3.1 Physical Characteristics

Sections 3.1.1 through 3.1.4 provide information on physical characteristics of the study area, including sediment quality; geology; hydrogeology/hydraulics, sedimentation, and sediment transport; and water quality.

3.1.1 Geology

This section discusses the existing soil characteristics, as well as the potential for seismicity and liquefaction in the study area. The geological region encompassing the study area is a structurally synclinal depression that was covered by various sedimentary deposits since the Jurassic Period (144 to 206 million years ago). From the Jurassic Period to the Miocene Epoch (5 to 24 million years ago), marine sediments consisting of siltstone, claystone, and sandstone were deposited into this syncline. Since the Miocene Epoch, layers of alluvium were deposited in the region by rivers, which carried eroded materials from the Klamath and Sierra Nevada Mountains. These later deposits typically consist of poorly sorted sands, silts, and clays. The total depth of deposits can be as great as 5 miles below ground surface; some of these alluvial layers are capped with layers of fine sediments or peat material that has formed in situ from the accumulation of organic matter (USACE 1980).

This section also describes the levees and berms along the channel and in dredged material placement sites. The text further discusses the importance of maintaining levee and berm integrity and stability to protect resources and infrastructure.

3.1.1.1 Baseline Conditions

Soil – The primary types of soil within the study area are organic, coarse-grained, and fine-grained. Organic soils, which are endemic to tidal wetlands that both flank and are located in portions of the SRDWSC, are dark-colored, peaty soils, formed from the decomposition of water-saturated layers of tules and other vegetation. Within the study area, peat soils are primarily dominant from Prospect Island (RM 22.0) south to Sherman Island (RM 5.0) (CCC 2007). This soil becomes saturated from seasonally high water tables, subsequently dries out, and is subject to aeolian erosion and subsidence. Subsidence is caused mainly by oxidation of peat, withdrawal of groundwater, and withdrawal of natural gas. Many of the islands in the Delta are subsiding, with rates reaching as much as 3.0 inches per year in some areas.

North of Prospect Island, naturally occurring coarse- and fine-grained soils are present as the organic layers become progressively shallower to the east across the Delta. The soils are primarily silts and clays with relatively low organic carbon content. They are usually poorly drained (unless artificially drained), and subject to regular flooding. Their color ranges from brown to dark gray and they contain a high concentration of salts. Mineral soils are also found in fill areas and in natural levee deposits throughout the study area.

Hydraulic, morphologic, and environmental information on the soils along the reaches of the SRDWSC is presented below. Although some generalities can be made concerning soil types, it should be emphasized that soil boring data are point-specific; therefore, the similarities and differences of soil types and conditions (such as compaction and cementation) could change among soil borings. These generalizations were initially presented in the SRDWSC Office Report (USACE 1990) and were adapted for use in this report.

From Reach 1 through most of Reach 3, soils consist of various mixtures of clay, silt, organic material (including foundation peats), and sand from the ground surface (mudline) to approximately 20 feet in depth. From depths of approximately 20 feet to 40 feet, soils are composed of clay and silt with intermixed fine to coarse sand and fine gravel at various intervals. Previous boring investigations also revealed the presence of very stiff clay layers at depths between 11 and 33 feet.

From the upper portion of Reach 3 through Reach 5, the presence of organic material becomes negligible and the primary soil is a mixture of clay, silt, and some sand from the ground surface (mudline) to approximately 20 feet in depth. From approximately 20 to 50 feet in depth, soils are composed of clay and silt with intermixed fine to coarse sand and fine gravel. Some borings in Reach 5 revealed the presence of hardpan layers and sandstone particles at various intervals from 3 to 30 feet in depth. This cemented material is believed to be the result of chemical and physical weathering due to climactic conditions. In samples tested using a Porter tube, a range of 24 to 128 blow counts (the number of strikes required to penetrate the Porter tube into these stiff layers) was recorded.

Seismicity and Liquefaction – The Great Valley fault zone is roughly perpendicular to the SRDWSC and bisects the channel in Reach 2. This fault zone is not a single fault, but an area that contains a series of deformations in the geologic formations. Although not exposed as a surface fracture, the Great Valley fault zone experiences seismic activity along a blind thrust plane. The last major earthquake that could have involved activity in this zone occurred in 1892 during the Vacaville-Winters earthquake (City of Rancho Cordova 2006). A probabilistic ground-motion map produced by the U.S. Geological Survey (USGS) in 2003 suggests that a 6.7-magnitude earthquake in the Great Valley fault zone would produce very strong to severe shaking and a peak ground acceleration in the channel area of approximately 18 to 65 units of force equal to the force exerted by gravity.

The Calaveras and Hayward fault zones are also in the study area. Any major seismic activity along these faults could be felt in the area. The National Earthquake Information Center has placed the Sacramento area (located near Reach 5) in seismic risk zone 3 (major risk and damage) and the Rio Vista area (located in Reach 2) in seismic risk zone 4 (major risk and damage and near major fault systems). The risk zone scale ranges from 0 (no risk and damage) to 4.

Liquefaction is a process in which saturated, loosely packed, coarse-grained soils transform from a solid to a liquid state. It is important to distinguish between susceptibility for liquefaction and the hazard for liquefaction. Susceptibility involves the presence of saturated sandy-to-silty Quaternary material, and hazard involves both the presence of such soils and the likelihood that they would be displaced during a particular seismic event so as to actually trigger liquefaction. Mapping from the USGS suggests that susceptibility increases from low to very high as the study area passes from Reaches 1 through 3 to the north into Reaches 4 and 5. However, the actual hazard of liquefaction would depend on the probability of a seismic event occurring at a particular fault or magnitude. A hazard map from the USGS suggests a 6.8-magnitude event along the Concord-Green Valley Fault (approximately 14 miles west of the study area) would result in a very low to moderately low risk for soil liquefaction in the study area.

Levees and Berms – A series of levees line the SRDWSC to protect adjacent agricultural lands. In addition, many of the dredged material placement sites contain berms or use the existing flood-control levees to contain the dredged material. Levees and berms are critical infrastructure to protect agricultural lands, water supplies, upland development, and other human uses such as roads and railways. The placement of dredged material into upland placement sites could have an impact on levee and berm stability. Levees could also be further stabilized by upland placement of dredged material.

3.1.1.2 Methodology for Determining Impacts

Information was compiled and collected to qualitatively evaluate the potential to create instability by placement of dredged material over or against existing levees and berms. Additionally, potential impacts were analyzed using professional expertise and judgment in evaluating the activities associated with the Proposed Project and -33 Feet MLLW Alternative as compared to the baseline and how these activities could interact and impact levee and berm stability.

3.1.1.3 Threshold of Significance

An alternative could have an impact on geological (abbreviated as G in the threshold below) conditions if it would cause the following:

- **G-1**: Destabilize or undermine levee or berm stability from placement of dredged material

3.1.1.4 Impacts and Mitigation Measures

G-1: Destabilize or undermine levee or berm stability from placement of dredged material

Future without Project Conditions (NEPA and CEQA Baseline)

Over the past 15 years, an average of approximately 190,000 cy of dredged material was placed in upland sites S1, S14, S16, S19, S20, and S31 per maintenance dredging event and did not result in destabilizing any levees or berms. No undermining or destabilization of existing berms is expected from future maintenance dredging operations. Therefore, no impacts to existing berms or levees are anticipated under Future without Project Conditions.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: None.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

As is described in Section 2, the height of existing berms would need to be raised or new berms would need to be constructed surrounding the proposed dredged material placement sites to accommodate the capacity needs for dredged material placement associated with the Proposed Project. Construction or raising of berms would be for the purposes of containing dredged sediment and not related to adjacent flood protection levees. Although an average of approximately 190,000 cy of dredged material was placed in upland sites per maintenance dredging event over the past 15 years and did not result in impacts to levee or berm stability in placement sites S1, S14, S16, S19, S20, and S31, the Proposed Project would add upland placement sites that have not been used for maintenance dredging in the past. The Proposed Project would also significantly increase the amount of material that would be placed at sites previously used for maintenance dredging material to potentially a little less than 10 million cy in ten placement sites, including those previously used for maintenance dredging.

The USACE is in the process of completing geotechnical investigations to ensure that levees and berms within the vicinity of the proposed dredged material placement sites would not be impacted from the placement of dredged material by the Proposed Project. To ensure berm stability, USACE would proportionately increase berm thickness with berm height. The USACE has determined proposed site-specific berm heights that would be structurally stable based on the geotechnical investigations completed to date while providing necessary capacity. Placement of pipes for conveyance of the dredged material slurry would also be specified to ensure that berm and levee stability is not compromised.

No existing levees or berms, including those to be constructed at new placement sites, are expected to be undermined or destabilized from dredging operations. Thus, as compared to the environmental baseline, no impacts to existing berms or levees are anticipated as a result of the Proposed Project.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: None.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

Under the -33 Feet MLLW Alternative, the placement of 5.2 million cy of material in seven dredged material placement sites (S1, S14, S16, S19, S20, S31, and 35) could impact the stability of the adjacent levees and containment berms. USACE studies and engineering design would be similar to those described for the Proposed Project. Impacts to levees and berms would be the same as those of the Proposed Project. Thus, as compared to the environmental baseline, no impacts to existing berms or levees are anticipated as a result of the -33 Feet MLLW Alternative.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: None.

3.1.1.4.1 Summary of Impacts and Mitigation Measures

Table 21 summarizes impact determinations, mitigation measures, and residual impacts after mitigation, if applicable, for each alternative for the impacts to geology described above.

Table 21
Summary of Impacts to Levee/Berm Stability and Mitigation Measures

Alternative	Impact	Mitigation	Residual Impact After Mitigation
G-1: Destabilize or undermine levee or berm stability from placement of dredged material			
Future without Project Conditions (NEPA and CEQA Baseline)	No impact	None	None
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	No impact	None	None
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	No impact	None	None

3.1.2 Hydrology, Hydraulics, Sedimentation, and Sediment Transport

This section provides baseline conditions and assesses potential impacts to hydrology, hydraulics, sedimentation, and sediment transport from the Proposed Project and alternatives, including potential effects on tidal hydraulics, currents, and circulation.

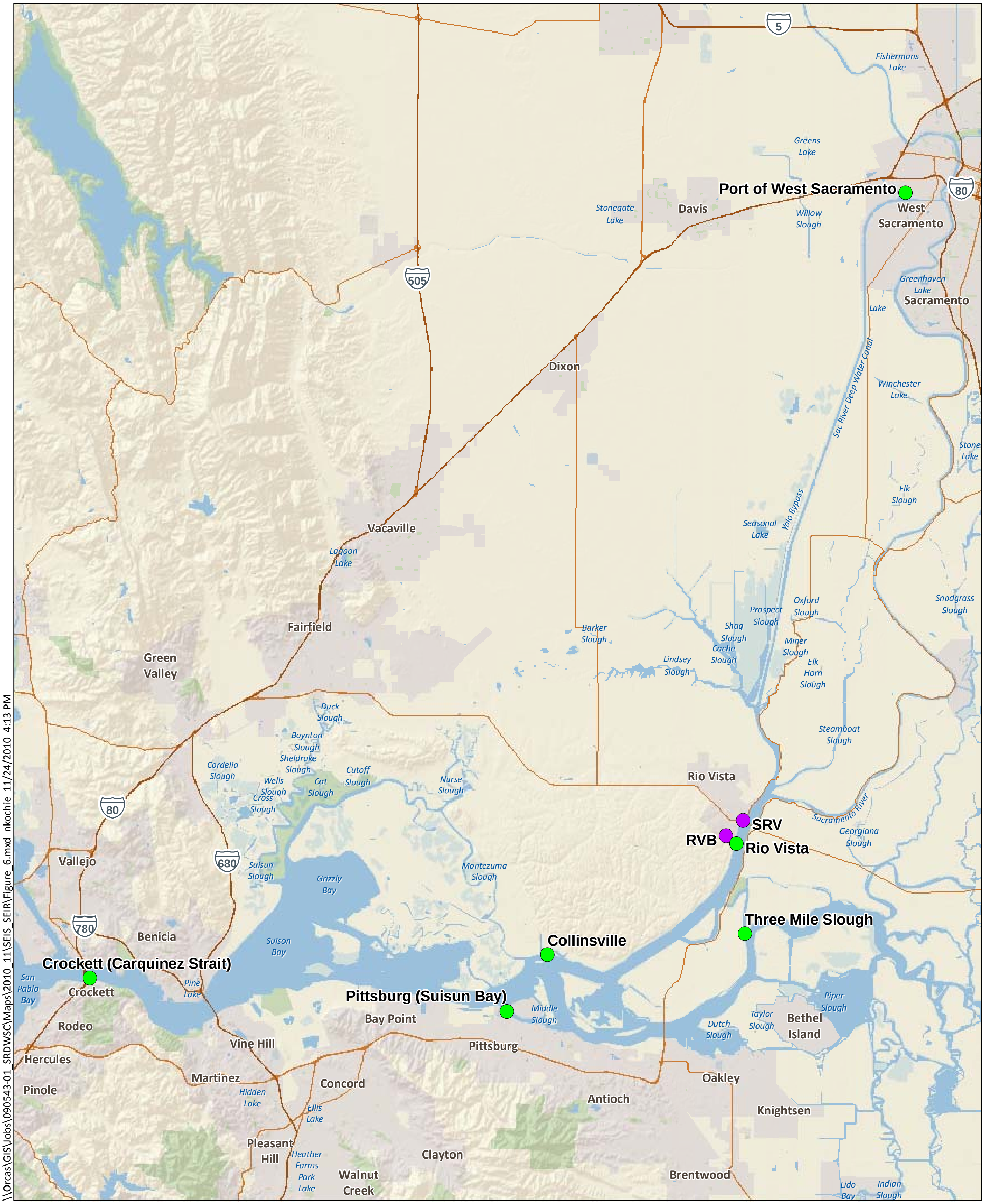
3.1.2.1 Baseline Conditions

3.1.2.1.1 Hydrodynamic Characteristics of the Delta

The Delta comprises a large network of river channels and smaller sloughs and is connected to the San Francisco Bay through Suisun Bay and the Carquinez Strait. At high tides, the direction of the flow is into the Delta and the river stage increases. At low tides, the river water flows out of the Delta and the river stage falls. As for much of the Delta, water flow rates, directions, and levels in both the man-made and natural portion of the SRDWSC are complex. Rising tides send flow up the Sacramento River and into the man-made portion of the SRDWSC, where flow is stopped by the locks between the Port and the Sacramento River. Flow from the Sacramento River also enters the SRDWSC at its lower end just north of Rio Vista in Reach 2 (and in trace quantities through the closed locks).

Most of the precipitation in the study area falls in winter and spring as rainfall; this enters the SRDWSC through surface runoff and from the various tributaries. Flow is also provided from tributaries such as Clarke Slough, Lindsey Slough, Cache Slough, and Miner Slough, and indirectly from the Sacramento River and its respective tributaries (Figure 6). The Yolo Bypass, which joins Prospect and Cache Sloughs, is also an important contributor to the SRDWSC flows. Inflows are controlled by upstream dams and reservoirs (such as the Red Bluff Diversion Dam and other features of the Central Valley Project), which restrain peak flows in the winter and spring for flood control and storage, and release water in the summer and fall to meet agricultural and municipal demands. Future flows would be determined in part by releases to accommodate endangered species of fish and other needs. There are also agricultural diversions and returns to various portions of the SRDWSC.

The William G. Stone Locks, located to the east of the Port's turning basin, limit the flow between the SRDWSC and the Sacramento River. Although they were permanently deauthorized in 2000, the locks leak, thus providing minor amounts of freshwater from the main-stem of the Sacramento River to the SRDWSC (Mayr 2006). Based on a study conducted from 2003 through 2005, flow rates just downstream of the locks range from 10 to 180 cubic feet per second, which is low in comparison to the remainder of the SRDWSC (Mayr 2006).



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Tidal Gauges

Water Quality Monitoring Stations

Figure 6
Tidal Gauges and Water Quality Monitoring Stations within the Study Area
SEIS/SEIR
Sacramento River Deep Water Ship Channel

3.1.2.1.2 Tidal Hydraulics

Astronomical tides in the study area are characterized as having a mixed semi-diurnal tidal cycle, which means that the area experiences two high and two low tides of unequal height each lunar day. Table 22 presents the mean and spring tidal (most extreme) ranges at tidal gauge locations both west of and within the study area (Figure 6). Spatial variation along the channel may be due to the geographic setting of the study area that decreases the tidal ranges at one downstream location, but amplifies it at an upstream location.

Table 22
Tidal Ranges along the SRDWSC

Station Location	Mean Tidal Range (feet)	Spring Tidal Range (feet)
Crockett (Carquinez Strait)	4.40	5.94
Pittsburg (Suisun Bay)	3.02	4.14
Collinsville	2.89	3.96
Three Mile Slough	3.01	4.05
Rio Vista	3.25	4.31
Port of West Sacramento	4.73[1]	-

Notes:
1 Based on the predicted tides of 2009
Source: National Oceanic and Atmospheric Administration 2009

As ocean tidal waves propagate into the SRDWSC, the tidal ranges of Pittsburg and Collinsville stations decrease, primary as a result of channel bottom friction and other conditions, such as the man-made flood protection devices or natural barriers that inhibit the exchange of water between the river channels and the ocean. While the tidal ranges increase between the Three Mile Slough, Rio Vista, and Port stations, this is mainly due to the amplification effect of resonance in the channel basin bounded by the locks near the Port. The measured tidal ranges at the upstream reach can be as high as 6 feet (which is higher than the downstream locations at the cities of Collinsville and Pittsburg in Suisun Bay) and as low as 2 feet, based on the tide measurement from July 2008 to January 2009 (Noble 2010).

3.1.2.1.3 Currents and Circulation

The flow direction generally follows tidal motion to move upstream during flood tides and downstream during ebb tides, particularly in the lower reaches of the study area. However, in the upstream reaches, the flow pattern and velocity may be altered because inflows play a more significant role in defining the flow field (speed and direction of flow) in the SRDWSC, even with the extremely limited leakage inflows from the locks. Two monitoring stations that measure flow velocities, among other parameters, within the SRDWSC are RYI (Reach 3) and SRV (Reach 2; Figure 6). As described in the complete *Hydraulics and Hydrology*

Report, included as Appendix J, flow velocities of three winter months (December 2006, January 2008, and January 2009) and three summer months (June 2006, August 2007, and August 2008) were compared at the two monitoring stations (Appendix J). The measured peak flow velocities remained relatively constant at approximately 2 to 3 feet per second, with no significant seasonal variation in magnitude.

As the precipitation-induced channel inflows increase in the winter months, flows in the upstream portion of the study area can become one-directional (i.e., toward downstream). During this period, the tidal influence is minimal and overshadowed by the precipitation-induced channel inflows. During the summer months, the flow pattern in the upstream portion of the study area most nearly corresponds to the flood/ebb tidal cycles as opposed to the channel inflows, which diminish during the summer months. Flow velocities in the upstream reaches of the study area appear to be considerably slower than in the downstream reaches. Summer and winter discharge rates in the lower reaches of the study area are significantly higher than discharge rates in the man-made portion of the SRDWSC. It appears that there is no significant seasonal variation in discharge rates at the monitors SRV and RYI. Discharge rates in the man-made portion of the channel can vary in response to the magnitude of precipitation-induced water inflows from the drainage basins, particularly in winter months.

The combined influence of upstream freshwater inflows and tide-driven ocean water flows, known as river stages, was also measured along the SRDWSC. Data indicate that river stages are higher upstream based on an identical vertical datum and that river stages in the upstream region are significantly influenced by localized inflows during wet winter months. During the summer months, river stages exhibit cyclic fluctuation due to the insignificant volume of the freshwater inflows compared to the tidal-induced water volume. Additional information on river stages can be found in Appendix J.

3.1.2.1.4 Sedimentation

Periodic maintenance dredging of sediment within the SRDWSC is required to maintain navigation depths. The temporal fluctuation of the dredging quantity depends primarily on the hydrologic conditions within the Sacramento River watershed. However, the sediment yield has continuously decreased in recent years. Many factors contribute to the decreasing sediment yield; these factors may include depletion of erodible sediment from hydraulic mining, sediment impoundment by reservoirs, and riverbank protection.

Table 23 presents the historical dredging record within the SRDWSC on a yearly basis. Sedimentation occurs primarily between RMs 3.5 and 14.0 as well as from RMs 33.0 to 42.0. The channel condition in the man-made reach from RMs 14.0 to 33.0 appears to be relatively stable. The annual average quantity of maintenance dredged material over 43 years (1966 to 2008) is approximately 333,400 cubic yards (cy). However, the average dredging volume is approximately 190,000 cy per year since 2000, which is indicative of a long-term reduction trend of sediment yield in the lower reaches of the Sacramento River watershed.

Table 23
Maintenance Dredging Record in SRDWSC

Year	Volume (cy)	Year	Volume (cy)	Year	Volume (cy)	Year	Volume (cy)
1966	2,220,000	1977	-	1988	-	1999	220,000
1967	183,800	1978	270,500	1989	-	2000	525,000
1968	-	1979	-	1990	-	2001	286,400
1969	890,600	1980	-	1991	-	2002	35,300
1970	-	1981	1,372,000	1992	-	2003	93,100
1971	712,000	1982	1,212,000	1993	238,000	2004	-
1972	146,000	1983	-	1994	-	2005	351,000
1973	-	1984	1,432,000	1995	103,800	2006	240,000
1974	1,065,300	1985	544,000	1996	-	2007	38,870*
1975	314,300	1986	940,000	1997	815,600	2008	125,000
1976	-	1987	-	1998	-		

Note: * Dredging activity was suspended in 2007 due to encountering delta smelt.

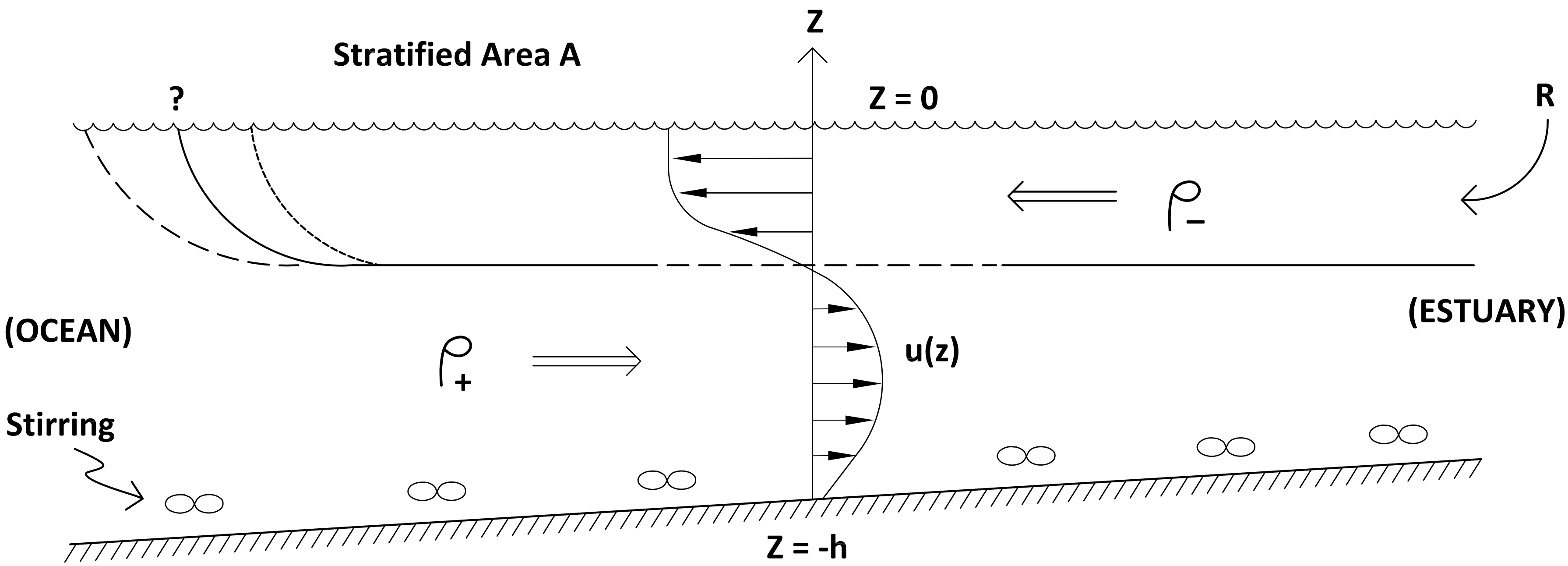
3.1.2.1.5 Groundwater

Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of rock formations. An unconsolidated deposit that can yield a usable quantity of water is called an aquifer. The Sacramento River hydrologic region is heavily groundwater reliant. Groundwater provides about 30% of the water supply for urban and agricultural uses in the region, and develops in both the alluvial basins and the hard rock uplands and mountains. The Sacramento Valley is geologically a large trough filled with sediments having variable permeability; as a result, well yields range from 100 to several thousand gallons per minute. Groundwater extraction for agriculture use primarily supplements surface waters that in-flow from the watershed.

Groundwater wells used for potable water in the study area are on the order of hundreds of feet deep due to the thickness of the overburden. Although seawater intrusion in shallow aquifers can be a problem in the coastal groundwater basins, no observations regarding saltwater intrusion into the deep aquifers along the Sacramento River are documented.

3.1.2.1.6 Saltwater Intrusion

The extent to which seawater penetrates the Delta is a long-standing water management concern, particularly during summers and years of low precipitation. About 20 million people depend on water flowing into the Delta for their water supply. In addition, some aquatic species of the upper estuary are adversely affected by high salinity. Water agencies, such as the California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR), which supply water for municipal and agricultural uses, are required to ensure the exported water for the Delta is below a certain salinity concentration. Salinity as it relates to water quality is further described in Section 3.1.3.1.4. Saltwater intrusion is caused by flow advection, dispersion, diffusion, and gravitational circulation. Freshwater is less dense than seawater and as a result, freshwater flows on top of seawater during the interaction of these two waters. This stratification and exchange of flows causes a shear stress to occur, thereby creating a mixing action that enhances salt intrusion (Figure 7). The extent of saltwater intrusion can be measured in the X2 distance. The X2 is defined as the distance from the Golden Gate Bridge to the tidally averaged near-bed 2-practical salinity unit (psu) isohaline (constant salinity). The X2 is not constant and shifts based on a number of factors, including tidal motion, freshwater inflows, and runoff. X2 distances in the study area tend to be larger during relatively increased freshwater flows that occur in the late fall and early winter months before the actual high flow occurs, as compared to the low flow summer season.



Schematic of a stratified region maintained by freshwater input in competition with bottom stirring. The estuarine circulation u(z) moves light water offshore at the surface and heavier water onshore in the lower layers thus increasing stratification.

SOURCE: MacWilliams and Gross 2010 (Appendix K).

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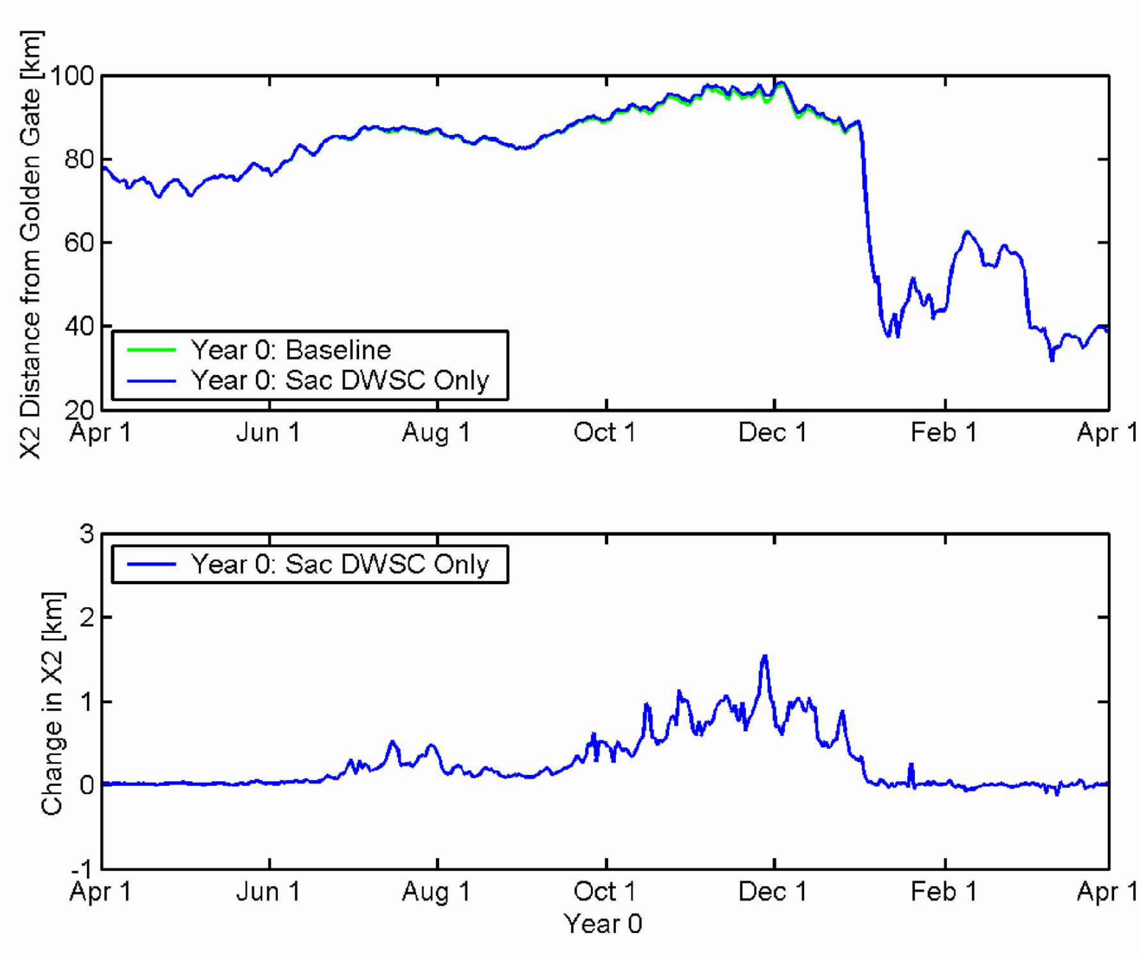
Figure 7
Salt Water Intrusion Shear Stress Mechanism
SEIS/SEIR
Sacramento River Deep Water Ship Channel

The UnTRIM three-dimensional hydrodynamic model for the San Francisco Bay and Delta system was used to model X2 distances within the San Francisco Bay and Delta system under a critical water year flow condition. Regulatory and resource agencies concurred with USACE's selection of this model and its methodology. Results of the model are summarized in the *Sacramento DWSC Modeling Results Summary*, included as Appendix K, and described in detail in the *Summary of the Sacramento DWSC and San Francisco Bay to Stockton Navigation Project Alternatives Modeling Report*, included as Appendix L. Year 0 X2 distances ranged from 32 to 98 miles from the Golden Gate Bridge (Figure 8). This variation corresponds to the flows conditions in March 1995 and December 1994, respectively.



SOURCE: MacWilliams and Gross 2010 (Appendix K).

Figure 8
Year 0 X2 Distances within the Sacramento River Delta
SEIS/SEIR
Sacramento River Deep Water Ship Channel

3.1.2.1.7 Shoreline Erosion

Waves breaking on shore can suspend sediment and erode the shoreline. Larger waves contain more energy and have greater capacity to mobilize sediment. Deep draft vessels traveling through the channel produce waves as a result of the bow wave and water displacement created as they pass through the water. Larger and more fully loaded vessels have the potential to create larger waves when compared to smaller and lighter vessels.

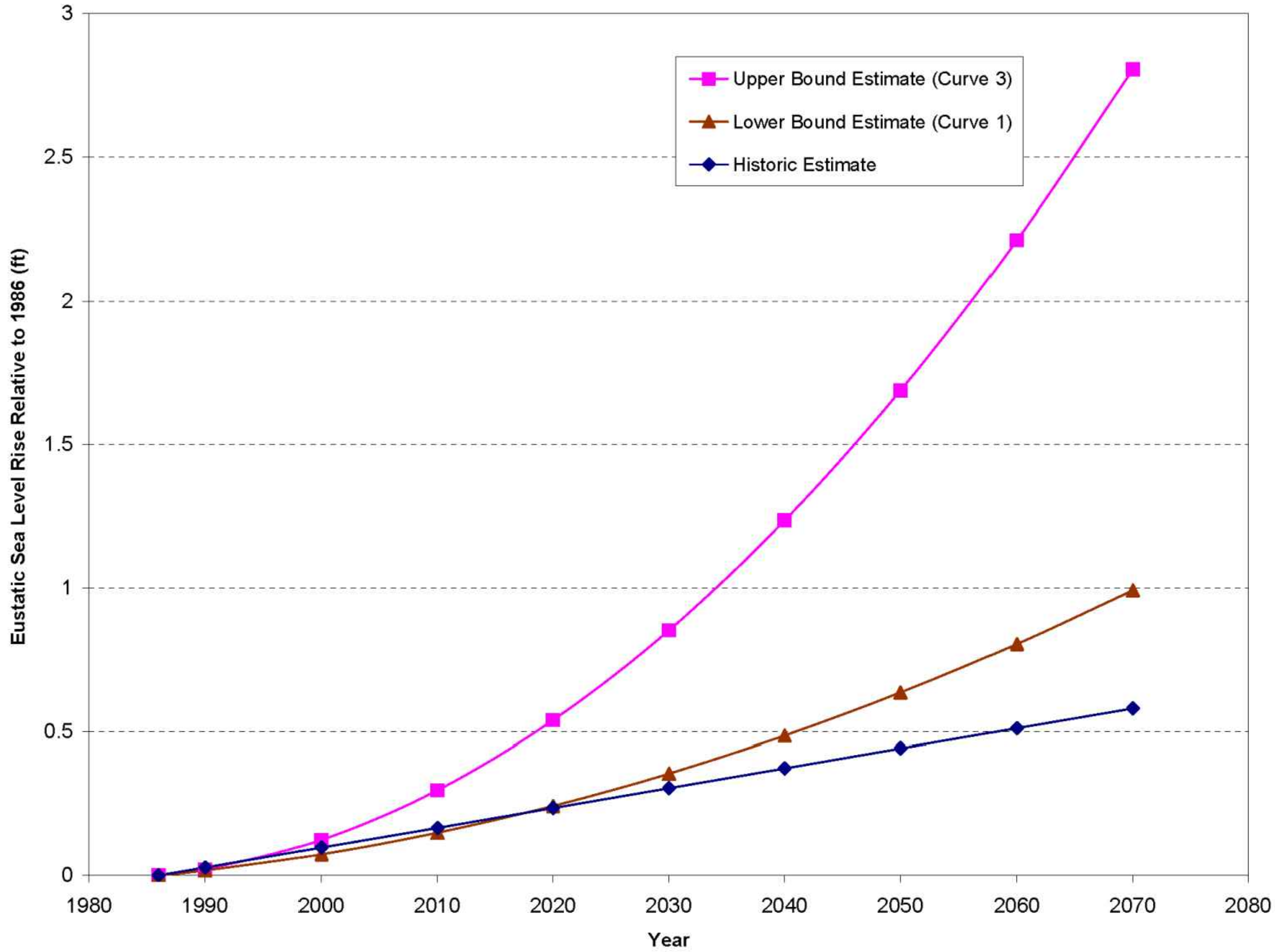
Wind waves are not likely to be a significant source of erosion in the study area due to limited fetch. Significant wind wave effect would require long fetch and a wider space to receive wind energy. A Delta Risk Management Strategy study that evaluated the potential impacts of wind waves in the absence of floods or seismic activity noted that wind waves would not be strong enough to cause erosion-induced levee failure (CDWR 2008b).

3.1.2.1.8 Sea Level Rise

Long-term changes in the elevation of sea level might result from influences such as climate change. This study only considers eustatic sea level rise because the channel depth and its related hydrodynamic properties are the primary control parameters. The ocean level has never remained constant over geologic time, but has risen and fallen relative to the land surface. A trendline analysis of yearly Mean Sea Level (MSL) data recorded at the Golden Gate Bridge from 1854 to 1999 indicate that the MSL upward trend is approximately 0.055 inches per year. However, the trend increased to 0.0069 feet per year from 1906 to 1999 (NOS 2001), which is indicative of an acceleration of sea level rising rate. Based on the deduced rate, the sea level at the Golden Gate Bridge is currently 7 inches higher than it was in 1920.

Several notable studies were prepared to predict the increasing rates of future sea level rise (National Academy Press 1987; Titus and Narayanan 1995; IPCC 2007). The trend of warmer global temperatures will accelerate melting of glaciers, which will consequently release more water into the oceans (Meier et al. 2007). In addition, warmer ocean temperatures cause the water to expand, further raising the sea level. These predictions have various degrees of uncertainty that are sensitive to the sea level rise modeling assumptions. The predicted future sea level rises range from about 0.3 to 0.6 feet between 2000 and 2050 (IPCC 2007). The CALFED Bay-Delta Program (CALFED) Independent Science Board suggests that sea level is likely to rise at least 2.3 to 3.2 feet by 2100, and even greater (6.5 feet or more) if ice cap melting accelerates (Healey 2007).

A report issued by National Research Council in 1987 (National Academy Press 1987) presented the estimated sea level rise rates for three different scenarios. Figure 9 shows the upper (Curve 3) and lower (Curve 1) bound estimates based on the base year of 1986. The water level upward trend of 0.0069 feet per year that was deduced from the Golden Gate Bridge monitoring station data between 1906 and 1999 is designated to be the minimum future sea level rise rate. The sea level rise relative to 1986, based on the minimum rate, is also plotted in the figure for comparison. Assuming that the base year (i.e., Year 0) is 2010, the resultant sea level rises at the end of 50-year project life (i.e., 2060) would range from a minimum of 0.35 feet to a maximum of 1.92 feet. The USACE has adapted a policy to consider three sea level rise scenarios for planning guidance: minimum (historical), intermediate (Curve 1), and maximum (Curve 3) rates.



SOURCE: Noble 2010 (Appendix I).

Figure 9
Estimated Sea Level Rise Rates
SEIS/SEIR
Sacramento River Deep Water Ship Channel

3.1.2.2 Methodology for Determining Impacts

Impacts to hydrology, hydraulics, sedimentation, and sediment transport were qualitatively and quantitatively evaluated in this Draft SEIS/SEIR. The analysis was based on the potential for the various alternatives to temporarily or permanently alter the hydrology, hydraulics, sedimentation, or sediment transport of the study area, and based on hydrodynamic modeling performed to evaluate impacts of the Proposed Project and alternatives (MacWilliams and Gross 2010). Additionally, potential impacts were analyzed using professional expertise and judgment to evaluate how the activities associated with the Proposed Project and alternatives could interact and impact hydrology, hydraulics, sedimentation, and sediment transport.

3.1.2.3 Thresholds of Significance

An alternative could have an impact on hydrology, hydraulics, sedimentation, or sediment transport (abbreviated as HHSST in the thresholds and mitigation measures in this section) if it would cause the following:

- **HHSST-1**: Change in hydrology causing an upstream shift of X2 (indicating upstream movement of saltwater intrusion) above modeled baseline conditions
- **HHSST-2**: Alteration of existing hydrology that would lead to erosion impacting the State Route (SR) 12/Rio Vista Bridge footings or the levees protecting Ryer and Prospect Islands that would cause flooding of those islands
- **HHSST-3**: Substantial modification of sedimentation or sediment transport processes within the SRDWSC in a way that results in significant effects on downstream areas
- **HHSST-4**: An increase in vessel wake force that would increase the rate of shoreline erosion, especially at Carquinez Regional Shoreline, Martinez Regional Shoreline, Bay Point Wetlands/Shoreline, and Browns Island

The following threshold was considered but not analyzed in this Draft SEIS/SEIR:

Deepening to a depth that causes saltwater intrusion into groundwater along the SRDWSC – Most groundwater wells used for potable water in the study area are on the order of hundreds of feet deep, due to the thickness of the overburden above the deep aquifer (Wu 2010a). Therefore, none of the alternatives have the potential to cause saltwater intrusion into groundwater along the SRDWSC.

3.1.2.4 Impacts and Mitigation Measures

HHSST-1: Change in hydrology causing an upstream shift of X2 (indicating upstream movement of saltwater intrusion) above modeled baseline conditions

Future without Project Conditions (NEPA and CEQA Baseline)

The results of the UnTRIM three-dimensional hydrodynamic model indicate that under Future without Project Conditions, sea levels would potentially rise by as much as 2 feet over the next 50 years. Assuming maintenance dredging of the SRDWSC continues at current rates, the effective depth of the SRDWSC would increase with rising sea levels. Increased channel depth would increase tidal channel flux, thereby potentially increasing the X2 intrusion of seawater into the SRDWSC. However, based on the model's comparison of current baseline conditions (Year 0) to an unwidened/undeepened SRDWSC as would be the case with sea level rise in 50 years (Year 50), X2 values were largely dependent on a moderate level of freshwater input into the SRDWSC via rainfall. X2 distances are similar for Year 0 and Year 50 under Future without Project Conditions, although both simulations varied slightly from the other. X2 values in both simulation cases ranged between 32 and 98 kilometers (km). During the simulation period, low X2 values occurred in late winter and early spring when high Delta outflows occurred. High values of X2 and larger changes in X2 occurred during the wet season (late fall and early winter). With an X2 less than 75 km, no saltwater intrusion would occur between January and June at both Year 0 and Year 50 under Future without Project Conditions.

Although sea level rise has the potential to change the depth of the SRDWSC and thus impact tidal flows under Future without Project Conditions, sedimentation and maintenance dredging would maintain channel and water depths constant at 30 feet MLLW (see Section 3.1.2.1.2). No change in the extent of X2 would occur under Future without Project Conditions other than that caused by natural precipitation levels. Thus, there would be less than significant impacts to the upstream shift of X2 under Future without Project Conditions.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

The Proposed Project would increase the depth of the SRDWSC by 5 to 7 feet, considering the target depth and 2-foot allowable overdepth. Year 0 X2 distances ranged between 32 and 98 km from the Golden Gate Bridge (Figure 8). Based on the model's comparison of Future without Project Conditions in Year 0 and in Year 50 (Figure 10) to the Proposed Project, X2 values were largely dependent on freshwater input into the SRDWSC via rainfall and runoff.

As is noted above, the UnTRIM three-dimensional hydrodynamic model for the San Francisco and Delta system was used to model X2 distances within the San Francisco Bay and Delta system under a critical water year flow condition (i.e. severe drought). Impacts would be even less during a typical water year. A summary of the effects is presented below:

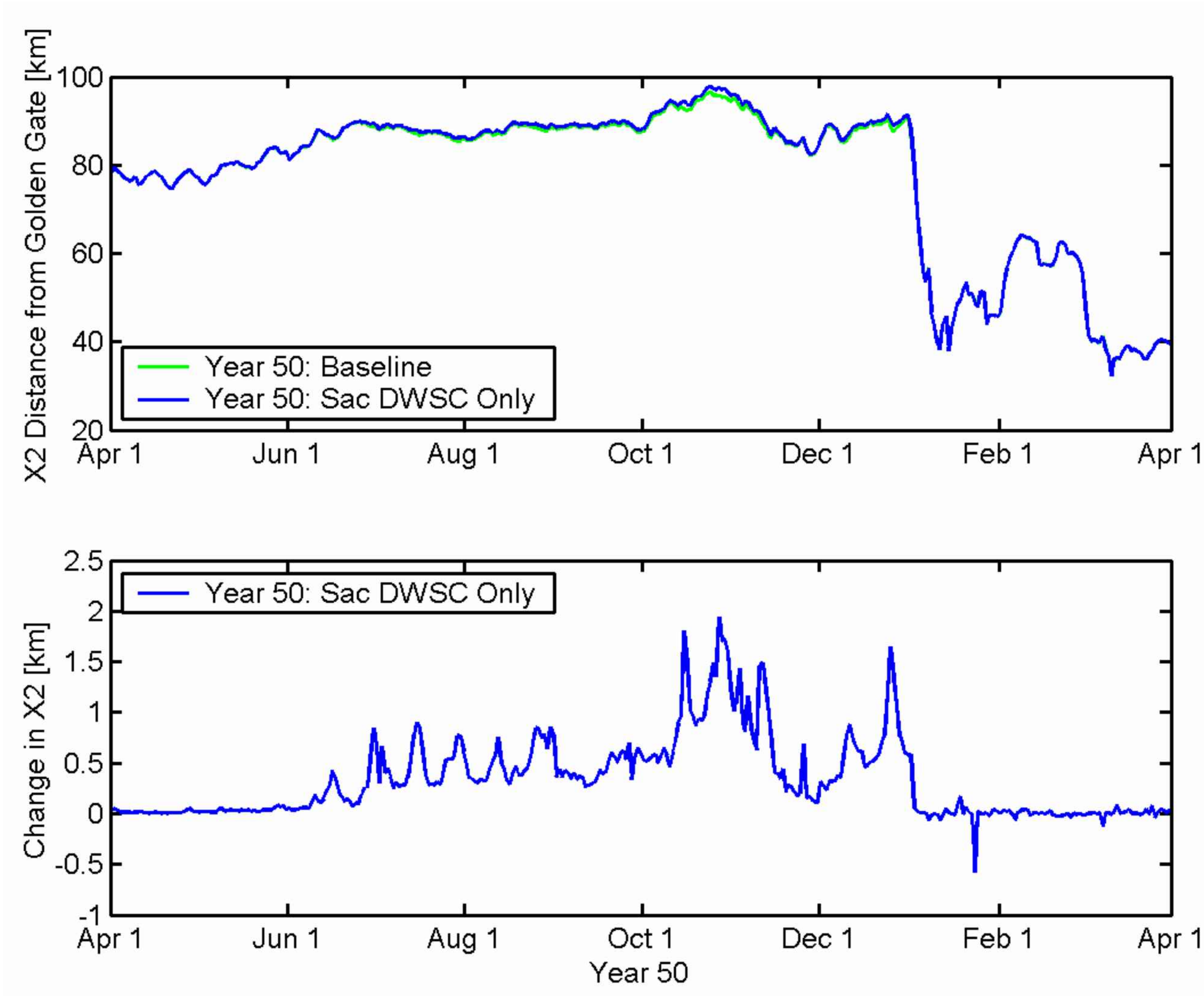
- There are no significant effects on water surface elevations or tidal flows for Year 0 or Year 50 conditions.
- There are no impacts on salinity when the X2 is less than 75 km from the Golden Gate Bridge.
- Minor salinity increases are predicted from September through mid-January when the X2 is between Collinsville and Rio Vista.
- Salinity increases of up to 0.15 psu during some periods (i.e., September through January) for Year 0 and Year 50 conditions for the Proposed Project.
- The median change in X2 for Year 0 is 0.11 km and for Year 50 is 0.17 km[14] (Figure 11).
- There are no quantitatively different effects of the Proposed Project for Year 0 and Year 50 (Figure 12).

The modeling results show that the effects of the Proposed Project related to aquatic organisms experiencing fluctuating X2 levels—as well as the measure of salinity intrusion into the Delta water supply—are small and considered minor. Thus, as compared to the environmental baseline, there would be less than significant incremental impacts to the upstream shift of X2 as a result of the Proposed Project.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

[14] When the X2 moves east of the confluence, an average value of X2 is used, which is measured along both the Sacramento and San Joaquin rivers.



SOURCE: MacWilliams and Gross 2010 (Appendix K).

Figure 10
Year 50 X2 Distances within the Sacramento River Delta
SEIS/SEIR
Sacramento River Deep Water Ship Channel

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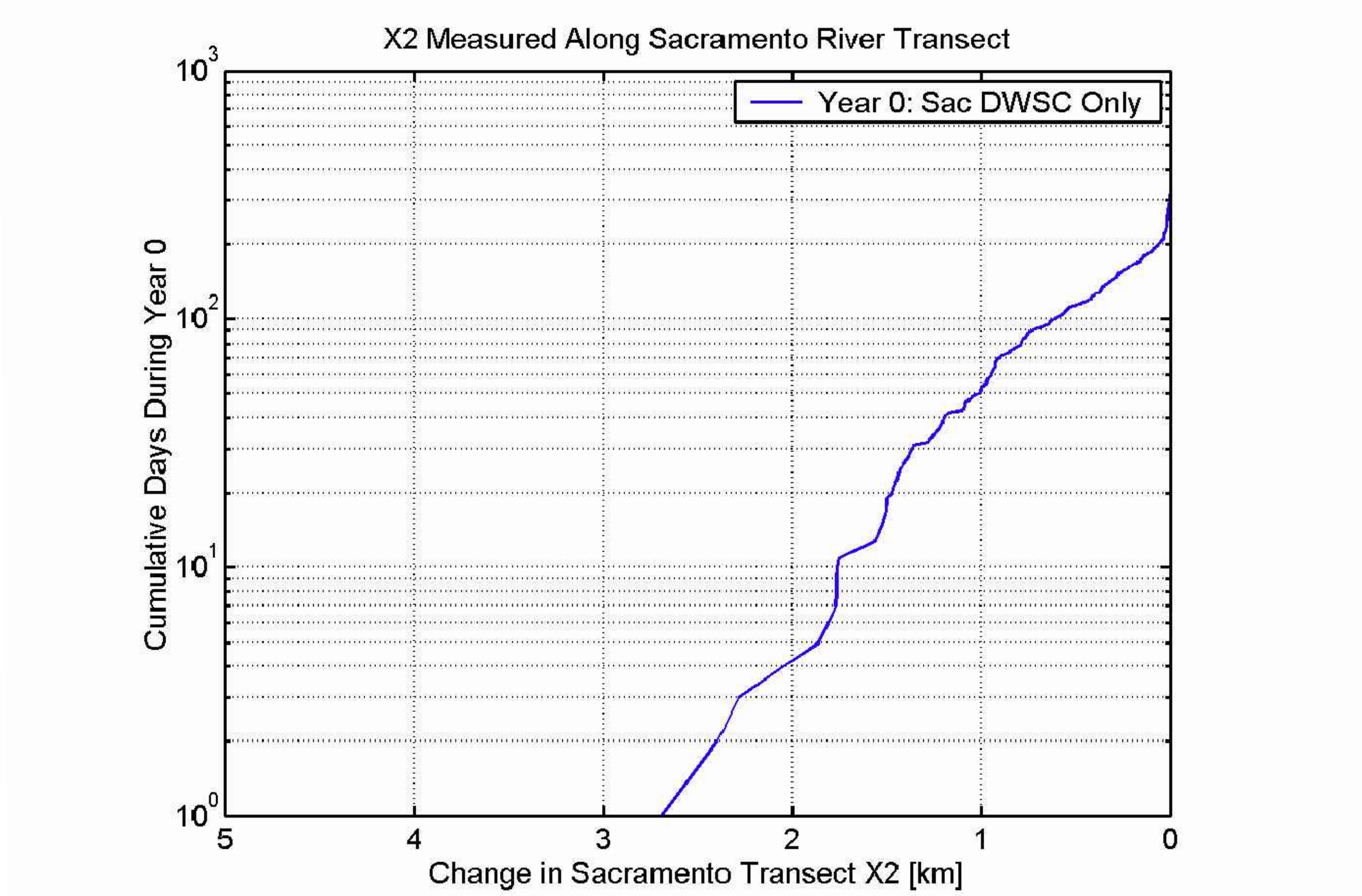


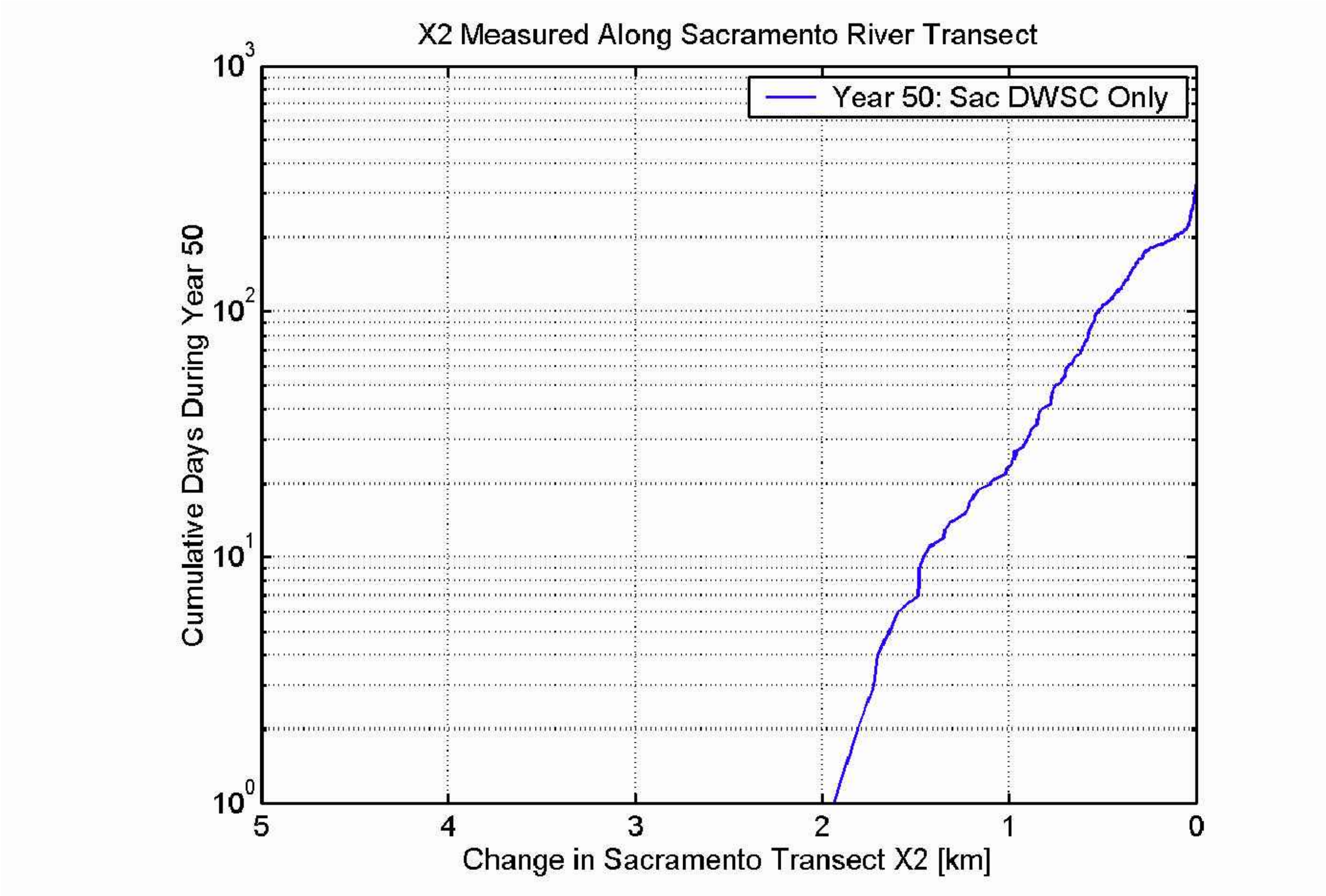
SOURCE: MacWilliams and Gross 2010 (Appendix K).

Figure 11

Year 0 Cumulative Days Proposed Project X2 Distances Exceed Future without Project Conditions

SEIS/SEIR

Sacramento River Deep Water Ship Channel



SOURCE: MacWilliams and Gross 2010 (Appendix K).

Figure 12
Year 50 Cumulative Days Proposed Project X2 Distances Exceed Future without Project Conditions
SEIS/SEIR
Sacramento River Deep Water Ship Channel

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

In the UnTRIM 3D hydrodynamic model, a separate simulation of the -33 Feet MLLW Alternative was not performed; however, impacts to the X2 as a result of this alternative are expected to be less than those of the Proposed Project. Thus, as compared to the environmental baseline, there would be less than significant incremental impacts to the upstream shift of X2 as a result of the -33 Feet MLLW Alternative.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

HHSST-2: Alteration of existing hydrology that would lead to erosion impacting the SR 12/Rio Vista Bridge footings or the levees protecting Ryer and Prospect Islands that would cause flooding of those islands

Future without Project Conditions (NEPA and CEQA Baseline)

Under Future without Project Conditions, a maximum increase of 2 feet in flood stage is expected, based on the Year 50 Curve 3 sea level rise rate. A similar water surface elevation increase is expected be observed at the SR 12/Rio Vista Bridge footings and at both Ryer and Prospect Islands. However, a change in the flood stage, or velocity, is not expected. Thus, there would be no impacts from erosion on the SR 12/Rio Vista Bridge footings or the levees protecting Ryer and Prospect Islands under Future without Project Conditions.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: None.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

As part of the UnTRIM 3D hydrodynamic model, flow rates at both Year 0 and Year 50 for the Proposed Project were modeled and compared to Future without Project Conditions. In general, little change was observed in flood stage, velocity, or flow rate in the simulations. However, there is a minimal reduction in flood stage due to the deepening of the SRDWSC and subsequent increase in channel cross-section area. As a result, no additional erosion-induced flood risks would result from the Proposed Project. Thus, as compared to the environmental baseline, there would be no impacts from erosion on the SR 12/Rio Vista Bridge footings or the levees protecting Ryer and Prospect Islands as a result of the Proposed Project.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: None.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

While flow rates of the -33 Feet MLLW Alternative were not modeled as part of the UnTRIM 3D hydrodynamic model, the results would be expected to be similar to those of

the Proposed Project and no additional erosion-induced flood risks would result. Thus, as compared to the environmental baseline, there would be no impacts from erosion on the SR 12/Rio Vista Bridge footings or the levees protecting Ryer and Prospect Islands as a result of the -33 Feet MLLW Alternative.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: None.

HHSST-3: Substantial modification of sedimentation or sediment transport processes within the SRDWSC in a way that results in significant effects on downstream areas

Future without Project Conditions (NEPA and CEQA Baseline)

A maximum increase of 2 feet in flood stage is expected under Future without Project Conditions. The 2-foot increase in water level elevation would increase approximately 6% of the submerged bank area, which has the potential to increase annual maintenance dredging volumes by the same percentage. Average maintenance dredging volumes between 2000 and 2009 were approximately 190,000 cy. The maximum potential increase of future maintenance dredging volumes is anticipated to be approximately 11,400 cy per year. This negligible increase would have a minimal impact on sedimentation or sediment transport processes within the SRDWSC. Thus, no impacts to the sedimentation or sediment transport processes within the SRDWSC are expected under Future without Project Conditions.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: None.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

Deepening the SRDWSC to -35 feet MLLW would increase the side slope area by an estimated 10% (Wu 2010b; Appendices K and L). In addition, sea level could rise by as much as 2 feet over the next 50 years. This would submerge more of the bank of the SRDWSC underwater, effectively further increasing the side slope area. The Proposed Project is expected to increase future maintenance dredging volumes by approximately 10% as compared to Future without Project Conditions (Wu 2010b). In recent years, maintenance dredging volumes in the SRDWSC have declined. Based on both the declining rates and the average maintenance dredging volume of approximately 190,000 cy, the maximum increase in maintenance dredging volumes after deepening the SRDWSC to -35 feet MLLW is estimated to be approximately 10% (or 19,000 cy), resulting in an estimated maximum annual volume of 209,000 cy.

The simulation results of channel bottom shear stress of the Proposed Project are slightly smaller than those of the baseline conditions, which indicates that slightly more sediment will be deposited on the channel bottom (Appendix L). These increased sedimentation rates largely reflect the movement of sediment from adjacent banks to the deepened channel; and the sediment would then be removed by annual scheduled maintenance dredging; therefore, downstream sediment transport is not expected to be impacted by the Proposed Project. Thus, as compared to the environmental baseline, there would be very little incrementally increased but less than significant impacts to downstream areas from changes in sedimentation or sediment transport resulting from deepening the SRDWSC as a result of the Proposed Project.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

The potential effects on sediment transport resulting from the -33 Feet MLLW Alternative are expected to be similar, if not less significant, than those of the Proposed Project. Thus, as compared to the environmental baseline, there would be incrementally increased but less than significant impacts to downstream areas from changes in sedimentation or sediment transport resulting from deepening the SRDWSC as a result of the -33 Feet MLLW Alternative.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

HHSST-4: An increase in vessel wake force that would increase the rate of shoreline erosion, especially at Carquinez Regional Shoreline, Martinez Regional Shoreline, Bay Point Wetlands/Shoreline, and Browns Island

Future without Project Conditions (NEPA and CEQA Baseline)

Waves generated by wind, current, or vessels can suspend shoreline sediment and result in erosion. The estimated number of vessel calls to the Port under Future without Project Conditions is anticipated to increase from approximately 58 in 2011 to approximately 143 in 2053 (Ilanco Environmental 2010b); however, the size of vessels is expected to remain the same because channel depth would be maintained at 30 feet MLLW. As such, vessel wake force is not expected to change under Future without Project Conditions. Thus, no impacts to the rate of shoreline erosion in the SRDWSC are expected under Future without Project Conditions.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: None.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

Under the Proposed Project, more fully loaded vessels on the SRDWSC could produce larger wakes. The potential impact of vessel generated ship waves was evaluated to determine the potential erosion to channel banks resulting from a deeper channel. Ship wave parameters and resulting shear stresses were computed based on the USACE Coastal Engineering Manual (USACE 2008d), conference proceedings (Sorensen and Weggel 1984), and linear wave theory. Vessel wave resulting shear stresses were computed for Future without Project Conditions and the Proposed Project for the new design vessel and the current maximum vessel specified by the *Operations Guidelines for the Movement of Vessels on San Francisco Bay and Tributaries* (San Francisco Bar Pilots 2010). Preliminary findings suggest minor decreases (between 12 and 15%) in ship wave-induced shear stresses under the Proposed Project as compared to Future without Project Conditions, indicating a reduction in vessel wave impacts (Appendix K).

Due to the narrow width of the channel at Carquinez Regional Shoreline, Martinez Regional Shoreline, Bay Point Wetlands/Shoreline, and Browns Island and the less than significant impact of vessel wakes on erosion rates (see Section 3.1.2.1.7), the potential for increased vessel wake force is not expected to increase erosion rates along the regional shoreline parks. Thus, as compared to the environmental baseline, there would be no impacts to the erosion rates at the regional shoreline parks as a result of the Proposed Project.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: None.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

Under the -33 Feet MLLW Alternative, more fully loaded vessels on the SRDWSC could produce larger wakes. The potential impact of vessel generated ship waves was not evaluated specific to this alternative as it was for the Proposed Project; however, vessel wave impact on bank erosion would be expected to be less than under Future without Project Conditions but greater than the under the Proposed Project. Ship wave parameters and resulting shear stresses were computed based on the USACE Coastal Engineering Manual (USACE 2003c). Preliminary findings suggest minor decreases in ship wave-induced shear stresses under the -33 Feet MLLW Alternative as compared to Future without Project Conditions and slight increases in shear stresses as compared to the Proposed Project. Thus, as compared to the environmental baseline, there would be no impacts to the erosion rates at the regional shoreline parks as a result of the -33 Feet MLLW Alternative.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: None.

3.1.2.4.1 Summary of Impacts and Mitigation Measures

Table 24 summarizes the impact determinations, mitigation measures, and residual impacts after mitigation, if applicable, for each alternative with respect to the hydrology, hydraulics, sedimentation, and sediment transport impacts described above.

Table 24
Summary of Hydrology, Hydraulics, Sedimentation, and Sediment Transport Impacts and Mitigation Measures

Alternative	Impact	Mitigation	Residual Impact After Mitigation
HHSST-1: Change in hydrology causing an upstream shift of X2 (indicating upstream movement of saltwater intrusion) above modeled baseline conditions			
Future without Project Conditions (NEPA and CEQA Baseline)	Less than significant impact	None	Less than significant impact
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	Less than significant impact	None	Less than significant impact
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	Less than significant impact	None	Less than significant impact
HHSST-2: Alteration of existing hydrology that would lead to erosion impacting the SR-12/Rio Vista Bridge footings or the levees protecting Ryer and Prospect Islands that would cause flooding of those islands			
Future without Project Conditions (NEPA and CEQA Baseline)	No impact	None	None
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	No impact	None	None
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	No impact	None	None
HHSST-3: Substantial modification of sedimentation or sediment transport processes within the SRDWSC in a way that results in significant effects on downstream areas			
Future without Project Conditions (NEPA and CEQA Baseline)	No impact	None	None
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	Less than significant impact	None	Less than significant impact
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	Less than significant impact	None	Less than significant impact
HHSST-4: An increase in vessel wake force that would increase the rate of shoreline erosion, especially at Carquinez Regional Shoreline, Martinez Regional Shoreline, Bay Point Wetlands/Shoreline, and Browns Island			
Future without Project Conditions (NEPA and CEQA Baseline)	No impact	None	None
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	No impact	None	None
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	No impact	None	None

3.1.3 Sediment Quality

This section provides baseline conditions and assesses potential impacts to sediment quality both in the SRDWSC and dredged material placement sites from the Proposed Project and alternatives.

3.1.3.1 Baseline Conditions

This section summarizes previously collected data, including information collected regarding chemicals of concern in the sediment. Sediment samples were collected from the SRDWSC in support of the 1980 EIS, 1986 Supplemental EIS, several maintenance dredging events between 2000 and 2007, and this SEIS/SEIR in February 2009. Sediment testing was conducted to quantify the bulk concentrations of sediment-associated heavy metals and pesticides, and evaluate potential releases during dredging and placement of dredged materials. This information was also used to determine appropriate dredged material placement options. The data summaries below compare the results of the sediment testing to regulatory criteria established by the U.S. Environmental Protection Agency (USEPA), Central Valley Regional Water Quality Control Board (RWQCB), and the California Department of Health Services.

1980 EIS – Six sites between Collinsville and the turning basin at the Port were sampled in 1975 for the 1980 EIS (USACE 1975, 1980). Analysis of sediments for heavy metals indicated that zinc exceeded 1971 USEPA maximum limits at three of the six sites: near Collinsville, at River Mile (RM) 33.0, and near the turning basin. Other heavy metals were below the USEPA limits. These tests indicated that certain heavy metals were in the material to be dredged but did not specify impacts of dredging and discharge of return water on the water column. Results also indicated that heavy metals tended to settle out in placement areas, but further analysis (specifically for elutriate testing) was recommended for future work.

1986 Supplemental EIS – The 1986 SEIS compared sediment results from previously collected data in 1975 (for the 1980 EIS) to the Soluble Threshold Limit Concentration (STLC) values for hazardous waste and 1984 USEPA water quality criteria. The observed heavy metal concentrations are compared to these criteria in Table 25. Heavy metal concentrations did not exceed STLC criteria but observed levels of both lead and mercury exceeded USEPA criteria. Nickel also exceeded recommended maximum levels, but the remaining analytes were within recommended limits.

Table 25
Heavy Metal Concentrations in Sediments, 1975 and 1984

Metal	STLC (mg/kg)	1984 USEPA Proposed Approach – Acute (µg/g)	1984 USEPA Proposed Approach – Chronic (µg/g)	EPA Max. Recommended for Agricultural Uses (µg/g)	High-Low Results of 1975 Samples (µg/g dry wt)
Arsenic	50	36.4	18.7	--	3.1 – 0.4
Cadmium	10	2.6	2.6	2.7	0.8 – 0.1
Chromium	560	--	--	--	134 – 29
Copper	250	285.6	197.2	144	71 – 11
Lead	50	190	7.6	511	13 – 3
Mercury	2	0.18	0.03	--	0.3 – 0.1
Nickel	200	--	--	82	178 – 46
Zinc	2,500	1,190	310	304	79 – 27

Notes:
-- = No value
mg/kg = milligrams per kilogram
µg/g = micrograms per gram
Table sources: USACE 1975; USACE 1980; USACE 1986

Maintenance Dredging – Sampling was conducted in the SRDWSC to characterize sediments prior to being dredged. Maintenance dredging and dredged material placement activities occurring in the SRDWSC since 2000 are summarized in Table 26, including sampling results from the 2000, 2002, 2003, 2005, 2006, and 2007 *Notices of Intent to Conduct Sacramento River Maintenance Dredging* (NOIs; USACE 2000, 2001, 2002a, 2003a, 2005, 2006a, 2007). Only sediments from those reaches requiring dredging were evaluated.

Table 26
Sediment Testing Results for Operations and Maintenance Dredging in SRDWSC since 2000

Year of Sampling	River Miles Dredged and Sampled	Placement Sites Used	Total No. of Samples	No. Samples (Organics/Heavy Metals) Exceeding WDR Criteria		
				MET Samples	DI-WET Samples	Sediment Composite Samples
2000	6.3-12.9 33.3-37.7	S16, S19, S31	12		1 (Arsenic)	
2001	4.8-6.2 9.0-9.4 42.6-43.6	S19, S20	6	2 (Mercury) 1 (Beta-BHC)	1 (Lead) 1 (Mercury)	5 (Chromium) 2 (Mercury) 1 (Nickel) 1 (B(a)P)
2002	4.5-5.1 6.0-6.4 7.7-7.9	S19, S20	2	2 (Mercury)	2 (Arsenic) 2 (Chromium) 2 (Copper) 2 (Lead) 2 (Mercury) 2 (Nickel)	1(Chromium) 1 (Mercury) 2 (Nickel) 1 (Zinc)

Year of Sampling	River Miles Dredged and Sampled	Placement Sites Used	Total No. of Samples	No. Samples (Organics/Heavy Metals) Exceeding WDR Criteria		
				MET Samples	DI-WET Samples	Sediment Composite Samples
					2 (Zinc)	
2003	5.1-6.4 8.2-8.4 30.5-33.5	S20, S31	5	1 (Chromium) 1 (Cadmium) 5 (Mercury)	4 (Arsenic) 4(Chromium) 5 (Copper) 5 (Lead) 5 (Mercury) 5 (Nickel) 4 (Zinc)	3 (Chromium) 1 (Copper) 2 (Mercury) 5 (Nickel)
2005	4.5-6.0 6.8-7.7 27.8-28.6 29.4-34.1	S31	9	4 (Mercury) 1 (Arsenic) 1 (PAHs) 2 (PCBs)	2 (Copper) 2 (Lead)	1 (Arsenic) 8 (Chromium) 2 (Mercury) 8 (Nickel)
2006	5.7-7.2 9.3-10.1 12.5-13.0	S16, S19	6			2 (Chromium) 1 (Mercury) 2 (Nickel)
2007	32.0-34.8	S31	2	1 (Mercury)	1 (Zinc)	1 (Copper) 2 (Nickel) 1 (Zinc)

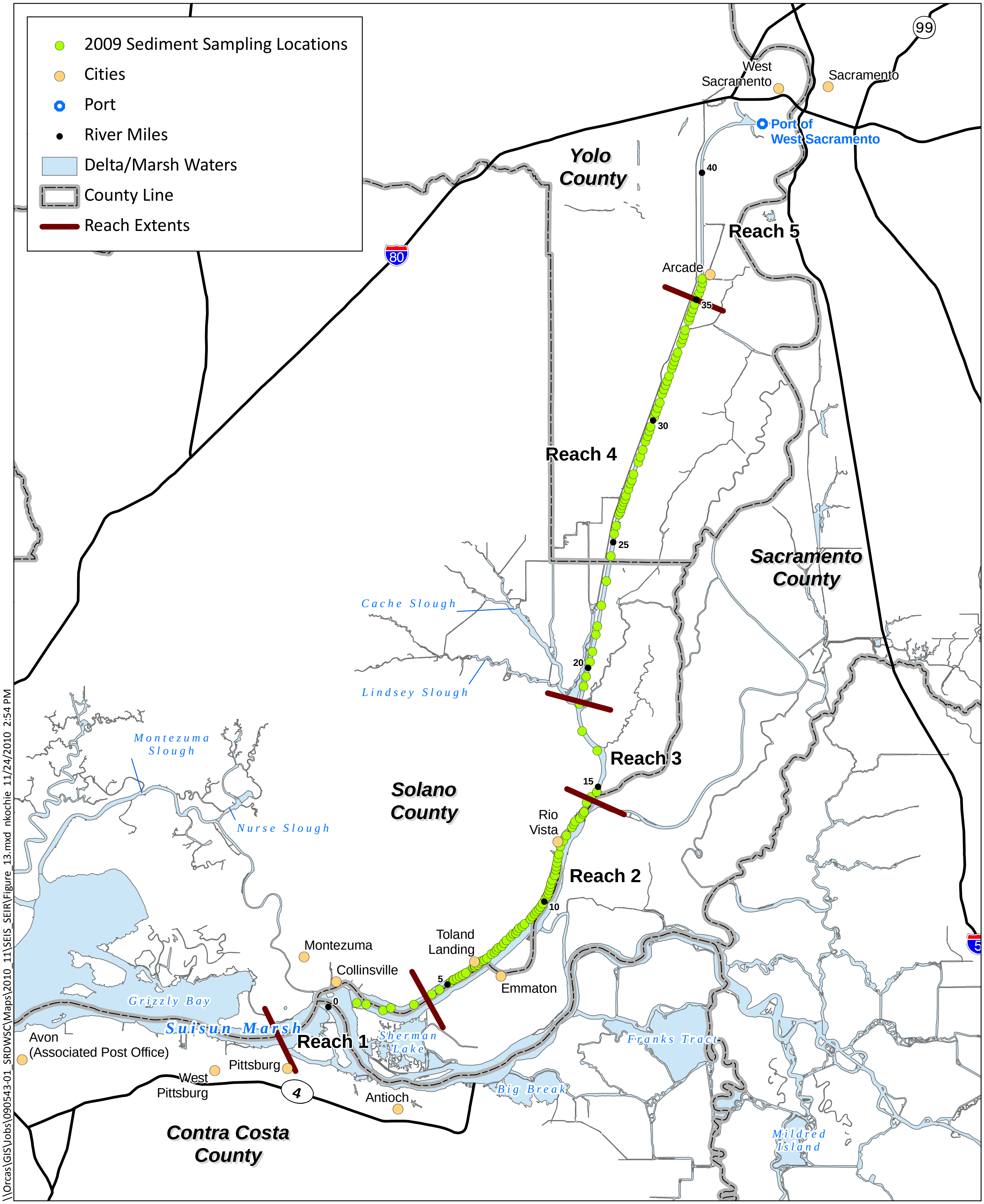
Screening criteria: WDR No. 5-01-116 and WDR No. 96-220 (Central Valley RWQCB 2001)
Table sources: USACE 2000, 2001, 2002a, 2003a, 2005, 2006a, 2007
MET: Modified Elutriate Test-analysis to predict the quality of effluent discharge from dredged material placement sites
DI-WET: Deionized Water-Waste Extraction Test-analysis for the leaching characteristics of the disposed dredged material within placement sites considering attenuation of the contaminants in the underlying soil
Discrete cores sample analysis: Samples collected below each sediment core sample to represent the sediment at the new surface horizon of the channel
Sediment composite samples: Composite samples created from individual core samples within each RM (or RM section); composites were designed to represent approximately every 49,100 cy of material to be dredged within each RM (or RM section)

For those reaches requiring dredging in the past 10 years (between RMs 4.0 through 44.0), there were sediment exceedances of criteria for metals, specifically chromium, mercury, and nickel, as well as benzo(a)pyrene. However, when standard attenuation was calculated for the maintenance dredging placement sites, Waste Discharge Requirement General Order (WDR) criteria were achieved and the Central Valley RWQCB issued a permit to dredge for every year. Attenuation is a calculation of the depth in the underlying soils required to reduce dredged material leachate (measured as Deionized Water-Waste Extraction Test [DI-WET]) to the groundwater criteria. This calculation is based on the DI-WET concentration (predicted dredged material leachate), the atomic weight of the metal of concern, cation exchange capacity in soil, the density of dredged material, and the density of underlying soil (within the placement site).

Sediment Testing 2009 – The USACE conducted sediment testing in support of planning of the Proposed Project in February 2009. The plan for testing was discussed in meetings of the Delta Long Term Management Strategy (LTMS) with input from the USEPA, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and the Central Valley RWQCB. The Delta LTMS and USEPA provided comments on the *Draft Sampling and Analysis Report*, which were incorporated in subsequent versions of the document (USACE 2010d). The *Sampling and Analysis Report* is included as Appendix M.

Sediment core sampling was conducted at 124 stations within the proposed dredging footprint. All sediment cores were collected to a depth of 35 feet MLLW plus 2 feet of allowable overdepth. One composite sample was targeted for every 49,100 cubic yards (cy) of material to be dredged within each RM. Figure 13 shows the actual sampling locations within the dredging footprint of the Proposed Project. Details associated with sediment core sampling and compositing schemes are described in Appendix M.

Modified elutriate tests (METs) and DI-WETs were performed on the composite samples to represent elutriate concentrations during dredging to the Proposed Project depth of 35 feet, as described in detail in Appendix M.



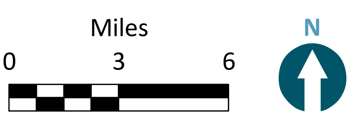


Figure 13
2009 SRDWSC Sediment Sampling Locations
SEIS/SEIR
Sacramento River Deep Water Ship Channel

Sediment chemistry results were compared to their corresponding criteria established in WDR No. 5-01-116 issued by the Central Valley RWQCB (2001). These criteria are based on USEPA Preliminary Remediation Goals (PRGs) for ecological or residential use or background concentrations of material within placement sites. Although this sampling effort was done outside the WDR criteria for maintenance dredging, comparison criteria were used as a point of reference to evaluate potential impacts due to dredging. Results were also compared to maximum sediment chemical concentrations provided in the NOIs (USACE 2001, 2002a, 2003a, 2005, 2006a, 2007) and used as the "background" for material already deposited in the placement sites. Results for arsenic, total chromium, and nickel in bulk sediment were compared to criteria consistently used in NOIs for maintenance dredging projects in the SRDWSC, which are based on a Delta-wide background study conducted at the University of California, Berkeley. Mercury in sediment was also compared to the mercury target of 0.2 milligrams per kilogram (mg/kg) in the Sacramento–San Joaquin Delta Estuary Total Maximum Daily Load (TMDL) for methylmercury.

3.1.3.1.1 Chemical Analyses of Bulk Sediment Composites

Metals, methylmercury, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, polychlorinated biphenyl (PCB) Aroclors, grain size, and total organic carbon (TOC) were measured in sediment composite samples from the SRDWSC and are presented in Table 27.

Table 27
Chemical Constituents that Exceeded Criteria in Sediment Composite Samples During 2009 Sediment Testing

Analyte	Maximum Value from Previous Pre-Dredge Studies (2000 - 2007)	WDR No. 5-01-116 Criteria	Criteria from NOIs for SRDWSC Dredging Projects	2009 Range of Concentration of Exceedances/No. Samples Exceeding Criteria
Arsenic (mg/kg)	13.2	--	11.6	13.2/1
Chromium (mg/kg)	122	--	59.1	59.5-176/40
Nickel (mg/kg)	238	--	64.5	67.2-96.5/14
Benzo(a)pyrene (µg/kg)	--	62	--	133/1

Notes:
-- = no corresponding criteria

In sediment composite samples, the metals arsenic, chromium, and nickel and the organic compound benzo(a)pyrene were detected at concentrations that exceeded WDR criteria and/or criteria from NOIs for maintenance dredging projects from 2000 to 2007 (Table 27). Chromium in 40 sediment composite samples and nickel in 14 sediment composite samples exceeded the criteria from NOIs for maintenance dredging projects.

Numerous factors suggest that measured chromium concentrations represent background conditions for the native material in the SRDWSC. Forty of 45 sediment composite samples, or 89% of samples from RMs 1.0 through 35.0, exceeded the background criterion for chromium. Concentrations of chromium are log-normally distributed, which is common for background concentrations of metals. There is a random spatial distribution of concentrations along the channel, which is contrary to anthropogenic sources of metals. Chromium concentrations have been consistently above the WDR criteria for maintenance dredging background values in pre-dredge characterization samples. Furthermore, the measured concentrations for chromium are all well below the risk-based USEPA Regional Screening Level (USEPA 2010) of 280 mg/kg for a residential receptor.

Similar to chromium, concentrations of arsenic in SRDWSC sediments are lognormally distributed and ubiquitous throughout the sampling locations but not at levels exceeding WDR criteria, except in RM 3.0. In previous pre-dredge characterization studies conducted between 2000 and 2007, arsenic exceeded WDR criteria Similar to the previous studies, few exceedances of this criterion were observed in the 2009 pre-dredge study. These results suggest that detected arsenic concentrations are similar to background concentrations and may be associated with native material in that area.

Nickel exceeded the WDR criteria between RMs 0.0 to 9.0 and again in RM 11.0. However, similar to chromium, nickel concentrations have been consistently above the WDR criteria for maintenance dredging background values in pre-dredge characterization samples. These findings indicate that nickel concentrations in SRDWSC material is at background levels and also may be associated with native material in those areas.

Semivolatile organic compounds analyzed as part of this project included PAHs and hexachlorocyclopentadiene. PAHs were detected in all samples, with the exception of samples taken in RMs 12.0, 22.0, and 23.0. All concentrations were below the detection limit or at extremely low levels, ranging from non-detect to 170 micrograms per kilogram (µg/kg). Benzo(a)pyrene was the only PAH to exceed the respective criteria in the WDR, at a concentration of 133 µg/kg (between RMs 16.0 and 18.0).

No organochlorine pesticides were detected in bulk sediments from the SRDWSC. It should be noted that although dieldrin was not detected in a sample taken in RM 3.0, the detection limit exceeded the criteria in the WDR.

No PCB Aroclors were detected in bulk sediments from the SRDWSC.

TOC concentrations in bulk sediment from the SRDWRC ranged from 0.0484% (RM 9.0) to

10.9% (RM 1.0).

Composite sediment samples contained exceedances of criteria for metals, specifically arsenic, chromium, and nickel, as well as an isolated benzo(a)pyrene exceedance. The observed metals exceedances were randomly distributed within the study area and were similar to past concentrations observed in dredged material between 2000 and 2007. These findings suggest that there are no new anthropogenic sources and composite sediment material is at regional background levels.

3.1.3.1.2 Discrete Sediment Sample Chemistry

Metals measured in discrete sediment samples from the SRDWSC are presented in Appendix M. Arsenic, chromium, lead, and nickel were detected at concentrations that exceeded sediment quality criteria (Table 28). The arsenic concentration in one sample (24.1 mg/kg) exceeded both criteria from NOIs for maintenance dredging projects (11.6 mg/kg) and the maximum value from previous maintenance dredging characterization studies (13.2 mg/kg). Chromium concentrations in 27 samples (ranging from 60.3 to 232 mg/kg) exceeded criteria from NOIs for maintenance dredging projects (59.1 mg/kg) or the maximum value from previous maintenance dredging characterization studies (122 mg/kg). Concentrations of chromium were all well below the risk-based USEPA Regional Screening Level (USEPA 2010) of 280 mg/kg for a residential receptor. The lead concentration in one sample (53.3 mg/kg) exceeded the maximum value from previous maintenance dredging characterization studies (41 mg/kg). Nickel concentrations in seven samples (ranging from 68.7 to 121 mg/kg) exceeded criteria from NOIs for maintenance dredging projects (64.5 mg/kg).

Table 28
Chemical Constituents in Discrete Sediment Samples (New Horizons) that Exceeded Criteria During 2009 Baseline Sampling

Analyte	Discrete Sediment (34 samples)			
	Maximum Value from Previous Pre-Dredge Studies (2000 - 2007)	WDR No. 5-01-116 Criteria	Criteria from NOIs for SRDWSC Dredging Projects	2009 Range of Concentration of Exceedances/No. Samples Exceeding Criteria
Arsenic (mg/kg)	13.2	--	11.6	24.1/1
Chromium (mg/kg)	122	--	59.1	60.3 – 232/27
Lead (mg/kg)	41	400	--	53.3/1
Nickel (mg/kg)	238	--	64.5	68.7 – 121/7

Notes:
-- = no corresponding criteria

Only one of 34 discrete samples (08SAC31; 0.25 mg/kg) for total mercury exceeded the Sacramento – San Joaquin TMDL sediment target (Central Valley RWQCB 2001). However, the estimated concentration was well below the maximum value seen in previously dredged material (0.68 mg/kg) and within the range seen in previously sampled dredged material.

3.1.3.2 Methodology for Determining Impacts

Impacts to sediment quality were quantitatively evaluated based on the potential for the various alternatives to temporarily or permanently pose additional risk to aquatic organisms or impair beneficial reuse of sediment. Criteria that were used to evaluate the sediment quality data included WDR No. 5-01-116 (based on USEPA PRGs for ecological or residential use or background concentrations of material within placement sites), risk-based USEPA Regional Screening Level for chromium, and the Sacramento – San Joaquin TMDL sediment target (Central Valley RWQCB 2001) for methylmercury.

3.1.3.3 Thresholds of Significance

An alternative could have an impact on sediment quality (abbreviated as SQ in the thresholds in this section) if it would cause the following:

- SQ-1: Exposure of a new surface after dredging that has chemical concentrations at levels likely to cause unacceptable additional risk over existing conditions to aquatic organisms, or likely to impair beneficial uses
- SQ-2: For dredged material proposed to be placed at upland placement sites, an elevation of soil chemical concentrations above USEPA PRGs for ecological or residential use, or above background concentrations found in Delta soil

3.1.3.4 Impacts and Mitigation Measures

SQ-1: Exposure of a new surface after dredging that has chemical concentrations at levels likely to cause unacceptable additional risk over existing conditions to aquatic organisms, or likely to impair beneficial uses

Future without Project Conditions (NEPA and CEQA Baseline)

Sedimentation is an ongoing, natural process within the SRDWSC and the United States' waterways in general. Consequently, regular maintenance dredging is required to maintain the SRDWSC. Under Future without Project Conditions, regular maintenance dredging would continue to occur as it has relative to current requirements for the -30 feet MLLW channel. Table 26 summarizes the sediment testing results of maintenance dredged material from 2000 to 2007. Future maintenance dredging would maintain the SRDWSC at a 30-foot depth; therefore, new exposed sediments would likely contain concentrations similar to those found during recent dredged material characterization activities. Recent sampling events have found concentrations of zinc, chromium, copper, and nickel in exceedance of the

WDR criteria. However, despite these exceedances, the Central Valley RWQCB has continued to issue permits to dredge every year from 2000 to 2009 because the exceedances were found to be relatively minor and insignificant. It is anticipated maintenance dredging under Future without Project Conditions would encounter similar results with no unacceptable risk over existing conditions. Continued maintenance dredging would not likely cause any risk over existing conditions to aquatic organisms nor would it cause impairment to beneficial use. Therefore, no impacts to sediment quality are expected under Future without Project Conditions.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: None.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

Assuming a conservative estimate of 2 feet of allowable overdepth, the Proposed Project would expose sediments between -35 and -37 feet MLLW. Sediment cores were collected at each RM within the study area for planning purposes in 2009. Although discrete data for the -33 to -35 foot MLLW interval do not exist from the sediment core analysis completed in 2009, it is expected that concentrations located in this interval would be similar to those located between -35 and -37 feet MLLW.

Newly exposed sediments as part of future maintenance dredging would likely contain concentrations similar to those found during recent dredged material characterization activities. Recent sampling events have found concentrations of arsenic, chromium, nickel, and benzo(a)pyrene in exceedance of the sediment quality criteria (Table 27). Despite these exceedances, the Central Valley RWQCB has continued to issue permits to dredge every year from 2000 to 2009 as the exceedances were found to be relatively minor. To determine whether the post-dredge surface would be similar to, less contaminated than, or more contaminated than the pre-dredged material, metals results for the Proposed Project's post-dredge surface (i.e., discrete) sediment samples were compared to the existing surface (i.e., composite) sediment samples collected within the same RM[15]. Results were evaluated using a relative percent difference (RPD) calculation, which is the difference between two results divided by the average of the results. RPD values were not calculated for non-detected results or results near or below the reporting limit. The difference was considered significant if the following criteria were met: 1) the RPD value exceeded 50 percent, with the discrete sample result being greater than the composite sample result; and 2) the discrete sample result exceeded sediment quality criteria described in Appendix M when the corresponding sediment composite sample result did not exceed the same sediment quality criteria.

[15] Sediment cores were collected at each RM within the study area for planning purposes in 2009. Cores were advanced to -37 feet MLLW. Discrete (-35 to -37 feet MLLW) and composite (mudline to -35 feet MLLW) samples from each core were analyzed for metals.

Table 29 shows the specific metals within discrete samples with concentrations in exceedance of corresponding composite sample metal concentrations and sediment quality criteria. Yellow highlights in the table indicate metals in post-dredge (discrete) samples in exceedance of Appendix M sediment quality criteria that were not in exceedance in pre-dredge (composite) sediment samples.

Table 29
Metals within Discrete Samples with Concentrations in Exceedance of Corresponding Metal Concentrations within Composite Samples and Sediment Quality Criteria[1]

River Mile	Metals Elevated in Discrete Relative to Composite Samples[2]
1	None
2	aluminum, barium, copper, mercury, vanadium, zinc
3	arsenic, molybdenum
4	None
5	None
6	None
7[3]	calcium (2), potassium
8	Sodium
9	None
10	None
11	aluminum, vanadium
12	None
13	None
14	None
15	None
16	Manganese
17	Manganese
18	None
19	Manganese
20	None
21	None
22	None
23	Lead
24	None
25	None
26	None
27	Calcium
28	None
29	None
30	None
31[3]	mercury (2), magnesium
32	None
33	None
34	None
35	None

Notes

1. Based on RPD greater than 50% only for cases where discrete metal concentration is greater than composite metal concentration within a specific RM
2. Yellow highlights indicate metals in post-dredge (discrete) samples in exceedance of Appendix M sediment quality criteria that were not in exceedance in pre-dredge (composite) sediment samples
3. There is more than one exceedance within this RM, as indicated within parentheses, because there was more than one composite sample

A total of 20 metals results at 11 locations were significantly higher within the discrete sample than the corresponding composite sample, based on the RPD criteria described above. However, of the Proposed Project's post-dredge (i.e., discrete) sample results, only two metals exceeded sediment quality criteria that were not exceeded in the corresponding pre-dredge (i.e., composite) samples. The two exceedances are as follows: the lead concentration at RM 23.0, which exceeded the sediment maximum value from previous maintenance dredging material evaluations; and the mercury concentration at RM 31.0, which exceeded sediment quality criteria. As described in detail in Appendix M, a review of the literature indicates that bioaccumulation levels of lead in aquatic organisms (0.5 to 2.5 mg/kg) exposed to lead-contaminated sediments (at concentrations ranging from 20 to 150 mg/kg) are well below levels shown to cause detrimental effects on aquatic organisms. Similarly, bioaccumulation levels of mercury in aquatic organisms (0.02 to 0.52 mg/kg) exposed to mercury-contaminated sediments (at concentrations ranging from 0.01 to 1.1 mg/kg) are well below levels shown to cause detrimental effects on aquatic organisms.

These results indicate that the newly exposed surface after dredging would not likely cause any additional risk over baseline conditions to aquatic organisms nor would it cause impairment to beneficial use. Thus, as compared to the environmental baseline, there would be less than significant incremental impacts to sediment quality as a result of the Proposed Project.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

Assuming a conservative estimate of 2 feet of allowable overdepth, the -33 Feet MLLW Alternative would expose sediments between -33 and -35 feet MLLW. Although discrete data for this depth interval do not exist from the sediment core analysis completed in 2009, it is expected that concentrations would be similar to those from between -35 and -37 feet MLLW. As with the Proposed Project, newly exposed sediments as part of future maintenance dredging would likely contain concentrations similar to those found during recent dredged material characterization activities. Recent sampling events have found concentrations of arsenic, chromium, nickel, and benzo(a)pyrene in exceedance of the sediment quality criteria (Table 27). Despite these exceedances, the Central Valley RWQCB has continued to issue permits to dredge every year from 2000 to 2009 because the exceedances were found to be relatively minor. Discrete sediment samples, indicative of the future post-dredge surface, demonstrated elevated lead and mercury at RMs 23.0 and 31.0 in exceedance of sediment quality criteria. However, as described under the Proposed Project, concentrations of these metals are well below those levels shown to cause detrimental effects to aquatic organisms. It is anticipated that dredging to -33 feet MLLW would encounter similar results with no unacceptable risk over existing conditions and no impairment of beneficial use. Thus, as compared to the environmental baseline, there would be less than significant incremental impacts to sediment quality as a result of the -33 Feet MLLW Alternative.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

SQ-2: For dredged material proposed to be placed at upland placement sites, an elevation of soil chemical concentrations above USEPA PRGs for ecological or residential use, or above background concentrations found in Delta soil

Future without Project Conditions (NEPA and CEQA Baseline)

Sediment exceedances of metals criteria, specifically chromium, mercury, and nickel, as well as an isolated exceedance of benzo(a)pyrene criteria, were identified during sampling in the portions of Reaches 2 through 5 of the SRDWSC requiring dredging from 2000 to 2007 (Table 26). Recent sampling events have found concentrations of zinc, chromium, copper, and nickel in exceedance of the sediment quality criteria (Table 27). However, despite these exceedances, when factoring in natural attenuation at the existing placement sites, the Central Valley RWQCB has continued to issue permits to conduct maintenance dredging every year from 2000 to 2009 because the exceedances were found to be relatively minor. Sediment quality of the removed material was, and is anticipated to remain, acceptable for placement and no unacceptable contamination of soils is anticipated to occur at the existing dredged material placement sites under continued maintenance dredging. Thus, no impacts to soil quality at the proposed dredged material placement sites are expected under Future without Project Conditions.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: None.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

Under the Proposed Project, dredged material would be placed at any of the ten upland dredged material placement sites identified in Section 2.2.2.2. As is noted above, sediment cores collected at each RM within the study area were advanced to the depth of 37 feet

MLLW to account for the overdepth. Analytical results of composite samples were compared to sediment quality criteria (based on USEPA PRGs for ecological or residential use) and are summarized in Table 27. Only one composite sample exceeded sediment quality criteria across all analytes: a sample collected between RMs 16.0 and 18.0 had benzo(a)pyrene concentrations at 133 μg/kg. The WDR criteria for benzo(a)pyrene is 62 μg/kg. A similar benzo(a)pyrene exceedance of 200 μg/kg was observed during testing of maintenance dredged material between RMs 3.0 and 43.0 in 2001; however, dredged material from both of these areas was placed at S20 despite the exceedances. As such, it can be assumed that benzo(a)pyrene concentrations at S20 are already higher than 133 μg/kg. In addition, as described in detail in Appendix M, a review of the literature indicates that bioaccumulation levels of benzo(a)pyrene in aquatic organisms (5.31 to 440 μg/kg) exposed to benzo(a)pyrene-contaminated sediments (at concentrations ranging from 32 to 1,570 μg/kg) are well below those levels shown to cause detrimental effects to relevant species. These results indicate that material removed during dredging would not likely cause any additional risk over baseline conditions to aquatic organisms nor would it cause impairment to beneficial use. Thus, as compared to the environmental baseline, there would be less than significant impacts to soil quality at the proposed dredged material placement sites as a result of the Proposed Project.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

Although the 2009 composite samples were not taken exclusively between the mudline[16] and -33 feet MLLW, dredged material concentrations under the -33 Feet MLLW Alternative would be expected to be similar to the Proposed Project. Results of the composite samples are summarized above. As described above, dredged material from RMs 16.0 and 18.0, where the benzo(a)pyrene exceedance was observed, would be placed at S20, where maintenance dredged material containing 200 μg/kg benzo(a)pyrene has previously been placed. In addition, as described in Appendix M, a review of the literature indicates that bioaccumulation levels of benzo(a)pyrene in aquatic organisms (5.31 to 440 μg/kg) exposed to benzo(a)pyrene-contaminated sediments (at concentrations ranging from 32 to 1570 μg/kg) are well below those levels shown to cause detrimental effects to relevant species. These results indicate that material removed during dredging would not likely cause any additional risk over baseline conditions to aquatic organisms nor would it cause impairment to beneficial use. Thus, as compared to the environmental baseline, there would be less than significant impacts to soil quality at the proposed dredged material placement sites as a result of the -33 Feet MLLW Alternative.

[16] Mudline is defined as the ground surface.

Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: The residual impact would be less than significant.

3.1.3.4.1 Summary of Impacts and Mitigation Measures

Table 30 summarizes the impact determinations, mitigation measures, and residual impacts after mitigation, if applicable, for each alternative with respect to the sediment quality impacts described above.

Table 30
Summary of Sediment Quality Impacts and Mitigation Measures

Alternative	Impact	Mitigation	Residual Impact After Mitigation
SQ-1: Exposure of a new surface after dredging that has chemical concentrations at levels likely to cause unacceptable additional risk over existing conditions to aquatic organisms, or likely to impair beneficial uses			
Future without Project Conditions (NEPA and CEQA Baseline)	No impact	None	None
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	Less than significant impact	None	Less than significant impact
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	Less than significant impact	None	Less than significant impact
SQ-2: For dredged material proposed to be placed at upland placement sites, an elevation of soil chemical concentrations above USEPA PRGs for ecological or residential use, or above background concentrations found in Delta soil			
Future without Project Conditions (NEPA and CEQA Baseline)	No impact	None	None
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	Less than significant impact	None	Less than significant impact
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	Less than significant impact	None	Less than significant impact

3.1.4 Water Quality

This section provides baseline water quality conditions including flow, constituents of concern, turbidity, nutrients, dissolved oxygen (DO), and salinity, and assesses potential impacts to water quality from the Proposed Project and alternatives.

3.1.4.1 Baseline Conditions

The Delta is a maze of river channels and diked islands covering roughly 738,000 acres with hundreds of miles of interlaced waterways. It serves as a water supply source for about 23 million people in California. The Sacramento River contributes approximately 62% of the total average annual inflow to the Delta.

3.1.4.1.1 Flow Discharge Rate

The Sacramento River contributes approximately 62% of the total average annual inflow to the Delta. The flow discharge rate, or the volume of water being moved over a given amount of time, at a particular river location can be directly computed from the average flow velocity multiplied by the river cross-section area at the location. As described in Section 3.1.2.1.3 and Appendix J, water velocities in the upstream reaches of the study area appear to be considerably slower than in the downstream reaches. Summer and winter discharge rates in the lower reaches of the study area are significantly higher than discharge rates in the man-made portion of the SRDWSC. Discharge rates in the man-made portion of the channel can vary in response to the magnitude of precipitation-induced water inflows from the drainage basins, particularly in winter months.

Minimal freshwater inputs, except rainwater runoff, exist in the man-made portion of the SRDWSC. Lower portions of the SRDWSC (Reaches 1, 2, and 3) are influenced by Sacramento River tributaries and tidal cycles.

3.1.4.1.2 Constituents of Concern

Water quality standards developed to meet Clean Water Act (CWA) and California Water Code requirements are contained in the State Water Resources Control Board (SWRCB) and Central Valley Regional Water Quality Control Board (RWQCB) *Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin* (Basin Plan; Central Valley RWQCB 2006). The Basin Plan identifies beneficial uses, water quality objectives, and implementation programs for waters within the Central Valley Basin. Beneficial uses identified in the Basin Plan for Delta surface water include: municipal and domestic supply, agricultural uses, industrial process supply, industrial service supply, body contact and other non-body contact recreation, warm and cold freshwater aquatic habitat, warm and cold water fish migration habitat, warm water spawning habitat, wildlife habitat, and navigation (Central Valley RWQCB 2006).

California Department of Water Resources (DWR) and Interagency Ecological Program (IEP) operate several water quality monitoring sites within and near the study area. Based on data collected at these monitoring sites and additional analyses mandated by the Basin Plan, the SWRCB and the Central Valley RWQCB have found Delta waters to contain sufficient concentrations of various pollutants that are in violation of water quality standards. As such, the standard of water quality for beneficial uses identified within the Delta is not being met. As a result of these violations of the CWA, the Central Valley RWQCB has developed and continues to develop Total Maximum Daily Load (TMDL) programs in an effort to control pollutants from their sources, which include municipal, domestic, industrial, and agricultural wastewater and stormwater.

In accordance with the Central Valley RWQCB's 303(d) list from 2006 and proposed changes to the list as indicated in the Central Valley RWQCB's 2009 Staff Report (Central Valley RWQCB 2009), the water quality of the northern and central Delta, but not necessarily within the SRDWSC, is impaired by excessive levels of the constituents described below.

Diazinon and Chlorpyrifos – Approximately 1 million pounds of these insecticide active ingredients were historically applied on Delta stonefruit and almond orchards during winters. Typically, the highest concentrations and longest exposures of diazinon and chlorpyrifos in surface water were in small water courses adjacent to high densities of orchards; however, after large storm events, pulses of diazinon and chlorpyrifos with concentrations high enough to affect sensitive invertebrate species were observed throughout the Delta (Central Valley RWQCB 2006). In 1998, the Central Valley RWQCB concluded that the occurrences of diazinon and chlorpyrifos in the Delta fit the recommended criteria for listing as high priority candidate toxic hot spots. In 2006, a Basin Plan Amendment for the control of diazinon and chlorpyrifos runoff and establishment of a TMDL in the Delta was approved and became effective as of October 2007.

Dichloro diphenyl trichloroethane (DDT) – DDT is one of the most well-known synthetic pesticides. DDT is both toxic to, and bioaccumulates in, fish, thereby posing a threat to the health of those who consume Delta fish as food. In accordance with the 303(d) list from 2006, the Central Valley RWQCB anticipates a TMDL for DDT will be established by 2011.

Invasive Species – In accordance with the 303(d) list from 2006, the Central Valley RWQCB anticipates a TMDL for invasive species (referred to by the Central Valley RWQCB as *exotic species*) will be established by 2019.

Polychlorinated biphenyls (PCBs) – In accordance with the 303(d) list from 2006, the Central Valley RWQCB anticipates a TMDL for PCBs will be established by 2019.

Unknown Toxicity – In accordance with the 303(d) list from 2006, the Central Valley RWQCB anticipates a TMDL for unknown toxicity will be established by 2019.

Group A Pesticides – Group A pesticides are documented downstream of agricultural fields where they are applied. In accordance with the 303(d) list from 2006, the Central Valley RWQCB anticipates a TMDL for Group A pesticides will be established by 2011.

Mercury – A human health advisory is in effect in the Delta because of elevated mercury levels in striped bass (*Morone saxatilis)* and other long-lived fish (Davis et al. 1999). Mercury levels are elevated due to historic hydraulic gold mining (Daskalakis and O'Conner 1995), which used it in processing. In addition, large amounts of mercury were transported across the valley and used in placer and lode gold mining in the Sierra Nevada Mountains between 1850 and 1890. Much of this mercury was washed into the study area by the Sacramento River and its tributaries. Other identified sources of mercury are from the resuspension of estuarine sediment and effluent from municipal and industrial discharges to surface water (Davis et al. 1999). Two forms of mercury are of concern: inorganic mercury and methylmercury. The Central Valley RWQCB is currently developing a TMDL for mercury levels to meet water quality standards for the Delta (Central Valley RWQCB 2008). Mercury occurs naturally in the aquatic sediment and soil in the project area.

3.1.4.1.3 Methylmercury

Methylmercury is formed by bacterial action from inorganic mercury. Methylation and demethylation are complicated processes and can occur simultaneously (LTMS 2010). While this process is not well understood, the rates of methylation and total abundance of methylmercury are highest in shallow natural aquatic systems (such as wetlands) with low levels of oxygen. Methylmercury can be toxic to humans, fish, and wildlife and is of particular concern because it may bioaccumulate (be present in successively increasing quantities higher in the food chain) and cause sub-lethal effects.

Various studies conducted in the San Francisco Bay and Delta area have examined the relation between mercury, methylmercury, and bioaccumulation (LTMS 2010). These studies report that methylmercury production rates, transport, and bioaccumulation vary greatly across a large range of spatial and temporal scales and are related to the quantity of organic material in the water and sediment, light level, hydroperiod, and naturally occurring chemicals such as iron and sulfur compounds.

The presence of methylmercury in the water in dredged material placement sites has generated recent attention. Methylmercury may accumulate in wildlife directly, from water in the placement sites, or indirectly, after water is released. A recent symposium on dredging operations and methylmercury was conducted by the San Francisco Bay Long Term Management Strategy (LTMS) summarizing previous and ongoing pertinent research (LTMS 2010). The interim conclusion was that although there is some cursory knowledge on the relation between some environmental factors and methylation rates, the state of the science is not sufficient to promulgate best management practices (BMPs) for minimizing methylation.

As part of an exploratory study, the quantity of methylmercury at S31 was monitored during the 2009 maintenance dredging of the SRDWSC. The purpose of the sampling effort was to determine whether dredged material placement sites produce methylmercury that could be discharged back into Delta water and whether longer holding of dredge slurry water at a site would reduce the amount of methylmercury that could be discharged. Water samples were collected and analyzed for methylmercury, total mercury, total organic carbon (TOC), and suspended sediment concentrations. Additionally, other water quality parameters known to influence methylation were measured including oxidation/reduction potential, DO, temperature, pH, and conductivity (Applied Marine Sciences 2010). In the study, rates of methylmercury in the water in dredged material placement sites increased. However, baseline data on both potential receiving water (SRDWSC) and natural occurrences (e.g., rainfall events) was not covered by this initial effort. Further work on the relationship between dredging and methylation will be conducted for maintenance dredging operations and a separate pilot project is being planned with the Central Valley RWQCB. It is expected that results of these studies will be available in spring 2011.

3.1.4.1.4 Project-Specific Water Quality Sampling Results

A water quality sampling effort was conducted on March 13, 2009, to quantify certain baseline water quality parameters (pH, temperature, turbidity, DO, and salinity) within the study area. Sampling locations are shown on Figure 14. A summary of the findings of this sampling event are presented below. This information was used to quantify potential impacts of the Proposed Project and alternatives.

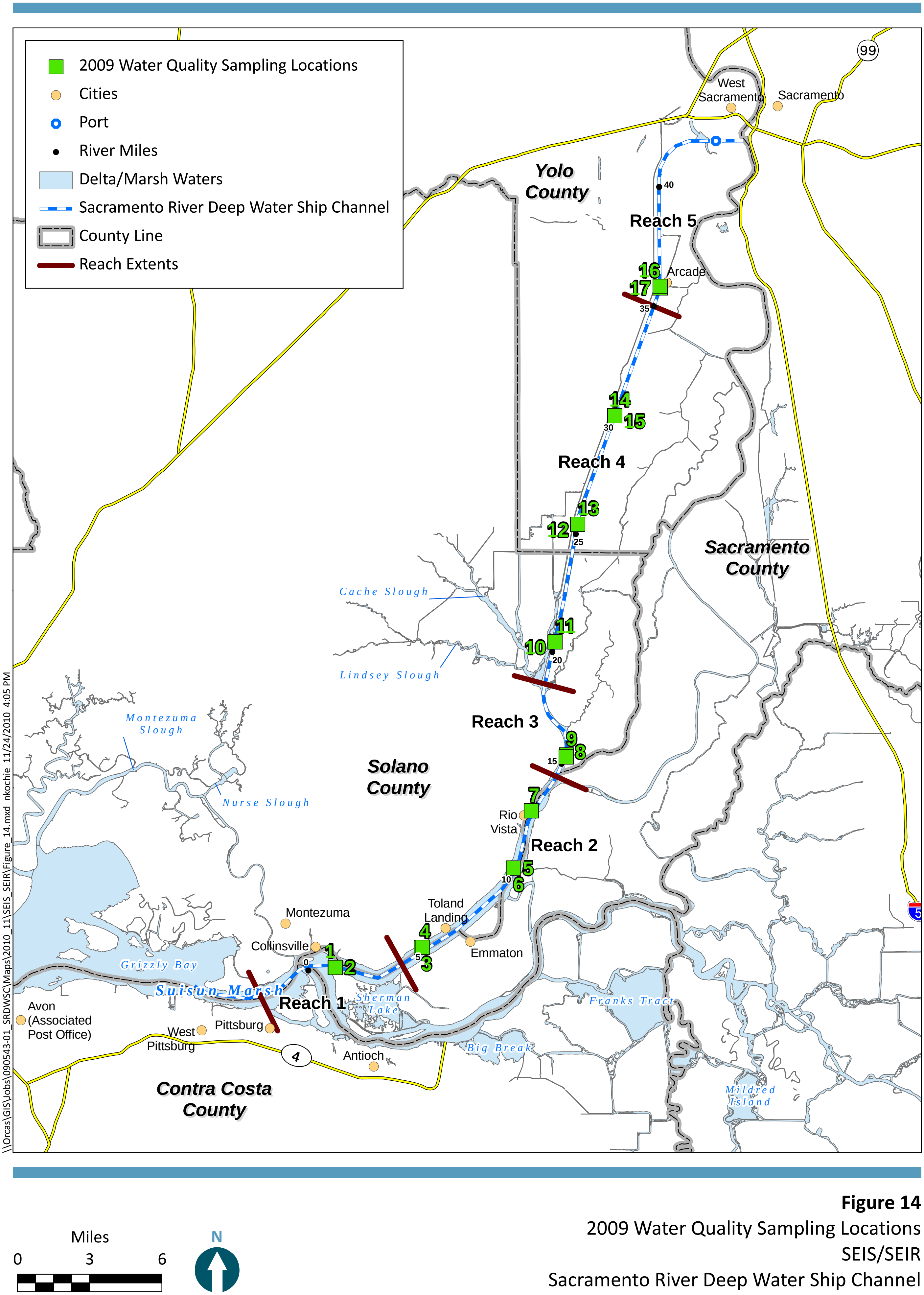


Figure 14
2009 Water Quality Sampling Locations
SEIS/SEIR
Sacramento River Deep Water Ship Channel

pH – The average pH levels of the study area waters were generally within the state standards for pH, which require levels to be within 6.5 to 8.5. Average pH levels ranged as follows: from 6 to 7 in Reach 1, from 7 to 8 in Reaches 2 through 4, and from just less than 5 to greater than 8 in Reach 5.

Temperature – The mean high and low temperatures of the study area waters differed by 1.54 degrees Celsius (°C). Reaches 1 through 3 all had temperatures of 12.35°C, while Reaches 4 and 5 had temperatures of 13.89°C. It should be noted that these temperatures were measured over a discrete interval, and wider daily and seasonal fluctuations are anticipated.

Turbidity – The average surface-level (0 to -1 foot MLLW) turbidity within the study area varied greatly, whereas subsurface level (-1 to -40 feet MLLW) turbidity measurements were greater than 30 Nephelometric Turbidity Units (NTU) throughout all reaches of the study area. The average surface and subsurface turbidity levels at each of the sampling locations on Figure 14 are provided in Table 31.

Table 31
Average Surface and Subsurface Turbidity

Sampling Location	Surface-Level Turbidity (NTU)	Subsurface-Level Turbidity (NTU)
1	0.78	42.13
2	26.90	35.04
3	12.68	93.73
4	16.82	45.25
5	58.50	19.28
6	12.60	23.46
7	1.40	15.70
8	11.10	18.37
9	9.84	20.50
10	N/A	36.79
11	22.53	36.48
12	24.00	26.03
13	7.45	20.27
14	16.30	70.31
15	42.31	17.65
16	0.41	24.67
17	1.30	37.87

Dissolved Oxygen – DO is the amount of oxygen dissolved in water. When DO levels decrease, it can result in significant impacts to fish and aquatic species that are reliant on DO to survive. According to the March 2009 sampling results, DO levels varied in the study area during that period, but were at healthy levels and consistently above the state water quality standard of a minimum of 5.0 milligrams per liter (mg/L). The average surface and subsurface DO levels at each of the sampling locations on Figure 14 are provided in Table 32.

Table 32
Average Surface and Subsurface DO

Sampling Location	Surface-Level DO (mg/L)	Subsurface-Level DO (mg/L)
1	10.19	10.18
2	10.06	10.11
3	10.18	10.21
4	9.96	10.06
5	9.87	9.97
6	10.05	10.10
7	12.68	10.20
8	9.98	10.04
9	9.81	9.85
10	N/A	10.22
11	9.75	10.17
12	11.22	10.34
13	10.72	11.28
14	11.45	11.62
15	10.76	11.29
16	10.88	11.31
17	11.41	11.65

Salinity – Electrical conductivity levels are an indicator of salinity; the higher the conductivity level, the greater the salinity. Salinity levels measured in the March 2009 sampling effort at the sampling locations on Figure 14 are provided in Table 33. Conductivity levels are provided Table 34. It appears that the data were affected by a rain event that led to dilution and lower than normal salinity levels in the lower reaches of the study area, where there are more freshwater inputs.

Table 33
Average Surface and Subsurface Salinity Levels

Sampling Location	Surface-Level Salinity (ppt)	Subsurface-Level Salinity (ppt)
1	0.02	0.14
2	0.13	0.14
3	0.05	0.14
4	0.11	0.14
5	0.09	0.15
6	0.05	0.15
7	0.02	0.16
8	0.04	0.14

Sampling Location	Surface-Level Salinity (ppt)	Subsurface-Level Salinity (ppt)
9	0.05	0.16
10	N/A	0.22
11	0.17	0.24
12	0.34	0.34
13	0.18	0.36
14	0.26	0.46
15	0.08	0.48
16	0.10	0.60
17	0.23	0.59

Notes:
ppt = parts per thousand

Table 34
Average Surface and Subsurface Conductivity Levels

Sampling Location	Surface-Level Conductivity (mS/cm)	Subsurface-Level Conductivity (mS/cm)
1	0.03	0.22
2	0.21	0.22
3	0.08	0.22
4	0.17	0.22
5	0.14	0.24
6	0.08	0.23
7	0.03	0.25
8	0.06	0.23
9	0.08	0.26
10	N/A	0.34
11	0.27	0.37
12	0.52	0.52
13	0.30	0.56
14	0.40	0.69
15	0.12	0.73
16	0.17	0.91
17	0.35	0.90

Notes:
mS/cm = microSiemens per centimeter

Based on historic measurements of electrical conductivity at the monitoring stations in the study area, salinity levels in the downstream reaches of the SRDWSC are much higher than the upstream reaches (Appendix J). Furthermore, upstream winter conductivity values were slightly higher than corresponding summer conductivity values. Specific to the March 2009 sampling results, it appears that the increased salinity during late fall and early winter is related to increased Delta outflow, which enhances mixing and increases salinity intrusion. Decreased salinity intrusion in the summer is related to reduced Delta outflows commonly occurring during the dry season.

3.1.4.1.5 Nutrients

When discussing water quality, the term "nutrients" typically refers to nitrogen and phosphorus. Plants and animals are mostly made up of compounds of macronutrients, which include carbon, hydrogen, oxygen, nitrogen, and phosphorus, and lesser amounts of sulfur, potassium, magnesium, and calcium. Plants obtain carbon, hydrogen, and oxygen from the air and water, where all three elements are abundant (as water and carbon dioxide [CO_2]). Therefore, when discussing water quality, the term "nutrients" refers to those elements that are necessary for plant growth but are likely to be limiting (i.e., plant growth stops when they are used up). Nitrogen and phosphorus are the most likely macronutrients to become limiting in aquatic environments.

Farmers apply fertilizer nutrients in the form of nitrogen, phosphorus, and potassium to prevent these elements from becoming limiting in the soil, and these nutrients may eventually enter the SRDWSC as runoff. In addition, these elements become concentrated in wastewater discharges and can promote aquatic plant and algal growth to an excessive extent. Nitrogen can be used by aquatic plants if it is dissolved in the water in an inorganic form, such as nitrates or nitrites, which is a combination of nitrogen and oxygen, or ammonia, a combination of nitrogen and hydrogen. High levels of ammonia were documented in and around the study area, and are believed to stimulate the growth of phytoplankton. The sources of high ammonia contributions are likely wastewater treatment plants (primarily the Sacramento Regional Wastewater Treatment Plant) and, to a lesser extent, agricultural run-off from the use of nitrogenous fertilizers (CALFED 2009).

Excessive aquatic plant nutrients in the form of nitrogen and phosphorus compounds are causing and/or contributing to water quality issues in the Delta. These issues include:

- Excessive growth of algae causes severe taste and odor problems for domestic water utilities that use Delta water as a raw water source, which then requires additional expenditure for water treatment. Harmful algal blooms may be caused by a combination of high nutrient concentrations and warm temperatures. The harmful algae compete with and may exclude diatoms and dinoflagellates, thus reducing primary production. Harmful algal blooms can produce powerful toxins that kill fish, shellfish, mammals, and birds, and may directly or indirectly cause illness in people. *Microcystis aeruginosa* (a common species of cyanobacteria) is an invasive alga that is common in the Delta during warmer months and may contribute to a reduction in copepod productivity (Lehman and Waller 2003).
- Excessive growths of water hyacinth (*Eichhornia crassipes*) and Brazilian elodea (*Egeria densa*), two highly invasive aquatic species, cause ecological impacts, impair

recreational use of the Delta, and require herbicides to control (thus adding to water quality concerns).

- Nutrient-rich waters may lead to increases in algal growth, which can reduce DO levels from respiration and decomposition.

3.1.4.1.6 Prior Maintenance Dredging Approvals and Use of a Mixing Zone

The Central Valley RWQCB adopted Waste Discharge Requirement (WDR) General Order No. 5-01-116 in 2001 for maintenance dredging of the SRDWSC. The WDR includes limitations and monitoring requirements for dredging, discharge of dredged materials into placement sites, and effluent from placement sites. The WDR allows the use of a "mixing zone" to determine compliance with discharge requirements. The mixing zone is defined as a volume of receiving water that is allocated for mixing with a wastewater discharge where water quality objectives and criteria may be exceeded without causing adverse effects to the overall waterbody. The mixing zone requirements in the WDR include a length of 300 feet and a maximum cross-section of 50% of the receiving waters (WDR 5-01-116), as well as other limitations and prohibitions on discharges. The Central Valley RWQCB considers the mixing zone when evaluating the results of elutriate testing and determining if discharges of constituents of concern would violate any water quality standards, as discussed below.

3.1.4.1.7 Water Quality Data Derived from Dredged Material Elutriate Testing

Elutriate runoff from dredged material in the form of effluent and leachate has the potential to impact surface and groundwater quality. The Modified Elutriate Test (MET) and Deionized Water-Waste Extraction Test (DI-WET) were used to test effluent and leachate concentrations, respectively, from dredged material. Elutriate testing was performed on maintenance dredging material between 2001 and 2007 as well as sediment cores collected for this SEIS/SEIR in 2009. Results of these tests are summarized below.

Prior Maintenance Dredging Elutriate Testing

Dredging operations have the potential to impact surface water quality through suspended sediment during dredging and effluent runoff from placed material. MET and DI-WET tests were performed for heavy metals on sediment removed during maintenance dredging between 2001 and 2007. Results are compared to sediment testing criteria in Table 26. Seven of nine metals tested in the DI-WET analysis and five of nine metals tested in the MET analysis showed exceedances of the WDR criteria. DI-WET mean and median concentrations for copper, lead, and mercury, as well as the MET mean mercury concentration, exceeded the WDR thresholds. Mercury was the only Sacramento River constituent of concern analyzed in the MET and DI-WET tests. The Central Valley RWQCB allows for consideration of a mixing zone in each case to address potential exceedances.

2009 Elutriate and Leachate Testing

For planning purposes, in 2009, sediment cores were taken at each RM within the channel. Details of the sediment sampling activities are provided in Section 3.1.3. A total of 44 sediment composite samples were created from these cores. These composite samples represented the material that would be dredged during channel deepening to the project depth of 35 feet MLLW (plus 2 feet allowable overdepth). MET and DI-WET tests were performed on the composite samples to represent elutriate concentrations during dredging to the Proposed Project depth.

MET tests were performed on the composite samples to represent potential elutriate and leachate concentrations during placement and within the placement site, respectively, as part of the Proposed Project depth. Specifically, MET samples were used to predict the quality of effluent likely to be discharged from confined placement sites during placement operations. DI-WET samples provide an indication of the concentrations in the potential leachate from the mass of the confined dredged material in combination with attenuation in the vadose zone[17] below the dredged material.

Conventional parameters (i.e., ammonia, biological oxygen demand, chloride, TOC, total dissolved solids [TDS], total suspended solids [TSS], conductivity, and pH), metals, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, organophosphorous pesticides, PCB Aroclors, and oil and grease were measured in MET samples. TOC, total solids, metals and methylmercury were measured in DI-WET samples. MET and DI-WET chemistry results were compared to their corresponding criteria established in WDR No. 5-01-116 issued by the Central Valley RWQCB (2001). While this sampling effort was done in support of this SEIS/SEIR, comparison criteria were used as a point of reference to evaluate potential impacts due to dredging. Results were also compared to maximum MET and DI-WET chemical concentrations provided in the Notices of Intent (NOIs) from previous pre-dredge sampling in the SRDWSC (Appendix M). Barium concentrations in MET samples were compared to the Central Valley Basin Plan effluent discharge limit for barium (100 µg/L) in the dissolved fraction.

Modified Elutriate Test Chemistry

The MET chemistry results showing exceedances of listed criteria are summarized in Table 35.

[17]The vadose zone is defined as the aerated region of soil above the permanent water table.

Table 35
Chemical Constituents that Exceeded Criteria in MET Samples During 2009 Baseline Sampling

Analyte	Maximum Value from Previous Pre-Dredge Studies (2000 - 2007)	WDR No. 5-01-116 Criteria	Central Basin Plan Effluent Discharge Limit	2009 Range of Concentration of Exceedances/ No. Samples Exceeding Criteria
Arsenic (µg/L)	10.3	10	--	12.9-23.3/2
Barium (µg/L)	--	--	100	111-910/21
Copper (µg/L)	13.4	10	--	10.5-26.3/3
Lead (µg/L)	11	2.5	--	4.3-5.9/2
Mercury (µg/L)	0.865	0.05	--	0.06-0.2/12
Selenium (µg/L)	4.1	5	--	4.4-15/8
Benzo(a)pyrene (µg/L)	--	0.0044	--	0.005-0.008/6
Benzo(b)flouranthene (µg/L)	--	0.0044	--	0.005-0.008/5
Chrysene (µg/L)	--	0.0044	--	0.006-0.008/4
Indeno(1,2,3-c,d)pyrene (µg/L)	--	0.0044	--	0.006-0.01/6
Oil and Grease (mg/L)	--	5	--	9-45.5/31
Ammonia (mg/L)[1]	--	--	--	0.3-42.3/39
Biochemical Oxygen Demand (mg/L)[1]	--	--	--	2.1-7.7/32
Chloride (mg/L)	--	106	--	113-2740/15
Total Dissolved Solids (mg/L)	--	450	--	452-5050/20
Conductivity (mS/cm)	--	0.7	--	0.705-9.03/20

Note:
1 No criteria for these analytes; samples elevated relative to site water within the same RM (Appendix M)
-- = no corresponding criteria

Conventional Parameters

- Ammonia concentrations in 39 samples were higher than corresponding site water concentrations, ranging from 0.3 to 42.3 mg/L.
- Biochemical oxygen demand concentrations in 32 samples were higher than corresponding site water concentrations, ranging from 2.1 to 7.7 mg/L.
- Chloride concentrations in 15 samples exceeded the corresponding WDR criteria (106 mg/L), ranging from 113 to 2,740 mg/L.
- TDS concentrations in 20 samples exceeded the corresponding WDR criteria (450 mg/L), ranging from 452 to 5,050 mg/L.
- Conductivity results in 20 samples exceeded the corresponding WDR criteria (0.7 mS/cm), ranging from 0.705 to 9.03 mS/cm.

Metals

MET metals, including arsenic, barium, copper, lead, mercury, and selenium, were detected at concentrations that exceeded the maximum value from previous dredge studies and/or the corresponding WDR criteria. Barium was detected at a concentration that exceeded criteria from the Central Valley Basin Plan (criteria only applies to barium).

- Arsenic concentrations in two samples exceeded the maximum value from previous dredge studies (10.3 µg/L) and the WDR criteria (10 µg/L), ranging from 12.9 to 23.3 µg/L.
- Barium concentrations in 21 samples exceeded the criteria from the Central Valley Basin Plan (100 µg/L), ranging from 111 to 910 µg/L.
- Copper concentrations in three samples exceeded the maximum value from previous dredge studies (13.4 µg/L) and the WDR criteria (10 µg/L), ranging from 10.5 to 26.3 µg/L.
- Lead concentrations in two samples exceeded the WDR criteria (2.5 µg/L), ranging from 4.3 to 5.9 µg/L.
- Mercury concentrations in 12 samples exceeded the WDR criteria (0.05 µg/L), ranging from 0.06 to 0.2 µg/L.
- Selenium concentrations in eight samples exceeded the maximum value from previous dredge studies (4.1 µg/L) and/or the WDR criteria (5 µg/L), ranging from 4.4 to 15 µg/L.

Organics

MET organics detected at concentrations that exceeded the WDR criteria included five PAHs and oil and grease.

- Benzo(a)pyrene concentrations in six samples exceeded the WDR criteria (0.0044 µg/L), ranging from 0.005 to 0.008 µg/L.
- Benzo(b)fluoranthene concentrations in five samples exceeded the WDR criteria (0.0044 µg/L), ranging from 0.005 to 0.008 µg/L.
- Chrysene concentrations in four samples exceeded the WDR criteria (0.0044 µg/L), ranging from 0.006 to 0.008 µg/L.
- Indeno(1,2,3-c,d)pyrene concentrations in six samples exceeded the WDR criteria (0.0044 µg/L), ranging from 0.006 to 0.01 µg/L.
- Oil and grease concentrations in 31 samples exceeded the WDR criteria (5 mg/L), ranging from 9 to 45.5 mg/L.

Deionized Water – Waste Extraction Test Chemistry

The DI-WET chemistry results showing exceedances of listed criteria are summarized in Table 36.

Table 36
Chemical Constituents that Exceeded Criteria in DI-WET Samples During 2009 Baseline Sampling

Analyte	Maximum Value from Previous Pre-Dredge Studies (2000 - 2007)	WDR No. 5-01-116 Criteria	2009 Range of Concentration of Exceedances/ No. Samples Exceeding Criteria
Arsenic (µg/L)	42.3	10	10.3-15.5/8
Copper (µg/L)	195	10	10.5-46.6/17
Lead (µg/L)	148	2.5	2.8-5.4/6

Metals
None of the DI-WET metals exceeded the maximum concentration detected in previous maintenance dredged material investigations; however, arsenic, copper, and lead were detected at concentrations that exceeded the corresponding WDR criteria.

- Arsenic concentrations in eight samples exceeded the WDR criteria (10 µg/L), ranging from 10.3 to 15.5 µg/L.
- Copper concentrations in 17 samples exceeded the WDR criteria (10 µg/L), ranging from 10.5 to 46.6 µg/L.
- Lead concentrations in six samples exceeded the WDR criteria (2.5 µg/L), ranging from 2.8 to 5.4 µg/L.

3.1.4.2 Methodology for Determining Impacts
Impacts to water quality were evaluated based on the results of project-specific sampling activities and information from past sampling and dredging activities.

3.1.4.3 Thresholds of Significance
An alternative could have an impact on water quality (abbreviated as WQ in the thresholds and mitigation measures in this section) if it would cause the following:

- WQ-1: A violation of water quality standards, including adopted TMDLs, which would impair beneficial uses of water
- WQ-2: Negative impact to groundwater quality from leaching of contaminants or surface water runoff from placement sites

The following thresholds were considered but not analyzed in this Draft SEIS/SEIR.

- **Impacts to drinking water quality at intakes (Mallard Slough, Rock Slough, Old River, Clifton Court Forebay)** – No drinking water intakes exist within the study area; therefore, drinking water would not be affected by any of the alternatives.
- **Impacts on the quantity of water coming through the SRDWSC and continuing downstream** – Minimal freshwater inputs (aside from rainwater runoff and the leak in the William G. Stone Locks) exist in the man-made portion of the SRDWSC. Lower

portions of the SRDWSC (Reaches 1, 2, and 3) are influenced by Sacramento River tributaries and tidal cycles. Therefore, the quantity of water coming through the SRDWSC and continuing downstream would not be affected by any of the alternatives.

3.1.4.4 Impacts and Mitigation Measures

WQ-1: A violation of water quality standards, including adopted TMDLs, which would impair beneficial uses of water

Future without Project Conditions (NEPA and CEQA Baseline)

Sedimentation and resulting maintenance dredging would continue under Future without Project Conditions. Constituents of concern released into the water column may become readily available for absorption or consumption by special status species and also have the potential to affect phytoplankton, plankton, and the benthic environment, which could reduce prey for other species. Once absorbed, many of the constituents of concern, such as methylmercury, selenium, and PCBs, can bioaccumulate up the food chain (USACE 2010h). It is expected that future sediment and water quality evaluations would show similar results to those from the previous maintenance dredging activities. The MET was used to evaluate chemical concentrations in effluent runoff from dredged material during maintenance dredging performed from 2001 to 2007. Five of nine metals (arsenic, cadmium, copper, lead, and mercury) tested in the MET analysis showed exceedances of the WDR criteria in at least one sample. Of those metals, only mercury mean and median concentrations exceeded the WDR criteria. TMDLs are established in the Delta for cadmium, copper, and zinc. Of 30 samples, two cadmium, five copper, and one zinc result exceeded the TMDL. Evaluation of a mixing zone extending 1,000 feet upstream and 300 feet downstream of a given dredging location and not occupying more than 50% of the cross section of the SRDWSC showed that concentrations would not exceed the WDR criteria.

During dredging and the discharge of dredged materials at placement sites, in-situ sediments and associated constituents of concern could be resuspended in the water column, thereby increasing turbidity. Larger plumes and elevated suspension levels typically occur at the bottom closer to the actual dredging action, and sediment plume sizes decrease exponentially with movement away from the dredging site both vertically and horizontally (Bridges et al. 2008; Nightengale and Simenstad 2001). Background concentrations of suspended particulates (and resulting turbidity measurements) also vary as a result of numerous natural and anthropogenic factors including ship traffic, erosion, storms, and seasonality.

A cutterhead dredge is basically a hydraulic suction dredge combined with a rotating cutterhead that cuts through the channel floor. The cutterhead slowly rotates, breaking up consolidated material and effectively guiding the material to the suction pipe. Suspended sediments plumes generated by hydraulic cutterhead dredges are generally limited, and remain in the lower portion of the water column due to the hydraulic action of the dredge that pumps material through a pipeline to the dredged material placement sites. Suspended sediment plumes generated in the immediate vicinity of the dredge are transported by currents to nearby areas until they settle out of the water column (Anchor 2003). The cutting action and turbulence associated with the rotation of the cutterhead resuspends sediments along the bottom of the seafloor. Studies have shown that typical resuspension rates range from less than 0.1% to more than 5%, with cutterhead type equipment producing resuspension rates at the low end of this range (Anchor 2003; Hayes and Wu 2001).

The extent of resuspension is a byproduct of several factors, including physical properties of the sediment, site conditions, nature and extent of debris and obstructions, and operational considerations of the dredge equipment and operator. Levels of suspended sediment are expected to be highest closest to the dredging operations. As distance from dredging operations increases, the amount of suspended sediments in the water column decreases as most material is gravitationally drawn out of the flow field, while some continues to be transferred downstream (Bridges et al. 2008).

Increased suspended sediments can impact aquatic organisms both directly and indirectly. The level of impact to individuals depends on the amount of time an individual is exposed to suspended sediments, the concentration of suspended sediment in the water column, and the composition of the sediments (fine-grained versus course-grained and chemical associations). Suspended sediment and turbidity can affect fish via several mechanisms, including direct mortality, gill tissue damage, physiological stress, and behavioral changes. Behavioral response to suspended sediment can include: avoidance and/or attraction to plumes (some juvenile salmonids and longfin smelt may be attracted to increased suspended sediment plumes to protect them from predation), disruptions in territoriality, alarm reaction, cover abandonment, reduced reaction to prey species, reduced feeding, disruptions in the ability to school, disruptions in spawning, and disruptions in homing and migration (Anchor 2003). Anchor Environmental CA, L.P. (2003) conducted an extensive literature review on the subject of dredging-induced turbidity and potential effects on aquatic organisms; the study concluded that it is very unlikely that TSS levels would reach harmful concentrations as a result of dredging. This result was based on a comparison of the dredging-induced suspended sediment concentrations observed in the field for numerous dredging projects to physical effects of these concentrations as reported in relevant project literature. The comparison indicated that most dredging projects are not expected to produce TSS concentrations in the range documented to cause significant adverse effects to sensitive aquatic biological organisms (Anchor 2003). The length of time it takes for the suspended material to settle, combined with the current direction and velocity, would determine the size and duration of the turbidity plume; however, it is expected that the mixing zone would rapidly return to baseline or pre-construction conditions upon completion of the construction activities. Settling rates are largely determined by the grain size of the suspended material. In addition, cutterhead dredging minimizes turbidity at the dredge location due to the suction of the dredge.

Potential impacts due to dredging also include short-term decreases in DO and increases in nutrients due to resuspension of sediment and sediment-bound organic material. These impacts would be temporary, generally confined to the dredging area, and would return to baseline following construction. Sublethal effects of DO levels below saturation can include metabolic, feeding, growth, behavioral, and productivity effects. Behavior responses can include avoidance and migration disruption (NMFS 2005). Based on a review of six studies on the effects of dredging on DO levels, LaSalle (1988) concluded that, considering the relatively low levels of suspended material generated by dredging operations and counterbalancing factors such as flushing, DO depletion around dredging activities is minimal. A number of other studies reviewed by LaSalle (1988) showed little or no measurable reduction in DO around dredging operations. Simenstad (1988) concluded that because high sediment biological oxygen demand is not common, significant depletion of DO is usually not a factor in dredging operations. A model created by LaSalle (1988) demonstrated that, even in a situation where the upper limit of expected suspended sediment is reached during dredging operations, DO depletion of no more than 0.1 mg/L would occur at depth. Any reduction in DO beyond background should be limited in extent and temporary in nature, and studies by the USACE Dredged Material Research Program (Lee et al. 1978; Jones and Lee 1978) support the notion that localized decreases in DO dissipate rapidly, and are often undetectable only a short distance from the dredge.

After placement of the dredged material slurry at upland placement sites, the water would pass through the site, settling out the solids and clarifying. It would discharge into and mix with the waters of the SRDWSC. The Central Valley RWQCB would authorize a water quality monitoring plan that the contractor, USACE, and the Port would be required to implement. In addition, USACE and the Port would propose a mixing zone and provide documentation to the Central Valley RWQCB that the SRDWSC has assimilative capacity for a mixing zone. The USACE and the Port are required to monitor turbidity, DO, temperature, and pH per the monitoring and reporting requirements set forth in the WDR. The 2008 and 2009 annual dredging water quality monitoring reports prepared by USACE include data on these parameters for maintenance dredging on the SRDWSC. Maintenance dredging in 2008 and 2009 was in compliance with the WDR. The 2008 and 2009 annual dredging water quality monitoring reports are included as Appendix N.

Based on the results of the elutriate testing, an evaluation of dredging-induced turbidity, changes in water quality parameters such as DO, and data collected from 2008 and 2009 maintenance dredging, impacts of ongoing dredging to water quality standards under Future without Project Conditions would be short-term and minor. Dredging and the discharge of large volumes of slurry from placement sites could result in short-term, localized increases in turbidity and dissolved concentrations of constituents of concern, as well as localized changes in DO and nutrient concentrations. However, these increases would be short-term, rapidly returning to baseline conditions, and would not violate WDR standards based on information gathered from past maintenance dredging episodes. Thus, short-term, less than significant impacts to water quality are expected under Future without Project Conditions. The mitigation measure below is proposed to reduce and control the short-term impacts (refer to Table 20 for a complete description of the mitigation measure).

Mitigation Measures:

- WQ-MM-1: Implement standard construction BMPs and requirements of the WDR

Residual Impact after Mitigation: After inclusion of the mitigation measure, the residual impact would be less than significant.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

As part of the 2009 sediment testing, MET tests were performed on 44 composite samples to represent elutriate concentrations during construction of the Proposed Project, including dredging and the placement of dredged material at any of the ten upland placement sites. MET chemistry results were compared to WDR criteria. These results are summarized in Section 3.1.4.1.5 and shown in Table 35. Total petroleum hydrocarbons; metals such as arsenic, copper, lead, mercury, and selenium; and PAHs such as benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-c,d)pyrene exceeded the WDR criteria.

Based on these exceedances, it is expected that the Proposed Project could have temporary, adverse impacts on water quality resulting from dredging and the return of dredged material effluent from placement sites. However, when 2009 MET results are compared to maximum MET chemical concentrations provided in the NOIs for 2001 through 2003 and 2005 through 2007 (USACE 2001, 2002a, 2003a, 2005, 2006a, 2007; Appendix M), impacts to water quality appear similar to past maintenance dredging baseline conditions. Only arsenic, copper, and selenium slightly exceeded maximum concentrations observed in maintenance dredging test results. The remaining six heavy metal concentrations were below maximum values presented in the NOIs. Evaluation of a mixing zone extending 1,000 feet upstream and 300 feet downstream of a given dredging location and not occupying more than 50% of the cross section of the SRDWSC showed that concentrations would not exceed the WDR criteria.

For the reasons described under Future without Project Conditions, dredging and discharge of large volumes of dredged material at the proposed placement sites would result in short-term, localized increases in turbidity and dissolved concentrations of constituents of concern, as well as localized changes in DO and nutrient concentrations. While overall larger volumes would be dredged with the Proposed Project as compared to Future without Project Conditions, the dredging and discharge rate into individual placement sites would be similar.

Thus, impacts to water quality are expected to be short-term and less than significant as a result of the Proposed Project. The mitigation measure below is proposed to reduce and control the short-term impacts (refer to Table 20 for a complete description of the mitigation measure).

Mitigation Measures:

- WQ-MM-1: Implement standard construction BMPs and requirements of the WDR

Residual Impact after Mitigation: After inclusion of the mitigation measure, the residual impact would be less than significant.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

Potential water quality impacts of the -33 Feet MLLW Alternative would be the same as those of the Proposed Project, although they would occur on relatively smaller scales due to the smaller volume of dredged material. Impacts from changes in dissolved concentrations of constituents of concern, and water quality parameters including turbidity, nutrients, and DO, would be short-term and rapidly return to baseline conditions once construction in a given area concludes. Thus, impacts to water quality are expected to be less than significant as a result of the -33 Feet MLLW Alternative. The mitigation measure below is proposed to reduce and control the short-term impacts (refer to Table 20 for a complete description of the mitigation measure).

Mitigation Measures:

- WQ-MM-1: Implement standard construction BMPs and requirements of the WDR

Residual Impact after Mitigation: After inclusion of the mitigation measure, the residual impact would be less than significant.

WQ-2: Negative impact to groundwater quality from leaching of contaminants or surface water runoff from placement sites

Future without Project Conditions (NEPA and CEQA Baseline)

DI-WET tests were performed on dredged material during maintenance operations between 2001 and 2007. DI WET tests are designed to estimate leachate concentrations from placed

sediment. Seven of nine metals (arsenic, total chromium, copper, lead, mercury, nickel, and zinc) tested in the DI-WET exceeded WDR criteria in at least one sample. DI-WET mean and median concentrations for copper, lead, and mercury also exceeded the WDR criteria. Of 30 samples, TMDLs for cadmium, copper, and zinc were also exceeded in 3, 12, and 11 samples, respectively. Given these elevated DI-WET concentrations, ongoing maintenance dredging and dredged material placement operations could have an impact on groundwater quality from leaching of contaminants. However, despite these exceedances, the Central Valley RWQCB factored in natural attenuation, found no unacceptable risk, and issued a permit to dredge each year. Thus, less than significant impacts to groundwater quality are expected under Future without Project Conditions.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: The residual impact would be less than significant.

Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening

DI-WETs were performed on the 44 composite samples collected by USACE in 2009 to represent leachate concentrations from dredged material at upland placement sites (Table 36). Metals (including mercury) were measured in DI-WET samples. DI-WET chemistry results were compared to WDR criteria. Arsenic was detected in eight samples at concentrations that exceeded the corresponding WDR criteria (10 µg/L). Copper was detected in 17 samples at concentrations that exceeded the corresponding WDR criteria (10 µg/L). Lead was detected in six samples at concentrations that exceeded the corresponding WDR criteria (2.5 µg/L). When 2009 DI-WET results are compared to maximum DI-WET chemical concentrations provided in NOIs to dredge from 2001 through 2003 and 2005 through 2007 (USACE 2000, 2001, 2002a, 2003a, 2005, 2006a, 2007; Appendix M), none of the samples exceeded maximum concentrations.

Based on the exceedances of WDR criteria, the Proposed Project could have an adverse impact on groundwater quality at any of the ten upland placement sites; however, impacts are expected to be less than significant once natural attenuation is considered (see Appendices K and L). Specifically, as part of previous pre-dredge sediment characterizations from 2000 to 2007, attenuation was determined for DI-WET metals criteria that were exceeded. When standard attenuation was calculated for the existing placement sites, WDR criteria were achieved and the Central Valley RWQCB issued a permit to dredge for every year. Because DI-WET results collected as part of the Proposed Project are comparable to previous studies, groundwater impacts are not expected. Thus, as compared to the environmental baseline, there would be less than significant incremental impacts to groundwater quality as a result of the Proposed Project.
Mitigation Measures: Mitigation is not required.
Residual Impact after Mitigation: The residual impact would be less than significant.

Channel Deepening to -33 Feet MLLW and Selective Widening Alternative

Sample results from the DI-WET described under the Proposed Project assumed that dredged material placed in placement sites would come from a depth of 35 to 37 feet, which is deeper than the depth of the -33 Feet MLLW Alternative. It is expected that concentrations located between -33 and -35 feet MLLW would be similar to those located between -35 and -37 feet MLLW. As such, impacts to groundwater quality under the -33 Feet MLLW Alternative would be similar to those of the Proposed Project. Thus, as compared to the environmental baseline, there would be less than significant incremental impacts to groundwater quality as a result of the -33 Feet MLLW Alternative.

Mitigation Measures: Mitigation is not required.

Residual Impact after Mitigation: The residual impact would be less than significant.

3.1.4.4.1 Summary of Impacts and Mitigation Measures

Table 37 summarizes the impact determinations, mitigation measures, and residual impacts after mitigation, if applicable, for each alternative with respect to the sediment quality impacts described above.

Table 37
Summary of Water Quality Impacts and Mitigation Measures

Alternative	Impact	Mitigation	Residual Impact After Mitigation
WQ-1: A violation of water quality standards, including adopted TMDLs, which would impair beneficial uses of water			
Future without Project Conditions (NEPA and CEQA Baseline)	Less than significant impact	WQ-MM-1	Less than significant impact
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	Less than significant impact	WQ-MM-1	Less than significant impact
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	Less than significant impact	WQ-MM-1	Less than significant impact
WQ-2: Negative impact to groundwater quality from leaching of contaminants or surface water runoff from placement sites			
Future without Project Conditions (NEPA and CEQA Baseline)	Less than significant impact	None	Less than significant impact
Proposed Project: Channel Deepening to -35 Feet MLLW and Selective Widening	Less than significant impact	None	Less than significant impact
Channel Deepening to -33 Feet MLLW and Selective Widening Alternative	Less than significant impact	None	Less than significant impact