, water quality sampling, and reporting to the State Water Board. In the event that the water quality sampling results indicate an exceedance of allowable pH and turbidity levels, the QSD would be required to modify the type and/or location of the BMPs by amending the SWPPP; such modifications would be uploaded by the QSD to SMARTS.

Accelerated water and wind erosion as a result of construction of the proposed water conveyance facility could occur under Alternative 1A, but proper implementation of the requisite SWPPP and compliance with the General Permit (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2) would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*) necessitating the preparation of a SWPPP and an erosion control plan. Because implementation of the SWPPP and compliance with the General Permit would control accelerated soil erosion, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, the impact would be less than significant. No mitigation is required.

### Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation during construction of Alternative 1A (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebays, sedimentation basins, solids lagoons). Table 10-5 presents an itemization of the effects on soils caused by excavation, overcovering, and inundation, based on GIS analysis by facility type. Because of the nature of the earthwork to construct many of the facilities, more than one mechanism of topsoil loss may be involved at a given facility. For example, levee construction would require both excavation to prepare the subgrade and overcovering to construct the levee. The table shows that the greatest extent of topsoil loss would be associated with overcovering such as spoil/RTM storage areas, unless measures are undertaken to salvage the topsoil and reapply it on top of excavated borrow areas or on top of the spoils once they have been placed.

**Table 10-5. Approximate Topsoil Lost as a Result of Excavation, Overcovering, and Inundation Associated with the Proposed Water Conveyance Facility**

| Topsoil Loss Mechanism | Acreage Affected |
|---|---|
| Excavation (intakes, shafts, borrow areas) | 823 |
| Overcovering (spoil storage, reusable tunnel material storage) | 5,093 |
| Inundation (forebays, sedimentation basins, solids lagoons) | 1,855 |
| Total | 7,771 |

Note: Some mechanisms for topsoil loss entail more than one process of soil loss. For example, construction of setback levees would first require overexcavation for the levee foundation (i.e., excavation), then placement of fill material (i.e., overcovering).

DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would also be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve irreversible removal, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. Despite a commitment for Disposal Site Preparation, the impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would partially mitigate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

A requirement of the General Permit is to minimize the extent of soil disturbance during construction. As described in Appendix 3B, *Environmental Commitments*, the SWPPPs prepared for construction activities will include a BMP that specifies the preservation of existing vegetation through installation of temporary construction barrier fencing to preclude unnecessary intrusion of heavy equipment into non-work areas. The BDCP proponents will ensure that the SWPPPs and BMPs limiting ground disturbance are properly executed during construction by the contractors.

However, the BMP specifying preservation of existing vegetation may only limit the extent of surface area disturbed and not the area of excavated soils. Accordingly, soil-disturbing activities will be designed such that the area to be excavated, graded, or overcovered is the minimum necessary to achieve the purpose of the activity.

Minimizing the extent of soil disturbance will reduce the amount of topsoil lost, this will result in avoidance of this effect over only a small proportion of the total extent of the graded area that will be required to construct the habitat restoration areas, approximately 5% or less. Consequently, a large extent of topsoil will be affected even after implementation of this mitigation measure.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Depending on the thickness of the topsoil[3] at a given construction or restoration site, up to 3 feet of the topsoil will be salvaged from construction work areas, stockpiled, and then applied over the surface of spoil and RTM storage sites and borrowed areas to the maximum extent practicable. Exceptions to this measure are areas smaller than 0.1 acre; areas of nonnative soil material, such as levees, where the near-surface soil does not consist of native topsoil; where the soil would be detrimental to plant growth; and any other areas identified by the soil scientist in evaluating topsoil characteristics (discussed below). This mitigation measure will complement and is related to activities recommended under Mitigation Measure AES-1c, in Chapter 17, *Aesthetics and Visual Resources* as well as to the environmental commitment for Disposal and Reuse of Spoils, RTM, and Dredged Material.

Topsoil excavated to install conveyance, natural gas, and sewer pipelines will be segregated from the subsoil excavated from open-cut trenches, stockpiled, and reapplied to the surface after the pipe has been installed.

The detailed design of the BDCP-related construction activities will incorporate an evaluation, based on review of soil survey maps supplemented by field investigations and prepared by a qualified soil scientist, that specifies the thickness of the topsoil that should be salvaged, and that identifies areas in which no topsoil should be salvaged. The soil scientist will use the exceptions listed above as the basis for identify areas in which no topsoil should be salvaged. The BDCP proponents will ensure that the evaluation is prepared by a qualified individual, that it adequately

[3] For the purposes of this mitigation measure, *topsoil* is defined as the O, Oi, Oe, Oa, A, Ap, A1, A2, A3, AB, and AC horizons. Three feet of topsoil was selected because it corresponds to the primary root zone depth of most crops grown in the Delta. With the exception of the Histosols (i.e., peat and muck soils), most of the topsoils in the Plan Area are less than 3 feet thick.

addresses all conveyance facilities, and that areas identified for topsoil salvage are incorporated into the project design and that the contractors execute the salvage operations.

A qualified soil scientist will also prepare topsoil stockpiling and handling plans for the individual conveyance and restoration components, establishing such guidelines as the maximum allowable thickness of soil stockpiles, temporary stockpile stabilization/revegetation measures, and procedures for topsoil handling during salvaging and reapplication. The maximum allowable stockpile thickness will depend on the amount of time that the stockpile needs to be in place and is expected to range from approximately three to 10 feet. The plans will also specify that, where practicable, the topsoil be salvaged, transported, and applied to its destination area in one operation (i.e., without stockpiling) to minimize degradation of soil structure and the increase in bulk density as a result of excessive handling. The stockpiling and handling plans will also specify maximum allowable stockpile sideslope gradients, seed mixes to control wind and water erosion, cover crop seed mixes to maintain soil organic matter and nutrient levels, and all other measures to avoid soil degradation and soil erosional losses caused by excavating, stockpiling, and transporting topsoil. The BDCP proponents will ensure that each plan is prepared by a qualified individual, that it adequately addresses all relevant activities and facilities, and that its specifications are properly executed during construction by the contractors.

Adherence to this measure will ensure that topsoil is appropriately salvaged, stockpiled, and reapplied. Nevertheless, adverse soil quality effects can also be associated with stockpiling. Such effects commonly include loss of soil carbon, degraded aggregate stability, reduced growth of the mycorrhizal fungi, and reduced nutrient cycling. Such effects may make the soil less productive after it is applied to its destination site, compared to its pre-salvage condition. Depending on the inherent soil characteristics, the manner in which it is handled and stockpiled, and the duration of its storage, the reapplied topsoil may recover quickly to its original condition or require many years to return to its pre-salvage physical, chemical, and biological condition (Strohmayer 1999; Vogelsang and Bever 2010).

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

The intakes, pumping plants, and pipelines would be constructed in areas in which the near-surface soils have approximately 2–4% organic matter content. Compared to organic soils, these mineral soils would not be subject to appreciable subsidence caused by organic matter decomposition because there is relatively little organic matter available to decompose. The tunnels would be constructed at a depth below that of the peat (Figure 10-2); consequently, subsidence caused by organic matter decomposition at tunnel depth is expected to be minimal. Without adequate engineering, the forebay levees and interior could be subject to appreciable subsidence.

Damage to or collapse of the pipelines and tunnels could occur where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Subsidence- or differential sediment–induced damage or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply, and producing underground cavities, depressions at the ground surface, and surface flooding. Facilities that have subsided would be subject to flooding, and levees that have subsided would be subject to overtopping.

Damage to other conveyance facilities, such as intakes, pumping plants, transition structures, and control structures, caused by subsidence/settlement under the facilities and consequent damage to or failure of the facility could also occur. Facility damage or failure could cause a rapid release of water to the surrounding area, resulting in flooding, thereby endangering people in the vicinity.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These studies would build upon the geotechnical data reports (California Department of Water Resources 2010a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). Such standards include the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, CBC, and USACE Design and Construction of Levees. The results of the studies, which would be conducted by a California registered civil engineer or California certified engineering geologist, would be presented in geotechnical reports. The reports would contain recommended measures to prevent subsidence. The geotechnical report will prepared in accordance with state guidelines, in particular *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (California Geological Survey 2008).

Liquid limit (i.e., the moisture content at which a soil passes from a solid to a liquid state) and organic material content testing should be performed on soil samples collected during the site-specific field investigations to determine site-specific geotechnical properties. High organic matter content soils that are unsuitable for support of structures, roadways, and other facilities would be overexcavated and replaced with engineered fill, and the unsuitable soils disposed of offsite as spoil, as described in more detail below. Geotechnical evaluations would be conducted to identify soils materials that are suitable for engineering purposes.

Additional measures to address the potential adverse effects of organic soils could include construction of structural supports that extend below the depth of organic soils into underlying materials with suitable bearing strength. For example, the CER indicates that approximately 35 feet of soil would be excavated and a pile foundation supporting a common concrete mat would be required for the intake pumping plants. The piles would be 24-inches in diameter and concrete-filled, extending to 65 to 70 feet below the founding level of the plant. Piles extended to competent geologic beds beyond the weak soils would provide a solid foundation to support the pumping plants.

For the sedimentation basins, the CER indicates that most of the underlying soils would be excavated to a depth of 30 feet below grade and removed from the site and suitable soil material imported to the site to re-establish it to subgrade elevation. Removal of the weak soils and replacement with engineered fill using suitable soil material would provide a solid foundation for the sedimentation basins.

At the proposed Byron Tract Forebay, the CER specifies that because most of the soils within the footprints of the forebay and the forebay embankments have high organic matter content, they would be excavated and removed from the site. Removal of the weak soils to reach competent soils would provide a solid foundation upon which to construct the forebay and its embankment.

At the spillway and stilling basin for the intermediate spillway, the CER indicates that unsuitable soils would be excavated to competent material and that the spillway would incorporate water-stopped contraction joints at intervals to accommodate a degree of settlement and subsoil deformation. Removal of the weak soils to reach competent soils and providing a joint system would provide a solid foundation for the spillway and stilling basin and enable the spillway to withstand settlement and deformation without jeopardizing its integrity.

Certain methods and practices may be utilized during tunnel construction to help reduce and manage settlement risk. The CER indicates that the ground improvement techniques to control settlement at the shafts and tunnels may involve jet-grouting, permeation grouting, compaction grouting, or other methods that a contractor may propose. Jet-grouting involves use of high-pressure, high-velocity jets to hydraulically erode, mix and partially replace the surrounding soil with a cementitious grout slurry, thereby creating a cemented zone of high strength and low permeability around of tunnel bore. Permeation grouting involves introduction of a low-viscosity grout (sodium silicate, microfine cement, acrylate or polyurethane) into the pores of the soil around the tunnel bore, which increases the strength and cohesion of granular soils. Compaction grouting involves injecting the soil surrounding the tunnel bore with a stiff, low slump grout under pressure, forming a cemented mass that increases soil bearing capacity. These measures would have the effect of better supporting the soil above the borehole and would prevent unacceptable settlement between the borehole and the tunnel segments. Additionally, settlement monitoring points, the number and location of which would be identified during detailed design, would be established along the pipeline and tunnel routes during construction and the results reviewed regularly by a professional engineer. The monitoring therefore would provide early detection of excessive settlement such that corrective actions could be made before the integrity of the tunnel is jeopardized.

Conforming with state and federal design standards would protect the integrity of the conveyance facilities against any subsidence that takes place. As described in section 10.3.1, *Methods for Analysis* and in Appendix 3B, *Environmental Commitments*, such design codes and standards include the California Building Code and resource agency and professional engineering specifications, such as the American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE-7-05, 2005. Conformance with these codes and standards is an environmental commitment by DWR to safeguard the stability of cut and fill slopes and embankments as the water conveyance features are operated. Conforming with the standards and guidelines may necessitate such measures as excavation and removal of weak soils and replacement with engineered fill using suitable, imported soil, construction on pilings driven into competent soil material, and construction of facilities on cast-in-place slabs. These measures would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. As a result, there would be no adverse effect.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, this impact is considered less than significant. No mitigation is required.

#### Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils

The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features, could be adversely affected by expansive, corrosive, and compressible soils.

### *Expansive Soils*

Soil expansion is a concern only at soil depths that are subject to seasonal changes in moisture content. Only a small portion of the Alternative 1A alignment possesses soils with high shrink-swell potential (note areas of high linear extensibility in Figure 10-4). Most of these areas are in Sacramento (Dierssen association) and Alameda (Rincon-San Ysidro association) Counties. Proposed locations for construction features (such as tunnel intakes and their associated structures, borrow/spoils sites, RTM areas, and temporary access roads) are generally situated in areas of soils with low to moderate shrink-swell potential (see Figure 10-4). However, a borrow/spoils area, a temporary work area, a concrete batch plant and a fuel station location in the southern portion of the Alternative 1A alignment, south of Clifton Court Forebay and the proposed Byron Tract Forebay, may contain soils with high to very high shrink-swell potential.

Soils with a high shrink-swell potential (i.e., expansive soils) could damage facilities or cause the facilities to fail. For example, foundations and pavements could be cracked or shifted and pipelines could rupture.

### *Soils Corrosive to Concrete*

The near-surface (i.e., upper 5 feet) soil corrosivity to concrete is high throughout much of the Alternative 1A alignment. The near-surface soils at the five intake and pumping plant facilities generally have a low corrosivity to concrete. The near-surface soils at the tunnel shafts have a low to high corrosivity to concrete. Data on soil corrosivity to concrete below a depth of approximately 5 feet (i.e., where pipelines, tunnels, and the deeper part of the tunnel shafts would be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Because soil corrosivity to concrete is high among the near-surface peat soils in the Delta, a high corrosivity is also expected to be present among the peat soils at depth. Site-specific soil investigations would need to be conducted to determine the corrosivity hazard at depth at each element of the conveyance facility. However, as described in 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify site-specific soil corrosivity hazards. The resulting geotechnical report, prepared by a California registered civil engineer or a California certified engineering geologist, would describe these hazards and recommend the measures that should be implemented to ensure that the facilities are constructed to withstand corrosion and to conform with applicable state and federal standards, such as the CBC.

Soils that are moderately and highly corrosive to concrete may cause the concrete to degrade, thereby threatening the integrity of the facility. Degradation of concrete may cause pipelines and tunnels to leak or rupture and cause foundations to weaken.

### *Soils Corrosive to Uncoated Steel*

The near-surface soils along the Alternative 1A alignment generally are highly corrosive to uncoated steel. Sections of the southern end of the alignment are moderately corrosive to uncoated steel. Data on soil corrosivity to uncoated steel below a depth of approximately 5 feet (i.e., where pipelines, tunnels, and the deeper part of the tunnel shafts would be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Site-specific soil investigations would need to be conducted to determine the corrosivity hazard at depth at each element of the conveyance facility.

Soils that are moderately and highly corrosive to uncoated steel (including steel rebar embedded in concrete) may cause the concrete to degrade, threatening the integrity of these facilities.

***Compressible Soils***

Soils that are weakly consolidated or that have high organic matter content (such as peat or muck soils) present a risk to structures and infrastructure because of high compressibility and poor bearing capacity. Soils with high organic matter content tend to compress under load and may decrease in volume as organic matter is oxidized. Much of the Alternative 1A tunnel alignment is underlain by near-surface soils that consist of peat. The soils in the area where the intakes and their associated structures would be located have a relatively low organic matter content. Based on liquid limits reported in county soil surveys, near-surface soils in the Alternative 1A alignment vary from low to medium compressibility.

Damage to or collapse of the pipelines, intakes, pumping plants, transition structures, and control structures, could occur where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Because of compressible soils, such effects could occur at the five intakes, all the pumping plants, and the sedimentation basins. Subsidence- or differential sediment–induced damage or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply and producing underground cavities, depressions at the ground surface, and surface flooding.

The tunnels would be constructed at a depth below the peat (Figure 9-4); therefore, subsidence caused by organic matter decomposition below the tunnels is expected to be minimal. Surface and subsurface settlement may occur during tunnel construction; however, certain methods and practices may be used during tunnel construction to help reduce and manage settlement risk. Chapter 9, *Geology and Seismicity*, discusses the risks of settlement during tunnel construction and methods to reduce the amount of settlement (Impact GEO-2).

Embankments that have subsided would be subject to overtopping, leading to flooding on the landside of the embankments. The embankment that would be subject to this hazard is the new Byron Tract Forebay.

***NEPA Effects:*** Various facilities would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. The CBC requires measures such as soil replacement, lime treatment, and post-tensioned foundations to offset expansive soils. The CBC requires such measures as using protective linings and coatings, dialectric (i.e., use of an electrical insulator polarized by an applied electric field) isolation of dissimilar materials, and active cathodic protection systems to prevent corrosion of concrete and steel.

Potential adverse effects of compressible soils and soils subject to subsidence could be addressed by overexcavation and replacement with engineered fill or by installation of structural supports (e.g., pilings) to a depth below the peat where the soils have adequate load bearing strength, as required by the CBC and by USACE design standards. Geotechnical studies would be conducted at all the facilities to determine the specific measures that should be implemented to reduce these soil hazards to levels consistent with the CBC. Liquid limit and soil organic matter content testing would be performed on collected soil samples during the site-specific field investigations to determine site-specific geotechnical properties. Settlement monitoring points would be established along the route during tunnel construction and results reviewed regularly by a professional engineer.

The engineer would develop final engineering solutions to any hazardous condition, consistent with the code and standards requirements of federal, state, and local oversight agencies. As described in section 10.3.1, *Methods for Analysis*, and in Appendix 3B, *Environmental Commitments*, such design codes, guidelines, and standards include the California Building Code and resource agency and professional engineering specifications, such as the DWR *Interim Levee Design Criteria for Urban and Urbanizing Area State Federal Project Levees*, and USACE *Engineering and Design—Earthquake Design and Evaluation for Civil Works Projects*.

By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion***: Many of the Alternative 1A facilities would be constructed on surface soils that are moderately or highly corrosive to concrete and uncoated steel, as well as soils that are moderately or highly subject to compression under load. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. Surface soils that are moderately to highly expansive are present throughout the Alternative 1A alignment except in the central part of the Delta, roughly between Staten Island and Bacon Island. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. However, DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes. The CBC requires measures such as soil replacement, lime treatment, and post-tensioned foundations to offset expansive soils. The CBC requires such measures as using protective linings and coatings, dialectric (i.e., use of an electrical insulator polarized by an applied electric field) isolation of dissimilar materials, and active cathodic protection systems to prevent corrosion of concrete and steel in conformance with CBC requirements. Potential effects of compressible soils and soils subject to subsidence could be addressed by overexcavation and replacement with engineered fill or by installation of structural supports (e.g., pilings) to a depth below the peat where the soils have adequate load bearing strength, as required by the CBC and by USACE design standards. Conforming with these codes and standards (Appendix 3B, *Environmental Commitments*) is an environmental commitment by DWR to ensure that potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, the impact would be less than significant. No mitigation is required.

### Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations

River channel bank erosion/scour is a natural process. The rate of natural erosion can increase during high flows and as a result of wave effect on banks during high wind conditions.

In general, changes in river flow rates associated with BDCP operations would remain within the range that presently occurs. However, the operational components would cause changes in the tidal flows in some Delta channels, specifically those that lead into the major habitat restoration areas (Suisun Marsh, Cache Slough, Yolo Bypass, and South Delta ROAs). In major channels leading to the restoration areas (e.g., Lindsey, Montezuma, and Georgiana sloughs and Middle River), tidal flow velocities may increase by an unknown amount; any significant increases could cause some localized accelerated erosion/scour. However, detailed hydrodynamic (tidal) modeling would be conducted prior to any BDCP habitat restoration work in these ROA areas, and the changes in the tidal velocities in the major channels connecting to these restoration areas would be evaluated. If there is any indication that tidal velocities would be substantially increased, the restoration project design would be modified (such as by providing additional levee breaches or by requiring dredging in portions of the connecting channels) so that bed scour would not increase sufficiently to cause an erosion impact. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration.

For most of the existing channels that would not be subject to tidal flow restoration, there would be no adverse effect to tidal flow volumes and velocities. The tidal prism would increase by 5–10%, but the intertidal (i.e., mean higher high water [MHHW] to mean lower low water [MLLW]) cross-sectional area also would be increased such that tidal flow velocities would be reduced by 10–20% compared to the existing condition. Consequently, no appreciable increase in scour is anticipated.

***NEPA Effects:*** The effect would not be adverse because there would be no net increase in river flow rates and, accordingly, no net increase in channel bank scour.

***CEQA Conclusion*****:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

#### Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19

Implementing conservation measures CM2–CM11 would include breaching, lowering, or removing levees; constructing setback levees and cross levees or berms; raising the land elevation by excavating relatively high areas to provide fill for subsided areas or by importing fill material; surface grading; deepening and/or widening tidal channels; excavating new channels; modifying channel banks; and other activities. Moreover, excavation and grading to construct facilities, access roads, and other features would be necessary under the two conservation measures that are not associated with the ROAs (i.e., *CM18 Conservation Hatcheries* and *CM19 Urban Stormwater Treatment*). These activities could cause adverse effects on soil erosion rates and cause a loss of topsoil, as discussed below.

##### *Water Erosion*

Activities associated with conservation measures that could lead to accelerated water erosion include clearing, grubbing, demolition, grading, and other similar disturbances. Such activities steepen slopes and compact soil. These activities tend to degrade soil structure, reduce soil infiltration capacity, and increase runoff rates, all of which could cause accelerated erosion and consequent loss of topsoil.

Gently sloping to level areas, such as where most of the restoration actions would occur, are expected to experience little or no accelerated water erosion because of the lack of runoff energy to entrain and transport soil particles.

Graded and otherwise disturbed tops and sideslopes of existing and project levees and embankments are of greater concern for accelerated water erosion because of their steep gradients. Soil eroded from the disturbed top and water side of levees could reach adjoining waterways (if present), unless erosion and sediment control measures are implemented.

***Wind Erosion***

Wind erosion potential varies widely among and within the ROAs (Figure 10-6). Areas within ROAs with high wind erodibility are largely correlated with the presence of organic soils. Wind erodibility in the Suisun Marsh, Cache Slough, and South Delta ROAs ranges from high to low. The Yolo Bypass ROA generally has a low wind erodibility hazard.

Implementation of conservation measures (e.g., excavation, filling, grading, and vehicle traffic on unimproved roads) that could lead to accelerated wind erosion are the same as those for water erosion. These activities may entail vegetation removal and degradation of soil structure, both of which would make the soil more subject to wind erosion. Removal of vegetation cover and grading increase soil exposure at the surface and obliterate the binding effect of plant roots on soil aggregates. These effects make the soil particles more subject to entrainment by wind.

Unlike water erosion, the potential for wind erosion is generally not dependent on slope gradient and location, nor is the potential affected by context relative to a receiving water. Without proper management, the wind-eroded soil particles can be transported great distances.

The transport of soil material from the conveyance facilities for use as fill in subsided areas within the ROAs could subject the soils to wind erosion, particularly if the fill material consists of peat. The peat would be especially susceptible to wind erosion while being loaded onto trucks, transported, unloaded, and distributed onto the restoration areas.

***NEPA Effects:*** These effects could potentially result in substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. The General Permit requires that SWPPPs be prepared by a QSD and requires SWPPPs be implemented under the supervision of a QSP. The QSD would select erosion and sediment control BMPs such as preservation of existing vegetation, seeding, mulching, fiber roll and silt fence barriers, erosion control blankets, watering to control dust entrainment, and other measures to comply with the practices and turbidity level requirements defined by the General Permit. Partly because the potential adverse effect on receiving waters depends on location of a work area relative to a waterway, the BMPs would be site-specific. The QSP would be responsible for day-to-day implementation of the SWPPP, including BMP inspections, maintenance, water quality sampling, and reporting to the State Water Board.

Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that accelerated water and wind erosion associated with implementation of the conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*). Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Topsoil effectively would be lost as a resource as a result of its excavation (e.g., levee foundations, water control structures); overcovering (e.g., levees, embankments, application of fill material in subsided areas); and water inundation (e.g., aquatic habitat areas).

***NEPA Effects:*** Implementation of habitat restoration activities at the ROAs would result in excavation, overcovering, or inundation of approximately 77,600 acres of topsoil. This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of conservation measures CM2–CM11 would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. This impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

With the exception of the Suisun Marsh ROA, the ROAs are not in areas of high subsidence nor where the soils have a high organic matter content (Figures 10-2 and 10-9). Consequently, only the Suisun Marsh ROA would be expected to be subject to substantial subsidence. Based on its current elevation, the Suisun Marsh ROA has not experienced significant subsidence, despite the fact that the soils are organic and of considerable thickness (Figure 10-3).

Damage to or failure of the habitat levees could occur, where these are constructed in soils and sediments that are subject to subsidence and differential settlement. Levee damage or failure could cause surface flooding in the vicinity.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. Such standards include the USACE Design and Construction of Levee and DWR Interim Levee Design Criteria for Urban and Urbanizing Area State-Federal Project Levees.

For example, high organic matter content soils and all soils otherwise subject to subsidence that are unsuitable for supporting levees would be overexcavated and replaced with engineered fill, and the unsuitable soils disposed of offsite as spoils. Geotechnical evaluations will be conducted to identify soils materials that are suitable for engineering purposes. Liquid limit and organic content testing should be performed on collected soil samples during the site-specific field investigations to determine site-specific geotechnical properties.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*****:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

### Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11

#### *Expansive Soils*

The ROAs generally have soils with moderate or high shrink-swell potential. The ROAs with a significant extent of highly expansive soils are the Yolo Bypass and Cache Slough ROAs (Figure 10-4). None appears to have appreciable areas of soils with very high expansiveness.

Potential adverse effects of expansive soils are a concern only to structural facilities within the ROAs, such as water control structures. Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas.

#### *Corrosive Soils*

Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun Marsh ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

#### *Compressible Soils*

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs. Areas of low to medium compressibility occur in the South Delta ROA. Silts and clays with a liquid limit less than 35% are considered to have low compressibility. Silts and clays with a liquid limit greater than 35% and less than 50% are considered to have medium compressibility and greater than 50% are considered highly compressible. Organic soils typically have high liquid limits (greater than 50%) and are therefore considered highly compressible.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive, and/or compressible soils would prevent adverse effects.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

### 10.3.3.3 Alternative 1B—Dual Conveyance with East Alignment and Intakes 1–5 (15,000 cfs; Operational Scenario A)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

The mechanisms of this impact are similar to those described for Alternative 1A; however, considerably more excavation would be necessary to construct the canal along the eastern alignment than would be necessary for tunnel boring under Alternative 1A. Construction of water conveyance facilities would involve vegetation removal; constructing building pads, levees, canals, and tunnel siphons; excavation; overexcavation for facility foundations; surface grading; trenching; road construction; spoil storage; soil stockpiling; and other activities over approximately 21,500 acres during the course of constructing the facilities. Vegetation would be removed (via grubbing and clearing) grading and other earthwork would be conducted at the intakes, pumping plants, the proposed Byron Tract Forebay, canal and gates between the Byron Tract Forebay tunnel shafts and the approach canal to the Banks Pumping Plant, borrow areas, RTM and spoil storage areas, setback and transition levees, sedimentation basins, solids handling facilities, transition structures, surge shafts and towers, substations, transmission line footings, access roads, concrete batch plants, fuel stations, bridge abutments, barge unloading facilities, and laydown areas. Some of the work would be conducted in areas that are fallow at the time. Excavation of a large volume of borrow material would be required to construct the canals. Some of the earthwork activities may also result in steepening of slopes and soil compaction, particularly for the embankments constructed for the intermediate forebay and the proposed Byron Tract Forebay. These conditions tend to result in increased runoff rates, degradation of soil structure, and reduced soil infiltration capacity, all of which could cause accelerated erosion, resulting in loss of topsoil.

#### *Water Erosion*

The excavation, grading, and other soil disturbances described above that are conducted in gently sloping to level areas, such as the interiors of Delta islands, are expected to experience little or no accelerated water erosion because of the lack of runoff energy to entrain and transport soil particles. Any soil that is eroded within island interiors would tend to remain on the island, provided that existing or project levees are in place to serve as barriers to keep the eroded soil (i.e., sediment) from entering receiving waters.

In contrast, graded and otherwise disturbed tops and sideslopes of existing and project canals, levees, and embankments are of greater concern for accelerated water erosion because of their steeper gradients. Although soil eroded from the land side of levees would be deposited on the island interiors, soil eroded from the disturbed top and water side of levees could reach adjoining waterways. Soil eroded from natural slopes in upland environments could also reach receiving waters.

***Wind Erosion***

Many of the primary work areas that would involve extensive soil disturbance (i.e., the canals, staging areas, borrow/spoil areas, and intakes) within the Alternative 1B footprint are underlain by soils with a moderate or high susceptibility to wind erosion (Natural Resources Conservation Service 2010a) (Figure 10-6). Of the primary areas that would be disturbed, the proposed borrow/spoil area southwest of Clifton Court Forebay, the proposed Byron Tract Forebay and parts of the southern half of the alignment generally have a low wind erosion hazard.

Construction activities (e.g., excavation, filling, grading, and vehicle traffic on unimproved roads) that could lead to accelerated wind erosion are generally the same as those for water erosion. These activities may result in vegetation removal and degradation of soil structure, both of which would make the soil much more subject to wind erosion. Removal of vegetation cover and grading increase soil exposure at the surface and obliterate the binding effect of plant roots on soil aggregates. These effects make the soil particles much more subject to entrainment by wind. However, most of the areas that would be extensively disturbed by construction activities are already routinely disturbed by agricultural activities, such from disking and harrowing. These areas are the pumping plants, most of the proposed Byron Tract Forebay, borrow areas, RTM and spoil storage areas, sedimentation basins, solids handling facilities, substations, access roads, concrete batch plants, and laydown areas. Consequently, with the exception of loading and transporting of soil material to storage areas, the disturbance that would result from constructing the conveyance facilities in many areas would not substantially depart from the existing condition, provided that the length of time that the soil is left exposed during the year does not change compared to that associated with agricultural operations. Because the SWPPPs prepared for the various components of the project will be required to prescribe ongoing best management practices to control wind erosion (such as temporary seeding), the amount of time that the soil would be exposed during construction should not significantly differ from the existing condition.

Unlike water erosion, the potential adverse effects of wind erosion are generally not dependent on slope gradient and location relative to levees or water. Without proper management, the wind-eroded soil particles can be transported great distances.

Excavation of soil from borrow areas and transport of soil material to spoil storage areas would potentially subject soils to wind erosion. It is likely that approximately 159 million cubic yards of peat soil material would be disposed of as spoils; this material would be especially susceptible to wind erosion while being loaded onto trucks, transported, unloaded, and distributed.

***NEPA Effects:*** These potential effects could be substantial because they could cause accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. While the SWPPPs would not be prepared until just prior to construction and application to the State Water Board for a General Permit, please see the discussion under Alternative 1A, Impact SOILS-1, for more details on what SWPPPs would entail, and likely BMPs which would be included.

Accelerated water and wind erosion as a result of construction of the proposed water conveyance facility could occur under Alternative 1B, but proper implementation of the requisite SWPPP and compliance with the General Permit (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2) would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, there would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the SWPPP, and Permit conditions, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation during construction of the water conveyance facilities associated with Alternative 1B (e.g., canal alignment, borrow areas, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebay, sedimentation basins, and solids lagoons). Table 10-6 presents an itemization of the effects on soils caused by excavation, overcovering, and inundation, based on GIS analysis by facility type. Due to the nature of the earthwork to construct many of the facilities, more than one mechanism of soil loss may be involved at a given facility. For example, levee construction would require both excavation to prepare the subgrade and overcovering to construct the levee. The table shows that the greatest extent of topsoil loss would be associated with overcovering such as spoil storage areas, unless measures are undertaken to salvage the topsoil and reapply it on top of excavated borrow areas or on top of the spoils once they have been placed.

**Table 10-6. Topsoil Lost as a Result of Excavation, Overcovering, and Inundation Associated with the Proposed Water Conveyance Facility**

| Topsoil Loss Mechanism | Acreage Affected |
|---|---|
| Excavation (intakes, canals, borrow areas) | 7,926 |
| Overcovering (spoil storage, reusable tunnel material storage) | 13,055 |
| Inundation (forebay, sedimentation basins, solids lagoons) | 851 |
| Total | 21,832 |

Note: Some mechanisms for topsoil loss entail more than one process of soil loss. For example, construction of setback levees would first require overexcavation for the levee foundation (i.e., excavation), then placement of fill material (i.e., overcovering).

DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would also be available to reduce the severity of this effect.

***CEQA Conclusion***: Construction of the water conveyance facilities would involve irreversible removal, overcovering, and inundation of topsoil over large areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

The northern half of the proposed canal alignment, the intakes, pumping plants, pipelines, and Byron Tract Forebay adjacent to the Clifton Court Forebay would be constructed where the near-surface soils contain less than approximately 2% organic matter; these areas therefore would not be subject to appreciable subsidence caused by organic matter decomposition. The southern half of the canal alignment, four siphons, and one tunnel would be constructed where the near-surface soils have approximately 4–23% organic matter content (Figure 10-2); consequently, subsidence caused by organic matter decomposition could be considerable. Without adequate engineering, part of the canal, siphons, and a tunnel could be subject to appreciable subsidence.

Damage to or collapse of the canal, tunnels, siphons, bridge abutments, and other facilities could occur where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Subsidence or differential sediment–induced damage or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply and producing underground cavities, depressions at the ground surface, and surface flooding. Facilities that have subsided would be subject to flooding.

Damage to other conveyance facilities, such as intakes, pumping plants, transition structures, and control structures, caused by subsidence/settlement under the facilities and consequent damage to or failure of the facility, could also occur. Facility damage or failure could cause a rapid release of water to the surrounding area, resulting in flooding, thereby endangering people in the vicinity. However, existing subsidence and soil organic matter content is generally low in the areas where these facilities are proposed, so there is little likelihood of this happening.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2009a, 2010c). Such standards include the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, CBC, and USACE Design and Construction of Levees. The results of the investigations, which would be conducted by a California registered civil engineer or California certified engineering geologist, would be presented in geotechnical reports. The reports would contain recommended measures to prevent subsidence. The geotechnical report will prepared in accordance with state guidelines, in particular *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (California Geological Survey 2008).

Liquid limit and organic material content testing should be performed on soil samples collected during the site-specific field investigations to determine site-specific geotechnical properties. High organic matter content soils that are unsuitable for support of structures, bridge abutments, roadways and other facilities would be overexcavated and replaced with engineered fill, and the unsuitable soils disposed of offsite as spoil, as described in more detail below. Geotechnical evaluations will be conducted to identify soil materials that are suitable for engineering purposes. Additional measures to address the potential adverse effects of organic soils could include construction of structural supports that extend below the depth of organic soils into underlying materials with suitable bearing strength. For example, the CER indicates that approximately 35 feet of soil would be excavated and a pile foundation supporting a common concrete mat would be required for the intake pumping plants. The piles would be 24-inches in diameter and concrete-filled, extending to 65 to 70 feet below the founding level of the plant. Piles extended to competent geologic beds, beyond the weak soils would provide a solid foundation to support the pumping plants.

For the sedimentation basins, the CER indicates that most of the underlying soils would be excavated to a depth of 30 feet below grade and removed from the site and suitable soil material imported to the site to re-establish it to subgrade elevation. Removal of the weak soils and replacement with engineered fill using suitable soil material would provide a solid foundation for the sedimentation basins.

Certain methods and practices may be utilized during tunnel siphon construction to help reduce and manage settlement risk. The CER indicates that the ground improvement techniques to control settlement at the shafts and tunnels may involve jet-grouting, permeation grouting, compaction grouting, or other methods that a contractor may propose. These measures would have the effect of better supporting the soil above the borehole and would prevent unacceptable settlement between the borehole and the tunnel segments. Additionally, settlement monitoring points, the number and location of which would be identified during detailed design, would be established along the pipeline and tunnel routes during construction and the results reviewed regularly by a professional engineer. The monitoring therefore would provide early detection of excessive settlement such that corrective actions could be made before the integrity of the tunnel is jeopardized.

Conforming with state and federal design standards would ensure that any subsidence that occurs under the conveyance facilities would not jeopardize their integrity. As described in the section 10.3.1, *Methods for Analysis*, and in Appendix 3B, *Environmental Commitments*, such design codes and standards include the California Building Code and resource agency and professional engineering specifications, such as the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005. Conforming with these codes and standards is an environmental commitment by DWR to ensure cut and fill slopes and embankments will be stable as the water conveyance features are operated. Conforming with the standards and guidelines may necessitate such measures as excavation and removal of weak soils and replacement with engineered fill using suitable, imported soil, construction on pilings driven into competent soil material, and construction of facilities on cast-in-place slabs. These measures would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. There would be no adverse effect.

***CEQA Conclusion***: Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, this impact is considered less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

The integrity of the water conveyance facilities, including the canal, intake facilities, pumping plants, access roads and utilities, and other features, could be adversely affected by expansive, corrosive, and compressible soils.

***Expansive Soils***

Soil expansion is a concern only at soil depths that are subject to seasonal changes in moisture content. The Alternative 1B alignment is underlain by soils with low to high shrink-swell potential (note areas of high linear extensibility in Figure 10-4). The majority of the soils with high shrink-swell potential are where the intakes, pumping plants, pipelines, sedimentation basin, one of the tunnels, and the northern third of the canal alignment are proposed. Most of these areas are in Sacramento County (Dierssen and Egbert-Valpac association soils). The remaining conveyance facilities would generally be located where the soils have low or moderate shrink-swell potential. Soil expansion-contraction is not expected to be a concern at these types of facilities.

Soils with a high shrink-swell potential (i.e., expansive soils) could damage facilities or cause the facilities to fail. For example, foundations and pavements could be cracked or shifted and pipelines could rupture.

***Soils Corrosive to Concrete***

The near-surface (i.e., upper 5 feet) soil corrosivity to concrete ranges from low to high along the Alternative 1B alignment, although most of the alignment is in areas of low to moderate corrosivity. The near-surface soils at the five intake and pumping plant facilities generally have a moderate corrosivity to concrete. The near-surface soils at the proposed tunnel alignment near Walnut Grove and the northern siphons have a moderate corrosivity to concrete. The proposed tunnel alignment near Stockton and the Clifton Court Forebay have low corrosivity to concrete. Data on soil corrosivity to concrete below a depth of approximately 5 feet (i.e., where pipelines, tunnels, and the deeper part of the tunnel shafts will be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Site-specific soil investigations will need to be conducted to determine this. Because soil corrosivity to concrete is high among the near-surface peat soils in the Delta, a high corrosivity is also expected to be present among the peat soils at depth. Site-specific soil investigations would need to be conducted to determine the corrosivity hazard at depth at each element of the conveyance facility. However, as described in 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify site-specific soil corrosivity hazards. The resulting geotechnical report, prepared by a California registered civil engineer or a California certified engineering geologist, would describe these hazards and recommend the measures that should be implemented to ensure that the facilities are constructed to withstand corrosion and to conform with applicable state and federal standards, such as the CBC.

Soils that are moderately and highly corrosive to concrete may cause the concrete to degrade, thereby threatening the integrity of the facility. Degradation of concrete may cause pipelines to leak or rupture and cause foundations to weaken.

***Soils Corrosive to Uncoated Steel***

The near-surface soils along the Alternative 1B alignment have a moderate or high corrosivity to uncoated steel. With the exception of a significantly sized area west of Stockton, virtually the entire alignment has a high risk of corrosion to uncoated steel. Data on soil corrosivity to uncoated steel below a depth of approximately 5 feet (i.e., where pipelines, tunnels, and siphons would be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Site-specific soil investigations would need to be conducted to determine the corrosivity hazard at depth at each element of the conveyance facility.

Soils that are moderately and highly corrosive to uncoated steel (including steel rebar embedded in concrete) may cause the concrete to degrade, threatening the integrity of these facilities.

***Compressible Soils***

Soils that are weakly consolidated or that have high organic matter content (such as peat or muck soils) present a risk to structures and infrastructure due to high compressibility and poor bearing capacity. Soils with high organic matter content tend to compress under load and may decrease in volume as organic matter is oxidized. The southern half of the Alternative 1B alignment is underlain by near-surface soils with significant organic matter content. Although the intakes would generally be located on mineral soils, according to the CER some of these soils are soft and have poor bearing capacity. Some of the pumping plants and pipelines also would be located on such soils. Based on liquid limits reported in county soil surveys, near-surface soils in the Alternative 1B alignment vary from low to medium compressibility.

Part of the Byron Tract Forebay embankment would be subject to this hazard.

Damage to or collapse of the intakes, pumping plants, transition structures, and control structures, could occur where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Because of compressible soils, such effects could occur at the five intakes, all the pumping plants, and the sedimentation basins, Subsidence- or differential sediment–induced damage to or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply and producing underground cavities, depressions at the ground surface, and surface flooding. Facilities that have subsided would be subject to flooding and levees that have subsided would be subject to overtopping and consequent flooding on the land side of the levee.

***NEPA Effects:*** Various facilities would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. The CBC requires measures such as soil replacement, lime treatment, and post-tensioned foundations to offset expansive soils, as well as such measures as using protective linings and coatings, dialectric isolation of dissimilar materials, and active cathodic protection systems to prevent corrosion of concrete and steel.

Potential adverse effects of compressible soils and soils subject to subsidence could be addressed by overexcavation and replacement with engineered fill or by installation of structural supports (e.g., pilings) to a depth below the peat where the soils have adequate load bearing strength, as required by the CBC and by USACE design standards. For example, the CER indicates that a deep foundation (pile) length of 65 to 70 feet below the founding level of the in-river intake may be required for adequate support of intake structures without excessive settlement. Geotechnical studies would be conducted at all the facilities to determine what specific measures should be implemented at each facility to reduce these soil hazards to levels consistent with the CBC. Liquid limit and soil organic matter content testing would be performed on soil samples collected during the site-specific field investigations to determine site-specific geotechnical properties. Settlement monitoring points should be established along the route during tunnel construction and results reviewed regularly by a professional engineer.

The engineer would develop final engineering solutions to any hazardous condition, consistent with the code and standards requirements of federal, state, and local oversight agencies (e.g., California Building Code, DWR Interim Levee Design Criteria for Urban and Urbanizing Area State Federal Project Levees, and USACE Engineering and Design—Earthquake Design and Evaluation for Civil Works Projects).

By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*:** Many of the Alternative 1B facilities would be constructed on surface soils that are moderately or highly subject to expansion, corrosive to concrete and uncoated steel, as well as soils that are moderately or highly subject to compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards (Appendix 3B, *Environmental Commitments*) is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 1B would use Operational Scenario A—the same scenario as Alternative 1A. Accordingly, the effects associated with river channel bank erosion/scour would be the same.

***NEPA Effects:*** As under Alternative 1A, the operational components would cause changes in the tidal flows in some Delta channels, specifically those that lead into the major habitat restoration areas

(Suisun Marsh, Cache Slough, Yolo Bypass, and South Delta ROAs). However, detailed hydrodynamic (tidal) modeling would be conducted prior to any BDCP habitat restoration work in these ROA areas, and the changes in the tidal velocities in the major channels connecting to these restoration areas would be evaluated. If there is any indication that tidal velocities would be substantially increased, the restoration project design would be modified (such as by providing additional levee breaches or by requiring dredging in portions of the connecting channels) so that bed scour would not increase sufficiently to cause an erosion impact. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration.

The effect would not be adverse because there would be no net increase in flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion:*** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 1B would be the same as under Alternative 1A. These activities would include breaching, lowering, or removing levees; constructing setback levees and cross levees or berms; raising the land elevation by excavating relatively high areas to provide fill for subsided areas or by importing fill material; surface grading; deepening and/or widening tidal channels; excavating new channels; modifying channel banks; excavation and grading to construct facilities, access roads, and other facilities; and other activities. These activities could cause adverse effects on soil erosion rates and cause a loss of topsoil through both water and wind erosion.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan.

Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that accelerated water and wind erosion associated with implementation of conservation measures CM2–CM11 would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, Environmental Commitments). Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of the implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of conservation measures CM2–CM11 would be the same under Alternative 1B as under Alternative 1A. Consequently, topsoil loss associated with excavation (e.g., levee foundations, water control structures), overcovering (e.g., levees, embankments, application of fill material in subsided areas), and water inundation (e.g., aquatic habitat areas) would also be the same as under Alternative 1A.

***NEPA Effects:*** Implementation of habitat restoration activities at the ROAs would result in excavation, overcovering, or inundation of a minimum of 77,600 acres of topsoil. This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of conservation measures CM2–CM11 would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of proposed conservation measures CM2–CM11 under Alternative 1B would be the same as under Alternative 1A. Similarly, the potential for injury or death to occur as a result of damage to or failure of the habitat levees where these are constructed in soils and sediments that are subject to subsidence and differential settlement would also be the same as under Alternative 1A. Levee damage or failure could cause surface flooding in the vicinity.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. Such standards include USACE's *Design and Construction of Levees* and DWR's *Interim Levee Design Criteria for Urban and Urbanizing Area State-Federal Project Levees.*

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion***: Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of proposed conservation measures CM2–CM11 under Alternative 1B would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete. Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects.

***CEQA Conclusion***: Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents will be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), the impacts would be less than significant. No mitigation is required.

### 10.3.3.4 Alternative 1C—Dual Conveyance with West Alignment and Intakes W1–W5 (15,000 cfs; Operational Scenario A)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

The mechanisms of this impact are similar to those described for Alternative 1A; however, considerably more excavation would be necessary to construct the canal along the western alignment than would be necessary for tunnel boring under Alternative 1A. Construction of water conveyance facilities would involve vegetation removal; constructing building pads, levees, canals, and a tunnel; excavation; overexcavation for facility foundations; surface grading; trenching; road construction; spoil storage; soil stockpiling; and other activities over approximately 17,400 acres during the course of constructing the facilities. Vegetation would be removed (via grubbing and clearing) grading and other earthwork would be conducted at the intakes, pumping plants, the proposed Byron Tract Forebay, canal and gates between the Byron Tract Forebay tunnel shafts and the approach canal to the Banks Pumping Plant, borrow areas, RTM and spoil storage areas, setback and transition levees, sedimentation basins, solids handling facilities, transition structures, surge shafts and towers, substations, transmission line footings, access roads, concrete batch plants, fuel stations, bridge abutments, barge unloading facilities, and laydown areas. Some of the work would be conducted in areas that are fallow at the time. Excavation of a large volume of borrow material would be required to construct the canals. Some of the earthwork activities may also result in steepening of slopes and soil compaction, particularly for the embankments constructed for the intermediate forebay and the proposed Byron Tract Forebay. These conditions tend to result in increased runoff rates, degradation of soil structure, and reduced soil infiltration capacity, all of which could cause accelerated erosion, resulting in the loss of topsoil.

***Water Erosion***

The excavation, grading, and other soil disturbances described above that are conducted in gently sloping to level areas, such as the interiors of Delta islands, are expected to experience little or no accelerated water erosion because of the lack of runoff energy to entrain and transport soil particles. Any soil that is eroded within island interiors would tend to remain on the island, provided that existing or project levees are in place to serve as barriers to keep the eroded soil (i.e., sediment) from entering receiving waters.

In contrast, graded and otherwise disturbed tops and sideslopes of existing and project canals, levees and embankments are of greater concern for accelerated water erosion because of their steeper gradients. Although soil eroded from the land side of levees would be deposited on the island interiors, soil eroded from the disturbed top and water side of levees could reach adjoining waterways. Soil eroded from natural slopes in upland environments could also reach receiving waters.

***Wind Erosion***

In the primary work areas that would involve extensive surface soil disturbance (i.e., the proposed Byron Tract Forebay on the northwestern side of Clifton Court Forebay, the canals, staging areas, borrow/spoil areas, and intakes), the soils generally have a low susceptibility to wind erosion (Natural Resources Conservation Service 2010a) (Figure 10-6).

Excavation of soil from borrow areas and transport of soil material to spoil storage areas potentially would subject the soils to wind erosion. It is likely that approximately 50 million cubic yards of peat soil material would be disposed of as spoils; this material would be especially susceptible to wind erosion while being loaded onto trucks, transported, unloaded, and distributed.

***NEPA Effects:*** These potential effects could be substantial because they could cause accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. While the SWPPPs would not be prepared until just prior to construction and application to the State Water Board for a General Permit, please see the discussion under Alternative 1A, Impact SOILS-1, for more details on what SWPPPs would entail, and likely BMPs which would be included.

Accelerated water and wind erosion as a result of construction of the proposed water conveyance facility could occur under Alternative 1C, but proper implementation of the requisite SWPPP and compliance with the General Permit (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2) would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, as a result of construction of the proposed water conveyance facilities, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the SWPPP and compliance with the General Permit, where applicable, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation during construction of the water conveyance facilities associated with Alternative 1C (e.g., canal alignment, borrow areas, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebay, sedimentation basins, solids lagoons).

Table 10-7 presents an itemization of the effects on soils caused by excavation, overcovering, and inundation, based on GIS analysis by facility type. Because of the nature of the earthwork to construct many of the facilities, more than one mechanism of soil loss may be involved at a given facility. For example, levee construction would require both excavation to prepare the subgrade and overcovering to construct the levee. The table shows that the greatest extent of topsoil loss would be associated with excavations such as for the canals, unless measures are undertaken to salvage the topsoil and reapply it on top of the excavated borrow areas or on top of spoils once they have been placed.

**Table 10-7. Topsoil Lost as a Result of Excavation, Overcovering, and Inundation Associated with the Proposed Water Conveyance Facility**

| Topsoil Loss Mechanism | Acreage Affected |
|---|---|
| Excavation (intakes, canals, shafts, borrow areas) | 11,462 |
| Overcovering (spoil storage, reusable tunnel material storage) | 5,804 |
| Inundation (forebay, sedimentation basins, solids lagoons) | 773 |
| Total | 18,039 |

Note: Some mechanisms for topsoil loss entail more than one process of soil loss. For example, construction of setback levees would first require overexcavation for the levee foundation (i.e., excavation), then placement of fill material (i.e., overcovering).

DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would also be available to reduce the severity of this effect.

***CEQA Conclusion*****:** Construction of the water conveyance facilities would involve irreversible removal, overcovering, and inundation of topsoil over large areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

The part of the alignment that includes the northern canal, intakes, pipelines, pumping plants, sedimentation basins, and some of the siphons would be constructed where the near-surface soils have approximately 2% organic matter content. Compared to organic soils, these mineral soils would not be subject to appreciable subsidence caused by organic matter decomposition because there is relatively little organic matter available to decompose. The remainder (southern) part of the northern canal alignment is underlain by near-surface soils having 4–12.5% organic matter content (Figure 10-2). The thickness of the peat ranges between 0 and 20 feet. The amount of existing subsidence is 0–10 feet, with the deeper subsided areas existing where the intermediate pumping plant is proposed. This southern part would be subject to appreciable subsidence.

The proposed tunnel section extends through an area where the near-surface soils have 4% to more than 22.5% organic matter content. The thickness of the peat ranges between approximately 5 and 25 feet. The amount of existing subsidence ranges between 5 and more than 20 feet. Because the tunnel section would be constructed below the peat, it would not be affected by subsidence caused by organic matter decomposition.

The proposed southern canal alignment generally would pass through an area where the soils have less than approximately 2% organic matter content and where there apparently has been no evidence of subsidence caused by organic matter decomposition. Compared to organic soils, these mineral soils would not be subject to appreciable subsidence caused by organic matter decomposition because there is relatively little organic matter available to decompose. Only the southern portion of the southern canal alignment (including the part of the new Byron Tract Forebay) is underlain by peat soils up to 5 feet deep. Without adequate engineering, parts of the canals, pipelines, intermediate pumping plant, some of the siphons, and other facilities could be subject to appreciable subsidence.

Damage to or collapse of the canal, tunnels, siphons, bridge abutments, and other facilities could occur, where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Subsidence- or differential sediment–induced damage or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply and producing underground cavities, depressions at the ground surface, and surface flooding. Facilities that have subsided would be subject to flooding.

Damage to other conveyance facilities, such as intakes, pumping plants, transition structures, and control structures, caused by subsidence/settlement under the facilities and consequent damage or failure to the facility could also occur. Facility damage or failure could cause a rapid release of water to the surrounding area, resulting in flooding, thereby endangering people in the vicinity. However, the amount of existing subsidence and soil organic matter content is generally low in the areas where these facilities are proposed, so the likelihood of this occurring is low.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2009b, 2010d). Such standards include the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, California Building Code, and USACE Design and Construction of Levees. The results of the investigations, which would be conducted by a California registered civil engineer or California certified engineering geologist, would be presented in geotechnical reports. The reports would contain recommended measures to prevent subsidence. The geotechnical report will prepared in accordance with state guidelines, in particular *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (California Geological Survey 2008).

Liquid limit and organic content testing should be performed on soil samples collected during the site-specific field investigations to determine site-specific geotechnical properties. High organic matter content soils that are unsuitable for support of structures, bridge abutments, roadways and other facilities would be overexcavated and replaced with engineered fill, and the unsuitable soils disposed of offsite as spoil, as described in more detail below. Geotechnical evaluations would be conducted to identify soils materials that are suitable for engineering purposes.

Additional measures to address the potential adverse effects of organic soils could include construction of structural supports that extend below the depth of organic soils into underlying materials with suitable bearing strength. For example, the CER indicates that approximately 35 feet of soil would be excavated and a pile foundation supporting a common concrete mat would be required for the intake pumping plants. The piles would be 24-inches in diameter and concrete-filled, extending to 65 to 70 feet below the founding level of the plant. Piles extended to competent geologic beds, beyond the weak soils would provide a solid foundation to support the pumping plants.

For the sedimentation basins, the CER indicates that most of the underlying soils would be excavated to a depth of 30 feet below grade and removed from the site and suitable soil material imported to the site to re-establish it to subgrade elevation. Removal of the weak soils and replacement with engineered fill using suitable soil material would provide a solid foundation for the sedimentation basins.

Certain methods and practices may be utilized during tunnel construction to help reduce and manage settlement risk. The CER indicates that the ground improvement techniques to control settlement at the shafts and tunnels may involve jet-grouting, permeation grouting, compaction grouting, or other methods that a contractor may propose. These measures would have the effect of better supporting the soil above the borehole and would prevent unacceptable settlement between the borehole and the tunnel segments. Additionally, settlement monitoring points, the number and location of which would be identified during detailed design, would be established along the pipeline and tunnel routes during construction and the results reviewed regularly by a professional engineer. The monitoring therefore would provide early detection of excessive settlement such that corrective actions could be made before the integrity of the tunnel is jeopardized. Conforming with state and federal design standards would ensure that any subsidence that occurs under the conveyance facilities would not jeopardize their integrity. As described in the section 10.3.1, *Methods for Analysis* and in Appendix 3B, *Environmental Commitments*, such design codes and standards include the California Building Code and resource agency and professional engineering specifications, such as the American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE-7-05, 2005. Conforming with these codes and standards is an environmental commitment by DWR to ensure cut and fill slopes and embankments will be stable as the water conveyance features are operated. Conforming with the standards and guidelines may necessitate such measures as excavation and removal of weak soils and replacement with engineered fill using suitable, imported soil, construction on pilings driven into competent soil material, and construction of facilities on cast-in-place slabs. These measures would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. There would be no adverse effect.

***CEQA Conclusion***: Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

The integrity of the water conveyance facilities, including the canal, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected by expansive, corrosive, and compressible soils.

***Expansive Soils***

Soil expansion is a concern only at soil depths that are subject to seasonal changes in moisture content. The Alternative 1C alignment is underlain by soils with low to high shrink-swell potential (note areas of high linear extensibility in Figure 10-4), with the majority of the soils with high shrink-swell potential occurring where the intakes, pumping plants, pipelines, and sedimentation basin are proposed. Most of these areas are in Sacramento County (Dierssen and Egbert-Valpac association soils) and in Contra Costa County (Sacramento-Omni association soils). The remaining conveyance features generally would be located where the soils have low or moderate shrink-swell potential, although soil expansion-contraction is not expected to be a concern at these types of facilities.

Soils with a high shrink-swell potential (i.e., expansive soils) could damage facilities or cause the facilities to fail. For example, foundations and pavements could crack or shift and pipelines could rupture.

***Soils Corrosive to Concrete***

The near-surface (i.e., upper 5 feet) soil corrosivity to concrete is low or moderate along the Alternative 1C alignment in the parts of the alignment proposed for the intakes, pumping plants, siphons, bridges, and all other facilities except the tunnel, which will be below the depth of the near-surface soils. Data on soil corrosivity to concrete below approximately 5 feet (i.e., where pipelines, tunnels, and the deeper part of the tunnel shafts will be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Because soil corrosivity to concrete is high among the near-surface peat soils on the Delta, a high corrosivity is also expected to be present among the peat soils at depth at each element of the conveyance facility. Site-specific soil investigations will need to be conducted to determine this hazard. As described in 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify site-specific soil corrosivity hazards. The resulting geotechnical report, prepared by a California registered civil engineer or a California certified engineering geologist, would describe these hazards and recommend the measures that should be implemented to ensure that the facilities are constructed to withstand corrosion and to conform with applicable state and federal standards, such as the CBC.

Soils that are moderately and highly corrosive to concrete may cause the concrete to degrade, thereby threatening the integrity of the facility. Degradation of concrete may cause pipelines to leak or rupture and cause foundations to weaken.

***Soils Corrosive to Uncoated Steel***

Virtually all the near-surface soils along the Alternative 1C alignment have a high corrosivity to uncoated steel. The only the exception is an area of moderate corrosivity east of the Cache Slough ROA. Data on soil corrosivity to uncoated steel below approximately 5 feet (i.e., where pipelines, tunnels, and siphons would be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Site-specific soil investigations will need to be conducted to determine the level of hazard.

Soils that are moderately and highly corrosive to uncoated steel (including steel rebar embedded in concrete) may cause the concrete to degrade, threatening the integrity of these facilities.

***Compressible Soils***

Soils that are weakly consolidated or that have high organic matter content (such as peat or muck soils) present a risk to structures and infrastructure due to high compressibility and poor bearing capacity. Soils with high organic matter content tend to compress under load and may decrease in volume as organic matter is oxidized. The non-tunnel sections of the alignment are underlain by soils that have an organic matter content of less than 2–4%. Although the intakes would generally be located on mineral soils, according to the CER some of these soils are soft and have poor bearing capacity. Some of the pumping plants and pipelines also would be located on such soils. Based on liquid limits reported in county soil surveys, near-surface soils within the Alternative 1C alignment vary from low to medium compressibility.

Part of the Byron Tract Forebay embankment would be subject to this hazard.

Damage to or collapse of the intakes, pumping plants, transition structures, and control structures, could occur where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Subsidence- or differential sediment–induced damage or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply and producing underground cavities, depressions at the ground surface, and surface flooding. Facilities that have subsided would be subject to flooding and levees that have subsided would be subject to overtopping and consequent flooding on the land side of the levee.

The tunnel siphons or culvert siphons would be constructed at a depth below the peat (Figure 9-4); consequently, subsidence caused by organic matter decomposition below the tunnels/culverts is expected to be minimal. Surface and subsurface settlement may occur during tunnel construction; however, certain methods and practices may be utilized during tunnel/culvert construction to help reduce and manage settlement risk. Chapter 9, *Geology and Seismicity*, discusses the risks of settlement during tunnel construction and methods to reduce the amount of settlement (Impact GEO-2).

***NEPA Effects:*** Various facilities would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. The CBC requires measures such as soil replacement, lime treatment, and post-tensioned foundations to offset expansive soils, as well as such measures as using protective linings and coatings, dialectric isolation of dissimilar materials, and active cathodic protection systems to prevent corrosion of concrete and steel.

Potential adverse effects of compressible soils and soils subject to subsidence could be addressed by overexcavation and replacement with engineered fill or by installation of structural supports (e.g., pilings) to a depth below the peat where the soils have adequate load bearing strength, as required by the CBC and by USACE design standards. For example, the CER indicates that a deep foundation (pile) length of 65–70 feet below the founding level of the in-river intake may be required for adequate support of intake structures without excessive settlement. Geotechnical studies would be conducted at all the facilities to determine what specific measures should be implemented at each facility to reduce these soil hazards to levels consistent with the CBC. Liquid limit and soil organic matter content testing would be performed on soil samples collected during the site-specific field investigations to determine site-specific geotechnical properties. Settlement monitoring points should be established along the route during tunnel construction and results reviewed regularly by a professional engineer.

The engineer would develop final engineering solutions to any hazardous condition, consistent with the code and standards requirements of federal, state, and local oversight agencies. As described in section 10.3.1, *Methods for Analysis*, and in Appendix 3B, *Environmental Commitments*, such design codes, guidelines, and standards include the California Building Code and resource agency and professional engineering specifications, such as the DWR Interim Levee Design Criteria for Urban and Urbanizing Area State Federal Project Levees, and USACE Engineering and Design—Earthquake Design and Evaluation for Civil Works Projects.

By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion***: Many of the Alternative 1C facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, as well as soils that are moderately or highly subject to compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards (Appendix 3B, *Environmental Commitments*) is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 1C would use Operational Scenario A—the same scenario as Alternative 1A. Accordingly, the effects associated with river channel bank erosion/scour would be the same.

***NEPA Effects:*** As under Alternative 1A, the operational components would cause changes in the tidal flows in some Delta channels, specifically those that lead into the major habitat restoration areas (Suisun Marsh, Cache Slough, Yolo Bypass, and South Delta ROAs); however, detailed hydrodynamic (tidal) modeling would be conducted prior to any BDCP habitat restoration work in these ROA areas, and the changes in the tidal velocities in the major channels connecting to these restoration areas would be evaluated. If there is any indication that tidal velocities would be substantially increased, the restoration project design would be modified (such as by providing additional levee breaches or by requiring dredging in portions of the connecting channels) so that bed scour would not increase sufficiently to cause an erosion impact. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration.

The effect would not be adverse because there would be no net increase in flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion***: Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 1C would be the same as under Alternative 1A. These activities would include breaching, lowering, or removing levees; constructing setback levees and cross levees or berms; raising the land elevation by excavating relatively high areas to provide fill for subsided areas or by importing fill material; surface grading, deepening and/or widening tidal channels; excavating channels; excavation and grading to construct facilities, access roads, and other facilities; and other activities. These activities could cause adverse effects on soil erosion rates and cause a loss of topsoil through both water and wind erosion.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan.

Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that accelerated water and wind erosion associated with implementation of the conservation measures would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers), and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of conservation measures would be the same under Alternative 1C as under Alternative 1A. Consequently, topsoil loss associated with excavation (e.g., levee foundations, water control structures), overcovering (e.g., levees, embankments, application of fill material in subsided areas), and water inundation (e.g., aquatic habitat areas) would also be the same as under Alternative 1A.

***NEPA Effects:*** Implementation of habitat restoration activities at the ROAs would result in excavation, overcovering, or inundation of a minimum of 77,600 acres of topsoil. This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion:*** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 1C would be the same as under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement would also be the same as under Alternative 1A. Levee damage or failure could cause surface flooding in the vicinity.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. Such standards include the USACE Design and Construction of Levee and DWR Interim Levee Design Criteria for Urban and Urbanizing Area State-Federal Project Levees.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 1C would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), the impact would be less than significant. No mitigation is required.

### 10.3.3.5 Alternative 2A—Dual Conveyance with Pipeline/Tunnel and 5 Intakes (15,000 cfs; Operational Scenario B)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 2A would include the same physical/structural components as Alternative 1A, but could entail two different intake and intake pumping plant locations. These locations would be where soils have similar erosion hazards and would not substantially change the project effects on water soil erosion. The effects of Alternative 2A would, therefore, be the same as under Alternative 1A. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility under Alternative 2A could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a

SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2) would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the requisite SWPPP, and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs the effect would be less than significant. No mitigation is required.

### Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities

Alternative 2A would include the same physical/structural components as Alternative 1A, but could entail two different intake and intake pumping plant locations. Construction operations would be the same as under Alternative 1A, and therefore the effects on topsoil under Alternative 2A would be the same as Alternative 1A. See the discussion of Impact SOILS-2 under Alternative 1A.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants): overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

#### Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

#### Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

### Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities

Alternative 2A would include the same physical/structural components as Alternative 1A, but could entail two different intake and intake pumping plant locations. These locations would be where soils have similar subsidence hazards and, without adequate engineering, certain structures could be subject to appreciable subsidence resulting in potentially adverse effects. Damage to or collapse of the project facilities could occur if they are constructed in soils and sediments that are subject to subsidence or differential settlement.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). As discussed under Alternative 1A, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity. There would be no adverse effect.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities in conformance with state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

### Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils

Alternative 2A would include the same physical/structural components as Alternative 1A, but could entail two different intake and intake pumping plant locations. These different locations would be where the soils have similar properties of expansiveness, corrosivity, and compressibility. The effects under Alternative 2A would, however, be the same as 1A. See discussion of Impact SOILS-4 under Alternative 1A.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*:** Some of the project facilities would be constructed on soils that are subject to expansion, corrosion to concrete and uncoated steel, and compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 2A would have different operations from those under Alternative 1A. However, operations under Alternative 2A would have a potential effect on accelerated bank erosion similar to those under Alternative 1A. The effects under Alternative 2A would, therefore, be similar to those under Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** Detailed hydrodynamic (tidal) modeling would be conducted prior to any BDCP habitat restoration work in these ROA areas, and the changes in the tidal velocities in the major channels connecting to these restoration areas would be evaluated. If there is any indication that tidal velocities would be substantially increased, the restoration project design would be modified (such as by providing additional levee breaches or by requiring dredging in portions of the connecting channels) so that bed scour would not increase sufficiently to cause an erosion impact. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration.

The effect would not be adverse because there would be no net increase in river flow rates and, accordingly, no net increase in channel bank scour.

***CEQA Conclusion*:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 2A would be the same as under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers), and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 2A as under Alternative 1A. Topsoil effectively would be lost as a resource as a result of its excavation, overcovering, and water inundation over extensive areas of the Plan Area. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 2A as under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 2A would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

#### 10.3.3.6 Alternative 2B—Dual Conveyance with East Alignment and Five Intakes (15,000 cfs; Operational Scenario B)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 2B would include the same physical/structural components as Alternative 1B, but could entail two different intake and intake pumping plant locations. These locations would be where the soils have similar erosion hazards and would not substantially change the project effects on soil erosion. The effects under Alternative 2B would, therefore, be the same as under Alternative 1B. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility under Alternative 2B could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, because DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 2B would include the same physical/structural components as Alternative 1B, but could entail two different intake and intake pumping plant locations. Construction operations would be the same as those under Alternative 1B, and therefore the effects on topsoil under Alternative 2B would be the same as those under Alternative 1B. See the discussion of Impact SOILS-2 under Alternative 1B.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., canal alignment, borrow areas, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebay, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over large areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 2B would include the same physical/structural components as Alternative 1B, but could entail two different intake and intake pumping plant locations. Soils in these locations would have similar subsidence hazards and would not substantially change the project effects on subsidence. The effects under Alternative 2B would, therefore, be the same as those under Alternative 1B. See the discussion of Impact SOILS-3 under Alternative 1B.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2009a, 2010c). As discussed under Alternative 1B, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, this impact is considered less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 2B would include the same physical/structural components as Alternative 1B, but could entail two different intake and intake pumping plant locations. These different locations would be where the soils have similar properties of expansiveness, corrosivity, and compressibility. The effects under Alternative 2B would, therefore, be the same as those under Alternative 1B. See the discussion of Impact SOILS-4 under Alternative 1B.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*:** Many of the Alternative 2B facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 2B would have operations different from those under Alternative 1A. However, operations under Alternative 2B would have a potential effect on accelerated bank erosion similar to those under Alternative 1A. The effects under Alternative 2B would, therefore, be similar to those of Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** Detailed hydrodynamic (tidal) modeling would be conducted prior to any BDCP habitat restoration work in these ROA areas, and the changes in the tidal velocities in the major channels connecting to these restoration areas would be evaluated. If there is any indication that tidal velocities would be substantially increased, the restoration project design would be modified (such as by providing additional levee breaches or by requiring dredging in portions of the connecting channels) so that bed scour would not increase sufficiently to cause an erosion impact. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration. The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion***: Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 2B would be the same as under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that accelerated water and wind erosion associated with implementation of the conservation measures would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers), and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of conservation measures would be the same under Alternative 2B as under Alternative 1A. Consequently, topsoil loss associated with excavation, overcovering, and water inundation over extensive areas of the Plan Area would also be the same as under Alternative 1A. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion***: Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 2B as under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement would also be the same as Alternative 1A. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 2B would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West

Delta ROA possess soils with high corrosivity to concrete. Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils. See the discussion of Impact SOILS-9 under Alternative 1A.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), the impacts would be considered less than significant. No mitigation is required.

### 10.3.3.7 Alternative 2C—Dual Conveyance with West Alignment and Intakes W1–W5 (15,000 cfs; Operational Scenario B)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 2C would include the same physical/structural components as Alternative 1C. The effects under Alternative 2C would, therefore, be the same as under Alternative 1C. See the discussion of Impact SOILS-1 under Alternative 1C.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 2C could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2) would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, the impact would be less than significant. No mitigation is required.

### Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities

Alternative 2C would include the same physical/structural components as Alternative 1C. The effects under Alternative 2C would, therefore, be the same as those under Alternative 1C. See the discussion of Impact SOILS-2 under Alternative 1C.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., canal alignment, borrow areas, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebay, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over large areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

#### Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

#### Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

### Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities

Alternative 2C would include the same physical/structural components as Alternative 1C. The effects of Alternative 2C would, therefore, be the same as those under Alternative 1C. See the discussion of Impact SOILS-3 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil stabilization that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water

Resources 2009b, 2010d). As discussed under Alternative 1C, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion***: Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 2C would include the same physical/structural components as Alternative 1C. The effects of Alternative 2C would, therefore, be the same as those of Alternative 1C. See discussion of Impact SOILS-4 under Alternative 1C.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion***: Many of the Alternative 2C facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 2C would have operations different from those of Alternative 1A. However, operations under Alternative 2C would have a potential effect on accelerated bank erosion similar to those under Alternative 1A. The effects of Alternative 2C would, therefore, be similar to those of Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** Detailed hydrodynamic (tidal) modeling would be conducted prior to any BDCP habitat restoration work in these ROA areas, and the changes in the tidal velocities in the major channels connecting to these restoration areas would be evaluated. If there is any indication that tidal velocities would be substantially increased, the restoration project design would be modified (such as by providing additional levee breaches or by requiring dredging in portions of the connecting channels) so that bed scour would not increase sufficiently to cause an erosion impact. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration. The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion*****:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 2C would be the same as under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*****:** Vegetation removal and other soil disturbances associated with construction of conservation measures could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 2C as under Alternative 1A. Topsoil effectively would be lost as a resource as a result of its excavation, overcovering, and water inundation over extensive areas of the Plan Area. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 2C as under Alternative 1A. Injury or death could result from damage to or failure of the habitat levees where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility, potentially resulting in loss, injury, or death. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Construction of the proposed conservation measures under Alternative 2C would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

***NEPA Effects:*** Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility, potentially resulting in loss, injury, or death. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

## 10.3.3.8 Alternative 3—Dual Conveyance with Pipeline/Tunnel and Intakes 1 and 2 (6,000 cfs; Operational Scenario A)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 3 would include the same physical/structural components as Alternative 1A, except that it would entail three fewer intakes and three fewer pumping plants. These differences would result in slightly less accelerated erosion effects than Alternative 1A. The effects of Alternative 3 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 3 could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for*

*Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating preparation of a SWPPP and an erosion control plan. As a result of implementation of the requisite SWPPP and compliance with the General Permit, where applicable, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs and the effect would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 3 would include the same physical/structural components as Alternative 1A, except that it would entail three fewer intakes and three fewer pumping plants. These differences would result in slightly less effects on topsoil loss than Alternative 1A. The effects of Alternative 3 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-2 under Alternative 1A.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion***: Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less than significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 3 would include the same physical/structural components as Alternative 1A, but would entail three fewer intakes and three fewer pumping plants. These differences would result in slightly less effects related to subsidence than Alternative 1A. The effects of Alternative 3 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-3 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in Section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). As discussed under Alternative 1A, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility, potentially resulting in loss, injury, or death. However, because DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 3 would include the same physical/structural components as Alternative 1A, except that it would entail three fewer intakes and three fewer pumping plants. These differences would result in slightly less effects related to expansive, corrosive, and compressible soils than Alternative 1A. The effects of Alternative 3 would, however, be similar to those of Alternative 1A. See discussion of Impact SOILS-4 under Alternative 1A.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion***: Some of the project facilities would be constructed on soils that are subject to expansion, corrosion to concrete and uncoated steel, and compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility, potentially resulting in loss, injury, or death. However, DWR would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 3 would have operations similar to those of Alterative 1A, but of a lesser magnitude with respect to potential effects on accelerated bank erosion because the flow from the north Delta would be 6,000 cfs rather than 15,000 cfs. The effects of Alternative 3 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** Detailed hydrodynamic (tidal) modeling would be conducted prior to any BDCP habitat restoration work in these ROA areas, and the changes in the tidal velocities in the major channels connecting to these restoration areas would be evaluated. If there is any indication that tidal velocities would be substantially increased, the restoration project design would be modified (such as by providing additional levee breaches or by requiring dredging in portions of the connecting channels) so that bed scour would not increase sufficiently to cause an erosion impact. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration. The effect would not be adverse because there would be no net increase in river flow rates and, accordingly, no net increase in channel bank scour.

***CEQA Conclusion***: Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 3 would be the same as under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the

BDCP proponents and their contractors would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. the BDCP proponents and their contractors would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 3 as under Alternative 1A. Topsoil effectively would be lost as a resource as a result of its excavation, overcovering, and water inundation over extensive areas of the Plan Area. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 3 as under Alternative 1A. Injury or death could result from damage to or failure of the habitat levees where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility, potentially resulting in loss, injury, or death. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 3 would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility, potentially resulting in loss, injury, or death. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

#### 10.3.3.9 Alternative 4—Dual Conveyance with Modified Pipeline/Tunnel and Intakes 2, 3, and 5 (9,000 cfs; Operational Scenario H)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Construction of water conveyance facilities would involve vegetation removal, constructing building pads and levees, excavation, overexcavation for facility foundations, surface grading, trenching, road construction, spoil and RTM storage, soil stockpiling, and other activities over less than 7,500 acres during the course of constructing the facilities. Vegetation would be removed (via grubbing and clearing) and grading and other earthwork would be conducted at the three intakes, associated pumping plants, the intermediate forebay, the expanded Clifton Court Forebay, canal and gates between the expanded Clifton Court Forebay twin tunnel shafts and the approach canals to the Banks and Jones Pumping Plants, borrow areas, RTM and spoil storage areas, setback and transition levees, sedimentation basins, solids handling facilities, transition structures, surge shafts and towers, substations, transmission line footings, access roads, concrete batch plants, fuel stations, bridge abutments, barge unloading facilities, and laydown areas. Some of the work would be conducted in areas that are fallow at the time. Some of the earthwork activities may also result in steepening of slopes and soil compaction, particularly for the embankments constructed for the intermediate forebay and the expanded Clifton Court Forebay. These conditions tend to result in increased runoff rates, degradation of soil structure, and reduced soil infiltration capacity, all of which could cause accelerated erosion, resulting in loss of topsoil.

***Water Erosion***

The excavation, grading, and other soil disturbances described above that are conducted in gently sloping to level areas, such as the interiors of Delta islands, are expected to experience little or no accelerated water erosion because of the lack of runoff energy to entrain and transport soil particles. Any soil that is eroded within island interiors would tend to remain on the island, provided that existing or project levees are in place to serve as barriers from keeping the eroded soil (i.e., sediment) from entering receiving waters.

In contrast, graded and otherwise disturbed tops and sideslopes of existing and project levees and embankments are of greater concern for accelerated water erosion because of their steep gradients. Although soil eroded from the landside of levees would be deposited on the island interiors, soil eroded from the disturbed top and water side of levees could reach adjoining waterways. Soil eroded from natural slopes in upland environments could also reach receiving waters.

***Wind Erosion***

Most of the primary work areas that would involve extensive soil disturbance (i.e., staging areas, borrow areas, and intakes) within the Alternative 4 footprint are underlain by soils with a moderate or high susceptibility to wind erosion (Natural Resources Conservation Service 2010a) (Figure 10-6). Of the primary areas that would be disturbed, only a portion of the proposed borrow/spoil area west of Clifton Court Forebay generally has a low wind erosion hazard.

Construction activities (e.g., excavation, filling, grading, and vehicle traffic on unimproved roads) that could lead to accelerated wind erosion are generally the same as those for water erosion. These activities may result in vegetation removal and degradation of soil structure, both of which would make the soil much more subject to wind erosion. Removal of vegetation cover and grading increase exposure to wind at the surface and obliterate the binding effect of plant roots on soil aggregates. These effects make the soil particles much more subject to entrainment by wind. However, most of the areas that would be extensively disturbed by construction activities are already routinely disturbed by agricultural activities, such from disking and harrowing. These areas are the pumping plants, the intermediate forebay, most of the expanded Clifton Court Forebay, borrow areas, RTM and spoil storage areas, sedimentation basins, solids handling facilities, substations, access roads, concrete batch plants, and laydown areas. Consequently, with the exception of loading and transporting of soil material to storage areas, the disturbance that would result from constructing the conveyance facilities in many areas would not substantially depart from the existing condition, provided that the length of time that the soil is left exposed during the year does not change compared to that associated with agricultural operations. Because the SWPPPs prepared for the various components of the project will be required to prescribe ongoing best management practices to control wind erosion (such as temporary seeding), the amount of time that the soil would be exposed during construction should not significantly differ from the existing condition.

Unlike water erosion, the potential adverse effects of wind erosion are generally not dependent on slope gradient and location relative to levees or water. Without proper management, the wind-eroded soil particles can be transported great distances.

Excavation of soil from borrow areas and transport of soil material to spoil storage areas would potentially subject soils to wind erosion. It is likely that approximately 8 million cubic yards of peat soil material would be disposed of as spoils; this material would be especially susceptible to wind erosion while being loaded onto trucks, transported, unloaded, and distributed.

***NEPA Effects:*** These potential effects could be substantial because they could cause accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Many SWPPPs and erosion control plans are expected to be prepared for the project, with a given SWPPP and erosion control plan prepared for an individual component (e.g., one intake) or groups of component (e.g., all the intakes), depending on the manner in which the work is contracted. DWR would be responsible for preparing and implementing a SWPPP and erosion control plan as portions of the construction are contracted out and applications are made to the State Water Board for coverage under a General Permit.

The General Permit requires that SWPPPs be prepared by a QSD and implemented under the supervision of a QSP. As part of the procedure to gain coverage under the General Permit, the QSD would determine the Risk Level (1, 2, or 3) of the project site, which involves an evaluation of the site's *Sediment Risk* and *Receiving Water Risk*. *Sediment Risk* is based on the tons per acre per year of sediment that the site could generate in the absence of erosion and sediment control BMPs. *Receiving Water Risk* is an assessment of whether the project site is in a sediment-sensitive watershed, such as those designated by the State Water Board as being impaired for sediment under Clean Water Act section 303(d). Much of the northern half of the Plan Area is in a sediment-sensitive watershed; such areas would likely be Risk Level 2. The remaining areas, generally southwest of the San Joaquin River, are not in a sediment-sensitive watershed and therefore may potentially be classified as Risk Level 1.

The results of the Risk Level determination partly drive the contents of the SWPPP. In accordance with the General Permit, the SWPPP would describe site topographic, soil, and hydrologic characteristics; construction activities and a project construction schedule; construction materials to be used and other potential sources of pollutants at the project site; potential non-stormwater discharges (e.g., trench dewatering); erosion and sediment control, non-stormwater, and "housekeeping" BMPs to be implemented; a BMP implementation schedule; a site and BMP inspection schedule; and ongoing personnel training requirements. The SWPPPs would also specify the forms and records that must be uploaded to the State Water Board's online SMARTS, such as quarterly non-stormwater inspection and annual compliance reports. In those parts of the Plan Area that are determined to be Risk Level 2 or 3, water sampling for pH and turbidity would be required; the SWPPP would specify sampling locations and schedule, sample collection and analysis procedures, and recordkeeping and reporting protocols.

The QSD for the SWPPPs would prescribe BMPs that are tailored to site conditions and project component characteristics. Partly because the potential adverse effect on receiving waters depends on location of a work area relative to a waterway, the BMPs would be site-specific, such that those applied to level island-interior sites (e.g., RTM storage areas) would be different than those applied to water-side levee conditions (e.g., intakes).

All SWPPPs, irrespective of the site and project characteristics, are likely to contain the following BMPs.

- Preservation of existing vegetation.
- Perimeter control.
- Fiber roll and/or silt fence sediment barriers.
- Watering to control dust entrainment.
- Tracking control and "housekeeping" measures for equipment refueling and maintenance.
- Solid waste management.

Most sites would require temporary and permanent seeding and mulching. Sites that involve disturbance or construction of steep slopes may require installation of erosion control blankets or rock slope protection (e.g., setback levees at intakes). Turbidity curtains would be required for in-water work. Excavations that will require dewatering (such as for underground utilities and footings) will require proper disposal of the water, such as land application or filtration. Soil and material stockpiles (such as for borrow material) would require perimeter protection and covering or watering to control wind erosion. Concrete washout facilities would be established to prevent surface and ground water contamination. Such BMPs, if properly installed and maintained, would ensure compliance with the pH and turbidity level requirements defined by the General Permit.

The QSP would be responsible for day-to-day implementation of the SWPPP, including BMP inspections, maintenance, water quality sampling, and reporting to the State Water Board. In the event that the water quality sampling results indicate an exceedance of allowable pH and turbidity levels, the QSD would be required to modify the type and/or location of the BMPs by amending the SWPPP; such modifications would be uploaded by the QSD to SMARTS.

Accelerated water and wind erosion as a result of construction of the proposed water conveyance facility could occur under Alternative 4, but proper implementation of the requisite SWPPP and compliance with the General Permit (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2) would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating preparation of a SWPPP and an erosion control plan. As a result of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation during construction of Alternative 4 (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). Table 10-8 presents an itemization of the effects on soils caused by excavation, overcovering, and inundation, based on GIS analysis by facility type. Because of the nature of the earthwork to construct many of the facilities, more than one mechanism of topsoil loss may be involved at a given facility. For example, levee construction would require both excavation to prepare the subgrade and overcovering to construct the levee. The table shows that the greatest extent of topsoil loss would be associated with overcovering such as spoil/RTM storage areas, unless measures are undertaken to salvage the topsoil and reapply it on top of excavated borrow areas or on top of the spoils once they have been placed.

**Table 10-8. Topsoil Lost as a Result of Excavation, Overcovering, and Inundation Associated with the Proposed Water Conveyance Facility**

| Topsoil Loss Mechanism | Acreage Affected |
|---|---|
| Excavation (intakes, shafts, borrow/spoil areas) | 623 |
| Overcovering (spoil storage, reusable tunnel material storage) | 3,499 |
| Inundation (forebays, sedimentation basins, solids lagoons) | 974 |
| Total | 5,096 |

Note: Some mechanisms for topsoil loss entail more than one process of soil loss. For example, construction of setback levees would first require overexcavation for the levee foundation (i.e., excavation), then placement of fill material (i.e., overcovering).

DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would also be available to reduce the severity of this effect.

***CEQA Conclusion***: Construction of the water conveyance facilities would involve irreversible removal, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

A requirement of the General Permit is to minimize the extent of soil disturbance during construction. As described in Appendix 3B, *Environmental Commitments*, the SWPPPs prepared for BDCP construction activities will include a BMP that specifies the preservation of existing vegetation through installation of temporary construction barrier fencing to preclude unnecessary intrusion of heavy equipment into non-work areas. The BDCP proponents will ensure that the SWPPPs BMPs limiting ground disturbance are properly executed during construction by the contractors.

However, the BMP specifying preservation of existing vegetation may only limit the extent of surface area disturbed and not the area of excavated soils. Accordingly, soil-disturbing activities will be designed such that the area to be excavated, graded, or overcovered is the minimum necessary to achieve the purpose of the activity.

While minimizing the extent of soil disturbance will reduce the amount of topsoil lost, this will result in avoidance of this effect over only a small proportion of the total extent of the graded area that will be required to construct the habitat restoration areas, perhaps less than 5%. Consequently, a large extent of topsoil will be affected even after implementation of this mitigation measure.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Depending on the thickness of the topsoil[4] at a given construction or restoration site, up to 3 feet of the topsoil will be salvaged from construction work areas, stockpiled, and then applied over the surface of spoil and RTM storage sites and borrowed areas to the maximum extent practicable. Exceptions to this measure are areas smaller than 0.1 acre; areas of nonnative soil material, such as levees, where the near-surface soil does not consist of native topsoil; where the soil would be detrimental to plant growth; and any other areas identified by the soil scientist in evaluating topsoil characteristics (discussed below). This mitigation measure will complement and is related to activities recommended under Mitigation Measure AES-1c, in Chapter 17, *Aesthetics and Visual Resources* as well as to the environmental commitment for Disposal and Reuse of Spoils, RTM, and Dredged Material.

Topsoil excavated to install conveyance, natural gas, and sewer pipelines will be segregated from the subsoil excavated from open-cut trenches, stockpiled, and reapplied to the surface after the pipe has been installed.

The detailed design of the BDCP-related construction activities will incorporate an evaluation, based on review of soil survey maps supplemented by field investigations and prepared by a qualified soil scientist, that specifies the thickness of the topsoil that should be salvaged, and that

[4] For the purposes of this mitigation measure, *topsoil* is defined as the O, Oi, Oe, Oa, A, Ap, A1, A2, A3, AB, and AC horizons. Three feet of topsoil was selected because it corresponds to the primary root zone depth of most crops grown in the Delta. With the exception of the Histosols (i.e., peat and muck soils), most of the topsoils in the Plan Area are less than 3 feet thick.

identifies areas in which no topsoil should be salvaged. The soil scientist will use the exceptions listed above as the basis for identify areas in which no topsoil should be salvaged. The BDCP proponents will ensure that the evaluation is prepared by a qualified individual, that it adequately addresses all conveyance facilities, and that areas identified for topsoil salvage are incorporated into the project design and that the contractors execute the salvage operations.

A qualified soil scientist will also prepare topsoil stockpiling and handling plans for the individual conveyance and restoration components, establishing such guidelines as the maximum allowable thickness of soil stockpiles, temporary stockpile stabilization/revegetation measures, and procedures for topsoil handling during salvaging and reapplication. The maximum allowable stockpile thickness will depend on the amount of time that the stockpile needs to be in place and is expected to range from approximately three to 10 feet. The plans will also specify that, where practicable, the topsoil be salvaged, transported, and applied to its destination area in one operation (i.e., without stockpiling) to minimize degradation of soil structure and the increase in bulk density as a result of excessive handling. The stockpiling and handling plans will also specify maximum allowable stockpile sideslope gradients, seed mixes to control wind and water erosion, cover crop seed mixes to maintain soil organic matter and nutrient levels, and all other measures to avoid soil degradation and soil erosional losses caused by excavating, stockpiling, and transporting topsoil. The BDCP proponents will ensure that each plan is prepared by a qualified individual, that it adequately addresses all relevant activities and facilities, and that its specifications are properly executed during construction by the contractors.

Adherence to this measure will ensure that topsoil is appropriately salvaged, stockpiled, and reapplied. Nevertheless, adverse soil quality effects can also be associated with stockpiling. Such effects commonly include loss of soil carbon, degraded aggregate stability, reduced growth of the mycorrhizal fungi, and reduced nutrient cycling. Such effects may make the soil less productive after it is applied to its destination site, compared to its pre-salvage condition. Depending on the inherent soil characteristics, the manner in which it is handled and stockpiled, and the duration of its storage, the reapplied topsoil may recover quickly to its original condition or require many years to return to its pre-salvage physical, chemical, and biological condition (Strohmayer 1999; Vogelsang and Bever 2010).

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

The three intakes, associated pumping plants, and pipelines would be constructed in areas in which the near-surface soils have approximately 2–4% organic matter content. Compared to organic soils, these mineral soils would not be subject to appreciable subsidence caused by organic matter decomposition because there is relatively little organic matter available to decompose. The tunnels would be constructed at a depth below that of the peat (Figure 10-2); consequently, subsidence caused by organic matter decomposition at tunnel depth is expected to be minimal. Without adequate engineering, the forebay levees and interior could be subject to appreciable subsidence.

Damage to or collapse of the pipelines and tunnels could occur where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Subsidence- or differential sediment–induced damage or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply, and producing underground cavities, depressions at the ground surface, and surface flooding. Facilities that have subsided would be subject to flooding, and levees that have subsided would be subject to overtopping.

Damage to other conveyance facilities, such as intakes, pumping plants, transition structures, and control structures, caused by subsidence/settlement under the facilities and consequent damage to or failure of the facility could also occur. Facility damage or failure could cause a rapid release of water to the surrounding area, resulting in flooding, thereby endangering people in the vicinity.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). Such standards include the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, CBC, and USACE Design and Construction of Levees. The results of the investigations, which would be conducted by a California registered civil engineer or California certified engineering geologist, would be presented in geotechnical reports. The reports would contain recommended measures to prevent subsidence. The geotechnical report will prepared in accordance with state guidelines, in particular *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (California Geological Survey 2008).

Liquid limit (i.e., the moisture content at which a soil passes from a solid to a liquid state) and organic material content testing should be performed on soil samples collected during the site-specific field investigations to determine site-specific geotechnical properties. High organic matter content soils that are unsuitable for support of structures, roadways, and other facilities would be overexcavated and replaced with engineered fill, and the unsuitable soils disposed of offsite as spoil, as described in more detail below. Geotechnical evaluations would be conducted to identify soils materials that are suitable for engineering purposes.

Additional measures to address the potential adverse effects of organic soils could include construction of structural supports that extend below the depth of organic soils into underlying materials with suitable bearing strength. For example, the CER indicates that approximately 35 feet of soil would be excavated and a pile foundation supporting a common concrete mat would be required for the intake pumping plants. The piles would be 24-inches in diameter and concrete-filled, extending to 65 to 70 feet below the founding level of the plant. Piles extended to competent geologic beds beyond the weak soils would provide a solid foundation to support the pumping plants.

For the sedimentation basins, the CER indicates that most of the underlying soils would be excavated to a depth of 30 feet below grade and removed from the site and suitable soil material imported to the site to reestablish it to subgrade elevation. Removal of the weak soils and replacement with engineered fill using suitable soil material would provide a solid foundation for the sedimentation basins.

At the proposed expanded Clifton Court Forebay, the CER specifies that because most of the soils within the footprints of the forebay and the forebay embankments have high organic matter content, they would be excavated and removed from the site. Removal of the weak soils to reach competent soils would provide a solid foundation upon which to construct the forebay and its embankment.

At the spillway and stilling basin for the intermediate spillway, the CER indicates that unsuitable soils would be excavated to competent material and that the spillway would incorporate water-stopped contraction joints at intervals to accommodate a degree of settlement and subsoil deformation. Removal of the weak soils to reach competent soils and providing a joint system would provide a solid foundation for the spillway and stilling basin and enable the spillway to withstand settlement and deformation without jeopardizing its integrity.

Certain methods and practices may be utilized during tunnel construction to help reduce and manage settlement risk. The CER indicates that the ground improvement techniques to control settlement at the shafts and tunnels may involve jet-grouting, permeation grouting, compaction grouting, or other methods that a contractor may propose. Jet-grouting involves use of high-pressure, high-velocity jets to hydraulically erode, mix and partially replace the surrounding soil with a cementitious grout slurry, thereby creating a cemented zone of high strength and low permeability around of tunnel bore. Permeation grouting involves introduction of a low-viscosity grout (sodium silicate, microfine cement, acrylate or polyurethane) into the pores of the soil around the tunnel bore, which increases the strength and cohesion of granular soils. Compaction grouting involves injecting the soil surrounding the tunnel bore with a stiff, low slump grout under pressure, forming a cemented mass that increases soil bearing capacity. These measures would have the effect of better supporting the soil above the borehole and would prevent unacceptable settlement between the borehole and the tunnel segments. Additionally, settlement monitoring points, the number and location of which would be identified during detailed design, would be established along the pipeline and tunnel routes during construction and the results reviewed regularly by a professional engineer. The monitoring therefore would provide early detection of excessive settlement such that corrective actions could be made before the integrity of the tunnel is jeopardized.

This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). Additionally, conforming with state and federal design codes and standards, including the California Building Code and resource agency and professional engineering specifications, such as the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity. Conforming with these codes and standards is an environmental commitment by DWR to ensure cut and fill slopes and embankments will be stable as the water conveyance features are operated (Appendix 3B, *Environmental Commitments*). Conforming with the standards and guidelines may necessitate such measures as excavation and removal of weak soils and replacement with engineered fill using suitable, imported soil, construction on pilings driven into competent soil material, and construction of facilities on cast-in-place slabs. These measures would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, this impact is considered less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils.

***Expansive Soils***

The Alternative 4 alignment is underlain by soils with low to high shrink-swell potential (note areas of high linear extensibility in Figure 10-4). The majority of the soils with high shrink-swell potential are where the intakes, pumping plants, pipelines, sedimentation basin, one of the tunnels, and the northern third of the canal alignment are proposed. Most of these areas are in Sacramento County (Dierssen and Egbert-Valpac association soils). The remaining conveyance facilities would generally be located where the soils have low or moderate shrink-swell potential. Soil expansion-contraction is not expected to be a concern at these types of facilities.

Soils with a high shrink-swell potential (i.e., expansive soils) could damage facilities or cause the facilities to fail. For example, foundations and pavements could be cracked or shifted and pipelines could rupture.

Soil expansion is a concern only at soil depths that are subject to seasonal changes in moisture content. The Alternative 4 alignment is underlain by soils with low to high shrink-swell potential (note areas of high linear extensibility in Figure 10-4). The majority of the soils with high shrink-swell potential are where the intakes, pumping plants, pipelines, sedimentation basin, borrow/spoils sites, RTM areas, and the northern third of the canal alignment are proposed. Most of these areas are in Sacramento (Dierssen and Egbert-Valpac association soils). The remaining conveyance facilities are generally situated in areas of soils with low to moderate shrink-swell potential (see Figure 10-4). However, a borrow/spoils area, a temporary work area, three concrete batch plants and three fuel station locations along the Alternative 4 alignment, may contain soils with high to very high shrink-swell potential.

Soils with a high shrink-swell potential (i.e., expansive soils) could damage facilities or cause the facilities to fail. For example, foundations and pavements could be cracked or shifted and pipelines could rupture.

***Soils Corrosive to Concrete***

The near-surface (i.e., upper 5 feet) soil corrosivity to concrete ranges from low to high along the Alternative 4 alignment, although approximately half of the alignment is in areas of low to moderate corrosivity. The near-surface soils at the three intake and pumping plant facilities generally have a moderate corrosivity to concrete. The near-surface soils at the tunnel shafts have a low to high corrosivity to concrete. Data on soil corrosivity to concrete below a depth of approximately 5 feet (i.e., where pipelines, tunnels, and the deeper part of the tunnel shafts would be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Because soil corrosivity to concrete is high among the near-surface peat soils in the Delta, a high corrosivity is also expected to be present among the peat soils at depth. Site-specific soil investigations would need to be conducted to determine the corrosivity hazard at depth at each element of the conveyance facility. However, as described in 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*), geotechnical studies would be conducted at all facilities to identify site-specific soil corrosivity hazards. The resulting geotechnical report, prepared by a California registered civil engineer or a California certified engineering geologist, would describe these hazards and recommend the measures that should be implemented to ensure that the facilities are constructed to withstand corrosion and to conform with applicable state and federal standards, such as the CBC.

Soils that are moderately and highly corrosive to concrete may cause the concrete to degrade, thereby threatening the integrity of the facility. Degradation of concrete may cause pipelines and tunnels to leak or rupture and cause foundations to weaken.

***Soils Corrosive to Uncoated Steel***

The near-surface soils along the Alternative 4 alignment generally are highly corrosive to uncoated steel. Sections of the southern end of the alignment are moderately corrosive to uncoated steel. Data on soil corrosivity to uncoated steel below a depth of approximately 5 feet (i.e., where pipelines, tunnels, and the deeper part of the tunnel shafts would be constructed) are not available. However, given the variability in the composition of the soils and geologic units on and within which the conveyance facilities would be constructed, corrosivity hazards are likely to range from low to high. Site-specific soil investigations would need to be conducted to determine the corrosivity hazard at depth at each element of the conveyance facility.

Soils that are moderately and highly corrosive to uncoated steel (including steel rebar embedded in concrete) may cause the concrete to degrade, threatening the integrity of these facilities.

***Compressible Soils***

Soils that are weakly consolidated or that have high organic matter content (such as peat or muck soils) present a risk to structures and infrastructure because of high compressibility and poor bearing capacity. Soils with high organic matter content tend to compress under load and may decrease in volume as organic matter is oxidized. Much of the Alternative 4 tunnel alignment is underlain by near-surface soils that consist of peat. The soils in the area where the intakes and their associated structures would be located have a relatively low organic matter content. Based on liquid limits reported in county soil surveys, near-surface soils in the Alternative 4 alignment vary from low to medium compressibility.

Damage to or collapse of the pipelines, intakes, pumping plants, transition structures, and control structures could occur where these facilities are constructed in soils and sediments that are subject to subsidence and differential settlement. Because of compressible soils, such effects could occur at the five intakes, all the pumping plants, and the sedimentation basins, Subsidence- or differential sediment–induced damage or collapse of these facilities could cause a rapid release of water to the surrounding soil, causing an interruption in water supply and producing underground cavities, depressions at the ground surface, and surface flooding.

The tunnels would be constructed at a depth below the peat (Figure 9-4); therefore, subsidence caused by organic matter decomposition below the tunnels is expected to be minimal. Surface and subsurface settlement may occur during tunnel construction; however, certain methods and practices may be used during tunnel construction to help reduce and manage settlement risk. Chapter 9, *Geology and Seismicity*, discusses the risks of settlement during tunnel construction and methods to reduce the amount of settlement (Impact GEO-2).

Embankments that have subsided would be subject to overtopping, leading to flooding on the landside of the embankments. The embankment that would be subject to this hazard is the expanded Clifton Court Forebay.

***NEPA Effects:*** Various facilities would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. The CBC requires measures such as soil replacement, lime treatment, and post-tensioned foundations to offset expansive soils. The CBC requires such measures as using protective linings and coatings, dialectric (i.e., use of an electrical insulator polarized by an applied electric field) isolation of dissimilar materials, and active cathodic protection systems to prevent corrosion of concrete and steel.

Potential adverse effects of compressible soils and soils subject to subsidence could be addressed by overexcavation and replacement with engineered fill or by installation of structural supports (e.g., pilings) to a depth below the peat where the soils have adequate load bearing strength, as required by the CBC and by USACE design standards. Geotechnical studies would be conducted at all the facilities to determine the specific measures that should be implemented to reduce these soil hazards to levels consistent with the CBC. Liquid limit and soil organic matter content testing would be performed on collected soil samples during the site-specific field investigations to determine site-specific geotechnical properties. Settlement monitoring points should be established along the route during tunnel construction and results reviewed regularly by a professional engineer.

The engineer would develop final engineering solutions to any hazardous condition, consistent with the code and standards requirements of federal, state, and local oversight agencies. As described in section 10.3.1, *Methods for Analysis*, and in Appendix 3B, *Environmental Commitments*, such design codes, guidelines, and standards include the California Building Code and resource agency and professional engineering specifications, such as the DWR Interim Levee Design Criteria for Urban and Urbanizing Area State Federal Project Levees, and USACE Engineering and Design—Earthquake Design and Evaluation for Civil Works Projects.

By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*:** Many of the Alternative 4 facilities would be constructed on soils that are subject to expansion, moderately or highly corrosive to concrete and uncoated steel, as well as soils that are moderately or highly subject to compression under load. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. Surface soils that are moderately to highly expansive exist throughout the Alternative 4 alignment except in the central part of the Delta between approximately Staten Island and Bacon Island. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. However, DWR would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes. The CBC requires measures such as soil replacement, lime treatment, and post-tensioned foundations to offset expansive soils. The CBC requires such measures as using protective linings and coatings, dielectric (i.e., use of an electrical insulator polarized by an applied electric field) isolation of dissimilar materials, and active cathodic protection systems to prevent corrosion of concrete and steel in conformance with CBC requirements. Potential adverse effects of compressible soils and soils subject to subsidence could be addressed by overexcavation and replacement with engineered fill or by installation of structural supports (e.g., pilings) to a depth below the peat where the soils have adequate load bearing strength, as required by the CBC and by USACE design standards. Conforming with these codes and standards (Appendix 3B, *Environmental Commitments*) is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

River channel bank erosion/scour is a natural process. The rate of natural erosion can increase during high flows and as a result of wave effect on banks during high wind conditions.

In general, changes in river flow rates associated with BDCP operations would remain within the range that presently occurs. However, the operational components would cause changes in the tidal flows in some Delta channels, specifically those that lead into the major habitat restoration areas (Suisun Marsh, Cache Slough, Yolo Bypass, and South Delta ROAs). In major channels leading to the restoration areas, tidal flow velocities may increase; this may cause some localized accelerated erosion/scour. Alternative 4 would have effects of a lesser magnitude with respect to potential accelerated bank erosion because the flow from the north Delta would be 3,000 cfs rather than 15,000 cfs, as it is under some of the other BDCP alternatives.

However, the increased flows would be offset as part of the conservation measures by the dredging of these major channels, which would create a larger channel cross-section. The larger cross section would allow river flow rates to be similar to that of other high tidal flows in the region. Moreover, as presently occurs and as is typical with most naturally-functioning river channels, local erosion and deposition within the tidal habitats is expected as part of the restoration.

For most of the existing channels that would not be subject to tidal flow restoration, there would be no adverse effect to tidal flow volumes and velocities. The tidal prism would increase by 5–10%, but the intertidal (i.e., MHHW to MLLW) cross-sectional area also would be increased such that tidal flow velocities would be reduced by 10–20% compared to the existing condition. Consequently, no appreciable increase in scour is anticipated.

***NEPA Effects:*** The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion*:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Conservation measures would include breaching, lowering, or removing levees; constructing setback levees and cross levees or berms; raising the land elevation by excavating relatively high areas to provide fill for subsided areas or by importing fill material; surface grading; deepening and/or widening tidal channels; excavating new channels; modifying channel banks; and other activities. Moreover, excavation and grading to construct facilities, access roads, and other features would be necessary under the two conservation measures that are not associated with the ROAs (i.e., *CM18 Conservation Hatcheries* and *CM19 Urban Stormwater Treatment*). These activities could lead to accelerated soil erosion rates and consequent loss of topsoil.

***Water Erosion***

Activities associated with conservation measures that could lead to accelerated water erosion include clearing, grubbing, demolition, grading, and other similar disturbances. Such activities steepen slopes and compact soil. These activities tend to degrade soil structure, reduce soil infiltration capacity, and increase runoff rates, all of which could cause accelerated erosion and consequent loss of topsoil.

Gently sloping to level areas, such as where most of the restoration actions would occur, are expected to experience little or no accelerated water erosion because of the lack of runoff energy to entrain and transport soil particles.

Graded and otherwise disturbed tops and sideslopes of existing and project levees and embankments are of greater concern for accelerated water erosion because of their steep gradients. Soil eroded from the disturbed top and water side of levees could reach adjoining waterways (if present), unless erosion and sediment control measures are implemented.

***Wind Erosion***

Wind erosion potential varies widely among and within the ROAs (Figure 10-6). Areas within ROAs with high wind erodibility are largely correlated with the presence of organic soils. Wind erodibility in the Suisun Marsh, Cache Slough, and South Delta ROAs ranges from high to low. The Yolo Bypass ROA generally has a low wind erodibility hazard.

Conservation measures construction activities (e.g., excavation, filling, grading, and vehicle traffic on unimproved roads) that could lead to accelerated wind erosion are the same as those for water erosion. These activities may entail vegetation removal and degradation of soil structure, both of which would make the soil more subject to wind erosion. Removal of vegetation cover and grading increase soil exposure at the surface and obliterate the binding effect of plant roots on soil aggregates. These effects make the soil particles more subject to entrainment by wind.

Unlike water erosion, the potential for wind erosion is generally not dependent on slope gradient and location, nor is the potential affected by context relative to a receiving water. Without proper management, the wind-eroded soil particles can be transported great distances.

The transport of soil material from the conveyance facilities for use as fill in subsided areas within the ROAs could subject the soils to wind erosion, particularly if the fill material consists of peat. The peat would be especially susceptible to wind erosion while being loaded onto trucks, transported, unloaded, and distributed onto the restoration areas.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. The General Permit requires that SWPPPs be prepared by a QSD and requires SWPPPs be implemented under the supervision of a QSP. The QSD would select erosion and sediment control BMPs such as preservation of existing vegetation, seeding, mulching, fiber roll and silt fence barriers, erosion control blankets, watering to control dust entrainment, and other measures to comply with the practices and turbidity level requirements defined by the General Permit. Partly because the potential effect on receiving waters depends on location of a work area relative to a waterway, the BMPs would be site-specific. The QSP would be responsible for day-to-day implementation of the SWPPP, including BMP inspections, maintenance, water quality sampling, and reporting to the State Water Board. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., levee foundations, water control structures); overcovering (e.g., levees, embankments, application of fill material in subsided areas); and water inundation (e.g., aquatic habitat areas) over extensive areas of the Plan Area. Implementation of habitat restoration activities at the ROAs would result in excavation, overcovering, or inundation of a minimum of 77,600 acres of topsoil. This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less than significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

With the exception of the Suisun Marsh ROA, the ROAs are not in areas of high subsidence nor where the soils have a high organic matter content (Figures 10-2 and 10-9). Consequently, only the Suisun Marsh ROA would be expected to be subject to substantial subsidence. Based on its current elevation, the Suisun Marsh ROA has not experienced significant subsidence, despite the fact that the soils are organic and of considerable thickness (Figure 10-3).

***NEPA Effects:*** Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. Such standards include the USACE Design and Construction of Levee and DWR Interim Levee Design Criteria for Urban and Urbanizing Area State-Federal Project Levees.

For example, high organic matter content soils and all soils otherwise subject to subsidence that are unsuitable for supporting levees would be overexcavated and replaced with engineered fill, and the unsuitable soils disposed of offsite as spoils. Geotechnical evaluations will be conducted to identify soils materials that are suitable for engineering purposes. Liquid limit and organic content testing should be performed on collected soil samples during the site-specific field investigations to determine site-specific geotechnical properties.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*****:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

### Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11

#### *Expansive Soils*

The ROAs generally have soils with moderate or high shrink-swell potential. The ROAs with a significant extent of highly expansive soils are the Yolo Bypass and Cache Slough ROAs (Figure 10-4). None appears to have appreciable areas of soils with very high expansiveness.

Potential adverse effects of expansive soils are a concern only to structural facilities within the ROAs, such as water control structures. Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas.

#### *Corrosive Soils*

Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

#### *Compressible Soils*

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs. Areas of low to medium compressibility occur in the South Delta ROA. Silts and clays with a liquid limit less than 35% are considered to have low compressibility. Silts and clays with a liquid limit greater than 35% and less than 50% are considered to have medium compressibility and greater than 50% are considered highly compressible. Organic soils typically have high liquid limits (greater than 50%) and are therefore considered highly compressible.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

### 10.3.3.10 Alternative 5—Dual Conveyance with Pipeline/Tunnel and Intake 1 (3,000 cfs; Operational Scenario C)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 5 would include the same physical/structural components as Alternative 1A, except that it would entail four fewer intakes and four fewer pumping plants. These differences would result in slightly less accelerated erosion impacts than Alternative 1A. The impacts of Alternative 5 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 5 could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, and the effect would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

***NEPA Effects:*** Alternative 5 would include the same physical/structural components as Alternative 1A, except that it would entail four fewer intakes and four fewer pumping plants. These differences would result in slightly less effects on topsoil loss than Alternative 1A. The impacts of Alternative 5 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-2 under Alternative 1A.

Topsoil effectively would be lost as a resource as a result of its excavation (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants; and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 5 would include the same physical/structural components as Alternative 1A, except that it would entail four fewer intakes and four fewer pumping plants. These differences would result in slightly less effects related to subsidence than Alternative 1A. The impacts of Alternative 5 would, however, be similar to those under Alternative 1A. See the discussion of Impact SOILS-3 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). As discussed under Alternative 1A, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 5 would include the same physical/structural components as Alternative 1A, except it would entail four fewer intakes and four fewer pumping plants. These differences would result in slightly fewer effects related to expansive, corrosive, and compressible soils than under Alternative 1A. The effects under Alternative 5 would, however, be similar to those of Alternative 1A. See discussion of Impact SOILS-4 under Alternative 1A.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*****:** Some of the project facilities would be constructed on soils that are subject to expansion, corrosion to concrete and uncoated steel, and compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 5 would have operations similar to those under Alterative 1A, but of a lesser magnitude with respect to potential effects on accelerated bank erosion because the flow from the north Delta would be 3,000 cfs rather than 15,000 cfs. The effects under Alternative 5 would, however, be similar to those under Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** The effect of increased channel flow rates on channel bank scour would not be adverse because, as part of the conservation measures, major channels would be dredged to create a larger cross-section that would offset increased tidal velocities. The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion*****:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

### Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19

Implementation of conservation measures under Alternative 5 would be the same as under Alternative 1A, except that only 25,000 acres of tidal habitat would be restored. The effects under Alternative 5 on accelerated erosion would, therefore, be similar to those under Alternative 1A, but of a lesser magnitude. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the project BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

### Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11

Conservation measures would be the same under Alternative 5 as under Alternative 1A. Topsoil would be lost as a resource as a result of its excavation, overcovering, and water inundation—except that only 25,000 acres of tidal habitat would be restored. The impacts of Alternative 5 on the loss of topsoil would, therefore, be similar to those under Alternative 1A, but of a lesser magnitude. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

#### Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

### Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11

Conservation measures would be the same under Alternative 5 as under Alternative 1A, except that only 25,000 acres of tidal habitat would be restored. The impacts of Alternative 5 related to subsidence would, therefore, be similar to those under Alternative 1A, but of a lesser magnitude. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*****:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

### Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11

Implementation of the proposed conservation measures under Alternative 5 would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

## 10.3.3.11 Alternative 6A—Isolated Conveyance with Pipeline/Tunnel and Intakes 1–5 (15,000 cfs; Operational Scenario D)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6A would involve physical/structural components similar to Alternative 1A, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to that in Alternative 1A and would not substantially change the project effects related to accelerated erosion. The impacts of Alternative 6A would, therefore, be similar to those of Alternative 1A. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 6A could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs and the effect would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6A would involve physical/structural components similar to Alternative 1A, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would involve construction operations similar to those of Alternative 1A and would not substantially change the project effects relating to the loss of topsoil. The impacts of Alternative 6A would, therefore, be similar to those of Alternative 1A. See the discussion of Impact SOILS-2 under Alternative 1A.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6A would involve physical/structural components similar to Alternative 1A, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to those under Alternative 1A and would not substantially change the project effects relating to subsidence. The impacts of Alternative 6A would, therefore, be similar to those under Alternative 1A. See the discussion of Impact SOILS-3 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and

Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). As discussed under Alternative 1A, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion***: Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 6A would involve physical/structural components similar to Alternative 1A, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to Alternative 1A and would not substantially change the project effects related to soil expansion, corrosivity, and compression. The effects of Alternative 6A would, therefore, be similar to those under Alternative 1A. See the discussion of Impact SOILS-4 under Alternative 1A.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion***: Some of the project facilities would be constructed on soils that are subject to expansion, corrosion to concrete and uncoated steel, and compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

### Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations

Alternative 6A would have operations different than those under Alternative 1A. However, operations under Alternative 6A would have a potential effect on accelerated bank erosion similar to that of Alternative 1A. The effects under Alternative 6A would, therefore, be similar to those under Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** The effect of increased channel flow rates on channel bank scour would not be adverse because, as part of the conservation measures, major channels would be dredged to create a larger cross-section that would offset increased tidal velocities. The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion*:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

### Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19

Implementation of conservation measures under Alternative 6A would be the same as under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 6A as under Alternative 1A. Topsoil effectively would be lost as a resource as a result of its excavation, overcovering, and water inundation over extensive areas of the Plan Area. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 6A as under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 6A would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

### 10.3.3.12 Alternative 6B—Isolated Conveyance with East Alignment and Intakes 1–5 (15,000 cfs; Operational Scenario D)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6B would involve physical/structural components similar to Alternative 1B, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to those in Alternative 1B and would not substantially change the project effects relating to accelerated erosion. The impacts of Alternative 6B would, therefore, be similar to those of Alternative 1B. See the discussion of Impact SOILS-1 under Alternative 1B.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 6B could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. As a result of implementation of the SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs and the impact would be a less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6B would involve physical/structural components similar to Alternative 1B, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would involve construction operations similar to those under Alternative 1B and would not substantially change the project effects relating to the loss of topsoil. The impacts of Alternative 6B would, therefore, be similar to those under Alternative 1B. See the discussion of Impact SOILS-2 under Alternative 1B.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., canal alignment, borrow areas, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebay, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6B would involve physical/structural components similar to Alternative 1B, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to those under Alternative 1B and would not substantially change the project effects relating to subsidence. The impacts of Alternative 6B would, therefore, be similar to those under Alternative 1B. See the discussion of Impact SOILS-3 under Alternative 1B.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2009a, 2010c). As discussed under Alternative 1B, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 6B would involve physical/structural components similar to Alternative 1B, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to Alternative 1B and would not substantially change the project effects relating to soil expansion, corrosivity, and compression. The effects under Alternative 6B would, therefore, be similar to those under Alternative 1B. See discussion of Impact SOILS-4 under Alternative 1B.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*:** Many of the Alternative 6B facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 6B would have operations that are different than that of Alternative 1A. However, operations under Alternative 6B would have a potential effect on accelerated bank erosion similar to Alternative 1A. The effects of Alternative 6B would, therefore, be similar to those under Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** The effect of increased channel flow rates on channel bank scour would not be adverse because as part of the conservation measures, major channels would be dredged to create a larger cross-section that would offset increased tidal velocities. The effect would not be adverse because there would be no net increase in river flow rates and accordingly, no net increase in channel bank scour.

***CEQA Conclusion*:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 6B would be the same as under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the

BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion associated with construction of the conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities. Permit conditions would include erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards. As a result of implementation of Permit conditions, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the conservation measures would be the same under Alternative 6B as under Alternative 1A. Consequently, topsoil loss associated with excavation, overcovering, and water inundation over extensive areas of the Plan Area would also be the same as under Alternative 1A. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the restoration areas would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 6B as under Alternative 1A. See description and findings under Alternative 1A. Similarly, damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement would also be the same as Alternative 1A. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion*****:** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 6B would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*****:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

#### 10.3.3.13 Alternative 6C—Isolated Conveyance with West Alignment and Intakes W1–W5 (15,000 cfs; Operational Scenario D)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6C would involve physical/structural components similar to Alternative 1C, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to those in Alternative 1C and would not substantially change the project effects relating to accelerated erosion. The impacts of Alternative 6C would, therefore, be similar to those of Alternative 1C. See the discussion of Impact SOILS-1 under Alternative 1C.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 6C could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. Because of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs and the effect would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6C would involve physical/structural components similar to Alternative 1C, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would involve construction operations similar to those under Alternative 1C and would not substantially change the project effects relating to the loss of topsoil. The impacts of Alternative 6C would, therefore, be similar to those under Alternative 1C. See the discussion of Impact SOILS-2 under Alternative 1C.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants);and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion***: Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less than significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 6C would involve physical/structural components similar to Alternative 1C, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to those under Alternative 1C and would not substantially change the project effects relating to subsidence. The impacts of Alternative 6C would, therefore, be similar to those under Alternative 1C. See the discussion of Impact SOILS-3 under Alternative 1C.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil stabilization that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. As discussed under Alternative 1C, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion***: Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 6C would involve physical/structural components similar to Alternative 1C, but existing connections between the SWP and CVP south Delta export facilities would be severed. These connections would be in soils similar to Alternative 1C and would not substantially change the project effects related to soil expansion, corrosivity, and compression. The effects under Alternative 6C would, therefore, be similar to those under Alternative 1C. See the discussion if Impact SOILS-4 under Alternative 1C.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*:** Many of the Alternative 6C facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, the impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 6C would have operations that are different from those under Alternative 1A. However, operations under Alternative 6C would have a potential effect on accelerated bank erosion similar to Alternative 1A. The effects of Alternative 6C would, therefore, be similar to those under Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** The effect of increased channel flow rates on channel bank scour would not be adverse because, as part of the conservation measures, major channels would be dredged to create a larger cross-section that would offset increased tidal velocities. The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion*:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

### Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19

Implementation of conservation measures under Alternative 6C would be the same as under Alternative 1A. Implementation of the conservation activities would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of conservation measures could cause accelerated water and wind erosion of soil. However, because the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities, which will require implementation of erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards, the impact would be less than significant. No mitigation is required.

### Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11

Conservation measures would be the same under Alternative 6C as under Alternative 1A. Topsoil effectively would be lost as a resource as a result of its excavation, overcovering, and water inundation over extensive areas of the Plan Area. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

#### Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

#### Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures would be the same under Alternative 6C as under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion:*** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 6C would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with

USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion***: Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

## 10.3.3.14 Alternative 7—Dual Conveyance with Pipeline/Tunnel, Intakes 2, 3, and 5, and Enhanced Aquatic Conservation (9,000 cfs; Operational Scenario E)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 7 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less accelerated erosion effects on soils than under Alternative 1A. The effects of Alternative 7 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 7 could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating preparation of a SWPPP and an erosion control plan. Because of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs, the effect would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 7 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less effects on topsoil loss than Alternative 1A. The impacts of Alternative 7 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-2 under Alternative 1A.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 7 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less effects related to subsidence than under Alternative 1A. The impacts of Alternative 7 would, however, be similar to those under Alternative 1A. See the discussion of Impact SOILS-3 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). As discussed under Alternative 1A, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion***: Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 7 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less effects related to expansive, corrosive, and compressible soils than under Alternative 1A. The effects of Alternative 7 would, however, be similar to those under Alternative 1A. See the discussion if SOILS-4 under Alternative 1A.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion***: Some of the project facilities would be constructed on soils that are subject to expansion, corrosion to concrete and uncoated steel, and compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 7 would have operations similar to those under Alterative 1A, but of a lesser magnitude with respect to potential effects on accelerated bank erosion because the flow from the north Delta would be 9,000 cfs rather than 15,000 cfs. The effects of Alternative 7 would, however, be similar to those under Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** The effect of increased channel flow rates on channel bank scour would not be adverse because, as part of the conservation measures, major channels would be dredged to create a larger cross-section that would offset increased tidal velocities. The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion***: Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 7 would be the same as those under Alternative 1A, with the additional restoration of 20 linear miles of channel margin habitat and 10,000 acres of seasonally inundated floodplain habitat. The effects under Alternative 7 would, therefore, be similar to those under Alternative 1A but of a greater magnitude. See discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. These requirements would apply to the additional 20 linear miles of channel margin habitat and additional 10,000 acres of seasonally inundated floodplain habitat under Alternative 7. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, because the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities, which will require implementation of erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures under Alternative 7 would be the same as those under Alternative 1A, with the additional restoration of 20 linear miles of channel margin habitat and 10,000 acres of seasonally inundated floodplain habitat. The effects under Alternative 7 would, therefore, be similar to those under Alternative 1A but of a greater magnitude. See discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion***: Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures under Alternative 7 would be the same as those under Alternative 1A, except that an additional 20 linear miles of channel margin habitat and an additional 10,000 acres of seasonally inundated floodplain habitat would be restored. Under Alternative 7, the additional 10,000 acres of seasonally inundated floodplain habitat could lessen the rate of subsidence in the restored areas, assuming that the restoration areas are subject to subsidence. Therefore, there could be a beneficial effect on soils in these areas. Otherwise, Alternative 7 would be similar to those under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion***: Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. Under this alternative, the additional 10,000 acres of seasonally inundated floodplain habitat could lessen the rate of subsidence in the restored areas, assuming that the restoration areas are subject to subsidence. This could be a beneficial impact on soils in these areas. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 7 would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

## 10.3.3.15 Alternative 8—Dual Conveyance with Pipeline/Tunnel, Intakes 2, 3, and 5 and Increased Delta Outflow (9,000 cfs; Operational Scenario F)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 8 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less accelerated erosion effects than under Alternative 1A. The effects of Alternative 8 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 8 could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating preparation of a SWPPP and an erosion control plan. Because of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs and the effect would be less than significant. No mitigation is required.

### Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities

Alternative 8 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less effects on topsoil loss than Alternative 1A. The effects of Alternative 8 would, however, be similar to those of Alternative 1A. See the discussion of Impact SOILS-2 under Alternative 1A.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., forebays, borrow areas, tunnel shafts, levee foundations, intake facilities, pumping plants); overcovering (e.g., levees and embankments, spoil storage, pumping plants); and water inundation (e.g., forebays, sedimentation basins, and solids lagoons). DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

#### Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Alternative 8 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less effects related to subsidence than Alternative 1A. The effects of Alternative 8 would, however, be similar to those under Alternative 1A. See the discussion of Impact SOILS-3 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010a, 2010b). As discussed under Alternative 1A, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Alternative 8 would include the same physical/structural components as Alternative 1A, except that it would entail two fewer intakes and two fewer pumping plants. These differences would result in slightly less effects related to expansive, corrosive, and compressible soils than Alternative 1A. The impacts of Alternative 8 would, however, be similar to those under Alternative 1A. See the discussion of Impact SOILS-4 under Alternative 1A.

***NEPA Effects:*** The integrity of the water conveyance facilities, including tunnels, pipelines, intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*****:** Some of the project facilities would be constructed on soils that are subject to expansion, corrosion to concrete and uncoated steel, and compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because DWR would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

Alternative 8 would have operations similar to those under Alterative 1A, but of a lesser magnitude with respect to potential effects on accelerated bank erosion because the flow from the north Delta would be 9,000 cfs rather than 15,000 cfs. The effects of Alternative 8 would, however, be similar to those under Alternative 1A. See the discussion of Impact SOILS-5 under Alternative 1A.

***NEPA Effects:*** The effect of increased channel flow rates on channel bank scour would not be adverse because, as part of the conservation measures, major channels would be dredged to create a larger cross-section that would offset increased tidal velocities. The effect would not be adverse because there would be no net increase in river flow rates and therefore no net increase in channel bank scour.

***CEQA Conclusion*****:** Changes in operational flow regimes could cause increases in flow rates in channels and sloughs, potentially leading to increases in channel bank scour. However, where such changes are expected to occur (i.e., at the mouths of tidal marsh channels), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 8 would be similar to those under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and

Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion*****:** Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, because the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities, which will require implementation of erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures under Alternative 8 would be similar to those under Alternative 1A. Topsoil effectively would be lost as a resource as a result of its excavation, overcovering, and water inundation over extensive areas of the Plan Area. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*****:** Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures under Alternative 8 would be similar to those under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion***: Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 8 would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion***: Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

### 10.3.3.16 Alternative 9—Through Delta/Separate Corridors (15,000 cfs; Operational Scenario G)

**Impact SOILS-1: Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Construction of water conveyance facilities under Alternative 9 would involve an array of intakes, pumping plants, pipelines, culvert siphons, canals, borrow areas, enlargement of a channel, and other facilities. Some of the facilities would primarily involve in-water work and would have no bearing on soils. The locations of some of the Alternative 9 facilities would be different than those of the other alternatives. At the primary two such locations, operable barriers would be constructed; these would involve grading for the work/staging areas, which would result in accelerated erosion. However, the soil disturbance work would be subject to the same regulatory compliance requirements to control erosion as under Alternative 1A. The impacts of Alternative 9 would, therefore, be similar to but of much lesser extent than under Alternative 1A. See the discussion of Impact SOILS-1 under Alternative 1A.

***NEPA Effects:*** Construction of the proposed water conveyance facility could occur under Alternative 9 could cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, DWR would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP and compliance with the General Permit would ensure that there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs as a result of construction of the proposed water conveyance facility, and therefore, there would not be an adverse effect.

***CEQA Conclusion*:** Vegetation removal and other soil disturbances associated with construction of water conveyance facilities could cause accelerated water and wind erosion of soil. However, DWR would seek coverage under the state General Permit for Construction and Land Disturbance Activities (as discussed in Appendix 3B, *Environmental Commitments*, Commitment 3B.2), necessitating the preparation of a SWPPP and an erosion control plan. Because of implementation of the requisite SWPPP and compliance with the General Permit, there would not be substantial soil erosion resulting in daily site runoff turbidity in excess of 250 NTUs and the effect would be less than significant. No mitigation is required.

**Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities**

Construction of water conveyance facilities under Alternative 9 would involve an array of intakes, pumping plants, pipelines, culvert siphons, canals, borrow areas, enlargement of a channel, and other facilities. (Some of the facilities would primarily involve in-water work and would have no bearing on soils.) The locations of some of the Alternative 9 facilities would be different from those of the other alternatives. At the primary two such locations, operable barriers would be constructed; these would involve construction operations similar to those under Alternative 1A. The effects of Alternative 9 would, therefore, be similar but of much lesser extent than under Alternative 1A. See the discussion of Impact SOILS-2 under Alternative 1A.

***NEPA Effects:*** Topsoil effectively would be lost as a resource as a result of its excavation (e.g., borrow areas, intake facilities, pumping plants); overcovering (e.g., spoil storage, pumping plants); and water inundation. DWR has made an Environmental Commitment for Disposal Site Preparation which would require that a portion of the temporary sites selected for storage of spoils, RTM, and dredged material will be set aside for topsoil storage and the topsoil would be saved for reapplication to disturbed areas, thereby lessening the effect. However, this effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion*:** Construction of the water conveyance facilities would involve excavation, overcovering, and inundation of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil despite a commitment for Disposal Site Preparation. The impact on soils in the Plan Area would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on or in Soils Subject to Subsidence as a Result of Constructing the Proposed Water Conveyance Facilities**

Construction of water conveyance facilities under Alternative 9 would involve an array of intakes, pumping plants, pipelines, culvert siphons, canals, borrow areas, enlargement of a channel, and other facilities. (Some of the facilities would primarily involve in-water work and would have no bearing on soils.) The locations of some of the Alternative 9 facilities would be different from those of any of the other alternatives. At the primary two such locations, operable barriers would be constructed; this area would be subject to the same engineering design standards as under Alternative 1A. The impacts of Alternative 9 would, therefore, be similar but of much lesser extent than those under Alternative 1A. See the discussion of Impact SOILS-3 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all facilities to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards. These investigations would build upon the geotechnical data reports (California Department of Water Resources 2001a, 2010b, 2011) and the CERs (California Department of Water Resources 2010e). As discussed under Alternative 1A, conforming with state and federal design standards, including conduct of site-specific geotechnical evaluations, would ensure that appropriate design measures are incorporated into the project and any subsidence that takes place under the project facilities would not jeopardize their integrity.

***CEQA Conclusion*:** Some of the conveyance facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities according to state and federal design standards and guidelines (e.g., California Building Code, American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, ASCE-7-05, 2005). Conforming with these codes would reduce the potential hazard of subsidence or settlement to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Because these measures would reduce the potential hazard of subsidence or settlement to meet design standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils**

Construction of water conveyance facilities under Alternative 9 would involve an array of intakes, pumping plants, pipelines, culvert siphons, canals, borrow areas, enlargement of a channel, and other facilities. (Some of the facilities would primarily involve in-water work and would have no bearing on soils.) The locations of some of the Alternative 9 facilities would be different than under the other alternatives. At the primary two such locations, operable barriers would be constructed; this area would be subject to the same engineering design standards for expansive, corrosive, and compressible soils as under Alternative 1A. The impacts of Alternative 9 would, therefore, be similar to but of much lesser extent than under Alternative 1A. See the discussion of Impact SOILS-4 under Alternative 1A.

***NEPA Effects:*** The integrity of the water conveyance facilities, including intake facilities, pumping plants, access roads and utilities, and other features could be adversely affected because they would be located on expansive, corrosive, and compressible soils. However, all facility design and construction would be executed in conformance with the CBC, which specifies measures to mitigate effects of expansive soils, corrosive soils, and soils subject to compression and subsidence. By conforming with the CBC and other applicable design standards, potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. There would be no adverse effect.

***CEQA Conclusion*:** Some of the project facilities would be constructed on soils that are subject to expansion, corrosion to concrete and uncoated steel, and compression under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression/settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes (e.g., CBC and USACE design standards). Conforming with these codes and standards is an environmental commitment by DWR to ensure that potential adverse effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be offset. Therefore, this impact would be less than significant. No mitigation is required.

**Impact SOILS-5: Accelerated Bank Erosion from Increased Channel Flow Rates as a Result of Operations**

***NEPA Effects:*** Operations under Alternative 9 would be different than those under the other alternatives. All flows would be moved through existing, new, and expanded channels and canals by operating the south Delta pumps. The cross-sectional area of those existing channels that could be subject to increased scour (i.e., three reaches of Old River and Victoria Canal) would be expanded to increase their flow capacity; the banks of other channels and canals may be armored with riprap to protect them from scour. Therefore, changes in channel flow rates are expected to be within the range that presently occurs. The effects under Alternative 9 would, therefore, be the similar to the No Action Alternative.

***CEQA Conclusion***: Changes in flows through existing, new, and expanded channels and canals and other changes in operational flow regimes could lead to increases in channel bank scour. However, where such changes are expected to occur (e.g., three reaches of Old River and Victoria Canal), the project would also entail expansion of the channel cross-section to increase the tidal prism at these locations. The net effect would be to reduce the channel flow rates by 10–20% compared to Existing Conditions. Consequently, no appreciable increase in scour is anticipated. The impact would be less than significant. No mitigation is required.

**Impact SOILS-6: Accelerated Erosion Caused by Clearing, Grubbing, Grading, and Other Disturbances Associated with Implementation of Proposed Conservation Measures CM2–CM11, CM18 and CM19**

Implementation of conservation measures under Alternative 9 would be similar to those under Alternative 1A. Implementation of the conservation measures would involve ground disturbance and construction activities that could lead to accelerated soil erosion rates and consequent loss of topsoil. See the discussion of Impact SOILS-6 under Alternative 1A.

***NEPA Effects:*** These effects could potentially cause substantial accelerated erosion. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, the BDCP proponents would be required to obtain coverage under the General Permit for Construction and Land Disturbance Activities, necessitating the preparation of a SWPPP and an erosion control plan. Proper implementation of the requisite SWPPP, site-specific BMPs, and compliance with the General Permit would ensure that accelerated water and wind erosion as a result of implementing conservation measures would not be an adverse effect.

***CEQA Conclusion***: Vegetation removal and other soil disturbances associated with construction of restoration areas could cause accelerated water and wind erosion of soil. However, because the BDCP proponents would seek coverage under the state General Permit for Construction and Land Disturbance Activities, which will require implementation of erosion and sediment control BMPs (such as revegetation, runoff control, and sediment barriers) and compliance with water quality standards, the impact would be less than significant. No mitigation is required.

**Impact SOILS-7: Loss of Topsoil from Excavation, Overcovering, and Inundation Associated with Restoration Activities as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures under Alternative 9 would be similar to those under Alternative 1A. See description and findings under Alternative 1A. Topsoil effectively would be lost as a resource as a result of its excavation, overcovering, and water inundation over extensive areas of the Plan Area. See the discussion of Impact SOILS-7 under Alternative 1A.

***NEPA Effects:*** This effect would be adverse because it would result in a substantial loss of topsoil. Mitigation Measures SOILS-2a and SOILS-2b would be available to reduce the severity of this effect.

***CEQA Conclusion***: Implementation of the conservation measures would involve excavation, overcovering, and inundation (to create aquatic habitat areas) of topsoil over extensive areas, thereby resulting in a substantial loss of topsoil. The impact would be significant. Mitigation Measures SOILS-2a and SOILS-2b would minimize and compensate for these impacts to a degree, but not to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternative 1A.

**Impact SOILS-8: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage from Construction on Soils Subject to Subsidence as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Conservation measures under Alternative 9 would be similar to those under Alternative 1A. Damage to or failure of the habitat levees could occur where these are constructed in soils and sediments that are subject to subsidence and differential settlement. These soil conditions have the potential to exist in the Suisun Marsh ROA. Levee damage or failure could cause surface flooding in the vicinity. See the discussion of Impact SOILS-8 under Alternative 1A.

***NEPA Effects:*** This potential effect could be substantial because the facilities could be located on unstable soils that are subject to subsidence. However, as described in section 10.3.1, *Methods for Analysis*, and Appendix 3B, *Environmental Commitments*, geotechnical studies would be conducted at all the ROAs to identify the types of soil stabilization that should be implemented to ensure that levees, berms, and other features are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.

With construction of all levees, berms, and other conservation features designed and constructed to withstand subsidence and settlement and through conformance with applicable state and federal design standards, this effect would not be adverse.

***CEQA Conclusion:*** Some of the restoration area facilities would be constructed on soils that are subject to subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards and guidelines (which may involve, for example, replacement of the organic soil), the impact would be less than significant. No mitigation is required.

**Impact SOILS-9: Risk to Life and Property from Construction in Areas of Expansive, Corrosive, and Compressible Soils as a Result of Implementing the Proposed Conservation Measures CM2–CM11**

Implementation of the proposed conservation measures under Alternative 9 would be the same as under Alternative 1A. Accordingly, construction of conservation measures in areas of expansive, corrosive, or compressible soils would have the same effects as under Alternative 1A. See the discussion of Impact SOILS-9 under Alternative 1A.

Seasonal shrinking and swelling of moderately or highly expansive soils could damage water control structures or cause them to fail, resulting in a release of water from the structure and consequent flooding, which would cause unplanned inundation of aquatic habitat areas. Soils in all the ROAs possess high potential for corrosion of uncoated steel, and the Suisun ROA and portions of the West Delta ROA possess soils with high corrosivity to concrete.

Highly compressible soils are in the Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, and South Delta ROAs.

***NEPA Effects:*** The conservation measures could be located on expansive, corrosive, and compressible soils. However, ROA-specific environmental effect evaluations and geotechnical studies and testing would be completed prior to construction within the ROAs. The site-specific environmental evaluation would identify specific areas where engineering soil properties, including soil compressibility, may require special consideration during construction of specific features within ROAs. Conformity with USACE, CBC, and other design standards for construction on expansive, corrosive and/or compressible soils would prevent adverse effects of such soils.

***CEQA Conclusion*:** Some of the restoration component facilities would be constructed on soils that are subject to expansion, corrosive to concrete and uncoated steel, and compress under load. Expansive soils could cause foundations, underground utilities, and pavements to crack and fail. Corrosive soils could damage in-ground facilities or shorten their service life. Compression or settlement of soils after a facility is constructed could result in damage to or failure of the facility. However, because the BDCP proponents would be required to design and construct the facilities according to state and federal design standards, guidelines, and building codes (which may involve, for example, soil lime stabilization, cathodic protection of steel, and soil replacement), this impact would be considered less than significant. No mitigation is required.

## 10.3.4 Cumulative Analysis

The cumulative effects analysis for soils considers the effects of implementation of the alternatives in combination with the potential effects of other past, present, and reasonably foreseeable future projects and programs. Implementation of the alternatives and other local and regional projects as presented in Table 10-9, could contribute to regional impacts and hazards associated with soils.

**Table 10-9. Programs and Projects Considered in the Soils Cumulative Analysis**

| Agency | Program/Project | Status | Description of Program/Project | Effects on Soils |
|---|---|---|---|---|
| California Department of Water Resources | Mayberry Farms Subsidence Reversal and Carbon Sequestration Project | Completed October 2010 | Permanently flooded a 308-acre parcel of DWR owned land (Hunting Club leased) and restored 274 acres of palustrine emergent wetlands within Sherman Island to create permanent wetlands and to monitor waterfowl, water quality, and greenhouse gases. | Inundation of topsoil over approximately 274 acres. |
| DWR | Dutch Slough Tidal Marsh Restoration Project | Planning phase | Wetland and upland habitat restoration in area used for agriculture. | Inundation and overcovering (by dredge spoils) of topsoil over much of 1,166-acre site. |

| Agency | Program/Project | Status | Description of Program/Project | Effects on Soils |
|---|---|---|---|---|
| Freeport Regional Water Authority and Bureau of Reclamation | Freeport Regional Water Project | Completed late 2010 | Project included an intake/pumping plant near Freeport on the Sacramento River and a conveyance structure to transport water through Sacramento County to the Folsom South Canal. | Loss of approximately 50–70 acres of topsoil from excavation and overcovering. |
| Reclamation District 2093 | Liberty Island Conservation Bank | Completed 2011 | This project included restoration of inaccessible, flood prone land to wildlife habitat. | Inundation of approximately 186 acres of topsoil. |
| City of Stockton | Delta Water Supply Project (Phase 1) | Currently under construction | This project consists of a new intake structure and pumping station adjacent to the San Joaquin River; a water treatment plant along Lower Sacramento Road; and water pipelines along Eight Mile, Davis, and Lower Sacramento Roads. | Loss of 106 acres of topsoil from excavation and overcovering. |
| DWR | Delta Levees Flood Protection Program | Ongoing | Levee rehabilitation projects in the Delta. | Unknown but probably small acreage of overcovering of topsoil. |
| USACE | Suisun Channel (Slough) Operations and Maintenance Project | Ongoing | Maintenance dredging of an entrance channel in Suisun Bay, with turning basin. | Unknown acreage of overcovering of topsoil from dredge material disposal. |
| DWR | Central Valley Flood Management Planning Program | Planning phase | Among other management actions, involves levee raising and construction of new levees for flood control purposes. | Unknown acreage of overcovering of topsoil from levee earthwork. |
| Bureau of Reclamation | Delta-Mendota Canal/California Aqueduct Intertie | Completed in 2012. | The purpose of the intertie is to better coordinate water delivery operations between the California Aqueduct (state) and the Delta-Mendota Canal (federal) and to provide better pumping capacity for the Jones Pumping Plant. New project facilities include a pipeline and pumping plant. | Loss of approximately 2 acres of topsoil from excavation and overcovering. |
| California Department of Water Resources | North Delta Flood Control and Ecosystem Restoration Project | Final EIR certified and Notice of Determination filed in 2010. | Project is intended to improve flood management and provide ecosystem benefits in the North Delta area through actions such as construction of setback levees and configuration of flood bypass areas to create quality habitat for species of concern. These actions are focused on McCormack-Williamson Tract and Staten Island. The purpose of the Project is to implement flood control improvements in a manner that benefits aquatic and terrestrial habitats, species, and ecological processes. | Unknown but probably significant acreage of overcovering of topsoil from tidal inundation, excavation and overcovering. |

The analysis focuses on projects and programs within the Plan Area that involve substantial grading, excavation, overcovering, or inundation. The principal programs and projects considered in the analysis are listed in Table 10-9. These programs and projects have been drawn from a more substantial compilation of past, present, and reasonably foreseeable programs and projects included in Appendix 3D, *Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions*. This analysis considers projects that could affect soils and, where relevant, in the same timeframe as the project, resulting in a cumulative impact.

When the effects of the BDCP on soils are considered in connection with the potential effects of projects listed in Appendix 3D, the potential cumulative effects on soils could range from beneficial to potentially adverse. The specific programs, projects and policies with the potential to combine with effects of the alternatives to create a cumulatively considerable impact are identified below for each impact category. The potential for cumulative impacts on soils is described for construction of the conveyance facilities and CM2–CM22 within the Plan Area.

***No Action Alternative***

The No Action Alternative in a cumulative condition would result in accelerated water and wind erosion as a result of implementation of numerous levee stabilization, dredge spoil disposal, and habitat restoration projects. However, federal, state, and local regulations, codes, and permitting programs would continue to require implementation of measures to prevent nonagricultural accelerated erosion and sediment transport associated with construction. The loss of topsoil as a result of excavation, overcovering, and inundation would continue in the Delta and statewide as a result of numerous land development and habitat restoration projects. Such losses of topsoil are effectively irreversible. In contrast, the loss of topsoil associated with habitat restoration projects typically results from overcovering, such as placement of dredge spoils in subsided areas, and inundation, such as the introduction of seasonal or perennial water into nonwetland environments to establish seasonal wetlands or freshwater or tidal marshes. Land subsidence in the Delta and the Suisun Marsh would continue. However, the rate of subsidence in the future may be slower than the current rate as the organic soils become more consolidated over time. Several projects are now underway that would have a beneficial effect on subsidence, some with the explicit goal of controlling or reversing subsidence. These entail inundating areas underlain by peat soils to restore or create tidal marsh habitat. The inundation would tend to reduce biological oxidation rates of the soil organic matter. Depending on the vegetation type, soil organic matter would accumulate over time in the restored marsh habitats, thereby raising the elevation of the area. Although these projects would tend to control or reverse subsidence only on the islands at which they are implemented, they would benefit the Delta as a whole by promoting the "blocking" effect of Delta islands on sea water intrusion in the Delta. The subsidence control/reversal projects would therefore help to maintain water quality and water supply in the Delta in the event of widespread levee failure. Ongoing and reasonably foreseeable future projects in the Plan Area are likely to encounter expansive, corrosive, and compressible soils. However, federal and state design guidelines and building codes would continue to require that the facilities constructed as part of these projects incorporate design measures to avoid the adverse effects of such soils.

In total, the plans and programs would result in the loss of at least 3,618 acres of topsoil from overcovering or inundation. The cumulative effect of these plans, policies, and programs along with the No Action Alternative would be deemed to have direct and adverse effects on topsoil loss in the Delta. Subsidence would be controlled or reversed on approximately 308 acres, resulting in a beneficial effect.

The Delta and vicinity are within a highly active seismic area, with a generally high potential for major future earthquake events along nearby and/or regional faults, and with the probability for such events increasing over time. Based on the location, extent and non-engineered nature of many existing levee structures in the Delta area, the potential for significant damage to, or failure of, these structures during a major local seismic event is generally moderate to high. In the instance of a large seismic event, levees constructed on liquefiable foundations are expected to experience large deformations (in excess of 10 feet) under a moderate to large earthquake in the region. There would potentially be loss of topsoil from inundation. (See Appendix 3E, *Potential Seismic and Climate Change Risks to SWP/CVP Water Supplies* for more detailed discussion). While similar risks would occur under implementation of the action alternatives, these risks may be reduced by BDCP-related levee improvements along with those projects identified in Table 10-9.

**Impact SOILS-1: Cumulative Impact on Accelerated Erosion Caused by Vegetation Removal and Other Soil Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

Construction activities associated with Alternatives 1A through 9 could result in accelerated erosion due to vegetation removal and other activities which cause soil disturbance. Accelerated water and wind erosion are expected to affect soils as a result of past, present, and reasonably foreseeable future projects.

***NEPA Effects:*** Although the BDCP alternatives are not expected to result in adverse effects on soil erosion, when combined with projects listed above that may generate a cumulative effect on soil erosion. However, the projects listed above would be required to comply with state water quality regulations (i.e., the storm water General Permit for Construction and Land Disturbance Activities) to control accelerated erosion and movement of sediment to receiving waters. Though past, current, and future projects may result in accelerated soil erosion, the various regulatory frameworks that govern within the Plan Area are expected to mitigate any potential adverse effects on soil erosion. BDCP is also subject to the same regulations as the projects listed in Table 10-9 and would have no adverse effect on soil erosion. Consequently, there would not be a significant cumulative impact and the incremental contribution of the BDCP would not be cumulatively considerable.

***CEQA Conclusion:*** The soil erosion that could occur in association with construction of all project alternatives would be mitigated through compliance with state water quality regulations. Other past, present and probable future projects and programs in the Plan Area that are identified in Appendix 3D might also result in accelerated erosion, but would also have to comply with state water quality regulations. Therefore, the impact of accelerated soil erosion associated with the project alternatives would not combine with the soil erosion risks from other projects or programs to create a substantial cumulative effect. This cumulative impact is considered less than significant. No mitigation is required.

**Impact SOILS-2: Cumulative Impact on Topsoil from Construction Activities Occurring Within the Plan Area**

For Alternatives 1A–9, the construction of conveyance facilities under CM1 could result in adverse effects on soils involving the substantial loss of topsoil. These effects result from the following actions.

- Excavation, such as for construction of canal foundations, pumping plant subgrades, and water control structures.
- Overcovering, such as from paving and from application of dredge spoils onto native topsoil.

- Inundation, such as from introducing seasonal or perennial water to a non-wetland area for the purpose of marsh restoration.

For Alternatives 1A–9, the construction of restored habitats associated with CM2–CM22 could also result in similar construction-related effects.

Other projects that may involve construction and habitat restoration activities with similar effects on the loss of topsoil are provided in Table 10-9.

***NEPA Effects:*** Implementing the projects and programs listed in Table 10-9 in combination with any of Alternatives 1A–9 would result in a substantial loss of topsoil. It is assumed that environmental commitments and mitigation measures to reduce topsoil loss similar to those identified for the alternatives analyzed in this document would also be implemented for at least some of these projects. However, it is assumed that a net loss of topsoil would occur despite the use of mitigation measures by the BDCP or other projects. Consequently, these effects, in combination with the BDCP, could result in a cumulatively adverse effect on the loss of topsoil. Due to the magnitude of the project footprint of Alternatives 1A-9, the amount of topsoil lost from construction would be substantial in comparison to the other projects considered in this cumulative analysis. Therefore, the incremental contribution of any one of the BDCP alternatives would be cumulatively considerable.

***CEQA Conclusion****.* Alternatives 1A–9, would result in adverse impacts on soils involving a significant loss of topsoil. Construction of the past, present, and reasonably foreseeable future projects listed in Table 10-9, taken in conjunction with BDCP Alternatives 1A-9 would result in a cumulative impact on topsoil loss. This cumulative impact is considered significant. Due to the magnitude of the project footprint for Alternatives 1A–9, the contribution from any of these BDCP alternatives would be cumulatively considerable. The following mitigation measures could reduce this effect, but not to a less than significant level. Therefore this cumulative impact is considered significant and unavoidable.

**Mitigation Measure SOILS-2a: Minimize Extent of Excavation and Soil Disturbance**

Please see Mitigation Measure SOILS-2a under Impact SOILS-2 in the discussion of Alternative 1A.

**Mitigation Measure SOILS-2b: Salvage, Stockpile, and Replace Topsoil and Prepare a Topsoil Storage and Handling Plan**

Please see Mitigation Measure SOILS-2b under Impact SOILS-2 in the discussion of Alternatives 1A–8.

### Impact SOILS-4: Cumulative Impact on Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive, Corrosive, and Compressible Soils

It is expected that past, present, and reasonably foreseeable future projects would be required to comply with design requirements (i.e., CBC) to offset potential adverse effects of subsidence and compressible, expansive, and corrosive soils. Moreover, these soil hazards existing at other project sites would be local to those sites and would not act in combination with those of the BDCP project. While the incremental contribution of the BDCP could be cumulatively considerable due to the scale of the alternatives, conforming with CBC and other BMPs would reduce the effects of the BDCP to acceptable levels and they would not be adverse. Accordingly, there would not be a significant cumulative impact.

***NEPA Effects:*** Construction activities associated with Alternatives 1A through 9 could result in an adverse effect on life and property as a result of construction of project facilities on expansive, corrosive and/or compressible soils. However, the BDCP alternatives are not expected to result in adverse effects on life and property as a result of constructing project facilities on expansive, corrosive and/or compressible soils because the BDCP proponents would conform with design requirements (i.e., CBC) to offset potential adverse effects of subsidence and compressible, expansive, and corrosive soils.

Given the extent of expansive, corrosive and/or compressible soils in the Project Area, past, present, and reasonably foreseeable future projects will likely have some project features located on these types of soils. However, these projects would not increase the risks to structures and people at the specific locations affected by BDCP alternatives. Additionally, the projects listed in Table 10-9 would also be required to conform with the same design requirements BDCP would be building under.

Therefore, the risks of loss, injury, or death associated with the alternatives would not combine with the risks from other projects or programs to create a cumulatively adverse effect at any one locality in the Plan Area. There would be no cumulative adverse effect.

***CEQA Conclusion:*** The hazard from expansive, corrosive and/or compressible soils that would exist and the potential adverse effects that could occur in association with construction of all project alternatives would be restricted to the locations of the construction activities of these alternatives. Other past, present and probable future projects and programs in the Plan Area that are identified in Appendix 3D would not increase the risks of loss, injury or death at the specific locations affected by project alternatives. Therefore, the risks of loss, injury or death associated with the project alternatives would not combine with the soil risks from other projects or programs to create a substantial cumulative effect at any one locality in the Plan Area. This cumulative impact is considered less than significant. No mitigation is required.

# 10.4 References Cited

American Society of Civil Engineers. 2005. *Minimum Design Loads for Buildings and Other Structures.* SEI/ASCE 7-05. Reston, VA.

Buol, S. W., F. D. Hole, and R. J. McCracken. 1980. *Soil Genesis and Classification*. 2nd edition. Ames, IA: Iowa State University Press.

California Department of Water Resources. 2005. *California Water Plan Update 2005*. Accounting for Climate Change. Maurice Roos.

———. 2007. *Technical Memorandum: Delta Risk Management Strategy (DRMS) Phase 1*. Topical Area: Subsidence. Draft 2. Prepared by URS Corporation/Jack R. Benjamin & Associates, Inc.

———. 2009a. *Conceptual Engineering Report—Isolated Conveyance Facility—East Option*. November 18. Revision 1. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2009b. *Conceptual Engineering Report—Isolated Conveyance Facility—West Option*. November 25. Revision 0. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2010a. *Conceptual Engineering Report—Isolated Conveyance Facility—All Tunnel Option*. March 10. Revision 0. Design Document 500-05-05-100-03. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2010b. *Conceptual Engineering Report—Isolated Conveyance Facility—Pipeline/Tunnel Option (formerly All Tunnel Option)—Addendum*. October 22. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2010c. *Conceptual Engineering Report—Isolated Conveyance Facility—East Option—Addendum*. October 25. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2010d. *Conceptual Engineering Report—Isolated Conveyance Facility—West Option—Addendum*. October 25. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2010e. *Option Description Report—Separate Corridors Option, Volume 1—Report*. June. Revision 0. Document 600-05-05-100-001. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2010f. *Draft Phase I Geotechnical Investigation—Geotechnical Data Report—Isolated Conveyance Facility West*. July 12. Revision 0. Document 002-31-05-183-001. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2010g. *Draft Phase I Geotechnical Investigation—Geotechnical Data Report—Isolated Conveyance Facility East*. July 12. Revision 0. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

———. 2011. *Draft Phase II Geotechnical Investigation—Geotechnical Data Report—Pipeline/Tunnel Option*. August 22. Revision 1.1. Delta Habitat Conservation and Conveyance Program. Sacramento, CA.

California Geological Survey. 2008. *Guidelines for Evaluating and Mitigating Seismic Hazards in California.* Special Publication 117A. Sacramento, CA.

Contra Costa County. 2005. *Contra Costa County General Plan 2005–2020*. Contra Costa County Community Development Department, Martinez, CA. Available: <http://www.co.contra-costa.ca.us/depart/cd/current/advance/GeneralPlan.htm>. Accessed: February 11, 12, and 13, 2009; January 24, 2012.

———. 2010. *Contra Costa County General Plan and Zoning*. Available: <http://www.co.contra-costa.ca.us/index.aspx?NID=382>. Accessed: November 8, 2011.

County of Sacramento. 2011. *Sacramento County General Plan of 2005–2030*. Amended and adopted November 9. Community Planning and Development Department. Sacramento, CA. Available: <http://www.msa2.saccounty.net/planning/Pages/GeneralPlan.aspx>. Accessed: January 24, 2012.

County of Yolo. 2009. *Yolo County 2030 Countywide General Plan*. November 10. Woodland, California. Available: <http://www.yolocounty.org/Index.aspx?page=1965>. Accessed: January 17, 2012.

Delta Protection Commission. 1993. *Background Report on Delta Environment: A Report to the Delta Protection Commission.* Background Report #1. December. Walnut Grove, CA.

Deverel, S. J., and S. Rojstaczer. 1996. Subsidence of Agricultural Lands in the Sacramento-San Joaquin Delta, California: Role of Aqueous and Gaseous Carbon Fluxes. *Water Resources Research*. 32(8):2359–2367.

Galloway, D. L., D. R. Jones, and S. E. Ingebritsen. 2000. *Ground-Water Resources for the Future: Land Subsidence in the United States.* U.S. Geological Survey Fact Sheet 165-00. December. Prepared by U.S. Geological Survey, Reston, VA.

Ingebritsen, S. E., M. E. Ikehara, D. L. Galloway, and D. R. Jones. 2000. *Delta Subsidence in California, the Sinking Heart of the State*. U.S. Geological Survey Fact Sheet 005-00. April. Prepared by U.S. Geological Survey, Reston, VA.

Michigan State University, Institute for Water Resources. 2002. *RUSLE Online Soil Erosion Assessment Tool, K Factor*. Available: <http://www.iwr.msu.edu/rusle/kfactor.htm>. Accessed: April 24, 2010.

Mount, J., and R. Twiss. 2005. Subsidence, Sea Level Rise, and Seismicity in the Sacramento–San Joaquin Delta. *San Francisco Estuary and Watershed Science* 3(1):1–18.

Natural Resources Conservation Service. 1980. *National Handbook of Conservation Practices, Conservation Practice Standard, Subsurface Drain (606)-1*. April. Washington, DC.

———. 2004. Soil Survey Laboratory Methods Manual. Soil Survey Laboratory Investigations Report No. 42. Version 4.0. November. Available: < http://soils.usda.gov/technical/lmm/>. Accessed: June 12, 2013.

———. 2010a. *Soil Survey Geographic (SSURGO) Database for Alameda, Contra Costa, Sacramento, San Joaquin, Solano, Sutter, and Yolo Counties, California.* Available: <http://soildatamart.nrcs.usda.gov>. Accessed: April 10, 2010.

———. 2010b. *National Soil Survey Handbook, Title 430-VI*. Part 618. Available: <http://soils.usda.gov/technical/handbook/>. Accessed: April 24, 2010.

Real, C. R., and K. L. Knudsen. 2009. *Application of New Liquefaction Hazard Mapping Technique to the Sacramento-San Joaquin Delta Area*. Final Technical Report. Collaborative Research with URS Corporation, California Geological Survey, December 23.

Rojstaczer, S., R. Hamon, S. Deverel, and C. Massey. 1991. *Evaluation of Selected Data to Assess the Causes of Subsidence in the Sacramento-San Joaquin Delta, California*. U.S. Geological Survey Open-File Report 91-193. Sacramento, CA.

Rojstaczer, S., and S. J. Deverel. 1993. Time Dependence in Atmospheric Carbon Inputs from Drainage of Organic Soils. *Geophysical Research Letters* 20(1):1383–1386.

———. 1995. Land Subsidence in Drained Histosols and High Organic Mineral Soils of California. *Soil Science Society of America Journal* 59:1162–1167.

San Francisco Bay Conservation and Development Commission. 1976. *Suisun Marsh Protection Plan*. December. San Francisco, CA.

Soil Conservation Service. 1966. *Soil Survey of Alameda Area, California*. Washington, DC: U.S. Government Printing Office.

———. 1972. *Soil Survey of Yolo County, California*. Washington, DC: U.S. Government Printing Office.

———. 1977a. *Soil Survey of Contra Costa County, California* Washington, DC: U.S. Government Printing Office.

———. 1977b. *Soil Survey of Solano County, California*. Washington, DC: U.S. Government Printing Office.

———. 1988. *Soil Survey of Sutter County, California*. Washington, DC: U.S. Government Printing Office.

———. 1992. *Soil Survey of San Joaquin County, California*. Washington, DC: U.S. Government Printing Office.

———. 1993. *Soil Survey of Sacramento County, California*. Washington, DC: U.S. Government Printing Office.

Solano County. 2008. *Solano County General Plan*. December. Fairfield, CA. Available: <http://www.co.solano.ca.us/depts/rm/planning/general_plan.asp>. Accessed: February 11, 12, and 13, 2009; January 17, 2012.

Strohmayer, P. 1999. Soil Stockpiling for Reclamation and Restoration Activities after Mining and Construction. *Restoration and Reclamation Review*, Vol. 4, No. 7. St. Paul, MN: Department of Horticultural Sciences, University of Minnesota.

U.S. Department of Commerce, National Bureau of Standards. *Underground Corrosion.* Circular 579. Table 99:167.

Vogelsang, K. M. and J. D. Bever. 2010. *The Use of Native Plants and Mycorrhizal Fungi for Slope Stabilization and Topsoil Management.* February. Prepared for California Department of Transportation, Roadside Research and Innovation. Sacramento, CA.

Weir, W. W. 1950. Subsidence of Peat Lands of the Sacramento–San Joaquin Delta, California. *Hilgardia* 20(3):37–55.