

## 7.1 INTRODUCTION

This technical report provides an assessment of the potential hydrodynamic, sediment transport, water quality, and biological changes to San Francisco Bay that would result from construction and operation of the three runway reconfiguration alternatives (Alternatives A3, BX-6, and BX-Refined or BX-R) being considered for SFO. This technical report is not the Environmental Impact Statement (EIS) for the proposed SFO Runway Reconfiguration Project, nor is it a complete assessment of project effects on the physical or biological environments. This technical report will be used as a resource in preparing the impact assessment for the EIS.

The assessment provided in this technical report considers changes caused by:

- Construction and operation of runway extensions and new runways in the Bay using runway platforms constructed on fill or a combination of fill and piles (known as the hybrid option)
- Dredging fill material required for the proposed project from a potential borrow site located within the City and County of San Francisco at the East Bay Shoals offshore of Bay Farm Island
- Dredging a basin for rehandling fill material imported to the Bay from existing upland quarries near Vancouver, B.C., the Columbia River in Oregon, or the San Francisco Bar Ship Channel at two alternative sites in the Bay: the East Bay Shoals and the San Bruno Shoals, located to the northeast of SFO

A more complete description of proposed project alternatives is provided in [Section 4](#) of this report.

This technical report also considers potential changes to the Bay caused by implementation of project alternatives and restoration of a large area of salt ponds in the South Bay. Two restoration sites were considered in the analysis: the 2,000-hectare (4,900-acre) Baumberg Complex near Hayward and a 1,200-hectare (2,900-acre) site in Redwood City near the west end of the Dumbarton Bridge.

Changes to Bay circulation, sediment transport, and water quality caused by construction and operation of project alternatives were predicted using computer models and published information on observed changes in the Bay and other estuaries. These predictions were used to evaluate potential changes in biological communities based on a conceptual model of the functional relationships between the physical and biological environments of the Bay. That conceptual model is introduced in [Section 1](#) and shows the major components of the Bay system, the links between the components, and the major drivers for interactions between the physical and biological environments. [Sections 5](#) and [6](#) discuss the potential changes identified as a result of the study.

The general approach to hydrodynamic, sediment transport, and water quality modeling consisted of the following steps:

- Literature Review. Previous hydrodynamic, sediment transport, and water quality studies conducted in San Francisco Bay were reviewed to develop the approach for this analysis. The results of that review are provided in [Section 3](#) of this report.

- Model Selection. The MIKE 21 model developed by the Danish Hydraulics Institute was selected for most of the simulations. TRIM3D was used for three-dimensional hydrodynamic modeling of salinity and chemical residence time.
- Model Grid Selection and Setup. A 200-meter (656-foot) resolution bathymetric grid of the entire Bay from the San Joaquin/Sacramento River Delta to the Pacific Ocean outside the Golden Gate was developed for modeling using bathymetric data developed by NOAA (1993), the USGS (Smith and Cheng 1994, 1998), and soundings in the Pacific Ocean conducted by NOAA.
- Model Calibration and Verification. The hydrodynamic, sediment transport, and water quality models were calibrated and verified primarily with existing data collected in the Bay by NOAA, USGS, and others. Temperature, salinity, current, tide, wave, and suspended sediment data collected for this proposed project at various Bay locations in September–October 1999, February–March 2000, and June–July 2001 by the Woods Hole Group were also used to calibrate and verify the models.
- Modeling. A number of modeling runs were conducted to predict hydrodynamic, sediment transport, and water quality changes associated with each runway reconfiguration alternative with the all-fill and hybrid platform options, dredging of the potential East Bay Shoals borrow site and partial filling of the final borrow pit, and restoration of South Bay salt ponds. Modeling was conducted to predict physical and chemical changes during representative dry, average, and wet years.
- Sensitivity Analysis. Modeling a complex system such as San Francisco Bay requires many assumptions. Many of the modeling parameters were varied across their possible range of values to assess the sensitivity of model results to these parameters.
- Water Quality Modeling. Near-field (greater resolution than the hydrodynamic model grid of 200 meters) water quality changes caused during construction were estimated using the USACE Automated Dredging and Disposal Alternatives Management Systems (ADDAMS) models. The water quality module of MIKE 21 was used to estimate far-field (greater than 200 meters) water quality changes associated with project construction and long-term changes in Bay circulation resulting from proposed project implementation.

In addition to modeling results, literature and data on Bay hydrodynamics, morphologic evolution, sediment transport and erosion, sea level rise, and water quality were used to evaluate potential changes caused by project alternatives. The results of chemical analyses of sediment samples collected in the vicinity of the reconfigured runways and potential East Bay Shoals borrow site were used to help evaluate water quality changes associated with dredging. Historic photographs of the South Bay were also used to evaluate long-term erosion potential associated with project alternatives.

Evaluation of biological changes that could result from project alternatives began with the development of an understanding of the species present in areas that could be affected by the proposed project and their uses of those areas. Dry season and wet season fish sampling was conducted in the vicinity of the reconfigured runway alternatives and the potential East Bay Shoals borrow site for a year. This sampling was done with many of the same gear types used by the CDFG in its annual fisheries sampling program that has been conducted for the past two

decades. Because the water is relatively shallow (intertidal to approximately 20 feet or 6 meters) in the area that would be occupied by any of the runway reconfiguration alternatives, resource agencies raised concerns that the sampling gear used may have missed some rare or important species. Therefore, the area was resampled using different gear types to ensure that a thorough survey had been accomplished. Benthic (bottom-dwelling) organisms were sampled in the potential runway project area and at the East Bay Shoals. Eelgrass surveys were conducted in the vicinity of the East Bay Shoals, along the Alameda shoreline east of the shoals, at the Coyote Point shoreline, and in the potential runway project area. Seasonal tidal-flat surveys were conducted to count shorebirds, gulls, and terns. Seasonal open-water aerial and boat surveys were done to count waterfowl and other diving birds. A survey of San Bruno Marsh was conducted to estimate numbers of the threatened clapper rails that use that habitat. In August 2002, least tern surveys were conducted to assess the potential for post-breeding adult and juvenile bird use of the potential runway project area and East Bay Shoals. Finally, a survey was conducted of marine mammal haul-out sites in the South Bay during the pupping season. The results of these studies are reported in [Section 2](#).

The data collected for the project was supplemented with information from other studies in the Bay. CDFG fisheries data collected over the past two decades at sampling stations near the airport were reduced and correlated to the fisheries data collected for the proposed project. Information in the literature and data collected by resource management agencies and for academic research was used to supplement data collected for the proposed project on benthic organisms, fish, plants, birds, and marine mammals.

The results of the analysis of biological changes associated with construction and operation of project alternatives is provided in [Section 6](#). Potential biological changes associated with project alternatives were estimated based on observations recorded for past physical disturbances in the Bay and in other marine estuaries, as well as other studies on the relationship of species to their environment. The potential toxicity of chemicals of concern to marine mammals, birds, and aquatic organisms caused by project-related dredging and filling was evaluated based on the changes in water quality estimated for the proposed project as well as published information on dose response and bioaccumulation. Toxicity and bioaccumulation were evaluated using the following steps:

- Identify chemicals of potential ecological concern (COPECs) in sediments to be dredged
- Identify groups of ecological receptors most likely to be exposed to chemicals released during dredging
- Identify potential toxicological effects of the COPECs
- Develop conservative estimates of risk from direct exposure and from exposure via the food chain
- Compare predicted effects under existing conditions to predicted effects under project operational conditions

Changes to water quality caused by dredging operations were evaluated using near-field modeling (to predict contaminant concentrations within the area of the suspended sediment plume) and far-field modeling (to predict contaminant concentrations throughout the Bay). The

following chemicals were evaluated based on a review of existing sediment and water quality data: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc, PAHs, PCBs, and organotins. Groups of ecological receptors were selected for the analysis based on potential exposure and included phytoplankton, aquatic invertebrates, fish, fish-eating birds, and marine mammals. Both direct toxicity and indirect toxicity via bioaccumulation were considered.

To evaluate direct toxicity, modeled water concentrations were compared to Regional Water Quality Control Board (RWQCB) water quality objectives (WQOs). Further evaluation of direct toxicity was conducted for COPECs that exceeded WQOs, including mercury, PCBs, PAHs, and copper. Results of elutriate bioassays on three aquatic species were reviewed. When sufficient data were available, modeled fish tissue concentrations were compared to tissue concentrations associated with adverse effects to fish. A literature search was conducted to identify concentrations in water that would be expected to cause toxicity to specific organisms.

In addition to evaluating potential biological effects due to pollutants released during dredging and placement of sediments, potential post-construction changes to chemical concentrations in surface sediments were evaluated. The purpose of this evaluation was to compare the surface sediments at the East Bay Shoals borrow site before dredging to the dredged sediments that could be placed on the surface of the borrow site following dredging because these surface sediments are what ecological receptors would be exposed to. Mean effects range-median quotients (mERMqs) and mean sediment quality guideline quotients (mSQGqs) were used as a method to predict the cumulative toxicity from multiple chemicals present in a given sediment sample.

Predictions of future physical and biological conditions cannot be made without some degree of uncertainty in the results regardless of the method used to make those predictions. The extent of uncertainty in this assessment of the proposed project is discussed, as relevant, throughout the technical report. The results presented in this summary account for the sources of uncertainty and reflect conservative estimates of the types and extent of changes in the physical and biological environments of San Francisco Bay expected to be caused by construction and operation of project alternatives.

## **7.2 HYDRODYNAMICS, SEDIMENT TRANSPORT, AND WATER QUALITY**

### **7.2.1 Hydrodynamics**

Hydrodynamics is a key component of the physical changes that could occur due to construction of the project alternatives. In this report, hydrodynamics includes changes to circulation patterns and current velocities. Circulation patterns can be affected when flows are diverted or the bathymetry is changed. Current velocities change from existing conditions when flows converge (causing increased velocity) or diverge (causing decreased velocity). The current velocity also changes if obstacles, such as piles, are installed in the flow path.

Three different methods were used to present how the hydrodynamics of the Bay may change due to the new platforms: residual currents, streaklines, and root mean square (RMS) speed. Comparisons between pre-project and post-project construction residual currents provide a

measure of how the tidally averaged current patterns may change which may provide a picture of how long-term sediment transport would occur after the proposed new runways are built. However, it is not clear whether small changes in residual currents are important because they are much smaller than tidal currents. Streaklines, which are created by following the path of particles, graphically depict the flow patterns during a portion of the tidal cycle. Converging streaklines are areas of increasing velocity. Diverging streaklines are areas of decreasing velocity. Long streaklines are areas with relatively large tidal excursion and short streaklines are areas of relatively small tidal excursion. RMS speed is a nondirectional representation of tidally averaged speed.

All three methods were consistent in showing that circulation changes due to the proposed new platforms would be confined to an area between Oyster Point on the north, Coyote Point on the south, and the eastern edge of the main South Bay channel about 2 km (1.24 miles) east of SFO. In general, all of the alternative runway reconfigurations except Alternative A3 hybrid would inhibit flow along the mudflats near SFO and tend to divert water to the east toward the main South Bay channel. Because of the orientation of the proposed new Runway 10L/28R platform, this effect would be greater during ebb tide than flood tide. During flood tide, flow would slightly curve to the east relative to existing conditions, but during ebb tide, water draining from the area between the 10/28 runway platforms and the shore would combine with the flow in the Bay east of SFO. This change in circulation would be greatest south of the airport and north of Coyote Point, and for all-fill options. Alternative A3 hybrid would not change circulation patterns because the only new runway would be constructed on piles.

In addition to changing circulation patterns near SFO, there would be some increase in current speed in the main South Bay channel for all of the runway reconfiguration alternatives except Alternative A3 hybrid. This increase in current speed would be due to increased flow being diverted around the proposed new runways. The increase in speed in the channel is predicted to be less than 4 cm/s (0.13 ft/s). Average current speeds in the channel near SFO currently range from about 32 to 42 cm/s (1.0 to 1.4 ft/s) with a maximum speed of about 70 to 100 cm/s (2.4 to 3.3 ft/s) (see [Section 3.3.1.2](#)). If restored salt ponds are added to the South Bay, the increase in current speed near SFO could be larger, up to 8 cm/s (0.3 ft/s) for the example sites used in the analysis. This is because opening the salt ponds to the Bay would increase the South Bay tidal prism, causing more water to flow down the main South Bay channel.

Current speed would also increase at the tips of the new Runways 19L and 28R. The increase could be between 8 and 16 cm/s (0.3 and 0.53 ft/s) for the platforms on fill and between 2 and 8 cm/s (0.07 and 0.3 ft/s) if the new Runway 10L/28R platform is constructed on piles.

For Alternative A3 hybrid, current speeds would decrease by less than 4 cm/s under and within a few hundred meters of the new Runway 10L/28R platform. Current speed would increase between 2 and 4 cm/s (0.07 and 0.13 ft/s) of the tip of new Runway 28R.

Since the changes to hydrodynamics would be mainly confined to the area near SFO, little difference is observed in changes to Bay circulation among alternatives. The hybrid platform options would generally have a smaller area of change since there would still be flow under the new pile-supported Runway 10L/28R platform. Also, the hybrid options would tend to divert less flow around the runways, so the increase in flow in the main South Bay channel would be less than for the all-fill options. However, the differences between the all-fill and hybrid options

are projected to decrease over the decades as sedimentation accumulates under the pile-supported Runway 10L/28R platform.

To provide a bulk measure of how a constriction in flow area due to new runway platforms could change the circulation in the Bay, a simple head loss calculation was conducted. The analysis is described in [Section 5.2.2.6](#). This analysis indicated that the additional head loss due to the proposed platforms is about 0.2 cm (0.08 inch) over a 5 km (3.1 mile) distance. This small increase in head loss is expected to have a negligible effect on Bay hydrodynamics, adding credence to the prediction that circulation changes would be local, not Baywide.

The potential East Bay Shoals borrow pit would produce a small change in current speeds in about a 1.5-km (2.4 miles) area surrounding the pit. Excavation of the pit would reduce bottom friction, resulting in reduced head loss over the pit. This would cause more flow into the borrow pit resulting in a decrease in current velocity of about 2 to 6 cm/s (0.07 to 0.2 ft/s) over the pit. Since the bathymetry would be unchanged up- and down-gradient of the pit, the increased flow into the pit would cause an increase in velocity at these locations of about 2 to 8 cm/s. This change in current speeds would decrease as the borrow pit filled with sediment (see [Section 7.2.2](#)).

## **7.2.2 Sediment Transport**

Changes in sedimentation can occur if the sediment supply or the hydrodynamics change, because changes in hydrodynamics can cause an area to become more depositional or erosional. Project alternatives are not expected to cause any changes to the sediment supply to the Bay. As described in [Sections 5.2.2](#) and [7.2.1](#), the project alternatives could change some of the hydrodynamics near SFO. On the southwestern side of the proposed new Runway 10L/28R platform and the existing Runway 10/28 platform, the average current speeds are predicted to be smaller, which would make the areas more depositional. At the tips of the runways the current speed is predicted to be faster, which would make the area more erosional. Finally, dredging fill for the project from the East Bay Shoals would create a borrow pit that would fill over time with sediments.

A tidal time scale model was developed for sediment transport in San Francisco Bay. The model is described in [Section 5.1](#). The model predicted suspended sediment concentrations and short-term changes in sedimentation. This model was used to evaluate long-term modifications to Bay bathymetry caused by project alternatives.

After project completion, the rates of sediment deposition and erosion in the vicinity of the new runway platforms, potential South Bay salt pond restoration, and potential East Bay Shoals borrow site could be different than for the No Action Alternative. As the bathymetry adjusts itself in response to the new conditions, the differences in sedimentation and SSCs with and without the proposed project would diminish. In other words, the long-term geomorphologic evolution of the Bay would continue to be governed by large-scale, Baywide processes (hydrodynamics and variations in sediment loading from the contributing watersheds). However, the proposed project could introduce some local bathymetric changes near the proposed new platforms and potential East Bay Shoals borrow site.

For all of the alternatives, the elevation of the area southwest of the 10/28 runway platforms (between the platforms and the west shore of the Bay) is predicted to rise by about 0.2 to 0.7 meter (0.66 to 2.3 feet) and remain subtidal over the 50-year period considered in this analysis. In general, the predicted geomorphological changes to the Bay in the SFO vicinity do not vary greatly between Alternatives BX-6 and BX-R. For Alternative A3 Fill, the area behind the existing and new Runway 10/28 platforms would be similar to the BX-6 and BX-R alternatives. The hybrid cases of Alternatives BX-6 and BX-R, there would be less deposition behind the new Runway 10L/28R platform than for the Fill option, so the long-term (50 years) increase in bed elevation is predicted to be less than 0.5 meter. In the case of Alternative A3 hybrid, the long term changes in bathymetry are similar in magnitude to the BX-6 and BX-R hybrid alternatives but less extensive in area.

Increased current speeds could result in erosion at the tip of new Runway 28R if the runway is constructed on fill. This could create a scour hole in the range of 1 to 2 meters (3.3 to 6.56 feet) in depth over 50 years.

Little deposition is predicted to occur between the new Runway 1L/19R and 1R/19L platforms proposed for Alternatives BX-6 and BX-R. The bulk of the sediment would settle out of the water column at the open end of this area near the tips of the runways, before it would reach the back of this semienclosed area. The area is predicted to collect about 0.5 meter of sediment and remain subtidal. A sediment model was used to predict maximum sedimentation rates based on the available sediment supply. These results are discussed in [Section 5.2.5.7](#). This analysis indicated that about 0.1 meter (0.33 feet) of deposition could occur between the new runway platforms if clay-silt settling velocities are used in the calculation. If it is conservatively assumed that 100 percent of the sediment suspended in the water that flows into the area between these two runway platforms settled out there, the bed elevation would rise about 2.6 meters (8.5 feet).

Restoration of South Bay salt ponds would result in redistribution of sediments independent of changes in sediment transport associated with the runway reconfiguration alternatives. The current speed would increase in the mudflats offshore of the example South Bay restoration sites, particularly near the Baumberg Complex, due to increased tidal flow caused by opening the restoration sites to the Bay. This would result in additional erosion of the mudflats bordering the restoration site on the order of 1 meter (3.3 feet) or more in 50 years. The main channel outside of the restoration sites would be deepened by about 0.5 meter (1.6 feet) in 50 years due to the higher currents associated with the larger tidal prism caused by opening the restoration sites to the Bay. Because current velocities would be low within the wetlands, sediment would be trapped in the sites and less sediment would be available elsewhere. Deposition would therefore be reduced along the eastern shore of the Bay within 7 km (4.3 miles) of the Baumberg Complex, as well as in the shallow mudflats south of Dumbarton Bridge.

In the long term, some mudflats bordering the example South Bay restoration sites could be reduced due to increased erosion and reduced sediment supply because of sedimentation in the restoration sites. The formation of new mudflats along the eastern shoreline of the Bay also would be less than predicted for the No Action Alternative. The extent of mudflats south of Dumbarton Bridge is predicted to increase under the No Action Alternative. With the opening of

the restoration sites, these mudflats would not increase in area because the wetlands would act as sediment sinks and deprive other areas of the sediment supply.

Sediment redistribution resulting from the proposed project alternatives and restoration of the South Bay wetland sites would be limited to the South Bay. Although use of the proposed East Bay Shoals borrow site could alter sediment flux in the Central Bay as well as the South Bay because of the borrow site's proximity to the Central Bay. Sediment retained in the borrow pit after fill material has been dredged from the borrow site could result in less sediment leaving the South Bay during ebb tide. The primary change in the Central Bay would be a decrease in deposition in the eastern shallow waters from the Bay Bridge northward.

The rate of deposition inside the borrow pit would be about 50 to 75 mm/year (2 to 3 inches/year) initially for both the hybrid and fill options in the deeper parts of the excavation. Over time, the borrow pit would become smaller as it filled with sediments. This would slow down the sedimentation rate as the tidal current adjusted itself to the changing bed elevation. Partially refilling the borrow pit with dredged material would decrease the time needed for the pit to completely fill in.

Approximately 35 mcy of material was dredged offshore of Bay Farm Island in an area adjacent to the potential East Bay Shoals borrow site between the 1940s and the mid 1960s. This material was used to create portions of Bay Farm Island. An additional 1.5 mcy was removed in about 1973. The original bathymetry of this borrow pit was not measured. However, based on bathymetric measures of the existing borrow pit taken in 1980 and 2000, the pit filled in about 3 meters (10 feet) over two decades, accounting for approximately 11 mcy of sediment.

The issue of increased sediment sinks caused by the runway platforms and the potential East Bay Shoals borrow site was analyzed using the geomorphic modeling described in [Section 5.1.4.3](#) and through an analysis of historic data. The analysis indicates that changes in other parts of the Bay as a result of sediment collecting in the East Bay Shoals borrow site would be minor. This conclusion is supported by observations of the existing Bay Farm Island borrow pit.

Bathymetric contours of the Bay taken at the turn of the century, in the 1950s, and at present were compared and indicate that Bay bathymetry has not been affected by the borrow pit while it has trapped millions of cubic yards of sediment. All of the sediment contained in the water that would flow between the new Runway 1/19 platforms and behind the Runway 10/28 platforms represents about 1 to 2 percent of the volume of sediment that moves under the San Mateo Bridge in the south or over a line parallel to Pier 24 in the north during an average 6.5-hour tidal period. It is unlikely that 100 percent of the sediment contained in the water would settle out between the Runway 1/19 platforms or behind the Runway 10/28 platforms. Deposition of 100 percent of the sediment in these locations would require a settling rate of about 30 mm/year (1.2 inches/year), which is five times the rate measured southwest of the existing Runway 10/28 platform. If the rate of settlement predicted by the geomorphic model were used, the amount of sediment trapped around the new runway platforms would represent less than 0.1 percent of the average tidal sediment flux at the San Mateo Bridge.

### **7.2.3 Water Quality**

The 30-day average concentrations of PAHs, PCBs, and mercury, and the 4-day average concentrations of nickel and copper were modeled during the dry season to evaluate potential

water quality changes associated with project alternatives. This provides a conservative estimate of the effects of the proposed project because concentrations of these chemicals would be highest during the dry season when there is the greatest amount of sediment resuspension from wind driven waves and the least amount of freshwater inflow to the Bay

### **7.2.3.1 Construction Effects**

Increases in total chemical concentrations of PAHs, PCBs, and mercury are predicted to occur during construction at SFO for all runway reconfiguration alternatives and at the potential East Bay Shoals borrow site for Alternatives A3 Fill, BX-6, and BX-R. These chemicals would be predominantly associated with suspended sediments, and predicted changes are equivalent to increases in SSCs. Increased concentrations of these chemicals are estimated to be:

- PAHs – 0.01 to 0.02 micrograms/liter ( $\mu\text{g/L}$ )
- PCBs – 0.0002 to 0.0004  $\mu\text{g/L}$
- Mercury – 0.002 to 0.005  $\mu\text{g/L}$

These increased concentrations would occur within several hundred meters of the dredges while Young Bay Mud (YBM) is excavated from the runway platform construction site and within about 5 km (3.1 miles) north and south of the potential East Bay Shoals borrow site. Within a 200-by-200 meter area surrounding the dredging operations, maximum increased concentrations of 0.09  $\mu\text{g/L}$ , 0.0020  $\mu\text{g/L}$ , and 0.022  $\mu\text{g/L}$  for PAHs, PCBs, and mercury, respectively, would also occur.

The increase in PAH concentrations associated with project construction would result in exceedance of the chronic PAH water quality objective (WQO) of 0.031  $\mu\text{g/L}$  at both the runway platform construction site and the East Bay Shoals. All of the areas affected by increases of PCBs associated with project construction already exceed the chronic PCB WQO of 0.00017  $\mu\text{g/L}$ . Therefore, project construction would not cause exceedance of the PCB WQO but rather contribute to increased concentrations of this chemical where the chronic WQO is already exceeded. Project construction would not cause an exceedance of the chronic mercury WQO of 0.05  $\mu\text{g/L}$ .

Project construction would result in maximum concentrations of 0.05 to 0.25  $\mu\text{g/L}$  of nickel in an area extending between 10 and 15 km (6.2 to 9.3 miles) north and south of the potential East Bay Shoals borrow site. These increases would not cause an exceedance of the chronic nickel WQO of 8.1  $\mu\text{g/L}$ .

Dissolved copper concentrations are predicted to increase during construction by a maximum of 0.05 and 0.5  $\mu\text{g/L}$  within 1 km (0.62 mile) of the potential runway construction site and within 10 to 15 km north and south of the potential East Bay Shoals borrow site for A3 Fill, BX-6, and BX-R alternatives. Copper concentrations up to 0.05  $\mu\text{g/L}$  above background may extend from the SFO construction site to the Dumbarton Bridge. Although the plume in the vicinity of the Dumbarton Bridge is predicted to cause additional exceedances of the chronic copper WQO of 3.1  $\mu\text{g/L}$  in a small area during the dry season, the results are within the uncertainty of the model.

Increases in dissolved copper concentrations above the acute WQO of 4.8  $\mu\text{g/L}$  are predicted to occur during dredging of two to four of the 13 dredging units in the proposed runway platform

area, depending on the alternative (see [Section 5.3](#)). Plumes associated with dredging are relatively narrow and change direction in response to the tide but areas where exceedances would occur are generally restricted to about 200 meters (656 feet) of the dredge. Additional exceedances of the acute WQO for copper are predicted to occur in a 60 x 60 meter (197 x 197 foot) area during placement of sand fill material at the East Bay Shoals rehandling facility when a large hopper dredge is used and current speeds are high. If a San Bruno Shoals rehandling basin were used for the project, there would be no exceedances of the acute WQO for copper. Finally, water decanting from North Bay upland confined disposal facilities would require dilution in receiving waters to meet applicable WQOs for dissolved copper in four of the 15 dredging units.

### **7.2.3.2 Operational Effects**

Increases in total chemical concentrations of PAHs, PCBs, and mercury are predicted to occur between Oyster Point and Coyote Point about 1 to 2 km (0.62 to 1.24 miles) offshore of the proposed new runway platforms for all alternatives and within 1 km of the potential East Bay Shoals borrow site for Alternatives BX-6 and BX-R. These chemicals would be predominantly associated with suspended sediments, and the predicted changes are equivalent to increases in SSCs. The maximum increased concentrations of these chemicals are estimated to be:

- PAHs – 0.01 to 0.02 µg/L for Alternative BX-6 and up to 0.04 µg/L for Alternative BX-R
- PCBs – 0.0002 to 0.0004 µg/L for Alternative BX-6 and up to 0.0008 µg/L for Alternative BX-R
- Mercury – 0.002 to 0.007 µg/L for Alternative BX-6 and up to 0.01 µg/L for Alternative BX-R

The increases in concentrations of these three chemicals would decrease with time as SSCs decrease with the equilibration of bathymetry in the vicinity of the potential new runway platforms and the East Bay Shoals borrow pit. Water quality modeling also indicated that the net effect of restoration of the example South Bay salt ponds would be a decrease in concentrations of PAHs, PCBs, and mercury by the following amounts:

- PAHs – -0.01 to 0.1 µg/L
- PCBs – -0.0002 to 0.02 µg/L
- Mercury – -0.002 to 0.024 µg/L

This decrease would result from sediment being trapped within the restoration sites.

Under the No Action Alternative, the 30-day averaged concentrations of PAHs and PCBs are predicted to exceed chronic WQOs in the dry season in much of the South Bay, and the 30-day averaged mercury concentration is predicted to exceed chronic WQOs in the Lower South Bay south of the Dumbarton Bridge. The proposed project would cause exceedances of chronic WQOs for PAHs in small areas near SFO for all runway reconfiguration alternatives and in the East Bay Shoals borrow site for Alternatives A3 Fill, BX-6, and BX-R. For mercury and PCBs, no additional areas of the Bay are predicted to exceed chronic WQOs that are not already exceeded under existing conditions. However, increases in concentrations in areas that already

exceed WQOs cause an increase in chemical exposure to organisms that inhabit the Bay. Changes in concentrations of chemicals associated with suspended solids would diminish with time as the sediment cycle of the Bay adapted to the altered physical environment.

For the No Action Alternative, the highest dissolved copper concentrations are predicted to occur in the South Bay below the Dumbarton Bridge during the dry season due to chemical effects favoring desorption of metals from suspended sediments. These concentrations may exceed chronic WQOs. For Alternatives BX-6 and BX-R, in combination with the potential East Bay Shoals borrow site and the restoration sites in the South Bay, increases in dissolved copper concentrations are predicted to occur immediately north of the potential East Bay Shoals borrow site and in the Bay adjacent to the restoration sites.

Dissolved copper concentrations at the potential East Bay Shoals borrow site are predicted to increase between 0.05 to 0.25 µg/L, with a slightly larger area affected by the all-fill option for all of the runway alternatives than by the hybrid option. Concentrations in the Bay immediately adjacent to the South Bay restoration sites may increase between 0.05 and 0.5 µg/L. No new sections of the Bay are predicted to exceed chronic WQOs for copper as a result of project alternatives.

None of the project alternatives are predicted to cause exceedances of the chronic WQOs for nickel. In addition, none of the alternatives are expected to cause measurable changes in salinity.

Water residence time, which is a measure of the degree of flushing in the Bay, was estimated near the mouth of Coyote Creek to address potential project changes on flushing in the South Bay below the Dumbarton Bridge. Residence times were also estimated for points north and south of SFO to evaluate the influence of circulation pattern changes associated with the runway reconfiguration alternatives.

For the far South Bay below the Dumbarton Bridge, both the MIKE 21 and TRIM3D models predict no change in water residence time due to the runway reconfiguration alternatives, potential South Bay restoration sites, and the potential East Bay Shoals borrow site. The water residence time immediately south of SFO was predicted to increase from 0.5 to 2 days with proposed new Runway 10L/28R constructed on fill. This would occur because the runway platform would physically hinder the exchange of water between the nearshore shallows and the main channel of the South Bay. In general, the influence of the proposed project on residence time is predicted to be about the same for wet and dry season conditions.

#### **7.2.4 Sediment Quality at East Bay Shoals Borrow Site**

As discussed in [Section 4.4.1](#), borrow operations at this site would begin with the removal and upland reuse of the YBM from the first area, or panel, to be dredged for fill. When the underlying sand has been removed from this first panel, YBM overburden from the next panel could be deposited in the first pit where fill dredging has been completed. This sequence of YBM overburden removal and disposal in a completed pit could progress across the borrow site until all of the needed fill has been removed.

This process would result in different surface sediments being exposed on the bottom of the Bay in the borrow area than currently exist there. The potential effects to benthic organisms from this change in sediments was evaluated using mean effects range-median quotients (mERMqs) and

mean sediment quality guideline quotients (mSQGqs). This evaluation was done for all of the runway reconfiguration alternatives except for Alternative A3 Hybrid because no fill would be obtained from the East Bay Shoals for that alternative.

The analysis was done by comparing mERMqs and mSQGqs calculated for existing surface sediments with quotients estimated for the sediments that would remain on the surface at the East Bay Shoals borrow site after dredging and YBM placement activities were completed. The YBM placed at the surface may come from a range of depths through the profile of material that would be dredged at the East Bay Shoals borrow site. Therefore, the preliminary dredging schedule developed for the project alternatives was used to ensure that the appropriate chemical data were used in the analysis (i.e., chemical results from top or bottom composite sample units). [Table 5.2.7-2](#) shows the current mERMqs and mSQGqs for surface sediments for the East Bay Shoals areas that would be dredged for each runway reconfiguration alternative. [Table 5.2.7-2](#) also shows the predicted mERMqs and mSQGqs for sediments expected to be placed at the surface in the borrow pits for each alternative. Predicted mERMqs and mSQGqs were based on the mERMqs and mSQGqs of the sediments in the dredging cells destined for each disposal pit, as shown in [Table 5.2.7-1](#).

As shown in [Table 5.2.7-2](#), all current and predicted mERMqs calculated for the surface sediments at the East Bay Shoals borrow site are between 0.115 and 0.156. Thompson et al. (1999) found that Baywide sediment samples with mERMqs ranging between 0.114 and 0.182 had a 50 percent probability of toxicity for amphipods. Fairey et al. (2001) calculated mSQGqs for all samples in three databases: the statewide California Bay Protection and Toxic Cleanup Program (BPTCP) database, NOAA's national sediment toxicity (SEDTOX) database, and NOAA's Biscayne Bay survey in Florida. All current and predicted mSQGqs calculated for surface sediments at the East Bay Shoals borrow site fall between 0.1 and 0.25, which corresponded with a probability of toxicity in 19 percent of samples in the Baywide data set from the Fairey et al. (2001) study. Mean ERMqs and mSQGqs in surface sediments before and after dredging do not change significantly for any location under any of the alternatives (they always fall within the range discussed above). However, mERMqs and mSQGqs do increase slightly under Alternatives BX-6 Fill, BX-6 Hybrid, and A3 Fill. Under Alternative BX-R Fill, mERMqs and mSQGqs increase for surface sediments located in Pits 3 and 4, while they decrease for surface sediments located in Pit 2 and remain the same for surface sediments located in Pit 1. Under Alternative BX-R Hybrid, mERMqs and mSQGqs calculated for surface sediments located in Pit 1 remain the same.

### **7.3 BIOLOGICAL COMMUNITIES**

The conceptual model of the Bay introduced in [Section 1](#) was used as a tool to clarify the relationships that needed to be considered in assessing the potential project effects on Bay biological communities. The model identifies a number of external physical, chemical, and biological factors or drivers that contribute to the overall functioning of the Bay ecosystem. Several of these factors, including ocean-water levels, climate/meteorology, water temperature, and sunlight, would not be affected by the proposed project. Based on the results of the hydrodynamic, sediment transport, and water quality studies conducted for the proposed project,

the most important physical and chemical drivers for biological communities that could be altered by project activities are:

- Changes in bathymetry resulting in changes in amount of habitat and water circulation
- Changes in turbidity resulting in changes in light penetration into the water column and suspended sediment concentrations
- Changes in water quality

### **7.3.1 Primary Productivity**

Phytoplankton represent the base of the food chain in the Bay. In the South Bay, the cycle of phytoplankton abundance is characterized in some years by a single, large phytoplankton bloom. The spring bloom in the South Bay results from the co-occurrence of increased springtime solar radiation, freshwater inputs, and an annually occurring period of reduced tidal mixing. These conditions create a two-layered system with an upper layer that has ideal nutrient and sunlight conditions to promote phytoplankton growth. In addition, when stratification occurs, the reduced mixing acts to isolate the phytoplankton in the upper layer from grazing pressure by filter-feeding benthic invertebrates on the bottom. Various factors including solar radiation, tidal and wind-driven mixing, freshwater inflows, stratification, nutrients, and turbidity drive the primary production in the South Bay. This process is described in [Section 6.2.1](#).

Of the various factors that influence primary productivity in the South Bay, only turbidity would be affected by the proposed project. Dredging at the East Bay Shoals and use of a rehandling basin at either the East Bay Shoals or San Bruno Shoals would increase turbidity over the project construction period. Turbidity acts to attenuate light penetration in the water column, reduce the depth of the photic zone, and depress phytoplankton photosynthesis and growth.

Using correlations between suspended sediments and light attenuation, the results of the hydrodynamic and sediment transport models were used to quantify the potential effects on photosynthesis within the South Bay. Simulations were conducted assuming the maximum dredging equipment in operation at a given time during the period when spring blooms are most common (February to April).

#### **7.3.1.1 Construction Effects**

Dredging activities during construction would increase suspended sediment concentrations at the proposed platform area. Dredging activities would also cause increased SSCs at the potential East Bay Shoals borrow site for Alternative A3 Fill and both fill and hybrid options for Alternatives BX-6 and BX-R if that site were used for borrow. Alternative A3 Hybrid would not use fill dredged from the Bay, so no effects would be created at the East Bay Shoals location. This alternative would use a rehandling basin at the San Bruno Shoals, which would increase SSCs there as a result of that construction activity.

The increase in suspended sediments from dredging and filling would cause decreases in photosynthetic rate. During peak dredging and filling operations, this would decrease phytoplankton production by approximately 11 and 14 percent for Alternatives BX-6 and BX-R, respectively, in the area affected by SCC. The area where changes in photosynthetic rates could

occur for these two runway reconfiguration alternatives would extend approximately 10 to 12 km (6.2 to 7.4 miles) north and south and 5 to 6 km (3.1 to 3.7 miles) east and west of the potential East Bay Shoals borrow site, and 8 km (5 miles) north and south and 3 km (1.9 miles) east and west of the proposed runway platform area. This would represent an approximate net decrease in productivity of approximately 2 percent for the entire South Bay during the construction period for these alternatives (It is understood that productivity varies widely across the South Bay, however for this estimate an even distribution of productivity across the entire South Bay has been assumed). Alternative A3 Fill is expected to result in approximately half of the effect of the BX-6 and BX-R alternatives. Use of a rehandling basin for Alternative A3 Hybrid would reduce productivity by less than half the reduction associated with Alternative A3 Fill. Details of this analysis are found in [Section 6.2.1](#) and [Appendix Y](#).

### **7.3.1.2 Operational Effects**

Effects to photosynthetic rate (and primary productivity) of project operations would be limited to the area of the proposed new runway platforms. Loss of potential productivity in the Bay would result from direct loss of Bay waters due to the runway platform. This loss would represent about a 0.4 percent (for Alternative A3 Hybrid) to 0.8 percent (Alternative BX-R Fill) decrease in productivity for the South Bay, assuming that productivity occurs homogeneously throughout the region. Predicted changes to photosynthetic rate due to changes in SSCs associated with the alternative platforms would be negligible. Small areas of potentially increased productivity off the tip of proposed runway 28R, extending about 4 km (2.5 miles) north and south, and about 1 km (0.62 miles) east and west, would be offset by small areas of decreased productivity south of proposed runway 28R extending approximately 4 km (2.5 miles) north and south and 2 km (1.24 miles) east and west. Details of this analysis are found in [Section 6.2.1](#) and [Appendix Y](#).

### **7.3.2 Benthic Communities**

Benthic organisms use four major habitat types in the vicinity of proposed project components. Rocky intertidal (riprap), intertidal mudflat, and subtidal soft-bottom habitats are present in the vicinity of SFO and the potential San Bruno Shoals rehandling basin. The proposed East Bay Shores borrow site and rehandling basin is offshore subtidal habitat. Rocky intertidal communities are found on the hard substrate of riprap surrounding the existing SFO runways. Organisms observed in this habitat during field studies included barnacles, algae, and yellow shore crabs. Over 192,000 individual benthic organisms comprising 218 taxa were identified during project field studies in the other three habitats. Nearly 94 percent of the species fell into three major phyla. Annelids were dominant and comprised 57 percent, followed by arthropods (25 percent) and mollusks (11.5 percent). The number of species of polychaete worms was by far the greatest. The benthic community sampled in the runway platform area, potential East Bay Shoals borrow site, and the existing Bay Farm Island borrow pit were similar to benthic communities described from other Central and South Bay soft-bottom habitats by others in 1985, 1986, 1988, 1989, and 1995.

The potential mechanisms through which the proposed project may affect benthic communities are identified within the framework of the conceptual model presented in [Section 1.3.2](#). These

mechanisms include changes to the physical environment resulting in permanent loss and temporary disturbance of habitat, changes in bottom elevations, and resuspension of sediments. Potential effects to benthic communities resulting from these changes include:

- Direct burial or removal of benthic organisms
- Permanent loss of natural sedimentary habitats
- Changes in benthic species assemblages
- Reduction in percentage of native species during recolonization of habitat disturbed by construction activities
- Loss of benthic prey for larger species such as fish, birds, and mammals
- Loss of benthic organisms exposed to toxic constituents from disturbance of sediments

### **7.3.2.1 Construction Effects**

Dredging and associated sedimentation during construction would result in disturbance to benthic habitats around the proposed new runway platforms, the San Bruno Shoals or East Bay Shoals rehandling basin, and the potential East Bay Shoals borrow site. Dredging would result in the direct removal of benthic organisms. Settling of sediment in areas adjacent to the dredging and filling operations could bury fauna or clog feeding and respiration structures, resulting in the loss of some organisms in these areas. Dredging could directly affect between 457 and 1,070 acres (185 and 433 ha) at the East Bay Shoals borrow site, up to 59 acres (24 ha) at the potential East Bay Shoals or San Bruno Shoals rehandling basin (if used), and approximately 124 to 173 acres (50 to 70 ha) at the new runway platform construction area. No effects at the potential East Bay Shoals borrow site would occur under Alternative A3 Hybrid because fill material for this scenario would come from outside of San Francisco Bay.

The dredging operations would not result in the permanent loss of organisms. Benthic organisms would recolonize areas that are disturbed but not filled after the disturbance is complete. Based on the literature cited in [Section 6.2.2](#), recovery of the disturbed areas is expected to begin almost immediately after the disturbance ceases in a given area and could take from months to a year or two before the normal seasonal, annual, and interannual variations in the benthic community mask further indications of changes in the community in response to the disturbance.

As stated in [Section 6.2.2](#), recovery may not mean that the same species assemblages, diversity, or abundances return to the area after the disturbance. The species that recolonize an area after disturbance would depend in part on factors such as the type of substrate remaining and the pool of available larvae. If recruitment is from adjacent undisturbed areas, benthic assemblages over time could resemble assemblages that now occur in these undisturbed areas. An example of benthic disturbance and recovery exists in the Bay Farm Island borrow pit discussed in [Section 7.2.2](#). A large amount of material was dredged there between the 1940s and mid 1960s to create portions of Bay Farm Island, and additional dredging was done in about 1973. The benthic community in this disturbed area is now nearly identical to the benthic communities found in adjacent undisturbed areas, including the East Bay Shoals borrow site. Infaunal samples taken from the Bay Farm Island borrow pit in 2000 were clustered with the

*Monocorophium/Ampelisca* assemblage, which was the most common and widespread assemblage in this area (Section 2.2). Although many nonnative species have been introduced into the Bay and have potentially displaced native species, several have become important food sources for other trophic levels.

### **7.3.2.2 Operational Effects**

The runway platforms for project alternatives would result in the permanent loss of soft bottom, shallow subtidal, and intertidal mudflat habitats and benthic organisms associated with those habitats. Permanent losses of shallow subtidal benthic habitat range from 118 ha (291 acres) (Alternative A3 Hybrid) to 346 ha (851 acres) (Alternative BX-R Fill). These losses represent approximately 0.4 to 1.2 percent of the shallow soft-bottom habitat in the South Bay. Permanent loss of mudflat habitat represents between 0.2 to 0.6 percent of the available South Bay mudflat habitat. Affected benthic species would include amphipods, bivalves, and polychaete worms (Section 2.2.3).

The runway platforms would increase hard substrate habitat in the South Bay in the form of sheet pile, rock, and in the case of the hybrid options, pilings. It is expected that colonization of the new hard substrates would be by species similar to those found along the existing runway perimeter. This hard substrate community is relatively sparse, with barnacles being the most common organism.

Hydrodynamic and sediment transport studies discussed in Section 5.2 do not indicate that project alternatives would cause substantial changes in habitat type over a 50-year period in areas not directly disturbed by runway placement. Changes in sedimentation and bathymetry resulting from runway placement suggests long-term shifting of sediments and gradual changes in depth similar to the trends predicted for the No Action Alternative, such as the deepening of the main channel in the South Bay and smoothing out of contour lines. These gradual changes in depth over long periods of time are not expected to alter benthic community structure as none of these changes would result in a fundamental change in habitat type (i.e., a change from mudflat to subtidal habitat or vice versa).

### **7.3.3 Eelgrass**

Eelgrass is a native marine vascular plant indigenous to the soft-bottom bays and estuaries of the northern hemisphere. Eelgrass plays many roles within estuarine systems. It clarifies water through sediment trapping and habitat stabilization. It also provides the benefits of nutrient transformation and water oxygenation. Eelgrass serves as a primary producer in a detrital-based food-web and is further directly grazed by invertebrates, fish, and birds, thus contributing to the system at multiple trophic levels. Additionally, it provides physical structure to the community and supports epiphytic plants and animals, which in turn are grazed upon by other invertebrates, larval and juvenile fish, and birds. Eelgrass beds serve as nursery areas for many commercially and recreationally important finfish and shellfish species, including those that are resident within bays and estuaries, nearly all of the anadromous fish species found along the Pacific Coast, and oceanic species that enter the estuaries to breed or spawn.

In portions of the South Bay that could potentially be affected by the proposed project, eelgrass occurs near Bay Farm Island, the Alameda shoreline, and in sparse patches near Coyote Point (Section 2.2.4). Surveys were conducted in these areas for this proposed project. In addition, surveys were recently conducted in the proposed runway platform area, though no eelgrass was located there (Appendix C-2).

### **7.3.3.1 Construction Effects**

Construction effects on eelgrass generally tend to be associated either with heavy sedimentation in the immediate proximity of the work area or increased turbidity in distant areas.

Sedimentation effects tend to be localized and highly predictable based on sediment properties, construction methods, and current patterns. Turbidity effects are, however, more difficult to predict with certainty.

Sedimentation is generally considered to have an acute effect on eelgrass. The estimated areal extent of sedimentation over the 6-year construction period for project alternatives is not expected to affect nearshore areas supporting eelgrass at Coyote Point or Bay Farm Island (Section 6.2.3). Eelgrass near the eastern edge of Bay Farm Island is located at the outer edge of where sedimentation might occur during dredging of the potential East Bay Shoals borrow site. Depositional rates, if any, in this bed would be low (-2 to 5 mm or -0.08 to 0.2 inch per month) and would only occur during dredging of the easternmost portions of the borrow site. Substrate in the eelgrass area near Bay Farm Island consists of fine sand that is swept by the currents. Deposition of fine-grained materials at the low rates predicted would be expected to be swept away and not substantially accumulate. Beds located along the Alameda shoreline and the northern edge of Bay Farm Island would not be affected by sedimentation, according to the sediment transport study results. Because the anticipated accretion rates are well below the rates reported to cause mortality in published studies (10 cm, or 3.9 inches, total), it is not anticipated that direct sedimentation would result in lethal effects to eelgrass beds in the Bay Farm Island area. The edge of the sediment plume from construction of the new runway platforms would be about 1 km (0.62 mile) from the eelgrass at Coyote Point.

Effects of turbidity on eelgrass are generally not measured as acute effects but rather tend to be associated with chronic changes in the environment, most notably a decline in ambient light available to support photosynthesis. Eelgrass effects associated with turbidity are noted as declines in plant vigor, bed thinning, and eventual mortality across turbidity gradients within the affected area. Indirect effects from turbidity caused by construction activities were assessed based on the construction scenarios discussed in Section 5.3.1. Based on these results, the SSC plumes from Alternatives A3 and BX-6 are not expected to move nearshore. However, for Alternative BX-R the primary SSC plume is predicted to extend nearshore over the location of the Bay Farm Island eelgrass bed. As a result, dredging associated with Alternative BX-R would be expected to cause changes in this eelgrass bed over the construction period.

The cumulative effects of turbidity caused by project construction and other naturally occurring sources of turbidity on eelgrass are more difficult to predict. While it is expected that some minor effect may occur in association with prolonged dredging and filling, effects would be expected to be localized in proximity to the activities (i.e., Coyote Point and Bay Farm Island). These may be noted as either eelgrass losses or sublethal declines in bed density or areal extent.

For Alternatives BX-6 and A3 Fill, both Bay Farm Island and Coyote Point eelgrass beds could potentially be affected by the cumulative additions of sediment. Alternative BX-R may affect the same beds, but at an incrementally higher risk to the Bay Farm Island site due to its greater initial turbidity plume and a commensurately greater distribution of sediments available for resuspension and transport. Alternative A3 Hybrid would only increase risks to the Coyote Point eelgrass beds.

### **7.3.3.2 Operational Effects**

Eelgrass occurs in very patchy areas near Coyote Point and in larger beds near Bay Farm Island. The runway reconfiguration would not result in the direct removal of any eelgrass. Results of the hydrodynamic studies do not suggest that long-term sedimentation or erosion would occur near these beds, thus no permanent changes to habitat type near these beds is expected to result from operation of project alternatives.

### **7.3.4 Fish**

Subtidal and intertidal habitats in the vicinity of project alternatives (including the potential East Bay borrow site and rehandling basin sites) support a diverse assemblage of marine and estuarine fish and macroinvertebrates (Section 2.2.5). Many of the species reside year-round within the estuary, while other species use the estuary on a seasonal basis as foraging habitat, spawning habitat, juvenile rearing and nursery area, and as a migratory corridor between the freshwater river systems and Pacific coastal waters (Section 2.2.5.3). The occurrence, abundance, and habitat usage among these species varies in response to biological and environmental factors that include seasonal and interannual variation in salinity, water temperature, and regional changes in population abundance. The occurrence of species in the subtidal and intertidal habitats in the vicinity of alternative project components also reflects specific habitat characteristics (e.g., availability of shallow subtidal sand substrate, piers and pilings, rocky outcroppings and riprap, etc. [Section 2.2.5.2]) that meet specific habitat requirements and habitat functions (e.g., foraging, spawning, cover and shelter, etc.) for each of the fish and macroinvertebrate species and lifestages present in the area.

Information from long-term Baywide and more recent site-specific fishery surveys was used as part of this assessment to characterize the species composition within the intertidal and subtidal areas in the vicinity of the runway reconfiguration site, potential East Bay Shoals borrow site, and alternative rehandling sites (Section 2.2.5.1). Information used in the assessment also focused on habitat functions for different species and lifestages (Section 2.2.5.3) and how project-related activities may affect the abundance, distribution, behavior, and overall habitat suitability (e.g., behavioral avoidance of areas having elevated SSCs, changes in current patterns and migration routes, physical exclusion from currently available and suitable subtidal and intertidal habitat, etc.).

Consideration was given to the occurrence of threatened or endangered fish within the proposed project area (Section 2.3.2.4) and to the habitat functions that may be affected by proposed project activities (e.g., behavioral changes and delays in steelhead migration, etc.). The proposed project area also has been identified as Essential Fish Habitat (EFH) for a number of marine, estuarine, and anadromous species that support commercial and recreational fisheries, either

within the Bay-Delta estuary or coastal waters ([Section 2.2.5.5](#)). Species such as Pacific herring, northern anchovy, and bay shrimp support commercial fisheries within San Francisco Bay ([Section 2.2.5.6](#)). The Bay-Delta estuary also supports recreational fisheries for species such as California halibut, leopard shark, surfperch, and striped bass ([Section 2.2.5.6](#)). The Bay has been identified as an obligate nursery habitat for species such as Pacific herring and Dungeness crab ([Section 2.2.5.3](#)) and hence is important habitat influencing the overall population dynamics for these and other fish and macroinvertebrate species.

#### **7.3.4.1 Construction Effects**

Construction-related activities associated with the proposed project would alter or modify aspects of the existing intertidal and subtidal habitats within the proposed project area that may affect the quality and availability of suitable habitat and habitat functions. Dredging at the proposed runway platform sites, East Bay Shoals borrow site, and rehandling basins resulting in habitat disturbance, exposure to increased SSCs, short-term acoustic effects from pile driving and boats, changes in water depth within the borrow area, and others were identified as potential physical stressors to fish and macroinvertebrates ([Section 6.2.4.2](#)). The assessment of effects resulting from these and other construction-related activities was based on information from hydrodynamic and water quality studies ([Section 5](#)) regarding the aerial extent of the suspended sediment plume from dredging and filling and information from the scientific literature regarding the anticipated biological response (e.g., behavioral avoidance, reduced foraging activity, sublethal physiological stress, acute mortality, etc.).

Construction activities are expected to result in the exclusion of fish and macroinvertebrates from subtidal and intertidal habitats ([Section 6.2.4.2](#)) within the construction vicinity. Exclusion of fish and macroinvertebrates from currently available habitat is expected to result in localized reductions in the abundance of these species as a direct result of the reduction in habitat quality and availability during construction. The adverse effects associated with construction are anticipated to occur throughout the 6-year construction period. Although construction effects are anticipated to terminate shortly after construction is complete, the adverse effects on multiple-year classes over the duration of construction activity may require an additional period of several years before populations are fully recovered. Although the biological effects varied among alternatives, the order of magnitude of construction effects was generally similar for all of the alternatives except Alternative A3 Hybrid. This alternative would have substantially less effects on fish and macroinvertebrates than other alternatives because it would not require dredging fill material from the Bay. However, Alternative A3 Hybrid would still result in localized loss of habitat and reduction in habitat quality because it would require some dredging at the platform site, development and use of the San Bruno Shoals rehandling basin, and pile driving.

#### **7.3.4.2 Operational Effects**

The proposed project would result in permanent changes to the intertidal and subtidal habitats ([Sections 6.2.4.1](#) and [6.3.1.1](#)) as a result of:

- New runway platforms excluding species from currently available habitat
- Changes in current patterns

- Changes in migration routes
- Changes in water depth at the potential East Bay Shoals borrow site without sediment replacement
- Permanent changes in habitat characteristics (e.g., reduction in availability of soft-bottom habitat, increase in the availability of rocky and piling substrate)

The effects of these permanent changes in habitat quality and availability vary among species and lifestages and have the potential to result in increases in habitat for some species (e.g., an increase in foraging and cover habitat for species such as surfperch and rockcrabs) and a reduction in habitat quality and availability for other species. Although the biological effects varied among alternatives, the order of magnitude of permanent effects was generally similar for all of the alternatives. As discussed in [Section 7.3.2](#), the proposed project would result in the loss of approximately 0.4 to 1.2 percent of the subtidal soft-bottom habitat in the South Bay and 0.2 to 0.6 percent of the intertidal habitat in the South Bay.

The proposed project would result in the permanent loss of both subtidal and intertidal habitat under the runway platforms built on fill and modify habitat quality and availability under the pile-supported Runway 10L/28R platform. A new Runway 10L/28R platform built on piles is anticipated to exclude species that currently use the soft-bottom subtidal and intertidal habitat in the area (e.g., English sole, starry flounder, surfperch, Pacific herring, northern anchovy, California halibut, juvenile Dungeness crab) and may reduce the abundance of these species in the immediate vicinity of the runway platforms. The addition of rocky and hard-substrate habitat in the intertidal and subtidal areas of the runway platforms may increase the availability of suitable habitat for some species and lifestages of fish and macroinvertebrates (e.g., shiner perch, rockcrab, etc.). Although quantitative data are not available on carrying capacity of habitats elsewhere within the Bay-Delta estuary, the assessment hypothesizes that specific habitat characteristics required by some species (e.g., subtidal sandy habitat for California halibut foraging and Dungeness crab nursery) have limited carrying capacity within the Bay and, therefore, effects on these species and their habitat would result in a direct population reduction. However, Bay habitat for pelagic species (e.g., Pacific herring, northern anchovy, topsmelt) may be able to assimilate all or a portion of those individuals displaced by permanent project features. Although localized changes in habitat function and species abundance are expected to occur within the immediate project vicinity, these fish and macroinvertebrate species also reside within other portions of the Bay and along the Pacific Coast.

Migratory species such as steelhead and chinook salmon are known to travel through the South Bay. However, it is not known whether they travel along the margins of the Bay or in the main channel. If these fish use the main channel, the proposed project would not affect their migration. If they use the western margin of the South Bay for migration, new runway platforms would result in delays or a longer duration of migration for these species. However, based on the best available scientific information, no incremental increase in mortality of these species could be determined ([Sections 6.2.4.1.4](#) and [6.3.1.1](#)). None of the alternatives would result in complete blockage of migration.

### **7.3.5 Birds**

Sixty-four species of waterbirds were observed in the vicinity of the runway alternatives during 13 ground surveys in 2000-2001. Of these, 42 percent were short- or long-legged waders, 28 percent were diving birds, 19 percent were gulls and terns, and 11 percent were surface-feeding ducks and geese. Winter was the peak season of use for 46 percent of all species, followed by fall (29 percent), spring (17 percent), and equal use among more than one season (8 percent). This pattern of seasonal use was found to be fairly typical of other portions of the Bay. Among shorebirds, western sandpiper, dunlin, and dowitcher species were found to be the most abundant species in the SFO vicinity. Among waterfowl (diving and dabbling ducks), scaup, bufflehead, and ruddy duck were found to be the most abundant species.

More than 60 species were identified during open-water boat surveys of the South Bay for this proposed project, with scaup and scoter together representing approximately 81 percent of the total number of individuals. The highest densities were observed along the eastern portion of the South Bay, concentrated in shallow bay habitat between Bay Farm Island and the San Mateo Bridge.

California clapper rail (a federally-listed endangered species) surveys in the 8.9-ha (22-acre) San Bruno Marsh to the north of SFO identified between 17 and 24 individuals during the spring of 2001. Post-breeding season California least tern (a federally-listed endangered species) surveys in the vicinity of the SFO recorded four individuals on a vegetated sand spit at the very southern extent of the study area near Coyote Point, where this species has been recorded previously.

#### **7.3.5.1 Construction Effects**

Some avian species would likely be totally excluded from areas where construction vessels and personnel are active over the 6-year construction period. Avian species would also be excluded from dredging and filling areas where benthic communities have been removed or buried and increases in SSCs have precluded most fish. Benthic invertebrate populations would take at least a few months to a year or two before recovery in dredged areas. This would preclude the use of those areas by some avian species.

#### **7.3.5.2 Operational Effects**

The magnitude of permanent habitat loss to avian species would vary depending on the runway alternative. Generally, Alternative BX-R (either all-fill or hybrid options) would result in the greatest extent of avian habitat loss, followed by Alternative BX-6 and Alternative A3. The range of alternatives would remove between 0.17 and 0.50 percent of shallow bay, between 0.11 and 0.29 percent of tidal flat, and less than 0.01 percent of tidal marsh habitat currently remaining in San Francisco Bay. The potential East Bay Shoals borrow site would convert between 0.3 and 0.6 percent of existing shallow bay habitat to deep bay habitat, or between 0.2 and 0.4 percent if the borrow site was partially refilled after construction.

A relatively high density of short-legged waders was recorded in the vicinity of the existing SFO runways during the spring season. Loss of tidal flat habitat would potentially affect between 1,868 (Alternative A3) and 4,887 (Alternative BX-R) short-legged waders depending on the alternative. However, in comparison to published estimates of Pacific Coast shorebird

populations, the number of individuals potentially affected represents no more than a maximum of 0.6 percent of any species population. In most cases, the number of short-legged waders potentially affected is between less than 0.1 and 0.2 percent of the Pacific Coast population.

The highest numbers of shorebirds was observed in the SFO vicinity during a brief migratory period in the spring. Habitat loss may be particularly stressful for birds during migration when they are already experiencing high energy demands associated with long-distance flight. Higher quality salt pond habitats are available within the South Bay region, where short-legged and long-legged waders that experience loss of habitat may relocate. Alternately, loss of habitat for a given species may experience population level effects such as decreased survival, as described in [Section 6.2.5.1.4](#).

Based on the density of individuals in the vicinity of SFO and the amount of habitat that would be lost, between 135 and 354 long-legged waders (including herons and egrets), between 749 and 1,812 diving birds, between 41 and 121 dabbling ducks (including geese), and between 161 and 473 gulls and terns would be affected by the proposed project. Of the wading birds, black-bellied plover, semipalmated plover, and dowitcher species, would likely be most affected relative to their total population occurring in San Francisco Bay. Up to 1.4 percent of semipalmated plovers, and up to 1.0 percent of dowitchers and black-bellied plovers would be affected. Of the diving ducks, bufflehead and scaup populations (up to 5.3 and 1.1 percent, respectively) would likely be most affected by the loss of habitat due to the high numbers that use the shallow bay habitat in the SFO vicinity. Of the dabbling ducks, a relatively high proportion of Canada goose and American coot populations would likely be affected (up to 1.5 and 1.7 percent, respectively). However, for Canada goose, this may be due to the very low population estimate of 108 individuals published in Accurso (1992), not because a large number use habitat near SFO.

Habitat adjacent to the reconfigured runways would likely undergo change that alters the value of that habitat to avian species. In general, some soft-bottom areas would be converted to hard-bottom areas. Sediment gradient and texture is likely to be altered, which may affect the distribution of shorebirds on the remaining tidal flat areas adjacent to runways. The reconfigured runway may also present a greater physical barrier to shorebirds and waterfowl species migrating between habitat patches to the north and to the south of the site.

### **7.3.6 Marine Mammals**

Although the Bay is a large water body located midway along the California coastline, the number of marine mammal species that use the Bay are limited and consist primarily of the harbor seal and California sea lion. Over the last several years, gray whales sightings in the Bay have increased. Other species that have been sighted in the Bay periodically include harbor porpoise, northern elephant seal, Steller sea lion, northern fur seal, and sea otters.

The harbor seal is the most common and abundant marine mammal in the Bay and the only marine mammal that is known to be permanent resident of the Bay. San Francisco Bay serves as a nursery, provides protected waters for resting, and is used as a foraging area by harbor seals. Generally, female harbor seals seek isolated, undisturbed areas for pupping and nursing, while all harbor seals use resting areas (called haul-out sites) that are free from frequent disturbance and near channels or open water. The closest haul-out site to the proposed new runways are

Corkscrew Slough, Greco Island, and Bair Island, which are approximately 16 km (10 miles) or more south of the existing SFO runways. Yerba Buena Island, another important haul-out and pupping site, is located approximately 8 km (5 miles) north of the potential East Bay Shoals borrow site.

### **7.3.6.1 Construction Effects**

Dredging at the proposed runway platform site, potential East Bay Shoals borrow site, and potential rehandling basin sites would create a sediment plume in the water column. Discharge of fill at a rehandling basin would also create a sediment plume. It is anticipated that marine mammals would avoid these near-field plumes because of the high SSCs and construction equipment noise. Foraging success in these areas would be expected to be lower because of decreased visibility and decreased availability of prey. Suspended sediment concentrations beyond about 200 or 300 meters (656 to 984 feet) from active dredging or fill sites are expected to be near ambient conditions and are not likely to have a substantial effect on marine mammal foraging.

Underwater noise from pile driving for the hybrid option for each alternative would affect marine mammals. The National Marine Fisheries Service has indicated that sound pressure levels of 190 dB should be the maximum level of noise exposure to marine mammals, particularly seals. Specific sound pressure levels that would potentially be generated by the proposed project are not known and would depend in part on factors such as the size and type of pile, size of the pile-driving hammer, resistance of the substrate, and water depth. However, it would be expected that marine mammals would avoid an area at least several hundred meters from active pile drivers used to construct a pile-supported Runway 10L/28R platform.

Airborne noise from construction-related activities could potentially disturb marine mammals. Observations by Caltrans during test pile-driving for the Bay Bridge seismic retrofit project suggested that airborne noise levels of 50-60 dBA above ambient may have contributed to responses of sea lions in the area. Observations at Castro Rocks have shown that work on the Richmond-San Rafael Bridge caused disturbance at rates approximately three to five times higher than before work began. No major haul-out site occurs in close proximity to SFO, San Bruno Shoals or the potential East Bay Shoals borrow site; therefore, it is expected that project construction would not interfere with use of these haul-out sites by marine mammals.

### **7.3.6.2 Operational Effects**

Each runway reconfiguration alternative would remove benthic foraging areas for marine mammals, although pilings used in the hybrid options may provide additional structure for some marine mammal prey. The loss of subtidal and intertidal habitat represents approximately 0.6 to 1.8 percent of the available subtidal and intertidal habitat in the South Bay depending on the alternative. This loss would reduce the amount of space available for foraging by harbor seals, and as discussed in [Section 6.2.4](#), result in potential reductions in resident fish species such as gobies or flatfish, which are prey for harbor seals. Pelagic species that are also harbor seal prey (e.g., topsmelt and Pacific herring) move throughout large areas of the Bay and coastal ocean waters, and therefore would be less affected by the loss of habitat than species such as gobies (see [Section 6.2.4](#)). The loss of potential foraging habitat and prey associated with this habitat

may increase the foraging pressure elsewhere. Based on studies conducted from 1990 to 1992, the area around SFO does not appear to be a primary foraging area for marine mammals. Harbor seals have been known to travel up to 51 miles (82 km) within a few days and have a foraging range of many ha within the Bay. The South Bay (south of the Bay Bridge) covers approximately 47,799 ha (19,352 acres) and is well within swimming range of a harbor seal. Assuming that the whole South Bay is potential foraging habitat for harbor seals, the project alternatives would remove between 0.3 percent (Alternative A3) and 0.8 percent (Alternative BX-R) of available foraging habitat.

Based on hydrodynamic and sediment transport studies for this proposed project, changes in bathymetry would be limited to the vicinity of project features such as the new runway platforms and the potential East Bay Shoals borrow site. No erosion is projected along the shorelines near important South Bay haul-out sites such as Bair Island, Greco Island, Corkscrew Slough, and Mowry Slough.

### **7.3.7 Bioaccumulation and Toxicity**

Chemicals released into the water column during dredging of sediments from the platform area and access channels, the potential East Bay Shoals borrow site, or the East Bay Shoals or San Bruno Shoals rehandling basin could affect biological organisms through either direct toxicity or bioaccumulation in the food chain. Direct toxicity refers to adverse effects to an organism caused by contact between the organism and contaminated environmental media (i.e., water or sediment). Bioaccumulation is the process by which living organisms can retain and concentrate chemicals both directly from their surrounding environment and indirectly through ingestion of prey. Indirect toxicity, or food-web toxicity, may occur in receptors whose primary exposure to chemicals occurs by way of diet (i.e., bioaccumulation). Generally, the evaluation conducted for the SFO Runway Reconfiguration Project was conducted to assess the effects that occur outside of the zone immediately affected by dredging and filling operations. Within the immediate vicinity of construction, aquatic organisms are more likely to be affected by physical factors, such as increased turbidity, burial, entrainment, habitat disturbance, and noise.

Comparison of chemical of potential ecological concern (COPEC) concentrations modeled in the near-field to acute WQOs demonstrates that copper is likely to be the only chemical of concern for acute toxicity to aquatic organisms. Further evaluation of literature-based toxicity data shows that while dissolved copper concentrations may exceed levels that are acutely toxic to invertebrates, levels that cause acute toxicity to fish are unlikely to be exceeded outside the immediate vicinity of the dredging or disposal area. Although plume sizes of copper WQO exceedances were estimated for various dredging scenarios, the largest conceivable plume of 860 meters by 40 meters (2,822 by 131 feet) is predicted to occur during clamshell dredging of SFO dredge unit 13V under slack tide conditions. During clamshell dredging under average background concentrations and current velocities, this plume is predicted to be approximately 130 meters long and 20 meters wide (427 by 66 feet). Maximum copper concentrations are reported in [Section 7.2.3](#).

Far-field water quality modeling predicted concentrations throughout the Bay for total PCBs, total PAHs, total mercury, dissolved copper, and dissolved nickel. Maximum predicted concentrations (4-day averages) of total mercury and dissolved nickel did not exceed chronic

WQOs. Although PCB concentrations exceed the chronic WQO in small areas in the South Bay, dredging and disposal for the project alternatives do not change the affected area compared with existing conditions. In the absence of a chronic WQO for PAHs, a literature review was conducted to evaluate toxicity data, and the lowest observable effects concentration of 4.9 µg/L was used for comparison to modeled PAH concentrations in water. Total PAH concentrations are not predicted to exceed the lowest observable effect concentration (LOEC) of 4.9 µg/L for any of the scenarios evaluated.

Predicted copper concentrations exceed chronic WQOs in several areas throughout the Bay, both under existing conditions and under runway construction conditions. Concentrations in the vicinity of construction activities are predicted to increase on average between 0.1 and 0.25 µg/L and up to 0.25–0.5 µg/L in the vicinity of the East Bay Shoals borrow site.

Elutriate bioassays evaluated the toxicity of the COPEC mixtures likely to be released to water during dredging and disposal. Although toxicity was exhibited in the undiluted elutriate for two out of three species tested, the LPC is not predicted to be exceeded outside of the mixing zone. The highest toxicity was exhibited in the potential San Bruno Shoals rehandling basin, where the EC<sub>50</sub> for the Mediterranean mussel occurred at a 17 percent elutriate concentration. Using a factor of 0.01 for the acute-to-chronic ratio, the LPC for this sample is 0.17 percent elutriate concentration. This indicates that a dilution factor of 588 would be necessary to dilute the elutriate sufficiently to avoid toxicity. No dredging-related toxicity would be expected outside the zone where that level of dilution occurs.

Based on water quality modeling and bioassay results, it appears that copper is the primary chemical of concern for both acute and chronic toxicity. While bioassay results indicate that dredging-related toxicity is not likely to be exhibited once adequate dilution occurs, water quality modeling predicts that both acute and chronic WQOs would be exceeded for copper. Because copper levels are high under existing conditions, even a small increase in concentrations may have an effect in some areas. Review of literature on copper toxicity indicates that invertebrates are more likely than fish to be affected by the concentrations of copper in surface water predicted during dredging and disposal activities.

To evaluate toxicity to upper trophic levels (i.e., aquatic birds and mammals) exposed to the chemicals via bioaccumulation, a food-chain model was developed. The bioaccumulative COPECs evaluated included mercury, PAHs, and PCBs. The representative species evaluated were the double-crested cormorant and the Pacific harbor seal. Using conservative parameters, the food-chain model was used to calculate protective water concentrations (concentrations that are not expected to result in any adverse effects) for each representative upper-trophic-level receptor. These protective concentrations were then compared to modeled water concentrations, which were averaged over the home range of the receptor.

For higher-trophic-level receptors, the exposure dose was estimated as a function of chemical concentrations in the water, several other parameters related to biotransfer through the food web, and the manner in which receptors use the habitat (e.g., behavior, dietary composition, food ingestion rates, etc). Exposure doses for receptors were estimated by a series of models to represent COPEC concentrations as they transfer from the water through the biotic compartments of the food web and into the dietary components of the receptors. Protective water concentrations (RBCs) were then calculated for each COPEC based on daily doses expected to

be protective. The food-web modeling focused on COPEC concentrations in the water column (including suspended sediments) because these concentrations are expected to change during dredging operations. Although receptors may also receive exposure from COPECs in bedded surface sediments, concentrations in those sediments are not expected to substantially change during or after dredging.

Spatial averages of modeled surface water concentrations of PCBs and mercury in the far field under the five scenarios (existing conditions, BX-6 Hybrid, BX-6 Fill, A3, and BX-R) do not exceed cormorant-based RBCs at the potential East Bay Shoals borrow site or runway platform areas for the wet or dry season. These results support the conclusion that unacceptable risks will not be posed to the cormorant or other piscivorous birds from dietary exposure to COPECs in the farfield during dredging and disposal activities. Insufficient data were available to evaluate potential effects of PAHs to avian receptors.

Spatial averages of modeled concentrations of PCBs, mercury, and total PAHs were screened against RBCs protective of the Pacific harbor seal. Little variation was exhibited in spatially averaged COPEC concentrations between the five scenarios evaluated. Concentrations of mercury and PAHs do not pose unacceptable risks to the seal at either of the locations evaluated (Coyote Point and the entire Central/South Bay). The RBC of 0.0026 µg/L for PCBs, derived from the Region 9 BTAG TRV, also does not show an unacceptable risk to the seal. However, the alternative RBC of 0.000035 µg/L for PCBs generated from a seal-based toxicity study is lower than modeled PCB concentrations for all exposure scenarios. This is an indication that existing PCB concentrations in the Central/South Bay and at Coyote Point may already present a potential risk to seals. Modeled water concentrations under existing conditions and the four construction scenarios are so similar that a distinction between noise from the model versus a very slight increase in chemical concentration (e.g., one ten-thousandth µg/L) is difficult to make.

## **7.4 WETLANDS**

Tidal wetlands closest to SFO include the San Bruno Marsh to the north and a strip of tidal wetland adjacent to existing Runway 1R. Pockets of isolated, disturbed seasonal wetland that are not under the jurisdiction of the USACE occur on the airfield itself. Changes to these seasonal wetlands caused by the proposed project are not addressed in this technical report but will be evaluated in other studies for the EIS.

[Section 6.4](#) provides changes to wetlands and other waters of the U.S. that could be caused by construction and operation of project alternatives. The proposed project would result in the removal of between 0.8 ha (2 acres) (Alternative A3) and 1.1 ha (2.7 acres) (Alternatives BX-6 and BX-R) of tidal wetland along existing Runway 1R. Construction of new runway platforms would also result in the removal of between 118 ha (291 acres) (Alternative A3 Hybrid) and 346 ha (851 acres) (Alternative BX-R Fill) of nonwetland waters of the U.S. and between 13 ha (32 acres) (Alternative A3 Hybrid) and 34 ha (84 acres) (Alternative BX-R Fill) of tidal flat.

A visual inspection of most of the shoreline between Bair Island and Oyster Point was conducted to identify locations of potential shoreline erosion. Most of this shoreline has been hardened and therefore is not subject to erosion. However, several wetland areas and Coyote Point Beach were identified as having “soft” shorelines. Waves are the dominant cause of shoreline erosion and

local instability of tidal wetlands. If wave height is reduced, a shoreline is less likely to erode; if the wave height is increased, shoreline erosion is more likely to occur.

Changes in wind waves associated with project alternatives are not expected to alter shoreline stability in the SFO vicinity for the following reasons:

- Most of the shoreline is lined with riprap, which protects the shoreline against waves much larger than would be present in the Bay under normal circumstances.
- As described in [Section 5.2.4](#), significant wave heights in the SFO vicinity (0.1 to 0.55 meter or 0.3 to 1.8 feet) are effectively reduced as a consequence of reduced fetch length.
- Wind speeds are lower for certain wave approach directions due to the shielding effect of the proposed new Runway 10L/28R platform (refer to [Section 5.2.4](#)).
- Westerly, southwesterly, and northwesterly winds are the dominant winds in the Bay. Waves generated by these winds would propagate toward the eastern shore of the South Bay.

Changes in water-level fluctuations can increase shoreline erosion by allowing larger waves access to the shoreline. The proposed project is not predicted to raise water levels in the Bay, so no additional shoreline erosion would be expected to occur from this mechanism.

A more indirect mechanism for shoreline erosion is mudflat erosion. Although the integrity of a shoreline is governed by the strength of the material it is made of and not necessarily related to the elevation and slope of the mudflat, if the extent of mudflat is reduced, larger waves could access the shoreline, thereby increasing the rate of erosion. However, hydrodynamic and sediment transport studies conducted for the proposed project do not predict any changes in either sedimentation rates, RMS speeds, or wave height that could increase shoreline erosion.