Central San Francisco Bay
Regional Sediment Management Plan

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Central San Francisco Bay Regional Sediment Management Plan

I. Introduction

Regional sediment management (RSM) is a planning approach to managing sediments within the context of an entire system or watershed, including sediment sources, movement and sinks within the system and exchange with the ocean. Application of RSM to San Francisco Bay (Bay) and its watersheds will assist watershed, flood control and coastal managers to better understand both the impacts of individual permit decisions locally and system-wide, and the impacts of systemic processes such as climate change and sea level rise on permitted projects. It recognizes that sediment – fine sediment, sand and cobble are important natural resources that make up the base of any habitat. In the case of San Francisco Bay, the watershed and all of its components begin in the Sierras, spend much time in the Bay and continue on until they reach the Pacific Ocean. Because physical processes drive biological processes, sediment dynamics are important components of estuarine systems that are integral to the environmental and economic vitality of the Bay Area.

Regional sediment management planning provides the opportunity to have a greater understanding of the inter-relationships between system processes – supplies of sediment and sinks, as well as the interactions between the physical processes and activities that occur in the Delta, San Francisco Bay and the central coast of California. Within the Bay, a number of activities take place that influence the movement of sediment from its origins in tributaries, including the Sacramento and San Joaquin rivers, to eventually the outer coast. Sediment could erode from or be deposited in marshes, mudflats and subtidal channels, bounce along the shoreline or simply be redistributed. Dams, reservoirs, dredging and mining activities, clearing of flood protection channels, and restoration of habitats are all direct anthropogenic linkages in the system. Through regional sediment management, improved knowledge of both the system itself and its associated activities can improve decision-making, policy and practices on a regional scale to reduce adverse impacts and enhance existing systems and habitats.

The State of California has recognized and emphasized the need to better manage sediment, particularly in coastal regions where public access to the shoreline provides opportunities for recreation, fishing and wildlife appreciation. The Coastal Sediment Work Group (CSMW), a collaborative taskforce of state, federal and local/regional entities, concerned about adverse impacts of coastal erosion and excess sedimentation on coastal habitats, is developing a Sediment Master Plan for coastal California. Recognizing that California has a physically diverse coastline, varying in use and governance, CSMW determined that regional plans were appropriate. Therefore the main thrust in developing the state sediment master plan is supporting and advancing regional sediment management plans. As such, CSMW has provided funding and technical support to a number of organizations throughout the coastal zone for development of these plans. Once complete, the regional entities can use the plans within their jurisdictional area to improve sediment management. This Central San Francisco Bay Regional Sediment Management Plan is the portion of the overarching plan under development for the Bay. Further work will be undertaken for each of the four embayments, including Central San Francisco Bay, San Pablo Bay, Suisun Bay and South San Francisco Bay.

The geographic study area for Central Bay of the San Francisco Bay RSM plan includes to the outer coast of San Francisco Bay, from Point Bonita to Point Lobos (estuary interface with the Pacific Coast); north to Point San Pablo across to San Pedro Point; and then south to San Leandro Channel (adjacent to Bay Farm Island) and across to Hunters Point; including local tributaries within the boundaries (Figure 1). The Delta, Suisun, San Pablo, the South Bay, local tributaries, and the outer coast are important considerations in any Bay sediment management strategy as sediment is supplied, exchanged and deposited in these areas.

Figure 1. Central San Francisco Bay Study Area.

In discussions with the CSMW prior to receiving funding, the CSMW limited the scope of work for this project to sand sources and beach nourishment projects within Central San Francisco Bay because the primary focus of the group has been coastal beaches and erosion processes associated with the outer coast. As San Francisco Bay has limited sand shoals, being an estuary with mainly fine grain sediments making up over 80% of the environment, the scope of the project was confined to Central San Francisco Bay. As BCDC continues its work on RSM, the other embayments will be added to the overall San Francisco Bay RSM plan. As with all planning work, staff relies on contributions, experience and expertise of the Bay Area agencies and stakeholders that manage or work in the Bay, its' watersheds and the nearshore coast in making recommendations for any management activities for these areas.

The San Francisco Bay Conservation and Development Commission (BCDC) is a California state planning and regulatory agency with regional authority over the San Francisco Bay, the Bay's shoreline band, and the Suisun Marsh. BCDC was created in 1965 and is the nation's oldest coastal zone management agency. Its mission is to protect and enhance San Francisco Bay and to encourage the responsible and productive use of the Bay for current and future generations. As part of the Bay Program, BCDC staff includes a sediment management team that focuses its work on dredging, sand mining, flood protection and habitat restoration projects where sediment is a contributing factor to the success of the restoration. As part of this work, BCDC is a partner in the Long Term Management Strategy for the Placement of Dredged Sediment in the Bay Region (LTMS) program. The partnering agencies are the US Army Corps of Engineers (USACE), US Environmental Protection Agency (USEPA), the San Francisco Regional Water Quality Control Board (Water Board) and BCDC. Together these agencies jointly manage dredging activities within the Bay as a regional program. BCDC has taken the lead in working on a RSM program for the Bay, and while working with LTMS partner agencies, BCDC will incorporate the LTMS and RSM planning components for sand mining, flood protection, habitat restoration and shoreline erosion issues, in consideration of climate change issues.

This planning process includes three components:

- Investigating and Understanding the Bay's physical processes
- Identify challenges and opportunities presented in the current physical process and management activities.
- Recommend possible changes to practices and activities to maximize sediment use as a resource, protect sensitive resources, improve the health of the Bay, align management activities, reduce project costs, and help address climate change impacts and other system stressors.

Understanding the San Francisco Bay System - Overview

San Francisco Bay lies between the Pacific Ocean at the Golden Gate and the confluence of the San Joaquin and Sacramento Rivers west of the Delta. Its watershed covers 4,600 square miles, of which the Bay encompasses 1,600 square miles and drains 40% of

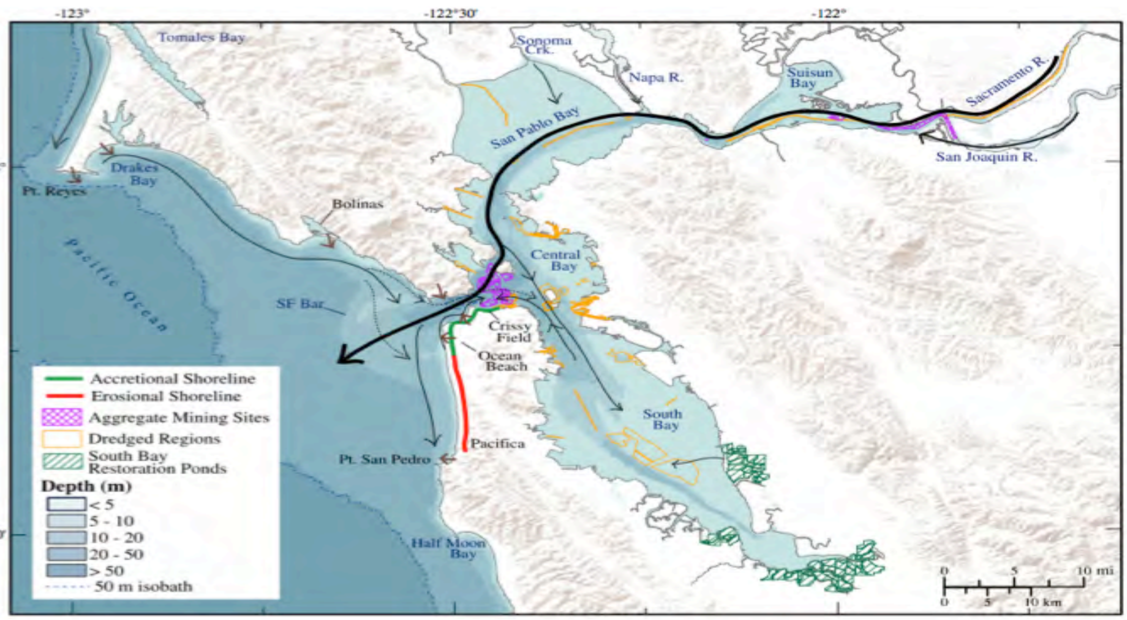
California's landscape (Figure 2). The Bay proper is approximately 50 miles long and three to thirteen miles wide, depending on where you measure. It is the largest Pacific estuary in the Americas and is both highly urbanized and rural in nature, with over 7.4 million people living within its nine bordering counties and 101 cities.

Figure 2. San Francisco Bay Drainage Basin

Because it is one of the world's largest natural harbors, it is home to five major ports, seven refineries, nearly 100 small marinas and docks, as well as seventeen deep and shallow draft federal navigation channels. Also, due to its location and ability to offload cargo to multi-modal transportation operations, it is home to the fifth largest port in the nation (Port of Oakland), which helps drive the economic engine of the Bay Area. At the same time, being a large estuary, the Bay has very significant environmental benefits that include serving as a nursery to numerous species amid massive habitat restoration projects throughout the region. To complicate the picture, just upstream, the Delta supplies fresh water to much of the state, while trying to maintain enough fresh water flow to support its own and the Bay's ecological resources.

A large portion of the Bay's sediments originated from the Sacramento and San Joaquin Rivers, which drains the Sierra Nevada mountains and Central Valley; and the smaller Bay tributaries. At present, suspended sediment from the Central Rivers and the smaller Bay tributaries enter in approximately equal amount, though supply varies both seasonally and annually, with a higher amount arriving during the rainy season and in higher runoff years (McKee *et al.*, 2013). The Central Rivers delivered an annual average of 1 million metric tons per year of sediment to the Estuary, while Bay tributary watersheds delivered 1.27 million metric tons (1.09 million cubic yards per year) (Lewicki and McKee, 2009). Because local watersheds have fewer large dams and are more erodible and steeper than Central Valley rivers, sediment contribution from these watersheds is more variable over time. Most of the sediment entering the Bay is fine mud and clay; however, it is estimated that about 300,000 cy of sand per year enters San Francisco Bay as bedload and in suspension, with local Bay tributaries accounting for approximately 218,000 cy and the Delta accounting for about 78,000 cy of sand on average (BCDC, 2015 Sand Budget Report). During extreme flows, sand was estimated to historically comprise as much as 50% of the suspended load entering the Bay (Porterfield, 1980), and may comprise up to 70% of the suspended load entering the Bay from local tributaries (McKee *et al.*, 2006).

Figure 3. San Francisco Bay sediment transport pathway.



In addition to the Central Valley rivers and Bay tributaries, other sediment sources include tidal marshes and wetlands, shoreline bluff and cliff erosion, resuspension of sediment from the Bay floor and transport of sediment from coastal sources through the Golden Gate.

Once inside the Bay, sediment is incorporated into mudflats, tidal marshes, deepwater sandy shoals, the muddy Bay floor, and beaches. Some sediment is redistributed within the Bay by wind waves and tidal circulation patterns, and some exits the Bay through the Golden Gate. From there, some sediment is carried by the tides to a 60 square mile underwater sand bar (the San Francisco Bar, or ebb-tidal delta), or to the outer coast region to the south. Some sediment returns into the Bay or enters the Bay from the open coast.

Sediment dynamics in the Bay are complex and change over time; the Bay sediment system has been erosional (more sediment leaving than entering) during some periods and accretional (more sediment entering than leaving) in others. In addition to this natural variability, humans have greatly modified sediment dynamics in the Bay and Delta. As a result of hydraulic mining during the Gold Rush, sediment input increased drastically: the annual sediment load between 1849 and 1919 was estimated to be 9 times higher than the pre-Gold Rush rate (Gilbert, 1917). This amounted to approximately 1.1 billion cubic yards, which could fill a large football stadium nearly 500 times. By 1999, the pulse of sediments from the Gold Rush had largely worked through the Bay system; suspended sediment flows into the Bay have since decreased markedly and are not expected to increase or return to previous levels.[1] In the early 2000s, suspended sediment concentrations in the Sacramento River were just half of the amount entering over the previous half-century. In addition, water control structures, large dams, reservoirs, flood control projects, and other modifications to upstream hydrology have reduced sediment inflows from the Bay and Delta tributaries.

With climate change, reduced water discharge from the Delta is expected, likely bringing even less sediment to the Estuary in the future (Schoellhamer, 2011). The state is currently proposing a project to reroute water through the Delta to improve water supply and ecological function. If this project were completed, sediment supply from the Delta would be further reduced by an additional 9%. Though less sediment entering the Bay could reduce dredging needs, sediments will increasingly be needed for maintaining and restoring beaches, tidal marshes, mudflats and subtidal areas along with other elements of shoreline protection. Finally, lowered suspended sediment concentrations in the water column may lead to increased frequency and severity of harmful algal blooms, as well as a more productive Estuary in general, as productivity is currently limited by its turbid waters.

In addition to the decrease of sediment inflows into the Bay, both navigational dredging and sand mining remove sediment from the Bay. Navigational dredging is conducted to maintain sufficient channel depth for ships to access harbors, marinas, and berths, both in deep water channels along the stem of the Bay and along the shoreline. Annual maintenance dredging volume is currently 1.5 to 2 million cubic yards, with periodic deepening projects increasing this average to as much as 3 million cubic yards annually. Dredged sediment is placed either at one of the in-Bay disposal sites, beneficially reused (i.e. in tidal marsh restoration projects), or taken to the San Francisco Deep Ocean Disposal Site. Sand mining occurs in both Central Bay and Suisun Bay, at an average volume of 900,000 cubic yards per year (sand mining volumes reported to BCDC from 1974-2013), with a maximum mined volume in one year of 1.98 mcy. Overall, humans remove more sediment from the Bay each year than enters it (DMMO Annual Report, 2012). At least 262 mcy of sediment, including 71 mcy of sand or coarser sized material, have been removed over the past century (Dallas and Barnard, 2011).

II. Embayments

As discussed briefly above, San Francisco Bay includes four embayments, beginning in the east: Suisun Bay, San Pablo Bay, Central Bay, and the South Bay. Each embayment has its own unique characteristics. Sediment moves between and within each of the embayments and the outer coast.

Suisun Bay is immediately adjacent to the Delta, and is more rural and brackish in nature. It is bordered on the east by the confluence of the Sacramento and San Joaquin Rivers Delta and on the west by the Carquinez Strait and San Pablo Bay. The shorelines are mostly hardened or earthen levees. There are some industrial uses along the shoreline including refinery and port wharf faces and water intake and discharge structures. A deep-water navigation channel runs through it and two areas have active sand mining sites. Currently, several restoration projects are proposed for this area. Work by the USGS has shown that this embayment is currently in an erosional state.

San Pablo Bay, due to its link to a more marine environment, is a bit more saline than Suisun Bay, though it has four large rivers feeding fresh water into it. It is also rural in nature with fringing marshes rimming much of its shoreline. San Pablo Bay currently has a number of wetland restoration projects underway, particularly on its northern shore. A deep-water navigation channel runs through it. As with Suisun Bay, surveys examined by USGS show that this area is in an erosional state.

Central Bay, which is the focus of this plan, is an urban area, with many industrial and commercial and residential uses along the shoreline. The shoreline is primarily hardened, but has limited wetland and beach shorelines. This part of the Bay is highly influenced by the Pacific Ocean and thus is marine in nature. It has multiple deep-water navigation channels running through it and active sand mining occurs between the Golden Gate and Angel and Alcatraz Islands. Like Suisun and San Pablo Bay, review of bathymetric maps and surveys by USGS has shown this area to be erosional.

South San Francisco Bay is also very urban but less industrial in nature than Central Bay. It is marine-like during dry periods, but can become brackish during rainy periods. The shoreline is mixed with large areas of wetland and other soft shorelines, as well as levees and hardened structures. Historically, the South Bay has been home to a large salt making industry. Much of the historic salt making areas are currently being restored to tidal marsh and managed wetlands. Unlike the rest of the Bay, the South Bay is in a depositional state.

The focus of this project is the Central San Francisco Bay as shown in Figure I. Future planning will address each of the embayments as development proceeds.

III. Central Bay – Planning Reaches

Central San Francisco Bay as defined in this planning effort lies between Point San Pablo (Contra Costa County) and San Pedro Point (Marin County) in the north, Bay Farm Island (Alameda County) and Hunters Point (San Francisco County) in the south, and the Golden Gate (Point Lobos and Point Bonita) in the west. Planning reaches for Central Bay were developed based upon the shoreline orientation and wave climate; geomorphic setting; watershed drainage; and land use and degree of development/urbanization in the area.

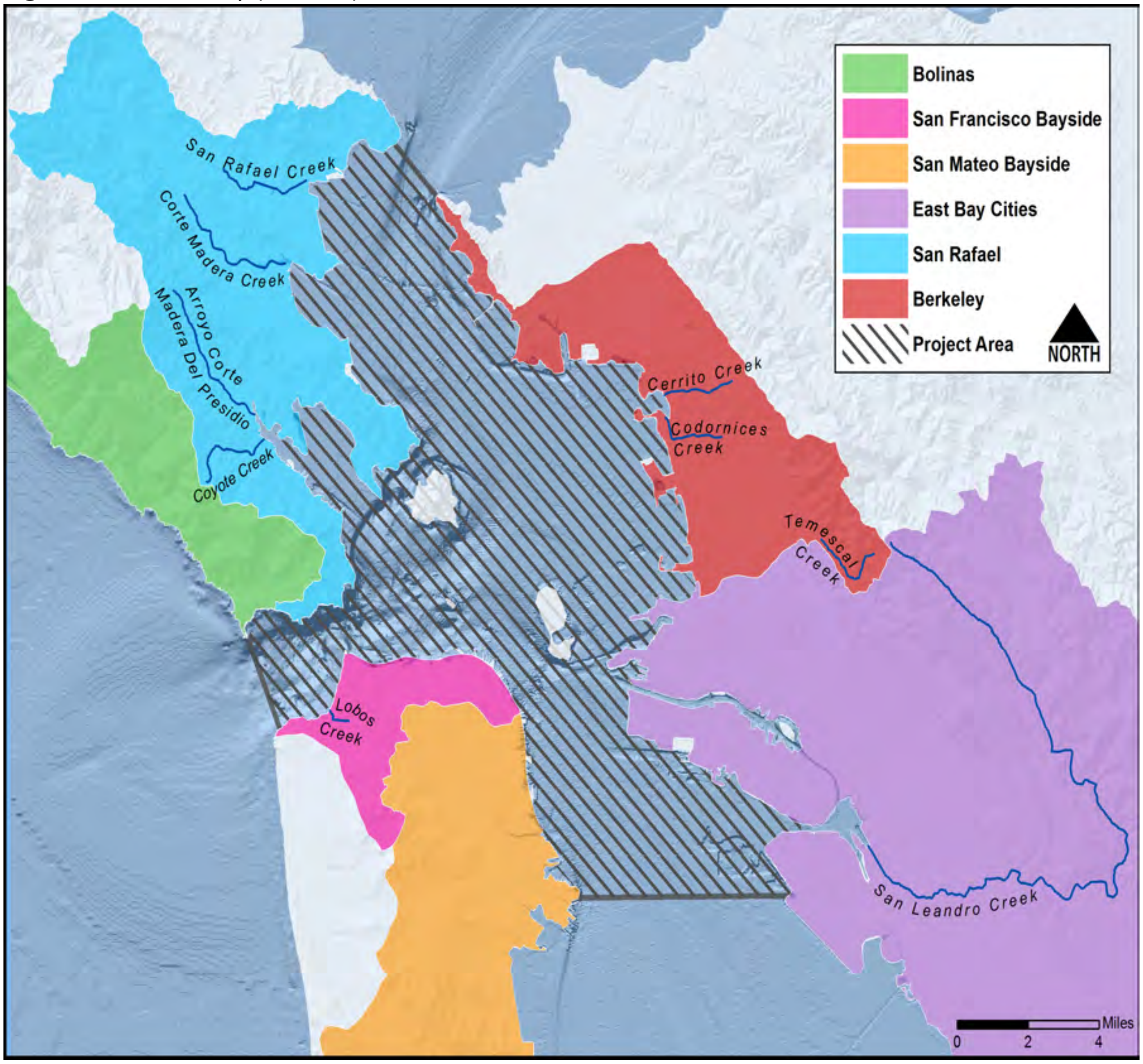
The State Coastal Conservancy, in conjunction with over 200 scientists and managers, recently completed an update to the Baylands Habitat Goals Project, entitled "*The Baylands and Climate Change, What We Can Do*"(2015) (Baylands Goals Update), which includes planning reaches based on recommendations made in the 1999 version of the project. The reaches used in the original Baylands Habitat Goals Project were also used in developing offshore reaches for the Subtidal Habitat Restoration Goals Project (2010). Because these two planning documents have significant regional support, they were influential in developing the reaches for the Central Bay RSM. Additionally the reaches described below align for the most part with previously defined shoreline regions for different beach types in Central Bay as described by Dr. Peter Baye in his 2007 paper "*Prospects for San Francisco Bay Beach Habitat Expansion*" describing historic and current beaches of the Bay.

Figure 4. Central San Francisco Bay planning reaches.

Watersheds.

In addition to being part of the larger Bay Delta Estuary, this embayment has six watersheds, delineated at the hydrological unit code (HUC) 10 scale, that drain into Central San Francisco Bay, with the Bolinas watershed mainly draining into the Pacific Ocean (Figure 3). While many rivers and creeks reached San Francisco Bay historically, few do today. This is primarily due to urbanization of the creeks, channelization, and flood protection measures that have either eliminated or rerouted the creeks into storm drains and waste water systems. Within the study area, only San Rafael, Corte Madera, Arroyo Corte Madera del Presidio, and Coyote Creeks in Marin County; Cerrito, Codornices, Temescal and San Leandro Creeks in the East Bay; and Islais Lobos Creek in San Francisco still reach the Bay today. By eliminating connections to the Bay, sediment supply routes from local watersheds are also eliminated or greatly reduced.

Figure 5. Central Bay (HUC 10) watersheds and creeks.



Land Use.

Central Bay is the most urban of San Francisco Bay's embayments and most of the shoreline in this area has been significantly altered over the past 150 years. Below, Figures 5 and 6 display the alterations that have occurred in terms of areas filled to create land, shown in black. The San Francisco waterfront consists of a great seawall over four miles long as well as the fill placed behind it, which created additional land for the city (Figure 7). Similarly, the Oakland waterfront was filled and dredged for port uses, so that little of its natural shoreline remains.

Figure 6. San Francisco Bay areas filled by 1998, (SFEI, 1998).

Figure 7. Central Bay areas filled by 1998, (SFEI, 1998).

Figure 8. San Francisco waterfront and sea wall, (Port of San Francisco).

Figure 9. Central Bay land cover.

As shown in Figure 8 above, the land cover through Central Bay is mixed, but primarily consists of high and medium intensity development, particularly along the waterfront where deep water makes ports and waterborne industry a priority use. The reaches also contain a fair amount of natural or restored shorelines, with beaches and marshes being prevalent in the SF, SF Gate and Marin Reaches, as well as the Richmond Reach. There are also several waterfront parks interspersed throughout the reaches that provide access and recreation opportunities for the public.

Reach Descriptions

1. **Southern Marin**

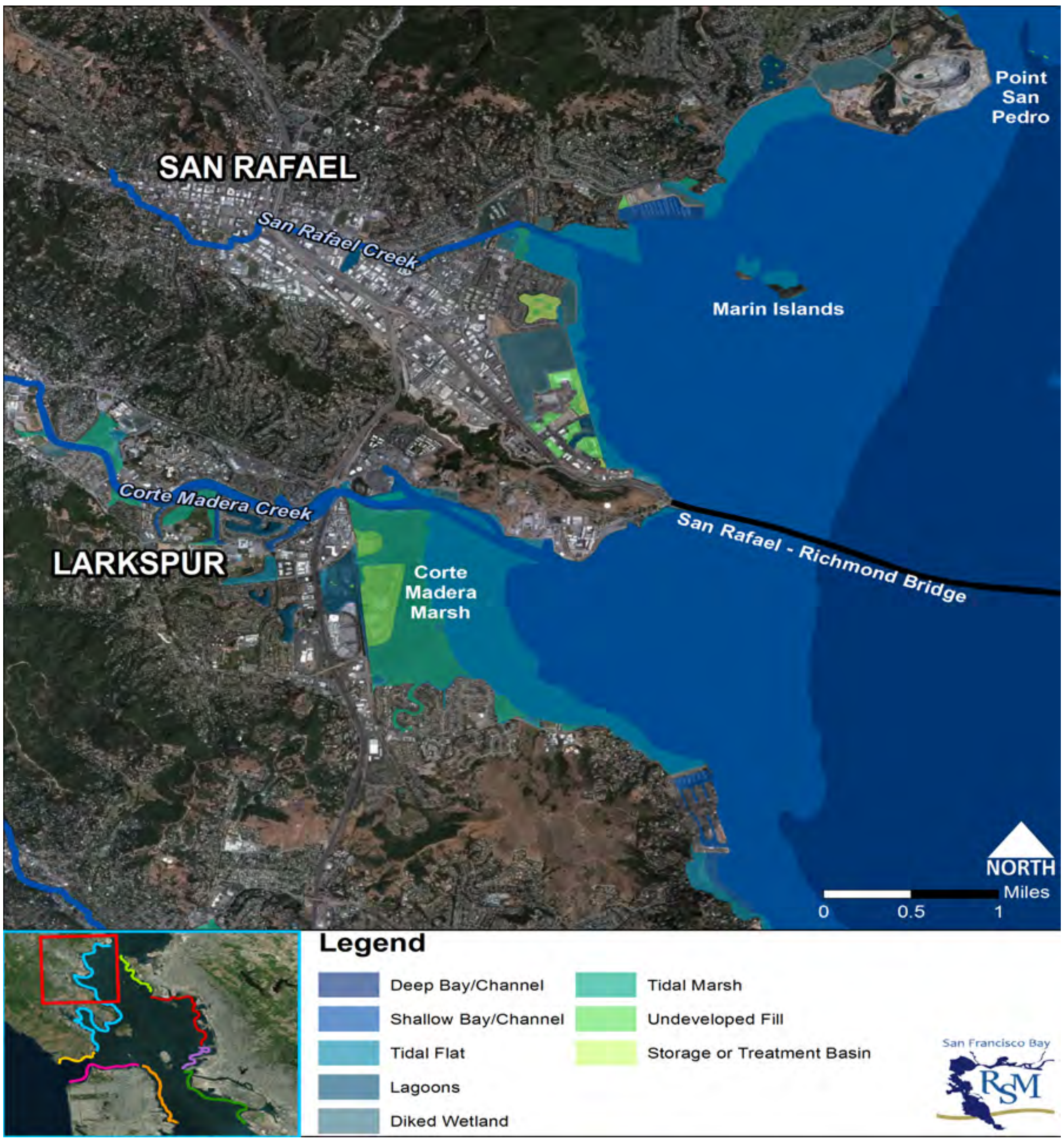


Figure 10. Southern Marin Reach, Point San Pedro to Corte Madera

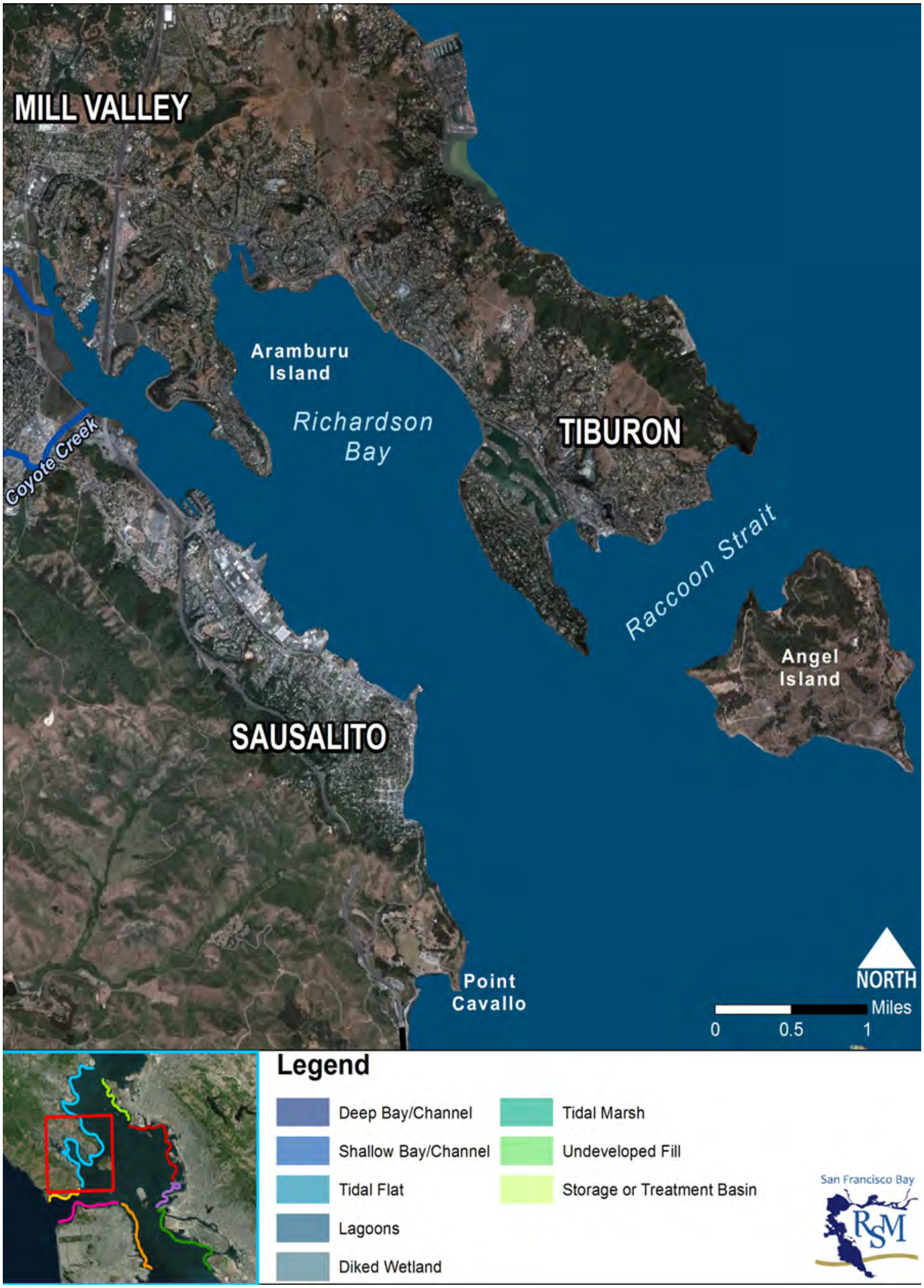


Figure 11. Southern Marin Reach, Corte Madera to Point Cavallo

The Southern Marin reach is designated from Point San Pedro in the north, along the southern coast of Marin County to Point Cavallo, and includes Angel Island. The geology of this area is primarily mountainous Franciscan complexes and mud deposits along the shoreline that created the tidal marshes and mudflats that are characteristic of the area. This area has mixed residential and commercial development just inland of the shoreline. In some areas, the terrain is quite steep and there is little shore, such as the eastern edge of the Tiburon and Belvedere peninsulas. Other areas, like Corte Madera and Mill Valley have fringing and restored marshes. Sausalito's shoreline is almost entirely occupied by marinas and houseboat developments, while areas along San Rafael have shorelines hardened by riprap, and a large, hard rock quarry is located on Point San Pedro. There are also many shoreline levees throughout the region. Angel Island is a state park and is managed in a fairly natural state with shorelines that are steep with several pocket beaches.

Mount Tamalpais is the dominant landform in Marin County and is the highest peak in the Bay Region. Historically, approximately 46 creeks drained from the steep watershed of Mount Tamalpais into the Bay, contributing large fluvial sediment loads that created the baylands and marsh complexes along the shoreline. Today, like much of the region, these baylands have largely been filled and urbanized for residential uses, and many of the natural channels or creeks have been disconnected from the Bay. However, five creeks within this reach remain connected to the Bay: San Pedro, San Rafael, Corte Madera, Arroyo Corte Madera del Presidio and Coyote Creeks, most of which flow through areas of Bay fill (SFEI 2014). The sediment loading from these creeks are unknown, with the exception of Corte Madera Creek, which has a sediment gauge and has been studied by USGS and other researchers. In Lewicki and McKee's 2009 paper, they estimated that Corte Madera creek produces approximately 334 tons of sediment per square kilometer per year on average, or 16,089 tons of sediment per year to the Bay.

Because Marin County has several healthy and restored marshes, special status species and habitats remain throughout this reach. Tidal marsh habitat exists in Mill Valley, Corte Madera and San Rafael. Richardson Bay is an important area for eelgrass and other aquatic plants that support Pacific herring. Sausalito is one of the only locations in the Bay Area known to support soft bird's-beak (*Chlorophyron maririmum* ssp. Palustre). Numerous listed species are found in the marshes of Marin County and adjacent shoreline habitats.

In addition to restored marshes, a beach habitat was constructed on Aramburu Island, an old dredge disposal site, which serves as one of the few haul-out and resting sites for harbor seals, terns, and shorebirds in this reach (*Baylands Ecosystem Habitat Goals Update 2015).*

Offshore sediments in this reach are primarily soft muds as shown through sediment testing and USGS research, with the exception of the deep waters of Raccoon Strait and around Angel Island, which are sand. Raccoon Strait is an extremely high energy and deep area, where much of the tidal waters are pumped through the channel on a daily basis. Richardson, Corte Madera and San Rafael Bays are calmer with fine sediments settling out of the water column resulting in broad, shallow flats, characteristic of much of the area.

2**. Golden Gate North**

Figure 12. San Francisco Golden Gate North

This reach is designated from Point Cavallo and west to Point Bonita at the outlet of Golden Gate Strait. It includes portions of the San Rafael and Bolinas watersheds, which have no creeks that flow into this reach. This shoreline area is part of the Marin Headlands, and the Golden Gate National Recreation Area and the shoreline areas remain largely undeveloped and in their natural state. There are mainly steep bluffs that back a few small pocket beaches, including Kirby Cove and Black Sands beach, which tend to have sand that is a larger grain size than beaches in other parts of the Bay. Additionally, it appears that the sand on these beaches is largely derived from erosion of the bluffs on the backshore of the beaches and alongshore transport from the Bolinas littoral cell. Sediment loading from this reach is currently unknown.

Because this area is located on the outer portion of San Francisco Bay, it is exposed to storm surge, strong wave action and currents more typical of the outer coast. These erosive forces act on the headlands, which are made up of the Franciscan complex, greystone, greywacky and diabase. In addition, the longshore transport along the outer coast provides sand around Point Bonita and into San Francisco Bay.

3. **San Francisco Reach.**

Figure 13. San Francisco Reach

This reach is designated from Point Lobos out to the outlet of the Golden Gate Strait and east to Pier 27 along the San Francisco Waterfront. The San Francisco Bayside watershed is associated with this reach, but only Lobos Creek flows into this reach. However, the National Park Service is undertaking a number of creek daylighting projects, so this may change in the near future as creeks are reconnected to the Bay or adjacent marshes. This particular reach includes highly urbanized areas and a large amount of Bay fill on the eastern side of the reach, which created the San Francisco Waterfront from the existing natural shoreline (Figure 5). Historically this shoreline was characterized as having large sandy beaches and dunes, bedrock headlands, and bayside marshes fed by creeks. The shoreline along the western end of the reach and out to Point Lobos mostly consists of bluffs that are fronted by beaches and natural shoreline areas.

This reach contains three large beaches: Crissy Field, Baker, and China beach. These beaches are influenced by the ocean swell and used by many visitors for scenic views of the Golden Gate Bridge. Crissy Field consists of a bayside sandy beach and a restored marsh and tidal lagoon. The tidal inlet does habitually close due to sand transport along the beach face. Significant numbers of people walk or jog along Baker Beach and Crissy Field. Crissy Field is the most visited beach within the San Francisco Bay, with recreational activities in addition to the beach, taking place along the promenade such as biking, walking, jogging and dog walking (King 2014). Baker Beach is a popular spot for surf fishing. Beaches along this reach tend to be greater than 0.5 miles in alongshore distance.

Continuing east of Crissy Field is San Francisco Marina, Marina Green, Fort Mason, Aquatic Park, and then followed by Port of San Francisco wharves through Pier 27. These features create a hardened shoreline with barriers for sediment and water movement between the land and the Bay. However, this area is susceptible to high wave energy leading to sand transport along the wharf faces, which is apparent in dredging projects. Aquatic Park is a beach enclosed by a sea wall that was created by moving sand from the downtown area of San Francisco to the shoreline. It requires regular maintenance to keep the sand well distributed along the beach.

Like the Golden Gate North Reach, strong waves and ocean currents directly entering the Bay from the Pacific Ocean significantly influence this reach. Point Lobos to Fort Point headlands experience high levels of erosion due to their exposure and soil types, which include colluvium, sandstone and outcroppings of serpentine. For this reach, some oceanic and Bay sediment transport estimates have been made, but there are no estimates for the sediment flows from Lobos Creek. The flow north and east of Point Lobos towards Baker Beach has been estimated at approximately 17,000-100,000 cy annually (Battalio and Trivedi, 1996). Estimates of longshore sand transport along Crissy Field and into the Bay show an average 30,000-100,00 cy per year with approximately 50,000 cy being deposited subtidally in the nearshore (Battalio, 2014). It is likely that the sand moves in pulses during large ocean swells in the winter months.

4. **San Francisco Bayside Reach.**

Figure 14. San Francisco Bayside Reach

This reach is designated from Pier 27 south along the San Francisco Waterfront to Hunters Point. Much of the waterfront in this reach is owned and operated by the City or the Port of San Francisco. This particular reach includes very highly urbanized and industrial areas with large amounts of historic Bay fill throughout the reach. This shoreline is primarily characterized by sea walls, wharves, and other maritime uses. Hunters Point, at the southern extent of the reach, historically had many uses, including a dairy farm, slaughter houses, ship building, a dry dock, a coal and gasification facility and finally the Naval Radiological Defense Laboratory, until its decommissioning in 1969. As a result, this area has been highly contaminated by a number of different compounds. It has been undergoing clean up by the EPA and Department of Toxic Substances Control for many years and portions of it are now being redeveloped.

Historically, there were seven creeks that drained into San Francisco Bay (SFEI 2014) in this reach. However, many of the creeks have been filled in or diverted in to the combined storm and sewer system and are no longer in existence (SFEI 2014). Only one of the historic creeks, Mission Creek remains connected to the Bay, but it is little more than a tidal channel built through fill of what was once Mission Bay.

While this area is highly urbanized, there are a few small pocket beaches and waterfront parks. Areas near Pier 94/96 are currently being restored to tidal and seasonal wetlands and adjacent to Pier 70 is a large restored marsh, Heron's Head Park. This restored wetland was created after a failed attempt to develop the peninsula into a port facility. As sediment deposited over time, marsh began to build up. A large effort to remove debris such as large chunks of asphalt and concrete furthered the restoration of the site and today it is teeming with birds, wildlife and human visitors.

The landside geology of this reach includes historic sand dunes, alluvium, bedrock outcroppings and tidal marshes, which have long been built upon. The Bay sediment in this area is primarily mud along the waterfront, but some sandy areas exist in the deeper areas around Treasure and Yerba Buena Islands. This area is also characterized by high wave energy and limited local sediment supply due to the hardened shoreline and lack of connection to the Bay (*Baylands Ecosystem Habitat Goals Update* 2015, p. 167).

5. **Richmond Reach**

Figure 15. Richmond Reach

This reach includes the area from Point San Pablo in the East Bay and south down to Point Richmond. It lies west of the Hayward fault and consists of Franciscan sedimentary rock and alluvium. There are no creeks that drain into the Bay. Development in this area is a mix of residential and highly industrial facilities, dominated by the Chevron Richmond Refinery. Due to security needs, large portions of the shoreline and hillside privately owned by Chevron, are off limits to the public, resulting in a large amount of the shoreline area remaining undeveloped.

As along the San Francisco Waterfront, the water is fairly deep here, making the site viable for offloading crude at the Chevron wharves. This area is also dredged regularly by both Chevron and the USACE to maintain safe navigation. South of the refinery there is a relatively small residential development – Point Richmond and just to the north of the Richmond San Rafael Bridge there is an abandoned marina.

Much of this shoreline is armored with riprap, interspersed with small pocket beaches that are backed by bluffs or cliffs. Because Point San Pedro (San Rafael) and Point San Pablo form a constriction point between San Pablo and Central Bay, the water moves quickly through this area, forming a naturally deep channel between the two points. Sandier sediments can be found in this deeper area, while fine grain sediments are characteristic of shoals closer to land and those dredged from the nearby berthing areas and federal navigation channels.

6. **Berkeley Reach:**

Figure 16. Berkeley Reach

This reach includes the areas from Point Richmond south to the Emeryville Marina. The development in this area is significantly industrial in the northern portion, with the Port of Richmond being a major feature and influence on the area. Adjacent and to the west of Richmond Inner Harbor is Brooks Island and seawall. This feature impacts sediment movement and wave energy along the shoreline, and also provides roosting areas for seabirds, such as the Brown Pelican. Traveling south along the shoreline, there are fringe marshes on the Bayside of a frontage road and footpath, with large marshes and a lagoon between it and the freeway. The freeway separates the Bay from the mixed-use development to the east, which is a combination of light industrial, commercial and residential uses.

This reach includes a few small pocket beaches along the shoreline, which are largely used by visitors for walking, dog walking, and picnicking (King 2014). The few small pocket beaches within this reach tend to be narrow, small beaches fronted by low tide mudflat terraces. Marshes and adjacent mudflats have built up along the shoreline or are remnants of those that once existed in this area. Some marshes appear to have built up alongside rock jetties put in place to protect the shoreline or marinas. In addition, historic landfills are evident in large areas of uplands jutting out into the Bay, such as the Albany Bulb and the Berkeley Marina. Albany Bulb is of special interest because it is a historic landfill with erosion issues on the Bay side. Recently, permits have been issued to provide some additional riprap, sandy beach and living shoreline features, including artificial oyster reefs to reduce erosional forces along its south facing side.

The geology of the area is almost entirely alluvium, with significant amounts of artificial fill. Historically, this reach was scattered with sand dunes and beaches, backed by grassland with streams draining the hills to the east. These streams supported, and in some cases still support, spawning and rearing habitat for steelhead as found along Codornices Creek. Today, alongside its remaining small fringe beaches, parks, and the tidal marshes and mudflats at Point Isabel, many natural habitats and shorelines have been developed to support transportation corridors and contain several marinas and harbors. Sensitive areas containing eelgrass, oysters, and macroalgal beds remain present. This is a high-energy wave climate due to the wind wave fetch from the west, and limited local sediment sources due to lack of connection of creeks to the Bay (*Baylands Ecosystem Habitat Goals Update 2015*). According to interviews with sediment managers along this shoreline, anecdotal evidence suggests that the Bay Bridge seems to have impacts on the sediment system within this reach.

7. **Oakland Reach**

Figure 17. Oakland Reach

This reach includes the areas just north and south of the base of the Bay Bridge (Interstate Highway 80) to the opening of the Oakland Inner Harbor, including portions of the Port of Oakland. Besides the tidal marsh and mudflats of the Emeryville Crescent, this reach is highly developed and industrial in nature. The shoreline here consists almost entirely of port facilities, includes berthing areas, wharves and cargo storage/loading areas. This area has been filled and dredged out many times over the past century to meet the needs of the military and maritime commerce. The exception to the industrial use south of the Bay Bridge, is a recently constructed shoreline park, beach and shallow aquatic restoration project, the Middle Harbor Enhancement Project (Middle Harbor), which reused material dredged during the Port of Oakland's 50-Foot channel deepening between 2000 and 2010. This large subtidal restoration project has reused both sand and fine grain sediments to create a sandy beach, a future shallow eelgrass bed, and an embayment. The final construction of the habitat is currently underway, with a large rock revetment being lowered this summer and habitat islands being created. The eelgrass planting will likely occur over the next two to three years.

The recent construction of the new east span of the Bay Bridge is changing flow and sediment transport patterns, as is the removal of the old east span. As this work is completed, new patterns of transport, deposition and erosion are likely to occur. Interestingly in the past two years, new sand deposits are occurring along the span, potentially creating a new beach.

The underlying geology of this area was beaches and sand dunes, long gone from the area due to development. During deepening of the Oakland Harbor to minus fifty feet Mean Lower Low Water (MLLW), a Holocene era riverbed previously unknown to the area was discovered. The riverbed is long gone, but the sandy sediments remain deep beneath the Bay mud. No creeks run through this reach today (Doak, 2010).

8. **Alameda Reach**

Figure 18. Alameda Reach

This reach extends from Alameda Point along Alameda Island, to Bay Farm Island, just north of the Oakland Airport. This reach includes urbanized areas, characterized by a reclaimed military base (Alameda Naval Airfield) on the northern portion of Alameda Island, and dense residential development on the remainder of the island and much of Bay Farm Island. Both islands are the result of a large amount of Bay fill and their shores are armored with riprap. Oakland Airport dominates the southern portion of Bay Farm Island and Alameda is home to old shipwork facilities, a remediated seaplane lagoon, and several small marinas. Alameda Island has no natural creeks, but like Bay Farm Island, has constructed lagoons rimmed by housing. San Leandro Creek's mouth lies at the southeastern shore of Bay Farm Island, feeding the adjacent Arrowhead Marsh.

Historically, Alameda Island was sand dunes and beaches with tidal flat and tidal salt marsh on the northern end. Bay Farm Island was created by dredged sediment from the Bay, creating a deep hole known as the Bay Farm Borrow Pit, which remains today. Despite the extensive development, this reach still supports sensitive habitats, including a steelhead run along the San Leandro Creek, select oyster and eelgrass beds, and harbor seals haul out sites and feeding grounds around San Leandro Bay. Of special note is the roughly 9.6 acres of land at Alameda Point's former Naval Air Station runway complex that is home to the largest breeding colony of the endangered California least terns (Pitkin 2011).

Like much of Central Bay, the Alameda reach sees a high-energy wave environment with limited local sediment sources (*Baylands Ecosystem Habitat Goals Update 2015*). San Leandro Creek was dammed in 1875 reducing its sediment load to the Bay to an estimated 559 tons per year (SFEI, 2016).

Crown Beach, an important recreational area that originated as a flood protection project, is located on the western shore of Alameda. In 1958, a land reclamation project moved the shoreline bayward, converting the shore into a wide recreational beach. Subsequently, the beach eroded through wave and wind action with a loss of sand estimated at 18,000 cy per year. Crown Beach was reconstructed in phases from 1982 through 1988 to protect the shoreline and city infrastructure from wave erosion and windblown sand. The initial (1981-1983) Crown Beach replenishment project included the placement of 208,000 cy of medium sand imported from Point Knox Shoal (off Angel Island) and distributed along 6,500 feet of beach. In addition, two groins were constructed at the northeastern and southwestern beach extent to capture sand as it moves along the beach. Additional placements occurred from 1985-1987 (170,000 cy), and in 2013 (80,000 cy), also from Point Knox Shoal (BCDC, 2015).

Maintenance of Crown Beach, either by sand moving or by imported sand placement, has been ongoing since 1983. Alongshore sand transport at Crown Beach moves material away (to the northwest and southeast) from a central beach nodal point (BCDC, 2015). The groin structures at the northwestern and southeastern boundaries trap transported sand on the beach side of the structures. On an annual basis, the East Bay Regional Parks District Operations and Maintenance Department redistributes the sand to the beach nodal point and to areas eroded by winter storms and wave action. Winter storms can cause severe and sudden erosion: in 2005, for example, a single winter storm event resulted in the loss of 20,600 cy of sand (BCDC, 2015). There is no natural sand transport to this beach, so efforts to maintain must continue, or the beach will erode away as occurred in the 1960's and 70's.

IV. Basis of Understanding

The physical processes of San Francisco Bay have long been the subject of study: understanding its development after the last ice age from a historic river to its current form as the largest estuary on the west coast of the Americas; analyzing the impacts of the Gold Rush on subtidal shoals and the rapid creation of fringing marshes; the diking and filling of historic marshes to create land; changes in the Bay from damming the rivers and creating massive water and flood control structures in the Delta; channelizing the local tributaries; and finally the recognition of a step change in sediment supply to the Bay, a result of the actions that came before, compounded by sea level rise. With study of each of these massive changes, we have gained a better understanding of the physical processes that control the Bay, but not a complete understanding.

An example of our limited understanding can be demonstrated by considering the Bay's sediment budget. While researchers from USGS and the San Francisco Estuary Institute (SFEI) have a long and detailed record of suspended sediments coming into the Bay from the Delta, bedload supply into the Bay continues to be a data challenge, with only estimates being available. The sediment outputs at the Golden Gate remain elusive, as this channel is so powerful that instrumenting it with appropriate gauges has proven nearly impossible. Similarly, data for the Bay's tributaries is only partially available as Lewicki and McKee's 2009 report and records of sediment removed from flood protection channels are also sparse. Dredging and sand mining data for the past twenty years is mostly complete and well understood, but records prior to that period and of larger extractions in the 1930's and 1960's are lacking.

In December 2013, the Journal of Marine Geology produced a special issue on San Francisco Bay, highlighting physical processes that govern the Bay environment. This collection of work is a significant resource for managers working in sediment management. Each paper also noted the data gaps that persist and limit our understanding. In order to help bridge those gaps of knowledge, modeling has become a powerful tool in predicting potential outcomes of different scenarios, from sea level rise, to changes in sediment supply, to marsh and mudflat development. While these tools are enhancing our abilities to consider possible futures, they too are limited by lack of data for necessary input. One data set frequently given as a "must have" is a single set of current Bay bathymetry to be input into models as well as to use as a basis for monitoring change.

As part of developing the RSM program, efforts were made to research shoreline change at the regional and local level. Local governments and agencies with shoreline management charges were contacted in an effort to understand shoreline erosion and deposition in the Central Bay. Information was solicited both at in person meetings and via an electronic survey. At the conclusion of this investigation, it became clear that there is little information about shoreline change available due to lack of monitoring. What very limited information is available across the region tends to be more anecdotal than empirical. There is mostly some knowledge of localized erosional areas and little about the shoreline in general. It was found that managers of recreational beaches, such as the Golden Gate National Recreation Area and East Bay Regional Parks, are in need of having a better understanding of the shoreline it manages.

An exception to this finding is the area around Corte Madera Marsh in Marin County. Due to NOAA funding leveraged with additional USGS work, this area was extensively studied for sediment transport patterns onto and off of the marsh. A wealth of information on this area can be found in the Corte Madera Baylands study (BCDC, ESA/PWA, 2013), and the additional research that has followed by researchers Dr. Jessie Lacy and Dr. Maureen Downing-Kuntz of USGS, and others. Other localized research was conducted at Crissy Field (Battalio, 2014), and at the adjacent San Francisco Marina (Moffat & Nichol, 2004) (Coast & Harbor Engineering, 2010) through analysis of coastal processes for project developments. Another site that is well studied on a local level is the shoreline of Crown Beach as part of the 1984 and 2013 beach nourishment efforts (Moffat & Nichol, 2006).

Because San Francisco Bay, like the outer coast of California, is large and diverse, it takes considerable effort to fully understand the shoreline. While it is generally understood that the Bay's shores contain levees, riprap, wharves, marshes and beaches, there has not been a concerted record-keeping effort that would allow easy access to understanding sections and their condition well. However, SFEI has recently undertaken a shoreline assessment project that is documenting the shoreline types of San Francisco Bay. Central Bay sections have been completed and can be seen in Figure 16.

Figure 19. SFEI shoreline assessment map

As can be seen along much of San Francisco and Oakland's waterfront, as with other highly developed areas of the Bay, the shoreline is armored with seawalls and flood protection levees. In less developed areas, there are berms, or unengineered levees that are likely remnant from historic diking and filling of marshes for agricultural and development purposes. These berms are often maintained by either placing riprap along the shoreline or by regularly adding soil and sediment to the top and sides of the existing berm.

In most areas, development, be it residential or commercial, is located in close proximately to the shore or creek. This proximity to Bay and riparian waters presents a challenge to any effort that seeks to create a more natural shoreline due to the need to protect existing structures and property. Without managed retreat from the shoreline, the developed areas are likely to remain adjacent to hardened shoreline structures.

Shoreline Trends. The two most significant drivers that will affect the Bay Area's shoreline trends are sea level rise and the reduced sediment supply from the Delta and other waterways. Because the landscape of the Bay Area consists of very flat, low-lying lands, interspersed with rock outcroppings creating headlands, rising Bay waters will elicit a response from regional and local government as the community begins to adapt. There are three general responses to sea level rise: managed retreat in which structures and the communities that use them move away from the shore to allow the Bay waters to rise; create hardened structures that resist rising waters; and a soft shoreline approach that uses wetlands, beach nourishment and living shorelines to dampen effects of sea level rise and storm surge associated with climate change. Ultimately, it is likely that a combination of the three responses will be employed. Currently, there is an increased interest in placing tide gates on creeks; increasing heights of existing levees; building sea walls; and the restoration or creation of wetlands and beaches to attenuate wave energy and flooding. All of these options would have significant implications for sediment supply and use. In the case of adding tide gates and seawalls, the supply of sediment to the Bay would be further reduced by further limiting riparian connections to the Bay. Shoreline exchange of sediment would also be impacted by the creation of additional seawalls or further hardening of the shoreline when adding riprap. Construction or restoration of wetlands will require more sediment either supplied naturally from the systems or imported through mechanical or hydraulic means. Construction or nourishment of beaches would likely require sand from subtidal shoals which could cause further erosion of the Bay sand shoals and beaches both within and outside of the Bay due to interrupted transport (these pathways are still poorly understood).

Anthropogenic impacts to Sediment System. There are many historic human impacts to the Bay sediment system, the most significant were: the Gold Rush and resulting pulse of sediment that moved through the Bay; diking and draining of the marshes around the Bay, resulting in a ninety percent reduction in this habitat type; and the rerouting of the Delta waters to the Central Valley and Southern California. These three actions were compounded by the channelization of most of the Bay's creeks and rivers into storm, sewer and flood protection channels that have even further reduced flow sediment from the surrounding landscape. Despite these challenges, efforts continue in how to best manage sediment for navigation and construction purposes, safe guard communities from flooding, provide recreational opportunities, and to restore estuarine habitats and their dependent species to health.

Navigation Dredging. San Francisco Bay is one of the nations great harbors with five major port facilities, seven refineries, and recreational boating a celebrated way of life in the Bay Area. Navigational dredging is conducted to maintain sufficient channel depth for ships to access harbors and marinas, both in deep water channels along the stem of the Bay and along the shoreline. While dredging disturbs the subtidal environment and is an expensive endeavor, it remains a necessary activity in a shallow Bay that supports the economics of the region, state and nation. As such, it is likely that dredging will continue on an annual basis to produce 2-3 million cubic yards of sediment that can either be disposed of as a waste product or beneficially reused in wetland and beach nourishment projects where appropriate. The regulatory and resource agencies are committed to beneficial reuse of the sediment as described in the LTMS program, if not at greater rates as sea level rise demands more use of this available resource.

Sand Mining. Not unlike navigational dredging, sand mining has occurred on an ongoing basis for decades, supplying the local construction industry with aggregate sands for ready-mix concrete, hot asphalt, and as fill sand for local construction and transportation projects. In 2015, the regulatory and resource agencies granted permits for up to 1.42 million cubic yards of mining annually. While it is unlikely this amount of mining will occur each year, this has the potential to further exacerbate an already erosional system. Current studies show that at the current extraction rate, less than 15 percent of what has been mined has been replenished by the natural system. Over time, the sand transport system may show further impacts from mining activities such that regulatory agencies may need to reduce mining activities or eliminate them. However, this is unlikely to occur prior to 2023, the end of the currently permitted period.

Flood Protection. Management for flood protection is the third largest impact to the Bay's sediment system. While on an individual channel or yearly basis the impact may seem small, taken as a group, the flood protection system in the Bay removes a significant amount of sediment, majority of which is coarse grain sediment that would otherwise enter the Bay from local sources. Flood protection managers have recognized the need to reconnect these channels to the marshes and the Bay, and are now considering innovative ways to reconfigure channels so they better move sediment through the system to the Bay and adjacent marshes while also providing much needed habitat. This is a burgeoning development and is encouraged by the regulatory and resource agencies.

Marsh Restoration. The Bay is rimmed by remnant marshes, with the Central Bay being extremely limited in this habitat, but each reach contains a few existing and restored marshes. Marshes, whether existing or restored, need sediment to maintain elevations capable of supporting vegetation. Marshes adjacent to creeks were supported historically by high flows during the winter that spread sediment from the creek bed over the marsh. Now, with creeks disconnected from the Bay and marshes, this source of sediment is lost. Bay waters also contribute suspended sediment as the tides cover and then recede from the marsh. Current modeling efforts have predicted that as the rate of sea level rise accelerates, increased sediment input will be needed for existing marshes to maintain their elevation, i.e., to remain vegetated rather than becoming intertidal mudflats or fully subtidal.

In addition to the sediment demands of existing marshes, many diked areas around the Estuary are being restored to tidal marsh and will require substantial amounts of sediment to reach marsh plain elevation. The majority of the larger restoration projects are located in the north and south bay, but this is equally important to restoration projects in Central Bay. As a region, we have developed the goal of increasing the amount of tidal marsh from approximately 45,000 acres to 95,000-105,000 acres (Goals Project, 1999). Subregional goals are to restore 12,000 acres of tidal marsh in the North Bay, 15,000 to 25,0000 acres in the South Bay, 17,000 to 22,000 acres in Suisun Bay, and 1,000 acres in Central Bay.

As of 2015, approximately 40,000 acres of tidal marsh restoration were in the construction and planning phases. Many of these areas are deeply subsided, thus these projects will require, in total, 163 to 202 million cubic yards of sediment in order to reach marsh plain elevation. In some cases, dredged sediments and construction/ excavated/ graded soils are being used to raise site elevations prior to restoring tidal action (e.g., Bair Island); in other cases, suspended sediment arriving with the tides is expected to accrete and build elevation at the site (e.g. Napa Salt Ponds, Cullinan Ranch). In the latter case, relying on suspended sediments from the Bay is expected to reduce available sediment supply to mudflats and other sediment sinks in the Estuary (U.S. Fish and Wildlife Service and California Department of Fish and Game, 2007). If this sediment is directly placed, the most available resource is sediment from navigation dredging, but offloading equipment and funding remain a challenge.

Beach Nourishment. Beaches in San Francisco Bay are fairly limited due to the lack of sand transport to the shoreline and the loss of historic dunes and landforms to development. However, some beaches do persist within the Bay, though mainly as pocket beaches. Beyond their provided habitat to a select group of plants and animals, beaches have high recreational value and therefore are a desired shoreline feature. In addition, beaches can protect shorelines from erosion due to their ability to attenuate waves. There have been few beach restoration or nourishment projects in the Bay to date, with the exception of Crown Beach in Alameda. Yet, as adaptation to sea level rise is becoming necessary, barrier beaches and fringing beaches in front of marshes are being considered. In addition, there are some plans to restore beaches long lost to development, particularly along the western side of the Bay where shoreline restoration is underway. Beach restoration and nourishment projects do require sand, which can be sourced from a few of the navigation dredging projects, but primarily from sand mining activities, which may put a greater demand on sand resources of the Bay.

A Note about Fill. Placing sediment in the Bay, to create, restore or enhance existing marshes, mudflats, beaches or shorelines, is considered fill in the Bay, or fill in waters of the state or nation by the regulatory and resource agencies. Fill reduces the surface area, volume, and tidal prism of the Bay, thus fill has significant effects on hydrology and sediment movement. Further, when placing fill to create or restore one habitat, another habitat is affected or converted from one type to another (e.g. upland to marsh, subtidal to intertidal beach, etc.). Each of the regulatory agencies in the Bay Area has policies and regulations designed to reduce or eliminate fill in order to protect water quality and habitat. Further, the resource agencies have policies and regulations designed to protect existing habitat and the species that depend on them. Therefore, conversion of habitat tends to be discouraged. With rising Bay waters, these policies are being further considered as to whether and how to appropriately accommodate additional fill when existing habitats, that possibly lack the ability to adapt quickly enough, may succumb to inundation. Further, understanding when is the appropriate time to intervene, given that existing habitat is so limited. Reducing limited habitat now for future benefits may push dependent species closer to extinction. The agencies are currently examining these and other issues associated with adaptation to sea level rise and how best to preserve and support habitat and shorelines in the face of rising Bay waters.

V. Sources of Sediment

Beach nourishment and wetland restoration require either coarse or fine sediment depending on the project design, location and local conditions. In addition to the supply of sediments that reach Bay beaches and wetlands through natural processes, these sites can be manually/mechanically supplemented with sediments from additional sources that exist within the Central San Francisco Bay. These sources include:

- Flood protection channel sediment
- Maintenance/navigational dredging sediment
- Commercially mined sand
- Sea cliff erosion
- Construction projects
- Dams and reservoirs
- Estuarine deposits

Sediment from Flood Protection Channels. As discussed previously, most of the creeks and rivers in Central Bay have either been buried or converted into storm or flood protection channels. While storm drains are regularly cleared of excess sediment, the sediment is often contaminated with urban chemical contaminants.

There are several flood protection channels throughout the Bay Area, which are dredged regularly, both in the upstream and lower portions of their reaches. The local public works or flood protection agencies for cities and counties perform this work on an annual or semi-annual basis. A rough estimate of the amount of sediment dredged from these channels annually is approximately 300,000 -400,000 cy (SFEI, 2015). Flood protection agencies have expressed an interest in providing sediment to projects on an as needed basis, but may need some additional funding and support. Currently, sediment from these channels is reused on existing levees, provided as free soils to those who are interested in hauling it to their site, or used for daily cover or disposed of at landfills throughout the region. These sediments consist of both coarse grain riverine sediments and fines of either fluvial or estuarine origins, with the latter being found primarily in the lower reaches of the channels.

Flood protection sediments could be used either in wetland restoration projects or as beach and shoreline nourishment if it is free of elevated levels of contaminants and the site is available for its use. Distance from the flood protection channel to the placement site needs to be reasonably short as longer distances may make the reuse infeasible due to travel time and cost. Work is currently being done to further connect flood protection agencies with opportunities to use these sediments for habitat and shoreline augmentation.

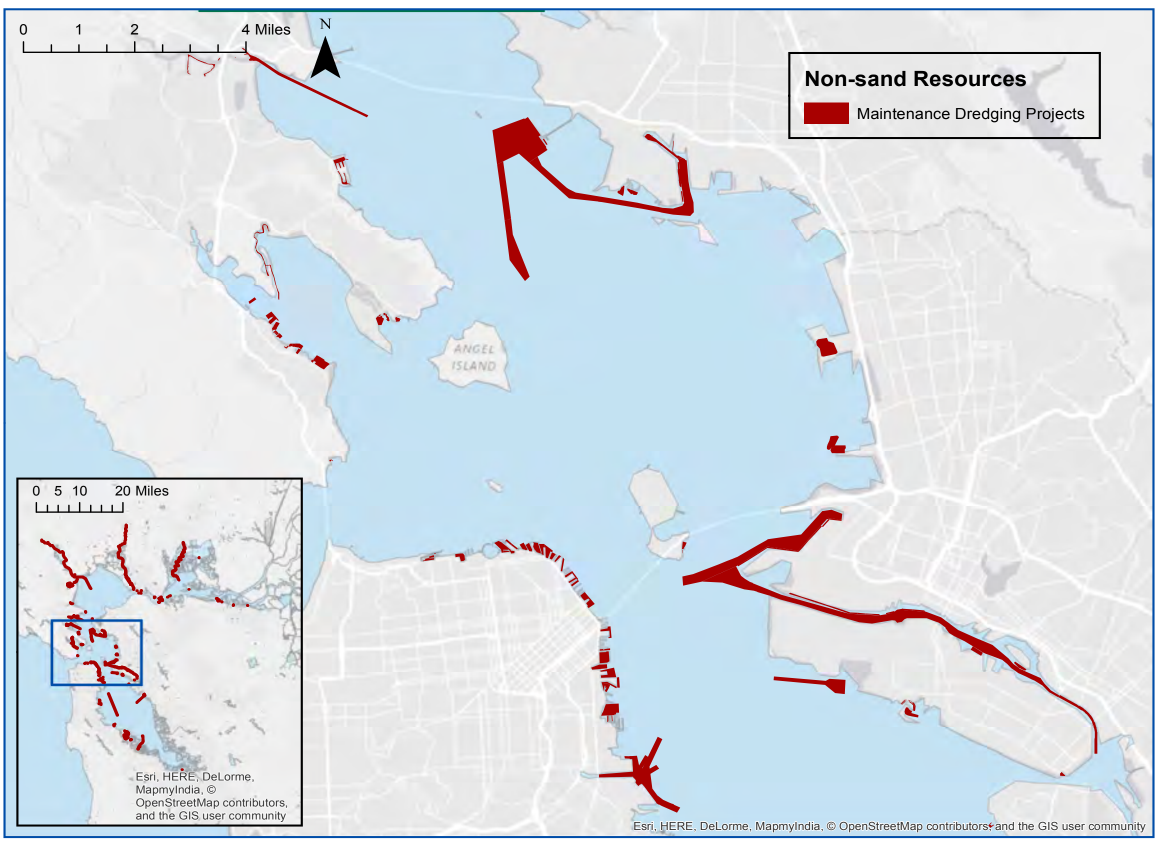


Figure 20. Maintenance dredging projects in Central San Francisco Bay.

Dredging in San Francisco Bay. Dredging within the Bay system includes navigational dredging, primarily for maintenance of existing channels, berths, and marinas, but periodically dredging is required for deepening projects or new work projects. Navigational dredging is conducted to maintain sufficient channel depth for ships to access harbors and marinas, both in deep water channels along the stem of the Bay and along the shoreline. Annual dredging volume is currently 2 to 3 million cubic yards. Much of this sediment is either returned to the Bay at designated disposal sites or beneficially reused (i.e. in tidal marsh restoration projects), while some is placed at the San Francisco Deep Ocean Disposal Site, located outside the Golden Gate in the Pacific Ocean. While most dredged material consists of mud, several projects dredge significant volumes of sand.

In most cases, these sediments are both physically and chemically suitable for use at wetland restoration projects in need of fine grain sediment. Each year, the number, volume and location of these dredging projects vary depending on sedimentation rates, funding and equipment availability. With few exceptions, sediment from these areas does not exhibit elevated levels of contaminates due in part to the frequency of the dredging activity.

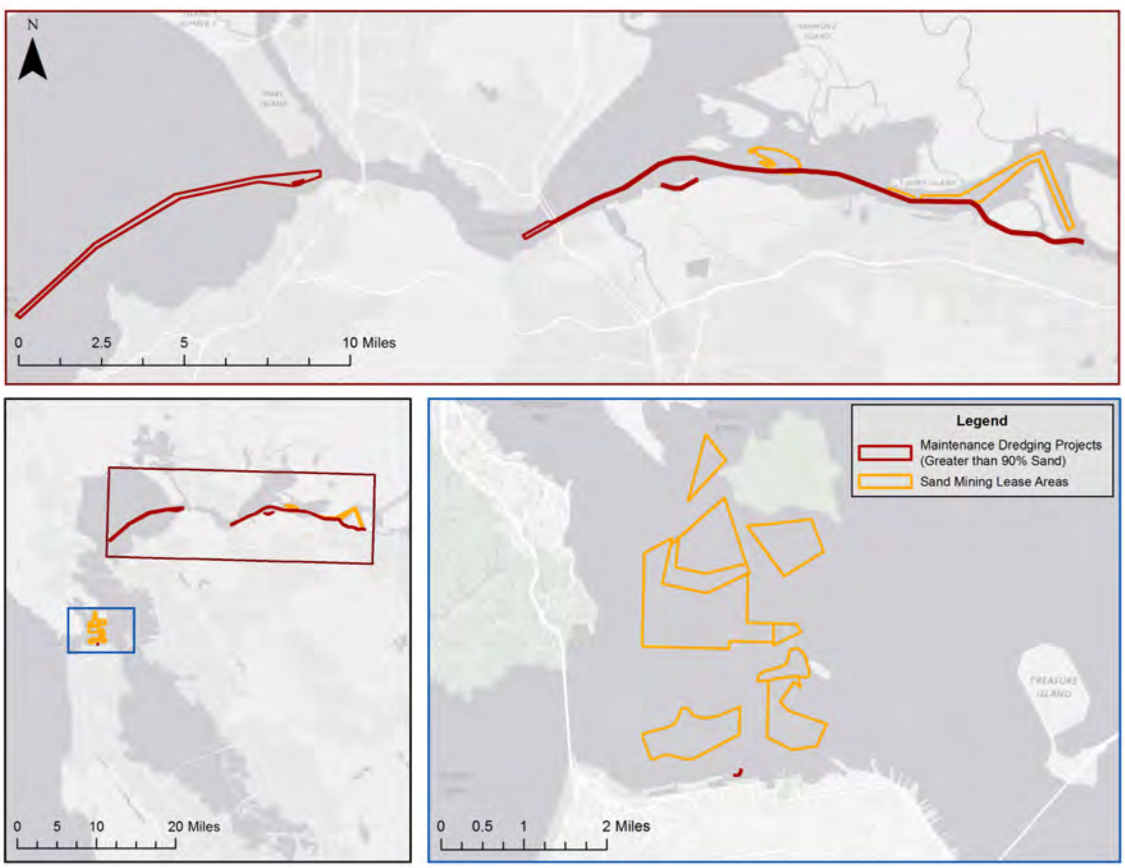


Figure 21. Permitted maintenance dredging projects (red) with sand and sand mining lease areas (yellow) in San Francisco Bay.

Maintenance Dredging Projects with Sand. There are four projects that are regularly dredged that contain sand. These include two federal channels, Pinole Shoal and Suisun Bay Channel; one refinery berth in Rodeo, Phillips 66; and one municipal marina, San Francisco Marina West's entrance channel (Figure 18). With the exception of the San Francisco Marina West, these federal navigation channels and refinery are required, through the Long Term Management Strategy for the Placement of Dredged Sediments in the Bay Region's (LTMS) Management Plan, to dispose eighty percent (80%) of their dredged sediment out of Bay (to reach an overall annual goal of 40% SFDODS and 40% upland and 20% in-Bay sediment placement). The options available to these dredge project sponsors include deep ocean disposal or beneficial reuse at the San Francisco Bar (SF-8) to help supply sand to the outer coastal littoral cell, or beneficial reuse at a habitat restoration project, or levee construction and maintenance. Maintenance dredging can vary from year to year, but overall, given the current placement options, maintenance dredging removes approximately 260,000 cy of sand per year from the Bay.

Table 1. Permitted maintenance dredge projects containing sand.

Maintenance Dredging -Sand Projects	Annual Average Volume Dredged	Current Placement	Suitability for Beach Nourishment
Pinole Shoals (Federal)	100,000-175,000 cy	Dispersive, in-Bay	High
Suisun Bay Channel (Federal)	100,000-200,000 cy	Dispersive, in-Bay	High
Philips 66 (refinery)	15,000 cy	San Francisco Bar (SF-8)	High
San Francisco Marina (municipal)	12,000-15,000 cy biannually	In-Bay, out of Bay, SF-8, beneficial reuse	High

Commercially mined sand. As discussed in BCDC's *San Francisco Bay Sediment Resources Report* (2015), in the Bay there is active sand mining of deep water shoals conducted by three sand mining companies that together hold six subtidal lease areas; five leased from the State Lands Commission and one from a private owner. Two of the lease areas are within Suisun Bay and four are within Central San Francisco Bay. Sand mining is conducted primarily for construction purposes, but sand can be purchased for other purposes from the mining companies. Sand mining operations in San Francisco Bay are authorized to remove up to 1.42 million cy annually from Central Bay and Suisun Bay lease areas, although, this quantity is not removed every year.

Table 2. Permitted sand mining resources in San Francisco Bay

Central San Francisco Bay Sand Leases	Annual Average Permit Volume	Peak Year Volume	Grain size	Total 10-Year Total Volume
Presidio Shoals (PRC 709)	170,000 cy	235,000 cy	0.15-1.18 mm	
Point Knox Shoal South (PRC 2036)	360,000 cy	450,000 cy	0.15–4.75 mm	
Point Knox Shoal (PRC 7779)	484,000 cy	550,000 cy	0.15-4.75 mm	
Alcatraz South Shoal (PRC 7780)	127,000 cy	160,000 cy	06. -2.36 mm	
Central Bay Leases Total Volume	1,141,000 cy	1,395,000 cy		11.41 mcy

Cliff Erosion. As described above, much of the Bay Area topography consists of relatively flat land that gently slopes into the Bay. Exceptions to this include Bay islands (Angel, Alcatraz, Brooks, etc.), and the steep slopes of the Marin Headlands, Tiburon Peninsula, and the area from Point Lobos to Baker Beach. All of these areas have capacity to add to the sediment system and adjacent beaches through erosion and landslides. Unfortunately, data on the quantity of sediment contributed annually or even by decade is not available.

Construction Projects. The Bay Area is currently going through a construction boom. During construction projects, there are often soils excavated from a site in preparation for development. Sources familiar with the construction industry report that there is clean dirt available for fill projects, and the South Bay Salt Ponds are considering using this source to create transitional habitat on the landside of the restoration project. Bair Island used 1 million cy of clean fill dirt in raising the elevations of Inner Bair Island prior to breaching the site to tidal action. The Water Board required testing of each truckload of soils brought onsite to ensure they were free of elevated levels of contaminants.

There is some concern that upland soils will be less appropriate for marsh vegetation development, but as this site develops and is studied, some of these concerns may be answered. In addition, there are large development sites in the planning phase (Treasure Island, Hunters Point, etc.) that require as much as 12 million cy of fill over the next several years. These projects may compete with the needs for restoration and beach nourishment projects. As a source of fill, the “dirt market” can be a viable resource, but is somewhat sporadic in availability.

Dams and Reservoirs. As briefly discussed in the watershed section, four counties surround the Central Bay study area. All have watersheds draining towards the San Francisco Bay, but not all of them have tributaries that join the Bay in the Central Bay study area. In Marin County there are nine dams, two of which drain into tributaries leading to the San Francisco Bay. Stafford Lake Dam drains into Novato Creek, which leads to San Pablo Bay and Phoenix Lake Dam drains into Corte Madera Creek, one of the creeks of the Central Bay study area. Alameda County has eight dams, two of these dams, those of San Leandro Reservoir and Lake Chabot, drain into San Leandro Creek, Alameda County's only tributary to the Bay within the Central Bay Study Area. San Francisco County has seven dams, none of which drain into tributaries that lead to the San Francisco Bay. Contra Costa County has four dams draining to two tributaries connecting to the San Francisco Bay, San Pablo Creek and Wildcat Creek. Both of these creeks reach the San Pablo Bay, which is not within the Central Bay study area. In reviewing the readily available information on these dams and reservoirs, the sediment load data was not available. It is possible that estimates could be made with future research on this issue.

Estuarine Deposits. Fine grain and coarse grain sediment is potentially available from other areas of the Bay, but would need to be permitted by a number of agencies (see regulatory setting document). Because sediment supply to the Bay from the Delta has been significantly reduced since the late 1990's, (Schoellhamer, 2003) current regulatory programs focus on using the existing dredging projects as sources of sediment.

Historically there have been a few projects that removed sediment from the Bay for large construction projects, primarily for public infrastructure. Two such projects include the building of Treasure Island and the transbay tube for the Bay Area Rapid Transit (BART) system. More recently the San Francisco Airport considered the Bay as a potential source of sand for a runway extension. There was significant investigation into both removing sand from existing shoals in Central Bay and dredging sand from beneath the layer of Bay mud, often revealed when deepening channels and berths. Sand dredged incidental to deepening projects may be a source for beach nourishment and/or habitat restoration, but would likely have a limited opportunistic project alignment.

Sediment Budget:

Although the Bay substrate is mostly made up of fine sediment, data has been collected on sand volumes, including inputs to the system, existing resources, and extractions of sand, allowing the development of a sand budget. Known losses from the Bay system include dredging and mining activities as well as sand traveling out the Golden Gate to the outer coast. Information is available for sand mined and dredged from the Bay via published literature and permit records from the San Francisco Bay Conservation and Development Commission and other regulatory agencies. Empirical information is not available regarding the amount of sand naturally leaving San Francisco Bay at the Golden Gate.

Historically, much of the sediment, approximately 1.0 metric tons per year of both coarse and fine was supplied to the Bay from the Delta (San Joaquin and Sacramento Rivers). Recent studies have shown a shift towards tributaries playing a more important role in the delivery of suspended sediment to the Bay (Lewicki and McKee 2009; McKee et al. 2013). The majority of sediment from small tributaries entering the Bay is supplied as suspended load (approximately 1.091 million cubic yards annually as estimated by

Lewicki & McKee 2009) and rainfall runoff processes are suggested to be likely drivers of variability in the delivery from small tributaries.

Recent estimates of coarse grain sand input into the Bay, based upon suspended sediment loads by Lewicki & McKee 2009 and assuming that 20% of the suspended sediment load to the Bay is sand, BCDC calculated that approximately 218,000 cy of sand enters the Bay as suspended sediment in the local tributaries. Due to a lack of information/data on bedload transport from local tributaries and understanding of the ability of sand-sized sediment to be transported through or deposited in the tidal reaches of these tributaries, BCDC has not estimated the tributary bedload contribution to the sand input into the Bay. The Delta and the local tributaries together are estimated to annually input approximately 296,000-300,000 cy of sand into San Francisco Bay at various locations surrounding Central Bay.

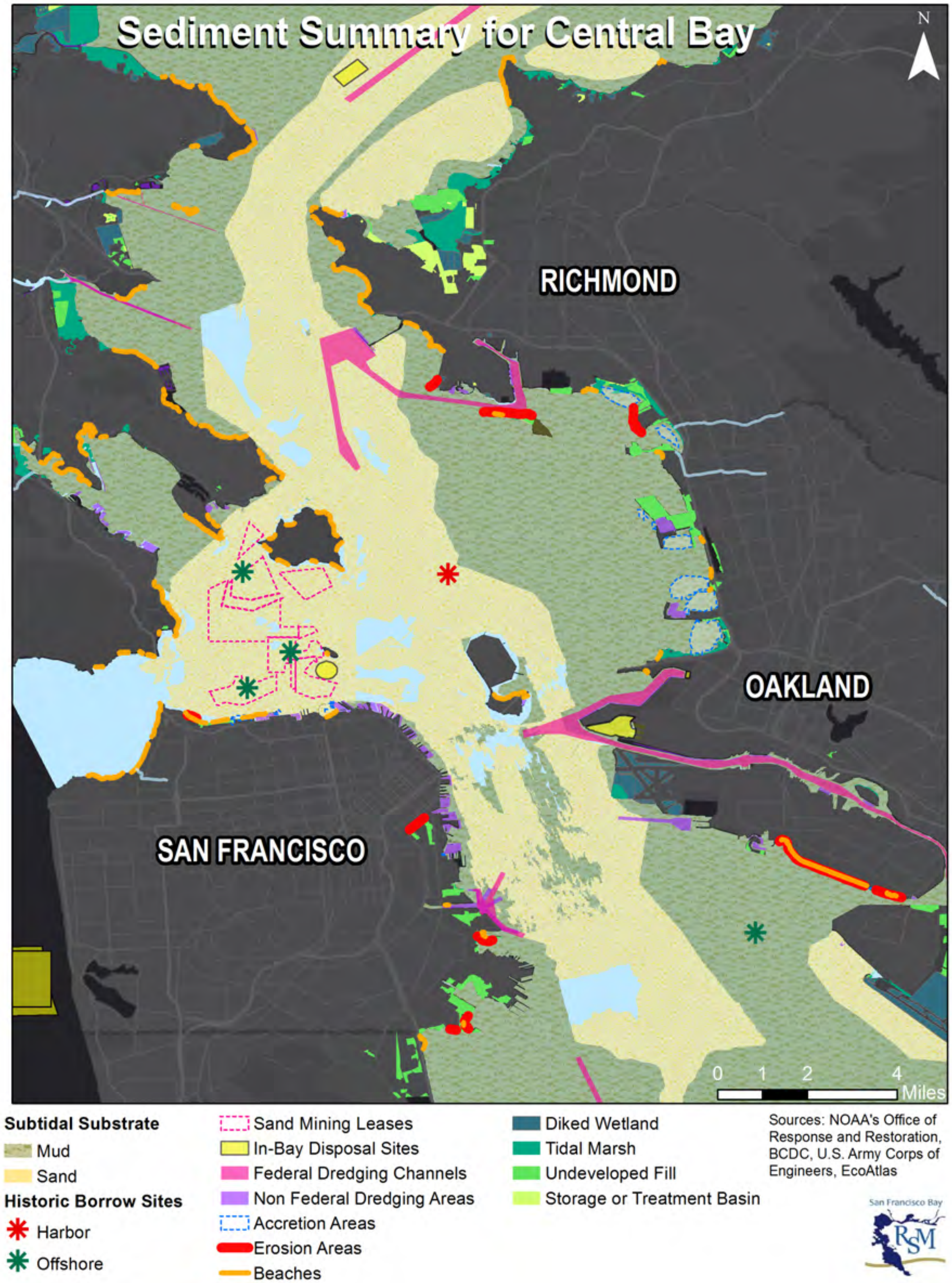


Figure 22. Sediment data summary.

Through analysis of sand wave forms and multibeam surveys, it has been determined that the net flux of sand is out of the Bay (Barnard, et. al. 2013), but the quantity is unknown. Additionally, availability and quantity of existing sand resources on the Bay floor has not been estimated because the breadth and depth of the resource has not been quantified.

Within San Francisco Bay, there are many areas where sand is removed from the system. These include navigational dredging projects, mostly within federal navigation channels and some marinas/refineries, and through sand mining that occurs within Central and Suisun Bays. Navigational dredging of the federal channels within San Francisco Bay removes approximately 100,000 to 200,000 cy from the Suisun Channel and approximately 130,000 cy of sand annually from Pinole Shoal. However, the material from both of these projects is transported to another downstream location and placed within part of the San Francisco Bay system, thus not removing sand from the system entirely. Additionally, the refineries remove approximately 15,000 cy of sand annually and some of this material ~5,000 cy is removed from the system and placed upland, while the remaining amount is transported through the Golden Gate to the Outer Coast, where it is disposed at the SF Bar to help nourish the outer coast littoral cell by adding sand into the system, via natural transport. The San Francisco Marina removes approximately 11,000 cy of sand per year and places it primarily at the San Rafael Rock quarry, which removes the sand from the system.

VI. Central Bay Challenges and Opportunities

Stakeholder Outreach

As part of the pilot Regional Sediment Management (RSM) Plan for Central San Francisco Bay and efforts to obtain information regarding shoreline conditions and areas of concern, BCDC staff developed a stakeholder outreach plan and presented at five meetings over the spring and summer of 2014. Local, state and federal agency staff were invited to discuss RSM planning and to identify Central San Francisco Bay shoreline accretion and erosion areas in their jurisdictions. Efforts were made to invite stakeholders of diverse interests, including representatives of ports and public utilities, marinas, parks, and local and regional public works, including flood control divisions.

In addition to presenting information on BCDC's RSM planning projects and current efforts, outreach materials were used to engage stakeholders in conversation about sediment issues around the Bay and to obtain feedback and data about critical erosion or sediment accumulation issues that existed within their service areas. The outreach materials included shoreline maps, RSM posters, hard copies of an RSM shoreline survey, sediment samples from beaches around the Bay, and additional publications related to sediment in San Francisco Bay. Following the meetings, an online survey was sent to all attendees to gain further information regarding the specific sediment related issues faced by the stakeholders. BCDC's "*Erosion and Accretion Areas of Concern*"

(2016) document summarizes the stakeholder feedback from the meetings and the online shoreline survey, and identifies problematic areas of erosion and accretion, as well as specific recommendations that may be considered in each of the reaches.

Table 3. Outreach Meetings.

2014 Date	Meeting Focus Area and Representatives
April 29	City & County of San Francisco: local, state and national parks, ports, utilities, developer
May 15	Marin County Public Work Association: municipal and county public works, planning and parks and utilities
May 20	Alameda County: regional parks, public works, recreational marinas, municipalities, utilities
June 11	East Bay Regional Parks: park superintendents
August 12	Contra Costa County: regional parks, municipal public works, flood control, utilities

The information obtained from the outreach meetings was incorporated with information provided in the *Baylands Ecosystems Habitat Goals Update* (2015) (BEHGU) to identify the challenges and opportunities that exist within the different reaches around Central Bay, as discussed below.

Table 4. Regional challenges and opportunities within Central San Francisco Bay.

Challenges	Opportunities
Coastal Processes and Sand Resources	
1. Local coastal processes (wave climate, sediment transport, etc.) are not well known or studied in many locations along the shoreline.	Continue surveys and monitoring where existing, and develop new monitoring to establish a sustainable low-cost, low maintenance sediment management regime.
2. Sand moves along the shoreline, accumulates in certain areas or along structures, and requires on-going maintenance to remove the material.	Beneficially reuse clean, dredged, sandy material from areas of accumulation to nourish nearby beaches.
3. Storm waves can impact some shoreline areas more than others, causing shoreline erosion and other damage.	Investigate whether "living shorelines" would be an effective measure for shoreline stabilization to provide wave attenuation and sediment stabilization.

4. Erosion of beaches in certain locations along the shoreline.	Continue investigating shoreline processes and whether beach nourishment provides a viable solution to shoreline erosion issues or if other methods of shoreline stabilization are more appropriate. Improving beaches improves beach habitat for sensitive species. Explore the use of small groins spaced along the beach to help prevent or reduce the amount of annual maintenance required.
Wetland Areas	
5. Not enough sediment supplied to wetlands to allow them to keep pace with future rising Bay waters.	Continue allowing natural sedimentation of marsh areas where appropriate and investigate methods of sediment augmentation in marshes that require it.
6. Marshes around parts of Central Bay are currently eroding.	Restoration of tidal wetlands, creation of transitions zones, protection of fringe marshes and subtidal habitats. Investigate incorporating habitat features in front of the marsh that may protect the marsh from erosion.
Watershed Systems	
7. Sediment delivery via the rivers and tributaries within the system is limited and has been reduced due to the altered watershed system.	Collaborate with watershed agencies to enhance fluvial sediment delivery to the Bay. Encourage the protection of creeks, and moving them through, not around, baylands to deposit sediment in the baylands. Encourage redesign of channels to improve sediment conveyance to the baylands.

Challenges	Opportunities
8. Sediment within the watershed gets trapped upstream behind water control structures within the tributaries.	Partner flood control channel dredging with nearby wetland or beach restoration areas to move sediment to these locations. Investigate cost-sharing opportunities to pay for the removal and placement of the sediment.
9. Sediment delivery from rivers and tributaries fluctuates and is dependent upon variability in the climate, making it difficult to predict.	Develop sediment budgets for all tributaries to the Bay. Develop a calibrated model, which can predict the rate of sediment delivery over time on the tributaries to the Bay.

Development	
10. Development and shoreline infrastructure around the Bay may be adversely impacted by sediment supply and local shoreline processes	Consider redesigning some shoreline areas in a way that eliminates or minimizes the need for maintenance and removal of sediment.
11. Large portions of San Francisco's Central Bay shoreline are armored or heavily developed.	Encourage new development to enhance or restore natural shoreline areas and shoreline processes as part of their project where appropriate and sustainable.
12. Some areas of natural shoreline remain around the San Francisco Bay	Conserve and enhance natural shoreline areas around San Francisco Bay. Investigate methods to help these areas keep pace with sea level rise.
Governance	
13. Obtaining regulatory permits for sediment management can be time consuming, expensive, difficult, etc.	Seek partnerships to assist acquiring funding for dredging and flood control projects, and identify nearby, cost-effective beneficial reuse sites. Develop a regional approach for end of channel sediment management, with a standardized or programmatic permit and mitigation that covers repetitive actions such as maintenance dredging at multiple locations.
14. A regional sediment management strategy will require multiple agencies working together to achieve the plan, not just a single agency.	Utilize the already existing interagency Dredge Material Management Office (DMMO) collaboration and bring in other regional entities (SFEI, Coastal Conservancy, etc.) to further develop and refine the RSM plan and to assist local agencies in implementation.
15. Obtaining community financial support for sediment management projects can be difficult	Assist local agencies in communicating the needs for sediment management to their constituents (provide flyers, presentations, etc.).
16. Shoreline stabilization projects can be costly and require the cooperation of multiple partners	Seek funding for shoreline stabilization projects and beneficially reuse dredged sediment

Southern Marin Reach:

Challenges:
Due to the low-lying natural landscape of this reach, largely unprotected by flood control levees, flooding exacerbated by sea level rise and high tide inundation threatens development as well as sensitive habitats.

Opportunities:
Studies near the mouth of Corte Madera creek and Aramburu Island can serve as building blocks for test pilot projects to design pocket beaches in identified locations, to protect against erosion. Additionally, augmenting coarse-grained gravel beaches and marsh-fringing beaches, with larger grained sediments, could be used as a tool to protect against wind-wave erosion, and provide high-tide roosting habitat for shorebirds and terns. Eventually, engineered barriers or managed retreat may still require consideration in long-term planning (*Baylands Ecosystem Habitat Goals Update 2015*, p.161-164). BEHGU also provides recommended actions for the Marin County shoreline that include restoration of tidal wetlands, creation of transitions zones, protection of fringe marshes and subtidal habitats, and to preserve rare high-marsh and transition zone plants.

San Francisco Gate North Reach:

Challenges:
This particular area of shoreline remains natural and fairly untouched by development.

Opportunities:
Shoreline areas within this reach should be managed to keep these areas as natural as possible and maintain natural shoreline processes, such as cliff erosion.

San Francisco Reach:

Challenges:
Infrastructure and certain habitat areas in this reach occur along a general sand transport pathway into San Francisco Bay. Accretion of sandy material occurs primarily at the east end of the Crissy Field shoreline and the Crissy Field marsh inlet often experiences closures as a result of sand deposition and must be maintained by the Golden Gate National Recreation Area (GGNRA). Until roughly 2011-2012, accretion also occurred further west along Crissy Field near the Coast Guard Pier. Moderate continual accretion of sandy material occurs along the riprap of the jetty, near the San Francisco Marina and entrance channel requiring maintenance dredging.

Opportunities:
Currently, the material excavated from the Crissy Field marsh tidal inlet is placed back on Crissy Field beach above the high tide line. The GGNRA engages with the scientific community, including Phil Williams and Associates, USGS, and others, to understand the marsh, sediment quality, and biological impacts of the system and their management actions. Surveys and monitoring can provide information to develop a sustainable and low-cost management regime that requires the minimum number of annual breaches to

the marsh tidal inlet, until a point at which the system may be able to regulate on its own or can be redesigned in a way that minimizes inlet closure. Additionally, the accumulated material near the San Francisco Marina and jetty could be beneficially reused to nourish beaches locally, provided that the nourishment project had a positive benefit-to-cost ratio and the cost of nourishment was low (e.g. in circumstances where the transportation distance for material is short and cost of delivery could be low). There may be opportunities, if appropriate, to stockpile and utilize the excavated/dredged sand for beach nourishment elsewhere in Central Bay.

San Francisco Bayside Reach:

Challenges:
The limited areas of natural landscape that remain, and the proximity of development to the waterfront in this reach, make protection of the landscape from sea level rise a challenge. Increased wave-action resulting from sea level rise will threaten the very few coarse beaches that exist along this reach. Maintenance of large industrial uses of the shoreline such as the Port of San Francisco will challenge the augmentation of beach habitats. Furthermore, contamination, wastewater treatment facilities, and utility corridors along this reach create obstacles for beach enhancement. Additionally, there are a few areas within this reach where moderately severe erosion, resulting mainly from storm wave impacts, occurs near wetland habitat areas located along the shoreline.

Opportunities:
Habitat restoration along Heron's Head Park is currently underway. Rare opportunities to protect, enhance, or create pocket sand beaches may exist in some areas (*Baylands Ecosystem Habitat Goals Update 2015*, p.168-170) of this reach. Eroding wetland areas may provide opportunities for restoration projects and to investigate the success of erosion control plantings, transition zones, or other living shoreline alternatives along the Central Bay shoreline. Additionally, opportunities may exist for new shoreline developments to incorporate natural shoreline features into the project design and restore natural environments along this reach in areas where they would be sustainable.

Richmond Reach:

Challenges:
This reach contains heavily industrialized areas, urban and suburban areas, and large portions of open space (near Point Pinole). Erosion occurs along the small riprapped areas (likely caused by wave action) and minor erosion occurs along the mudflats and rocky beaches near Point Pinole. To the north of this reach, there is also significant shoreline erosion near the mouth of Pinole Creek. Additionally, within this reach there is minor accretion occurring near some of the marshes and wetlands around Point Pinole, which appear to be filling in slowly over time with silty material. Moderate seasonal accretion occurs on an annual basis in the majority of channels throughout Contra Costa County (Rodeo Creek, Rheem Creek and Pinole Creek seem to have the worst accretion issues at their mouths). Accreted sediment generally consists of both sand and silt.

However, very little sediment is removed from flood control channels due to the difficulty to obtain permits quickly, lack of funding for the projects, and difficulty anticipating project costs.

Opportunities:
Continue allowing natural sedimentation of marsh areas near Point Pinole to help marsh habitats in this reach keep pace with sea level rise. Investigate methods to augment sediment delivery to marshes or wetlands in these areas where needed. Encouraging the protection of creeks and their connection to existing baylands, consistent with recommendations in BEHGU. Investigate opportunities for beneficial reuse of sediments dredged from the creeks for nearby marsh restoration projects where appropriate.

Berkeley Reach:

Challenges:
Minimal seasonal erosion occurs along beach areas adjacent to parklands managed by East Bay Regional Parks (EBRP). Increased wave-action resulting from sea level rise will threaten the remaining unique habitats like coarse beaches that exist along this reach. The proximity of development to the waterfront and extensive fill make protection or enhancement of remaining unique natural shorelines a challenge as sea level rises (*Baylands Ecosystem Habitat Goals Update 2015*, p.178). Moderate continuous erosion of riprap occurs along portions of this reach. Additionally, large areas of fine-grained material accrete subtidally and require small, local marinas to dredge to maintain entrance channels, which can be costly.

Opportunities:
There is potential for living shoreline projects to provide multiple benefits such as wave attenuation, sediment stabilization, and flood protection along with protection of critical habitat for sensitive species on portions of this reach (*Baylands Ecosystem Habitat Goals Update 2015*, p.1789). There are several potential opportunities for sand beach enhancement projects such as at Albany Beach (Eastshore State Park), Point Isabel Regional Shoreline, and Barbara & Jay Vincent Park in Richmond (*San Francisco Bay Subtidal Habitat Goals Report 2010,* p. 70). There are also opportunities for restoration of tidal wetlands, beaches, and the creation of transitions zones, as well as protection of plant habitat and shorebird roosting sites within this reach.

Oakland Reach:

Challenges:
This reach has largely industrial land uses along the shoreline and encompasses property owned and operated by the port of Oakland. Existing beaches along this reach (mainly Radio Beach) may be threatened by erosion resulting from increased wave action related to sea level rise, with adjacent development limiting restoration efforts for both beaches and wetland habitats. Additionally, coarse-grained sediment may accumulate around the new footings/connection for the Highway 80 Bay Bridge.

Opportunities:
There may be some sites within this reach where natural shoreline areas, shoreline parks and subtidal habitat features can be restored or created to enhance natural shoreline areas. Erosion was not reported to be an issue within this reach, but the accumulation of sediment around the Bay Bridge may result in future issues within this reach and within the Berkeley Reach located just north.

Alameda Reach:

Challenges:
Like the Berkeley Reach, the coarse beaches along this reach are threatened by erosion resulting from increased wave action related to sea level rise, with adjacent development limiting restoration efforts. Currently, the sand on Crown Beach shifts continuously, eroding at one end and accreting at the other, requiring ongoing yearly maintenance to move material around on the beach and requiring renourishment approximately every 20 years. Ferryboat traffic within this reach may impact the stability of certain shoreline features. Additionally, small amounts of erosion occur along the riprapped shoreline areas of this reach and require annual maintenance. Along the Martin Luther King Jr. Regional Shoreline, erosion occurs in the marshes and wetlands, and minor amounts of erosion occur in the adjacent channels and riparian areas along the shoreline.

Opportunities:
Restoration of sheltered, low-lying sand beaches along Alameda and Bay Farm Island could provide habitat for the reintroduction of California seablite, an endangered coastal shrub being introduced in San Francisco Bay for its advantageous habitat qualities and adaptability to sea level rise. Living shoreline designs along portions of the shoreline could provide near-term benefits such as wave attenuation, sediment stabilization, and flood protection on portions of this reach (*Baylands Ecosystem Habitat Goals Update 2015*, p. 174). Renourishment of Crown Beach will likely be required into the future since this beach offers flood protection for the adjacent homes within the community. Unless a redesign of the Crown beach system is considered or the physical characteristics at the site change over the next 20 years, renourishment will be required. There may be opportunities within this reach to reuse sediment dredged from San Leandro Creek or other adjacent sites with suitable sediment to augment the wetlands along Martin Luther King Jr. Regional Shoreline Park. Additionally, improving tidal and diked habitats through restoration and addressing invasive *Spartina* may help alleviate some of the sediment issues within the reach.

VII. The Plan

The Long Term Management Strategy for the Placement of Dredged Material in the Bay Region (LTMS) program is the dredged sediment management plan for San Francisco Bay. The program's goals include maximizing beneficial reuse of dredged sediment through wetland restoration, levee maintenance and construction projects. The LTMS partner agencies include the San Francisco Bay Regional Water Quality Control Board

(Water Board), U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE), State Lands Commission (SLC) and BCDC. In addition, the LTMS agencies collaborate regularly with State Coastal Conservancy (SCC), NOAA Fisheries Service (NOAA Fisheries), U.S. Fish and Wildlife Service (FWS) and the Department of Fish and Wildlife (CDFW).

The LTMS program has been successful because it has created a coalition of agencies, ports, industry, fisherman, and the environmental community working towards a common goal. The LTMS model will be built upon and expanded to fit the needs of sediment managers on a regional scale, to include flood protection measures, habitat restoration, sand mining and other sediment management activities to intentionally consider the broader issues associated with the changing sediment paradigm. The LTMS agencies have agreed to expand the management program to include other management activities, but has yet to develop the mechanism for doing so. Work in this regard will continue within the LTMS program and stakeholders.

VIII. Recommendations

Although, much is known about sediment in and around San Francisco Bay, there are still many unknowns regarding the sediment system. An understanding of sediment dynamics is particularly important for evaluating the existing system and predicting the impact of sea level rise and global climate change on the Bay. Decreases in local or regional sediment supply can exacerbate erosion and inundation in areas by preventing tidal flats and wetlands from maintaining their elevation in the tidal frame. On the flip side, accretion of sediment can pose problems for critical infrastructure and be costly to remove. For shoreline managers around San Francisco Bay, new information related to sediment supply and dynamics near and around their site could prove critical to their management decisions. Regional scientists and sediment managers around San Francisco Bay participated in a sediment workshop to identify key data gaps and needs that would benefit the region and provide important information to allow managers to make informed decisions (Table 4).

More specifically, the following are examples of data needs and studies noted as crucial to making informed decisions. Higher resolution information is needed on Bay sediment dynamics to develop a regional sediment management strategy. For example, while suspended sediment levels are being measured by USGS at several Bay stations, the stations do not measure current flow and thus cannot be used to determine sediment flux. There is insufficient data on nearshore sediment processes to understand sediment exchange between tidal flats and wetlands. The impacts of wind-wave energy in tidal restoration projects are poorly understood and controversial. Adequate measurements are not available for the sediment supply from Bay tributaries. An up-to-date and accurate map of the stratigraphy of the Bay floor is not available. The exchange of sediment with the ocean has not been directly measured. While numerical models of water circulation and currents have become increasingly sophisticated and accurate, application of these models to make reliable and validated estimates of sediment transport within the Bay has not been accomplished. Additionally, local, nearshore processes are not well understood around the Bay, except in heavily studies areas such as the Corte Madera Marsh. For much of the Bay, little is known about the transport of sediment on and offshore or between adjacent shoreline areas. Much of this information is necessary in considering appropriate management actions along the shoreline.

Table 5. Critical regional monitoring and data needs for San Francisco Bay.

Monitoring and Data	Research Need Addressed	Management Need Addressed
• Baywide bathymetry below mean lower low water (MLLW) • Bathymetry of the Bay bed	• Accurate modeling efforts • Informing the sediment budget	• Monitoring shoreline change and identifying risks • Decisions about handling the disposal of dredged material and permitting of sand mining
• Region-wide, continuous monitoring of suspended sediment concentrations and bed load of major channels, steep tributaries, and embayments • Varying across time, space, tidal cycle, season, and climate	• Predicting marsh accretion rates • Modeling sediment movement • Understanding sediment supply from both watersheds and other embayments	• Informing the design and permitting of restoration projects • Better management of flood control channels and dredging projects

Recommendations by Reach. Recommendations provided are divided into three general categories: Study Activity, Project Activity and Management Activity. Study activity is generally recommended when additional information is needed regarding a site or reach prior to making a recommendation for projects or management activities. Information gathered by the study activity would assist in determining what activity, if any, is needed. A project activity is suggested, generally at a specific site where a known issue or need has been identified, either by managers or property owners. A proposed project would likely represent a physical change in the site, for example restoring a specific marsh or nourishing a beach. A management activity is recommended when the current management of the site or reach, if change may result in better sediment balance or shoreline stability.

Southern Marin Reach:

Project Activity

1. Gather more information on the status and trends of the Marin shoreline by working with local managers.
2. Further investigate the value of recreational beaches to Marin residents.
3. Monitor to determine the extent of marsh erosion or inundation and identify potential solutions to protect/restore the marshes.
4. Restore Bel Marin Keys Unit V and return the area to tidal action.

San Francisco Gate North Reach:

Study Activity

1. Identify and further understand shoreline processes, including the contribution of cliff erosion to Bay sediment supply through work with researchers and managers.

San Francisco Reach:

Project Activity

1. When possible, beneficially reuse clean dredged sandy material from the San Francisco West Marina sand trap to nourish nearby Baker and Ocean beaches.
2. Re-evaluate the location of the wave attenuator and its relationship to the sand at the mouth of San Francisco Marina West Harbor to determine if it is increasing sand deposition at this site.
3. Consider the recreational benefits of a beach nourishment project at Baker Beach.

San Francisco Bayside Reach:

Project Activity

1. Investigate whether "living shorelines," such as shellfish bed establishment would be an effective measure for shoreline stabilization along portions of this reach or if other nature based methods could be used to dampen wave energy in areas of erosion.
2. Encourage the incorporation of natural shoreline features in new development projects where bathymetry and sediment supply would support such features.

Richmond Reach:

Study Activity

1. Study low bluff erosion potential to understand contribution to Bay sediment supply.
2. Monitor pocket beaches for sand transport, erosion, and accretion.

Project Activity:

1. Continue to reuse dredged sediment for wetland restoration projects and consider whether there are potential restoration opportunities within this reach.
2. Remove sediment transport constrictions just north of the Richmond Bridge.

Berkeley Reach:

Project Activity

1. Study McLaughlin Eastshore State Park's physical shoreline processes and recreation potential to determine if beach nourishment is a viable solution to erosion occurring in this reach.
2. Investigate whether living shorelines can be utilized to protect parts of the shoreline from erosion or whether other methods of stabilization should be utilized.
3. Due to the high use and recreational aspects of this park, if bathymetry supports it, consider a beach nourishment project at Point Isabel Regional Shoreline and remove riprap to reconnect the shoreline to subtidal areas.

Oakland Reach:

Project Activity

1. As sites are redeveloped, restore shoreline profiles and habitat supported by localized physical processes, and create recreational opportunities.
2. Monitor the sand accreting at the base of the Bay Bridge, and if creating a navigational hazard, identifying synergies between potential beach nourishment or for shoreline stabilization projects nearby that may need sandy material.
3. Restore tidal wetlands and beaches where appropriate and sustainable.
4. Create of transitions zones behind habitat features.

Alameda Reach:

Project Activity

1. Continue annual sand redistribution at Crown Beach to maintain this shoreline and beach. Monitor the beach nourishment and erosion process to further refine beach management. Investigate the use of small groins made of natural materials, spaced along the beach to help reduce the need for annual redistribution of sand.
2. Consider use of living shorelines on erosive edge of Bay Farm Island to dissipate wave energy.

3. Study potential to realign San Leandro Creek to increase water and sediment flow while creating habitat features.
4. Reuse sediment dredged from San Leandro flood protection channel or other adjacent sites with suitable sediment to augment the wetlands along Martin Luther King Jr. Regional Shoreline Park.
5. Consider whether adjustments can be made to the dam at Lake Chabot to augment sediment supply to the San Leandro estuary.

<u>Management Activity:</u>

1. Explore potential restoration activities within the reach and cost sharing mechanisms between dredging projects and placement sites.

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Appendix A

Beach Erosion Areas of Concern Report

Erosion and Accretion Areas of Concern

Central San Francisco Bay

San Francisco Bay Conservation and Development Commission

January 2016

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Beach Erosion and Accretion Concern Areas (BECAs)

Introduction

As part of a pilot Regional Sediment Management (RSM) Plan for Central San Francisco Bay, San Francisco Bay Conservation and Development Commission (BCDC) staff developed a stakeholder outreach plan and presented at a series of five meetings to discuss RSM planning and to gather information on Central San Francisco Bay shoreline accretion and erosion areas based upon local, state and federal agency staff input. Meetings took place between April 29th, 2014 and August 12th, 2014 and included: a meeting with stakeholders from the City and County of San Francisco held at BCDC; the Marin Public Works Association Meeting; a BCDC-hosted meeting at the Regional Water Board office in Oakland for Alameda County attendees; the East Bay Regional Parks (EBRP) Superintendent monthly meeting; and a meeting with Contra Costa County shoreline managers at the Contra Costa County Flood Control Offices. Staff presented information on BCDC's RSM planning projects and current efforts. Outreach materials, including shoreline maps, RSM posters, hard copies of an RSM shoreline survey, sediment samples from beaches around the Bay, and additional publications related to sediment in San Francisco Bay were brought to the meeting to engage stakeholders in conversation about sediment issues around the Bay and to obtain feedback and data about critical erosion or sediment accumulation issues that may exist within their service areas. Following the stakeholder meetings, an online survey was sent to all attendees to collect further information regarding the specific sediment issues these managers face and their current management actions.

Attendees of the meetings consisted of: BCDC staff; the San Francisco Public Utilities Commission, Port of San Francisco, State and National Parks; planning, public works, parks, and transportation agency staff from Marin County, with one representative from PG&E; staff from Alameda County municipalities' public works departments, waterfront management, parks and utilities; EBRP staff members; and Contra Costa County shoreline managers including the City of Hercules, Contra Costa County Public Works and Flood Control, and Veolia Water Utility contracted by the City of Richmond. The following document is a summary of the feedback received from the aforementioned stakeholder meetings as well as in the online shoreline survey, and serves to represent problematic areas of erosion and accretion as well as potential recommendations. Accompanying data in the form of GIS shapefiles or .KML files may be requested from BCDC staff.

BCDC staff developed the planning reaches for Central San Francisco Bay based upon the shoreline orientation and wave climate, geomorphic setting, watershed drainage, degree of development/urbanization and land use in the area, and are consistent with planning areas used in other regional resource management documents (**Figure 1**).

Information collected from stakeholders, including information from the online surveys and hand drawn areas on the outreach meeting maps, were used to assess sediment issues occurring in each reach as described by the managers of these shoreline areas. Problem areas for erosion (red lines) and accretion (green polygons) were illustrated on maps by the stakeholders during each RSM meeting and digitized by BCDC staff (Figure 2). Any comments written on the outreach meeting maps were also integrated into the analysis and recommendations provided in the following document, but BCDC staff felt it necessary to keep the information illustrated on the maps separate from data obtained from the online survey during the analysis to be clear on the source of the data. However, much of the information from the online surveys further clarifies areas of concern and problems at the sites that were illustrated on the maps.

The responses provided to the online survey were exported and reviewed by BCDC staff. BCDC staff summarized the stakesholder information, and used direct responses from the survey where possible, to provide further information about the issues occurring within the different planning reaches. Information from the online surveys specifically related to erosion areas (red pentagon) and accretion areas (green pentagon) were then incorporated and overlaid with the digitized stakeholder outreach meeting maps (Figure 2). Additionally, staff included in this analysis the locations and information obtained from an economic analysis of beach nourishment in San Francisco Bay performed by Dr. Phil King and his staff, which determined the cost/benefit ratios for these hypothetical beach nourishment projects (yellow triangles). BCDC staff did not develop specific criteria for evaluating concern areas or what constitutes an area of concern, but left this up to the stakeholders that manage their shoreline areas. Although BCDC did gather information about the relative severity of the particular problem from the managers in the online survey, we did not have criteria to evaluate or compare the severity of the problem across sites and responses.

Some areas that were digitized from the outreach meeting maps may not have further explanations related to the specific issue of concern or the severity of the problem at that site, if the information was not included as a comment on the map or further explained in the online survey. In addition, it should be noted that some polygons (such as the Mission Bay red polygon, XXXX) present on the map contain information related to a larger shoreline area and not just the specific site the polygon was placed. This information can be seen in the GIS layer, but cannot be shown on the map (Figure 2). BCDC staff developed the recommendations provided in this document through analysis of areas in close proximity to one another, relevant information contained in the beach nourishment economic analysis, and through current management techniques employed by the stakeholders. The recommendations provided in this document are not exhaustive and serve mainly as a starting place for conversations for resolving the Region's sediment issues.

Figure 1 BCDC Central Bay RSM Pilot Study Reaches

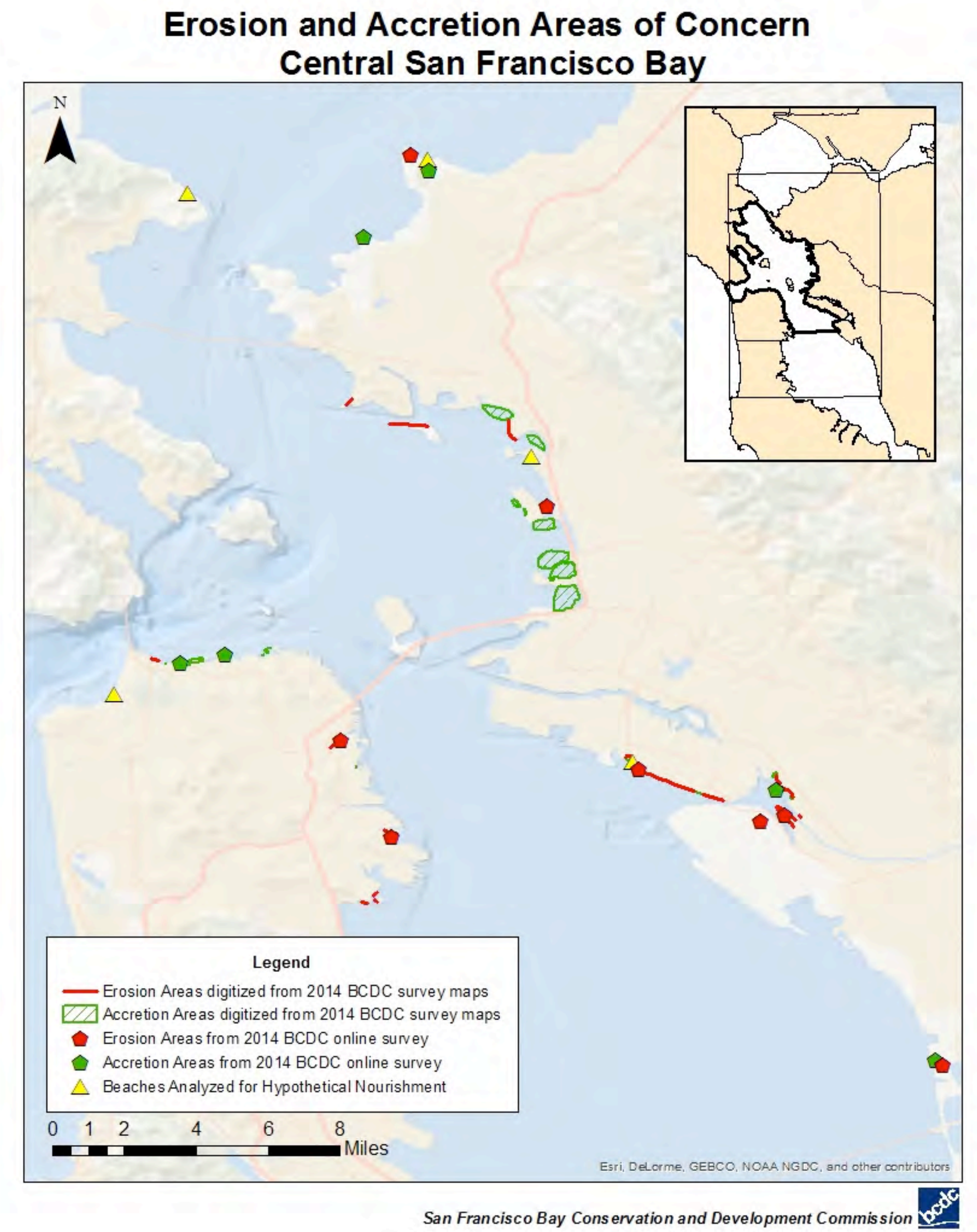

Figure 2 Overview of BECA locations in and around the Central Bay Pilot Study Area

Marin County

There may be areas of erosional concern along the Marin County shoreline, however, this information was not captured in the 2014 sediment survey of Central Bay counties, and is not covered here. Although the Marin County stakeholder meeting was held, BCDC did not receive any responses to the online survey from managers in Marin, despite sending survey reminders, and did not receive input on the outreach meeting maps. Therefore, any areas of erosion or accretion in the Marin County reach potentially specified by Marin County managers could not be effectively represented in this document.

However, the updated Baylands Ecosystem Habitat Goals (2015) identifies problems areas in southern Marin County such as low-lying urbanized lands subject to flooding and the risk of increased marsh erosion. The Goals also provides recommended actions for the Marin County shoreline that include restoration of tidal wetlands, creation of transitions zones, protection of fringe marshes and subtidal habitats, use of fine and coarse grained sediment to reduce erosion of baylands, and to preserve rare high-marsh and transition zone plants.

San Francisco

SAN FRANCISCO REACH AREAS

Crissy Field shoreline

Reach: San Francisco

GIS layer: Accretion Point Shapefile

Survey Source Agency: Golden Gate National Recreation Area (GGNRA) – National Park Service (NPS)

Setting: Wetland/marsh areas are fronted by sandy beach. Adjacent land uses are primarily recreational, though the restored marsh is a habitat feature.

Problem Assessment: Accretion occurs primarily at the east end of the Crissy Field shoreline; until roughly 2011-2012, accretion also occurred further west near the Coast Guard Pier. This no longer appears to be an accretional area however, and the beach appears to have receded somewhat recently, suggesting it may have reached equilibrium. Shoreline managers did also indicate a minor area of erosion slightly west of the Coast Guard Pier, however no other information regarding the severity of the erosion or specifics of the problem were provided on the outreach meeting maps, BCDC staff only note that the managers reported an issue with erosion along this area of coastline.

Management Actions: The Golden Gate National Recreation Area (GGNRA) dredges the Crissy Field marsh inlet 2-3 times per year to re-establish tidal flows between the marsh and the Bay.

The material excavated from the channel is placed back on the Crissy Field beach above the high tide line.

Topographic and bathymetric surveys were conducted 1-2 times per year from 1999-2006. These surveys were concentrated at the east end of the Crissy Field shoreline near the restored marsh and inside the marsh. Volume calculations were done based on these surveys. The entire Crissy Field shoreline (from Fort Point to East Beach) was surveyed three times in 2007 and 2008 (October 2007, January 2008, and October 2008). Surveys included land-based surveys on the beach as well as water-based surveys. Water surface elevation data is collected from inside Crissy marsh (1999-present) and documents all of the inlet closures that have occurred as a result of sand deposition.

Photo monitoring of East Beach at the east end of the Crissy Field marsh has been done at least monthly since 2002. In addition, GGNRA sketches the marsh inlet channel and beach on a monthly basis.

GGNRA engages with the scientific community, including PWA, USGS, and others, to understand the marsh, sediment quality, and biological impacts of the system and their management interventions.

Recommendations: Continue to reuse material excavated from the marsh inlet to nourish the beach. Continue surveys and monitoring to establish a sustainable and low-cost management regime that requires the minimum number of annual breaches to the marsh tidal inlet, until a point at which the system may be able to regulate on its own or can be redesigned in a way that eliminates or minimizes the inlet closure. Continue engaging with the scientific community in analysis to gain understanding of sediment transport in this area. Potential reconnection of daylighted Tennessee Hollow watershed to increase fluvial flow.

San Francisco Marina

Reach: San Francisco

GIS layer: Accretion Point Shapefile

Survey Source Agency: San Francisco Department of Public Works (DPW)

Setting: Jetty adjacent to marina near parks and residential land uses.

Problem Assessment: Moderate continual accretion of sandy material along riprap of jetty, near the marina, and the marina’s entrance channel.

Management Actions: Approximately 15,000 cubic yards (cy) of dredging occurs annually. Cost and excess sediment supply were reported as the primary challenges to sediment management, with minor additional challenges with permitting and sediment contamination.

Recommendations: When possible, beneficially reuse clean dredged sandy material from the jetty to nourish nearby Baker and Ocean beaches. Baker beach (yellow triangle, Figure 2) was identified as a beach where nourishment could increase its recreational value slightly, and provide a positive benefit-to-cost ratio, so long as the cost of nourishment is low (e.g. in circumstances where the transportation distance for material is short and cost of delivery could be low) (Dr. King. 2013).

SAN FRANCISCO BAYSIDE REACH AREAS

Mission Creek Park

Reach: San Francisco Bayside

GIS layer: Erosion Point Shapefile

Survey Source Agency: Mission Bay Parks (The Mission Bay Park system is managed by MJMMG, a private management group, through a contract with the City and County of San Francisco Office of Community Investment and Infrastructure).

Setting: 1.5 miles along both banks of Mission Creek Park and shoreline areas of Mission Bay Parks Project http://missionbayparks.com/map/. Predominantly, open space and industrial land uses nearby.

Problem Assessment: There is mild to moderate erosion along approximately 25% of the shoreline in this reach, adjacent to plantings along the Mission Parks esplanade/pathway.

Management Actions: Currently working to identify causes of the erosion and identify the responsible party.

Recommendations: Protect creeks that are near and reach Bay and encourage realignment so they flow through baylands to the Bay rather than around them. Further, establish more erosion control plantings along banks and transition zones, or investigate other living shoreline alternatives.

San Francisco Waterfront Wetland Areas

Reach: San Francisco and San Francisco Bayside

GIS layer: Erosion Point Shapefile

Survey Source Agency: Port of San Francisco

Setting: Approximately 7.5 miles of waterfront within the City and County of San Francisco, from Aquatic Park to Hunters Point consisting primarily of engineered shoreline areas (seawalls, bulkheads, and rip rap), with some natural shoreline areas as well (wetlands, channels, and parks). The likely location of erosion is just south of Heron's Head Park. Dredging by the Port of San Francisco occurs for operational needs all along the San Francisco Waterfront.

Problem Assessment: There is moderately severe erosion resulting from storm wave impacts adjacent to the wetland portions of this shoreline each year. This sediment is a mix of sandy and silty material depending on the position on the shoreline. Additionally, managers indicated erosion issues occurring near Candlestick Point State Recreation Area, however managers did not provide further details regarding the severity of the problem or the specifics of the issues at this site.

Management Actions: Shoreline stabilization is anticipated to protect against shoreline erosion.

Recommendations: Investigate whether "living shorelines" could be an effective measure for shoreline stabilization along portions of this area or if other shoreline stabilization methods could be used. Assess whether shellfish bed restoration in areas where erosion is occurring would be appropriate, as this is consistent with the San Francisco Bay Subtidal Habitat Goals Report (Figure 7-6).

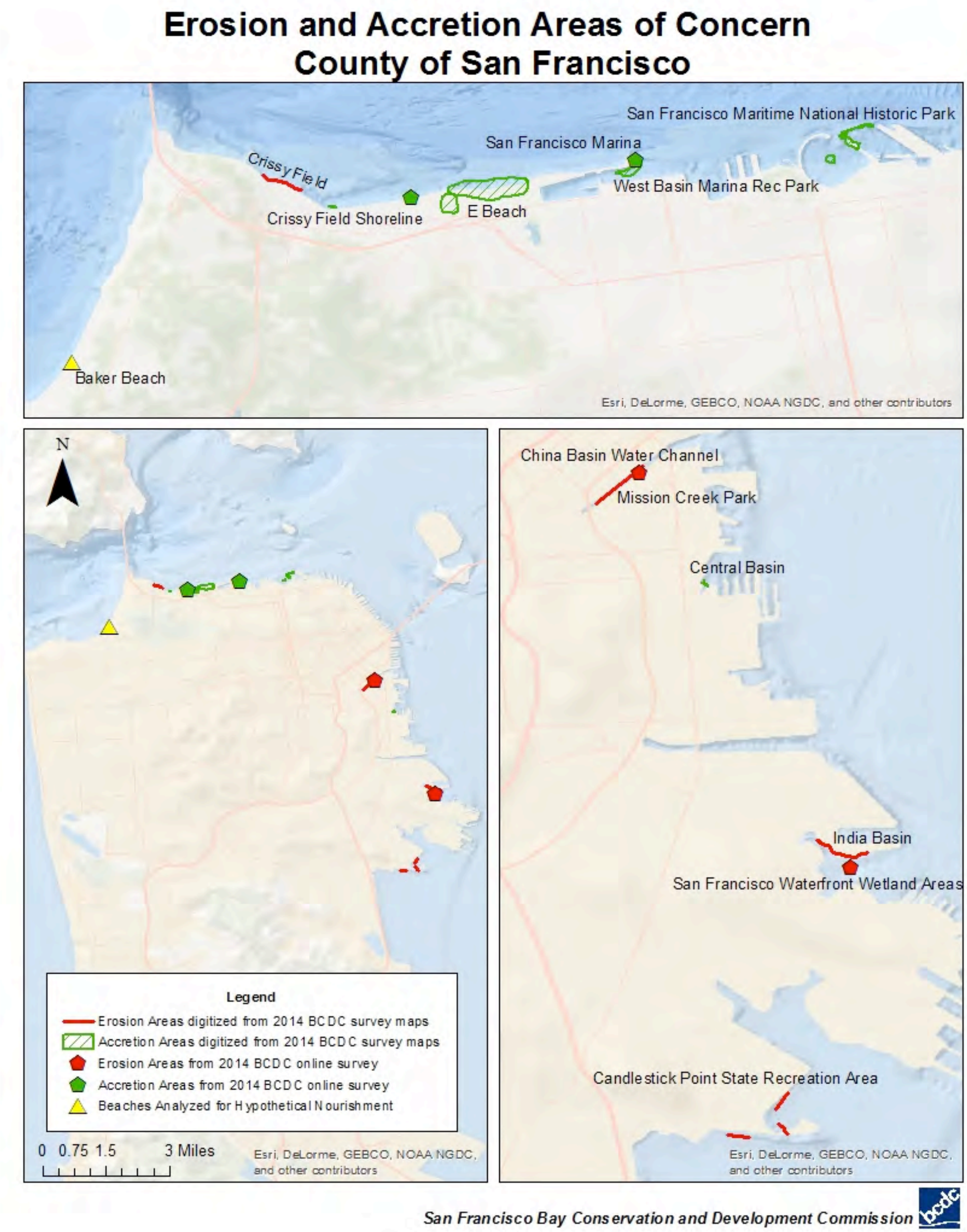

Figure 3 BECAs along the San Francisco and San Francisco Bayside Reaches

Contra Costa County

RICHMOND REACH AREAS

Point Pinole Regional Park Shoreline

Reach: North of Richmond Reach

GIS layer: Erosion Point Shapefile

Survey Source Agency: East Bay Regional Park District and Contra Costa County Flood Control and Water Conservation District

Setting: The Point Pinole Regional Park shoreline is surrounded by urban, suburban, open space, and industrial land uses.

Problem Assessment: Erosion occurs along the riprapped areas (likely caused by wave action) and minor erosion occurs along the mudflats and rocky beaches of Point Pinole. There is also significant shoreline erosion just north of the mouth of Pinole Creek.

Management Actions: Along the Point Pinole shoreline, there is currently a proposal for shoreline stabilization, but there is not yet funding for this project.

Recommendations: Seek funding for shoreline stabilization projects and beneficially reuse dredged sediment from nearby channels along eroding mudflats where suitable. Actions such as exploring living shorelines design to provide wave attenuation and sediment stabilization as well as creating transition zones are consistent with the Bay Ecosystem Habitat Goals (2015)

Point Pinole Regional Park Shoreline

Reach: North of Richmond (most of Contra Costa County and all the creeks discussed are outside of the pilot study area for Central Bay)

GIS layer: Accretion Point Shapefile

Survey Source Agency: East Bay Regional Park District (EBRPD)

Setting: Areas adjacent to Point Pinole Regional Park include mainly urban, suburban, industrial and open space land uses.

Problem Assessment: There is minor accretion occurring near some of the marshes and wetlands around Point Pinole, which appear to be filling in slowly over time with silty material.

Management Actions: Currently, managers around Point Pinole remove all debris (wood, trash, etc.) to maintain maximum tidal flow to prevent the marsh from filling in over time. Political support and public demand appear to be the major drivers of sediment management activities in these areas.

Recommendations: Continue allowing natural sedimentation of marsh areas near Point Pinole, to protect against sea level rise. If natural sedimentation does not occur at a sufficient rate, consider sediment augmentation through use of dredged sediments to support marsh vegetation.

San Pablo and Wildcat Creek (as well as other channels in Contra Costa County)

Reach: North of Richmond (most of Contra Costa County and all the creeks discussed are out of pilot study area for Central Bay)

GIS layer: Accretion Point Shapefile

Survey Source Agency: Contra Costa County Flood Control and Water Conservation District (CCCFCD)

Setting: Flood control channels, specifically the outlets into receiving waters, across all of Contra Costa County, including cities and unincorporated areas, in addition to the Point Pinole Regional Park shoreline. Adjacent land uses to the flood control channels vary from parkland and open space to commercial and industrial (waste water treatment plants).

Problem Assessment: Moderate seasonal accretion occurs on an annual basis in the majority of channels throughout Contra Costa County (Rodeo Creek, Rheem Creek and Pinole Creek seem to have the worst accretion issues at their mouths). Accreted sediment consists of both sand and silt. It is presumed that the flood protection channels were constructed with a flow line below the elevation of the mud flats of the receiving waters. A pilot channel was constructed; however, the energy of the stream is not sufficient to prevent the pilot channel from filling in. Once a silt/sand bar forms at the mouth, additional deposition readily occurs in the upstream channel.

Management Actions: Very little sediment removal from flood control channels occurs anymore from due to the regulatory climate and lack of income/funding, which makes these actions less feasible.

> "Our lack of sediment management actions are driven by two main factors: cost, and permitting / mitigation. When we have flood damages resulting from sediment-caused by lack of channel capacity, then we may have political support and public demand. But those forces are largely absent at this time. Our funding for channel maintenance varies by watershed because watershed tax rates were frozen by proposition 13. Some watersheds, like Walnut Creek, have relative adequate funding. Others, such as Wildcat and Rodeo Creeks, have minimal funding, that covers only a fraction of needed maintenance. And Pinole Creek receives a whopping $0 per year, yet there is still a maintenance obligation. The perceived un-sustainability of maintenance dredging makes this even a more difficult justification for

scarce maintenance funds. The mitigation required for temporary disturbance of receiving waters is way beyond our means. About a decade ago, we explored what it would take to dredge lower Rodeo Creek, and quickly dropped that idea when it was found to take about 20-30 years of expected revenue, and the effect of the dredge would last for maybe two seasons.

I feel we have enough information, but lack the resources to do anything about it. What would be helpful to us is a more regional approach for end of channel sediment management, where there would be a standardized permit and mitigation (or some type of long term programmatic permit) that covers this repetitive action at multiple locations. As of now, we feel that we would be reinventing the wheel, so to speak, each time, at great effort and expense. And with no guarantee we would ever be able to get permits for this work.

If there were only some sort of mechanism, or group we could join or participate in, where the total impacts were known and mitigated, and our proportional impact could be quantified, budgeted and planned for. Then, perhaps, at least some of our watersheds could return their systems' capacity back to design levels." (Paul Detjens, Survey 2014)

Recommendations: For accretion along Contra Costa County creek channels, seek partnerships to assist acquiring funding for dredging projects, and identify nearby, cost-effective beneficial reuse sites. Develop a regional approach for end of channel sediment management, with a standardized or programmatic permit and mitigation that covers repetitive actions like maintenance dredging at multiple locations. Develop a mechanism or group that flood control managers can join and participate in, where the total impacts of projects are known and mitigated for, and each entity's proportional impact could be quantified, planned for and budgeted. Encouraging the protection of creeks, moving them through, not around, baylands is an action consistent with Baylands Ecosystem Habitat Goals (2015)

Point Richmond, Brooks Island, and Point Isabel

Reach: Richmond reach in Contra Costa County

GIS layer:

Survey Source Agency:

Setting:

Problem Assessment: Areas of erosion were illustrated along Point Richmond, Brooks Island and Point Isabel, however managers did not provide further details regarding the severity of the problem or the specifics of the issues at this site.

Recommendations: Continue allowing natural sedimentation of marsh areas near Point Pinole, to protect against sea level rise. If natural sedimentation does not occur at a sufficient rate, consider sediment augmentation through use of dredged sediments.

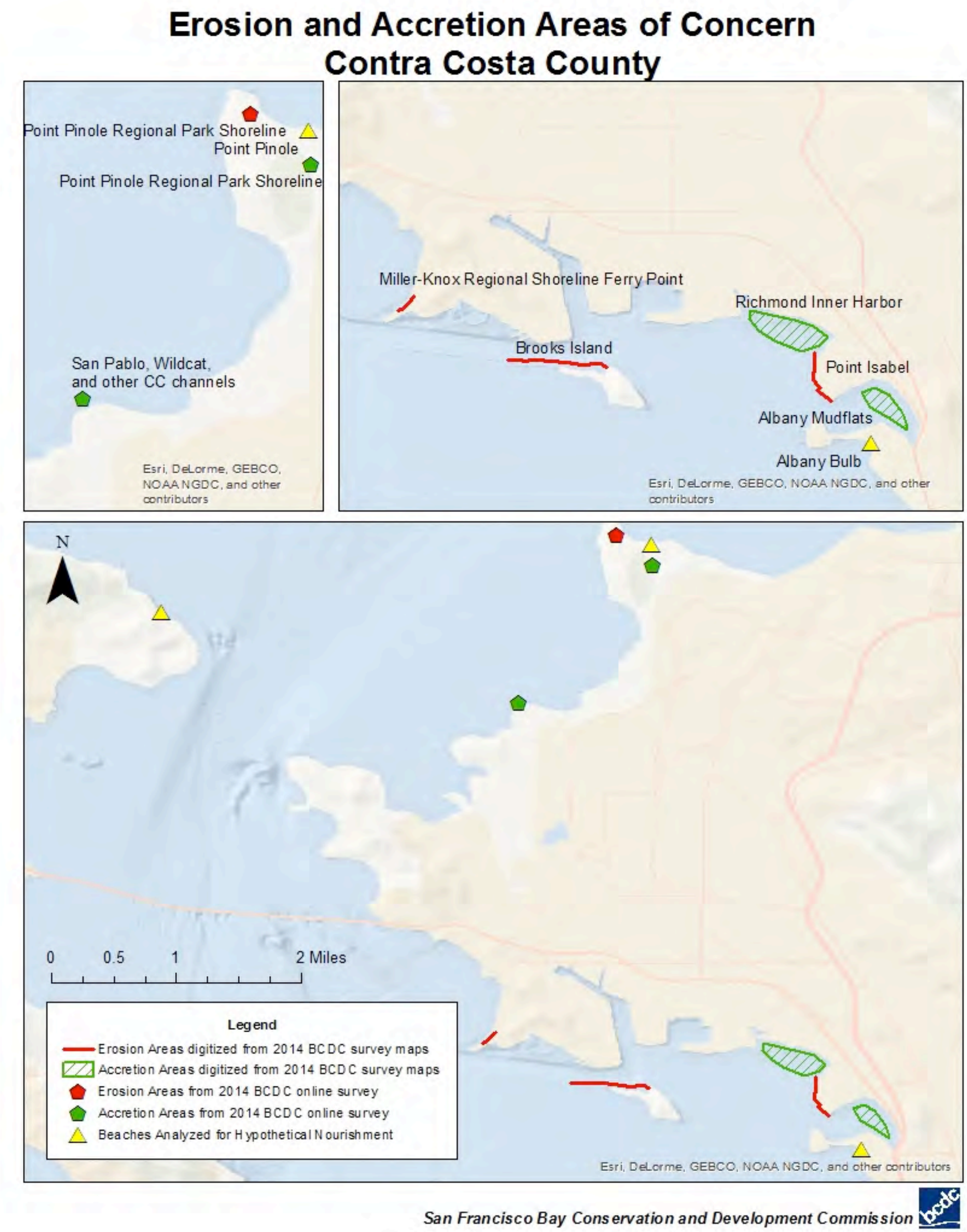

Figure 4 BECAs near the Richmond Reach

Alameda County

BERKELEY REACH AREAS

McLaughlin Eastshore State Park

Reach: Berkeley

GIS layer: Erosion Point Shapefile

Survey Source Agency: East Bay Regional Park District (EBRPD)

Setting: Urban, open space, and industrial nearby land uses surround McLaughlin Eastshore State Park, which includes riprapped shoreline, marshes, wetlands, and sandy beach areas stretching 7.5 miles south from the Contra Costa/Alameda County shoreline to the Bay Bridge.

Problem Assessment: Moderate continuous erosion of riprap occurs, and minimal seasonal erosion along beach areas adjacent to parkland has been reported by EBRPD staff. Permitting is reported as the most significant challenge to sediment management, along with moderate barriers due to cost, sediment supply, and contamination. Regulatory compliance appears to be the major driver of sediment management actions within the McLaughlin Eastshore State Park.

Management Actions: Along McLaughlin Eastshore State Park, there is currently no management action taken to address the erosion occurring along sandy beaches and riprapped areas of shoreline.

Recommendations: Dr. Phil King's economic analysis of beach nourishment projects identified nearby Albany Beach as a location where public benefits from beach nourishment greatly outweigh the costs. Beach nourishment may provide a viable solution to other beaches along this shoreline that face erosion issues. However, McLaughlin Eastshore State Park's physical shoreline processes and recreational potential would first need to be investigated in order to conclusively recommend this action. Improving beaches leads to improved beach habitat for sensitive plant species and the potential development of transition zones.

McLaughlin Eastshore State Park

Reach: Berkeley

GIS layer: Accretion Shapefile

Survey Source Agency:

Setting: Urban, open space, and industrial nearby land uses surround McLaughlin Eastshore State Park, which includes riprapped shoreline, marshes, wetlands, and sandy beach areas stretching 7.5 miles south from the Contra Costa/Alameda County shoreline to the Bay Bridge.

Problem Assessment: Large areas of subtidal accretion (green polygons) occur along this reach. However, managers illustrated the issue on the outreach meeting maps, but did not provide further details regarding the severity of the problem, specifics of the issues at this site, or the sediment type on the maps or in their online survey.

Recommendations: The Baylands Ecosystem Habitat Goals (2015) provides recommended actions for the Alameda County shoreline that include restoration of tidal wetlands, beaches, the creation of transitions zones, as well as protection of plant habitat and shorebird roosting sites.

ALAMEDA REACH AREAS

Crown Beach

Reach: Alameda

GIS layer: Erosion Point Shapefile

Survey Source Agency: East Bay Regional Parks District (EBRPD)

Setting: The beach stretch includes a long stretch of City of Alameda-owned beach along Shoreline Drive, which has residential and commercial uses across the street, and Robert Crown Memorial Beach, which is a State park. Both beaches are managed by EBRPD.

The beach area is about 2.5 consecutive miles long, plus an additional ¼ mile section, consisting primarily of sandy beach, but also including some riprap and seawall/bulkhead structures, as well as a very small Marine Conservation Area (consisting mostly of tidal mudflats).

Problem Assessment: Sand on the artificial Crown Beach shifts continuously, eroding at one end and accreting at the other, requiring ongoing yearly maintenance to move material around on the beach. A major replenishment was necessary in 2013 to restore the beach width with approximately 82,400 cubic yards of sand.

There is minor seasonal accretion of the beach, mostly around the groins. Sand is regularly moved by truck and distributed along the beach in areas where the beach looks thin. Figure 2, indicates erosion issues along the entirety of Crown Beach and just south of the beach, which were illustrated by the managers on the outreach meeting maps.

Management Actions: The EBRP must repeatedly dig out the storm drain outfalls on the beach when buried by sand.

Two groin walls were built that catch the sand during winter storms. Each year the captured sand is re-dispersed along the beach where it is thin. Currently the beach is designed for re-nourishment roughly every twenty years.

Maintenance of Crown Beach, either by sand redistribution or by imported sand placement, has been ongoing since 1983. Alongshore sand transport at Crown Beach moves material away (to the northwest and southeast) from a central beach nodal point. The groin structures at the northwestern and southeastern boundaries trap transported sand on the beach side of the structures. On an annual basis, the East Bay Regional Parks District Operations and Maintenance Department redistributes the sand to the beach nodal point and to areas eroded by winter storms and wave action. Winter storms can cause severe and sudden erosion: in 2005, for example, a single winter storm event resulted in the loss of 20,600 cubic yards of sand.

The purpose of the Crown Beach nourishment project in 2013 was to restore Crown Beach to its original engineered configuration for flood protection and to maintain the provision of shoreline and habitat protection, public access, and recreation opportunities. Based on various data sources, sand loss at Crown Beach from 1988-2006 was approximately 82,400 cubic yards (20% of 1988 beach volume). The 2013 replenishment project included the placement of 82,600 cubic yards of sand obtained from Central Bay mining efforts, and the shoreward extension of the southeastern groin.

Recommendations: This beach is an engineered/designed system and can continue to operate as is, providing annual sand redistribution. Re-nourishment will likely be required in the next twenty years, unless a redesign of the system is considered or the physical characteristics at the site change over the next 20 years. Continue exploring the use of small groins spaced along the beach, such as trees, to help prevent or reduce the amount of annual maintenance required.

San Leandro Bay

Reach: Alameda

GIS Layer: Accretion Point Shapefile

Survey Source Agency: East Bay Regional Parks District (EBRPD)

Setting: There are parks, wetlands, flood control channels, shoreline structures, and marshes along the Martin Luther King Jr. Regional Shoreline, southeast of the mouth of San Leandro Bay.

Problem Assessment: Continuous accretion occurs near the mouth of San Leandro Bay. *Spartina* causes accretion and sedimentation to mouths of local channels.

Management Actions: The East Bay Regional Park District has discussed channel erosion and accretion issues with the Alameda County Flood Control and Water Conservation District (ACFCD). Sediment issues are surveyed by ACFCD. The sediment comes from the flood channels and creeks, which are managed by the flood control district. The main drivers of management actions appear to be economic impacts, environmental pressure and regulatory compliance. Cost appears to be the biggest challenge for managing sediment in these areas.

Recommendations: Partner flood control channel dredging with shoreline restoration projects or areas within Martin Luther King Jr. Regional Shoreline Park where erosion is occurring and the sediment is suitable for placement at these sites. Explore potential cost sharing mechanisms for dredging and placement at the restoration sites. Improving tidal and diked habitats through restoration and addressing invasive *Spartina* are actions consistent with those noted in the Bay Ecosystem Habitat Goals (2015).

Bay Farm Island and Martin Luther King Jr. Regional Shoreline

Reach: Alameda

GIS layer: Erosion Point Shapefile

Survey Source Agency: City of Alameda and East Bay Regional Parks District

Setting: Bay Farm Island is protected from coastal flooding and inundation by several standalone structures and tide gates along the shoreline. The Oakland International Airport is currently protected by a system of levees. Occasionally dredging of the approach to the Harbor Bay Ferry terminal is necessary (roughly once in the past 10 years).

There are parks, wetlands, flood control channels, shoreline structures, and marshes along the Martin Luther King Jr. Regional Shoreline.

Problem Assessment: The riprap on Bay Farm Island erodes seasonally – it shifts downhill on a continuous basis and requires yearly maintenance. During the last El Nino, the riprap, some shoreline behind it, and the shoreline bike path were eroded away during storms.

Along the Martin Luther King Jr. Regional Shoreline, most of the erosion appears to be occurring in the marshes and wetlands, and minor amounts of erosion occurring in the channels, and riparian areas along the shoreline. Erosion appears to occur continually on the riprapped areas and along the marshes, wetland, and riparian areas, and appears to occur more seasonally in the channels.

Management Actions: Preventative maintenance for the riprap on Bay Farm Island. The US Army Corps of Engineers is currently studying the riprap on Bay Farm Island to determine what size would be adequate to resist erosion.

Minor repair of riprap and storm damage on Bay Farm Island prevents further storm damage to facilities behind the riprap. Lack of funding prevents the City of Alameda from installing larger riprap, which the City believes would provide better protection and decrease yearly maintenance.

Recommendations: Continue preventative maintenance of riprap along Bay Farm Island or plan adaptive management for important infrastructure. Strengthen and raise the shoreline, and stabilize using living shoreline infrastructure when possible.

Reuse sediment dredged from San Leandro Creek or other adjacent sites with suitable sediment to augment the wetlands along Martin Luther King Jr. Regional Shoreline Park.

HAYWARD REACH AREAS

Although Hayward is south of the Central Bay pilot study area, the following responses are included so as not to lose the information gleaned from the 2014 sediment survey.

Hayward Regional Shoreline (Accretion)

Reach: South of Alameda Reach

GIS layer: Accretion Point Shapefile

Survey Source Agency: East Bay Regional Park District (EBRPD)

Setting: Mostly open space and industrial land uses in this area. With wetlands and riprapped shoreline protection features along the shoreline.

Problem Assessment: Areas of accretion occur along the marshes/wetlands and the channels and consist mainly of silt and fine-grained material. Minor amounts of material are continually trapped behind tide gates in the channels. The accretion occurs near a marsh restoration area (Hayward Marsh).

Management Actions: The estimated volume of sediment that needs to be removed is 30,000 to 50,000 cubic yards, depending on how much is needed to retain flow in the channels. No dredging has occurred since the marsh restoration work in 1984, however, there is hope of dredging in the near future. The biggest challenges for management of these accretional areas are permitting, the cost for reuse of the material, and the mitigation costs for the work. Obtaining the necessary permits in a timely manner is problematic, as is obtaining the funding.

Recommendations: Depending upon sediment quality, reuse material dredged from within channels for placement at a nearby beneficial reuse site where material can feasibly be pumped or costs can be shared with the receiving site. Keeping the channels clear works towards the Bay Ecosystem Habitat Goals (2015) of keeping tributaries connected to the Bay.

Hayward Regional Shoreline (Erosion)

Reach: South of Alameda Reach

GIS layer: Erosion Point Shapefile

Survey Source Agency: East Bay Regional Park District (EBRPD)

Setting: Mostly open space and industrial land uses in this area, with wetlands and riprapped shoreline protection features along the shoreline.

Problem Assessment: Most of the coastal erosion occurs along the marsh/wetland areas with some erosion also along the riprapped sections of the shoreline and sandy beach areas. Erosion appears to occur during episodic events, caused by wave events and high tides along the riprap and wetland areas. However, erosion along sandy beaches appears to occur seasonally and be driven by wind and wave events. Erosion appears to be relatively severe along this shoreline area.

Management Actions: When erosion events occur, the current management action is to armor or re-armor the shoreline areas. As erosion is an ongoing problem along the Hayward Shoreline, the potential for streamlining the permits necessary for repairs was indicated as being very helpful.

Recommendations: Investigate potential living shoreline structures or other natural alternatives for shoreline stabilization that may be effective given the existing conditions at this site.

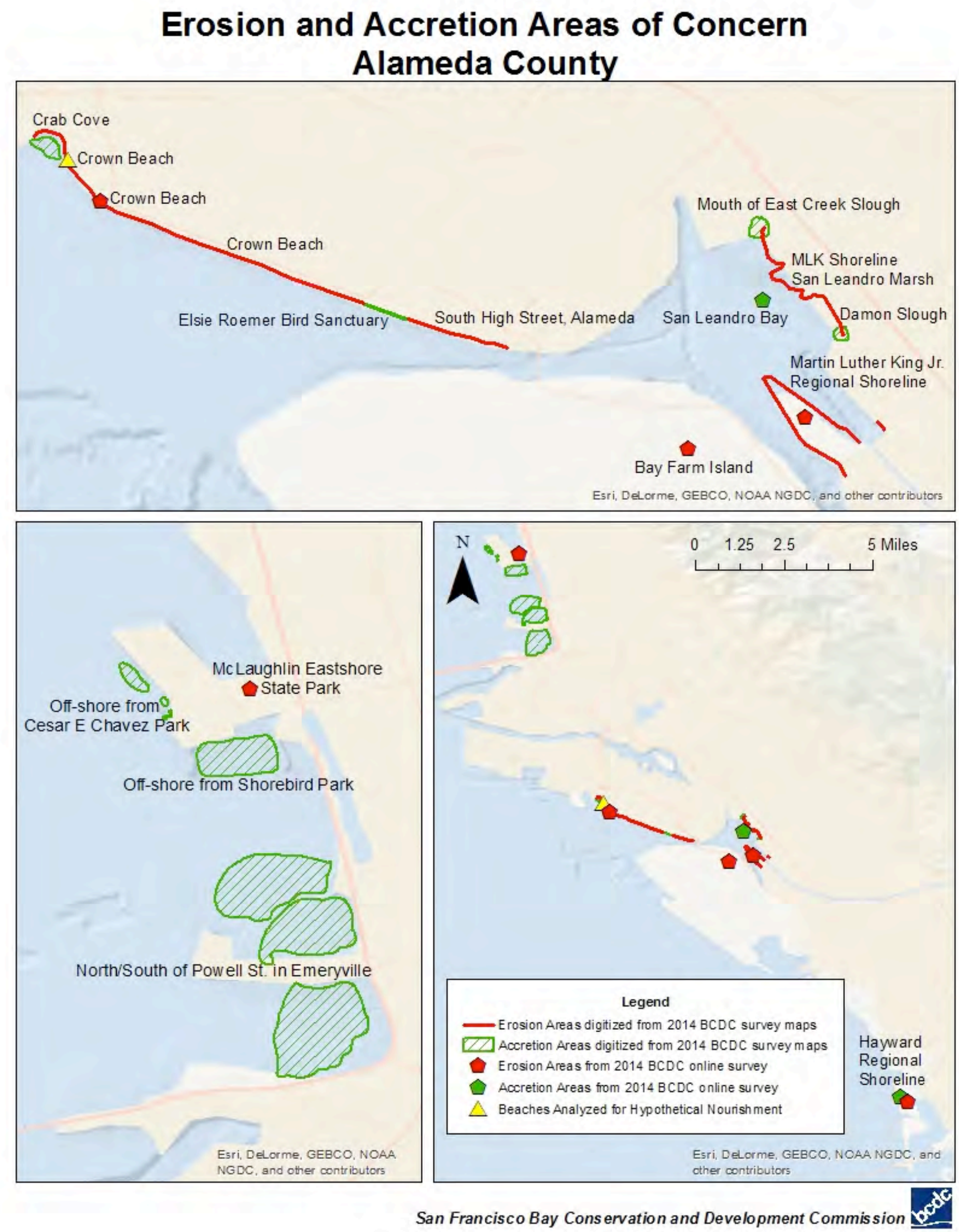

Figure 5 BECAs along the Berkeley and Alameda Reaches

Appendix B

Economic Analysis of Recreation Assets of Beaches

Executive summary

The economic analysis in this paper was prepared as part of the Coastal Regional Sediment Master Plan (CRSMP) for the central San Francisco Bay area. The State of California has conducted a number of these plans for other coastal areas across the state. The purpose of the economic analysis is twofold: (1) to characterize and quantify (where possible) recreational activity at beaches in the inner bay, (2) to provide a very basic analysis of the costs and benefits of nourishment at a few selected sites.

Between May, 2013 and June, 2014 we were able to catalog the accessibility (by mass transit) and the amenities available at 22 different beaches within the central area of the San Francisco Bay. We were also conducted head and car counts at each beach to estimate annual attendance at each beach. The head counts also allowed us to gather data regarding the primary activities in which people engage during their beach visits. This information will be useful for future coastal planning within the central bay area.

Our second task conducts a rudimentary analysis of the costs and benefits associated with the nourishment of the more popular beaches in the central bay. BCDC provided us with data regarding the pre-nourishment beach-widths, the hypothetical increase to these beach-widths and the estimated erosion rates for each of these beaches. We were then able to estimate the degree to which nourishment of these beaches would increase both the number visits to each beach as well as the recreational value associated with any such visit. These estimates allow us to compare the total increase in recreational value to the costs, which corresponded to the nourishment of each beach. These benefit/cost ratio are shown below.

Table A. Summary of Benefit/Cost Ratio for Selected Beaches Inside San Francisco Bay

5-Year Forecast	McNears	Baker Beach	Crown Beach	Albany Bulb	Pt. Pinole
Total Cost of Nourishment	$ 67,071	$ 2,527,597	$ 1,936,000	$ 12,963	$ 27,921
Initial Sandy Beach Width (feet)	35	107	50	9	15
Beach Fill (cy)	2,795	105,317	80,667	540	1,163
Attendance Increase Doubled	3.1%	30.8%	30.8%	6.2%	3.1%
Addition to Recreational Value (PV)	$ 1,280,711	$ 2,660,270	$ 10,110,700	$ 105,061	$ 23,979
Benefit per Cubic Yard	$ 458.27	$ 25.26	$ 125.34	$ 194.52	$ 20.61
Cost per Cubic Yard	$ 24.00	$ 24.00	$ 24.00	$ 24.00	$ 24.00
Benefit/Cost Ratio (Add'l Rec. Benefits/Project Cost)	**19.1**	**1.1**	**5.2**	**8.1**	**0.9**

Introduction

The economic analysis in this paper was prepared for the San Francisco Bay Conservation and Development Commission (BCDC) as part of the Coastal Regional Sediment Master Plan (CRSMP) for the central San Francisco Bay area. The State of California has conducted a number of these plans for other coastal areas across the state. The analysis was developed to assist in assessing the recreational value of San Francisco Bay beaches, and the potential benefits of any proposed beach nourishment projects. Currently, only one beach nourishment project has been conducted, with no additional projects proposed, but due to both the recreational opportunities and the potential to minimize some effects of projected sea level rise, some may be proposed in the future. The purpose of the economic analysis is twofold: (1) to characterize and quantify (where possible) recreational activity at beaches in the inner bay, (2) to provide a very basic analysis of the costs and benefits of nourishment at a few selected sites.

One challenge with this study is that there is almost no data on recreational activity at these beaches. Many beaches across the state keep lifeguard or other counts on beach visitation. However, the vast majority of the beaches in this study have no lifeguards and no official counts. The type of recreational activity at these beaches is also different from a typical southern California beach or even some well-known northern California beaches (e.g., Stinson Beach).

Given these limitations, much of the effort in this study was aimed at providing a baseline analysis for each of these beaches. Research assistants conducted counts at all of the beaches enumerated below including categorizing the different recreational activities.

Methodology

The methodology that we employed for this analysis can be broken down into four separate tasks. Accordingly, we have separated this report into four sections that correspond to each of these tasks. While more detailed descriptions of these tasks will be provided within their corresponding sections below, we can at this time summarize these four tasks as follows:

Surveying the Beaches: Since several of the central bay area beaches are relatively unknown to most people, our report begins with a brief survey of these beaches in order to familiarize the reader with the area. In order to do this we sent several research assistants throughout the central bay in June of 2013 so as to get a basic overview of the beaches within the area. Of particular interest to this report were the accessibility of public transportation to as well as the amenities available at each of these beaches.

Attendance Counts and Activity Distributions: The second task involves estimating how many people visit each of these beaches and for what purpose. From May of 2013 to June of 2014, several research assistants were sent to the beaches within the central bay in order to collect attendance data for each beach. The research assistants also gathered data regarding how many of the visitors at the more popular beaches were engaged in various activities ranging from sun-bathing to dog-walking.

Beach-Width and Erosion Data: The next stage of our analysis involved gathering data on the effects that a beach nourishment project would have on the widths of selected beaches in the central bay. BCDC provided us with data regarding the projected width of each beach both prior to as well as immediately after the proposed nourishments are performed. We were also provided with preliminary data regarding the erosion rates for these beaches such that we were able to calculate each beach's width 5 years into the future. Using data collected from other surveys, we were thus able to estimate the effect that any proposed beach nourishments in the central bay would have on beach attendance.

Economic Analysis: In the final stage of our analysis we took the data gathered in the previous stages and were able to provide a cost/benefit analysis of potential beach nourishments. Although most of the beaches in the central bay area are free of charge, there is a recreational value associated with each beach that measures how much, in dollars, a visit to the beach is worth to its visitors. An increase in beach-width contributes to an increase in the recreational value of a visit to the beach which, in turn, contributes to an increase in beach attendance. By dividing these benefits by the cost of nourishment, we are able to arrive at the benefit/cost ratio for each beach. Benefit/cost ratios of greater than one are considered positive (the value of the nourishments being greater than the price paid for them) and thus generally justify the expenditure, while projects with a benefit/ratio of less than one are generally viewed as less economically justifiable (the value of the nourishments being less than the price paid).

Survey of Beaches

Since several of the central bay area beaches are relatively unknown to most people, our report begins with a brief survey of these beaches in order to familiarize the reader with the beaches in question. In June of 2013, several research assistants visited beaches throughout the central bay in order to get a basic overview of the beaches within the area. Of particular interest to this report were the accessibility of public transportation to as well as the amenities available at each of these beaches. In order to ensure consistency within and across their reports, we instructed these research assistants ahead of time as to which amenities they should document.

Angel Island

Angel Island State Park is the largest island in the San Francisco Bay and offers some of the best views of the surrounding Bay Area. The island has many hiking trails with camp sites in addition to several recreational activities such as tram and Segway tours of historic sites, bike rentals, a kayak camp and a café provided by the Angel Island Company. The island also offers excellent views of the San Francisco skyline, the Marin County Headlands and Mount Tamalpais. Angel Island also has a number of small pocket beaches, the most popular of which being Quarry and Perles Beaches. However, even these beaches receive very few visitors throughout the year. Dogs are not allowed on the island, with the exception of service animals and access to the island is by private boat or public ferry only.

Photograph 1. Perles Beach on Angel Island

Amenities: restrooms, restaurant/snack bar with live music on weekends, picnic tables, bike rental, bike trails, hiking trails, campgrounds, many historical sites and buildings (immigration station, batteries, hospital, general's house, etc), volleyball net, baseball field, fishing, visitor center, tram tours, hiking/segway/diggler tours and summer camp for kids.

Parking Capacity: None

Mass transit: From San Francisco, Oakland and Alameda use the Blue & Gold Ferry Service and from Tiburon use the Tiburon/Angel Island Ferry Service.

Baker Beach

Baker Beach is located in the Presidio, the most northwest part of San Francisco. The main entrance is located off Lincoln Boulevard with additional access through the Sea Cliff residential area, on 25th avenue. The beach is little more than a half-mile long and offers views of the Golden Gate Bridge and Marin Headlands. On a typical foggy day, the majority of beach goers are dog walkers. On a sunny day, the beach gets very crowded and parking becomes limited. There is a large picnic area with tables, grills, and restrooms, which is located in the cypress grove, east of the larger parking lot. The historic Battery Chamberlin is another draw; it sits above the beach on a path mostly used by joggers. In addition to the sandy beach, there are several coastal hiking trails. The northernmost section of the beach hosts clothing-optional sunbathers. Dogs are allowed and tend to outnumber people. There are two large parking lots that together hold 200, with additional parking on Bowley St., off Lincoln Blvd. and street parking in Sea Cliff. Public transit accessibility is good, the 29 Muni bus stops on Bowley St.

Photograph 2. Baker Beach

Amenities: picnic area with tables and grills, restrooms, the historic Battery Chamberlin, hiking trails, view of Golden Gate Bridge and Marin headlands

Parking capacity: 199 with additional parking on Bowley St., off Lincoln Blvd.

Mass transit: Muni 29, about a seven-minute walk from the stop .

Crissy Field

Crissy Field is part of the Golden Gate National Recreation area. The beach has a 1.3-mile promenade, picnic areas with barbeques, wetlands, a community center, café, occasional art installations and spectacular views. The east section of the beach provides restrooms, outdoor showers and a café. The West Bluff is a smaller beach with fewer dogs and mainly attracts families with children; setting up tents is a popular way to comfortably shield children from the sun. The lawn holds several barbeques and 15 picnic tables. The water is usually clean however there are warnings if conditions permit. The wharf, or pier, attracts fishermen, and others who photograph the bridge. The promenade is popular among runners, walkers, dog walkers, and bicyclists. There are several trails that diverge from the main promenade. Many tourists visit this beach because it is a large area with spectacular views in addition to it being a popular destination for bike tours. The Crissy Field Center provides educational programs for children, who frequently visit the beach mainly during the summer time. The restored marsh hosts native wildlife and serves as an attraction. Windsurfers and kite flyers utilize Crissy Field's wind factor. Beach wheelchairs are available upon request. There are parking lots near the east beach and more parking behind the west bluff, the fee varies depending on the day of the week. Street parking on Mason St. is also available. Public transit accessibility is fair, the 28 Muni line stops in the area.

Amenities: Restrooms, outdoor showers, two cafes, boardwalk/promenade, views, pier, Crissy Field Center, picnic areas, wetlands and wildlife

Parking Capacity: 768 (+140+street parking)

Mass transit: Muni 28, a 20-25 minute walk from the Cranston Road stop or the Richardson and Francisco St stop

Paradise Beach Park

Paradise Beach Park is a 19-acre regional park along the East shore of the Tiburon Peninsula, with an entry fee ranging from $8-10. This is a scenic space with benches, picnic tables, barbeque pits, a fishing pier, a big lawn, horseshoe court, restrooms, a grove of redwood trees and a beach. However, the beach is very small in width and is cobble instead of sand. The beach here is not the main attraction, it is not visible unless right near the water. Fishermen are frequent visitors. Dogs are not allowed. There are two sizable parking lots with roughly 100 spots. Access to the beach is not optimal, Golden Gate Transit to Tiburon followed by a 10 min cab ride to the Park.

Amenities: fishing pier, picnic tables, bbq, swimming, benches, restrooms,

Parking capacity: roughly 100

Mass transit: Golden Gate Transit to Tiburon, then 10 min cab ride

Fort Baker

Fort Baker is a military base situated almost directly under the north end of Golden Gate Bridge, Horseshoe Bay is the body of water to the east. The shoreline is divided into three small beaches that are situated in Horseshoe Bay. One is a cobble beach, functioning more as a waterfront. There are a couple of picnic tables close to the water. The other beach, roughly 200ft in length, is sandier. There is a very small beach next to the pier that has rockier sand. The beach is not the main attraction. The pier is a popular location for fishing. There are ten parking spots on Moore Road, next to the pier. There is additional parking in the lot located next to the

Bay Area Discovery Museum and Cavallo Point Lodge. There are hiking trails around this area offering many views. There is no available public transit.

Amenities: picnic tables, pier, scenery, institutions in close proximity

Parking capacity: parking lot holds 10, additional parking in larger lots a couple hundred feet away

Mass transit: no

Kirby Cove

This is a very small coarse sand beach just west of the north side of the Golden Gate Bridge. The parking area is above Battery Spencer on Conzelman Road, requiring a mile-long trail hike down to the beach. The beach at Kirby Cove is also a campground site with four campsites, which include pit toilets, barbeque pits, picnic tables and fire rings. Reservations are necessary prior to campsite use. This site attracts visitors because of its views of the bridge and the city skyline, however this site is widely unknown. Public transportation does not run near Kirby Cove, one must drive down to the site from the street and then hike down.

Amenities: scenery, campsite with pit toilets, barbeque pits, picnic tables and fire rings

Parking capacity: 21 at the top of the hill

Mass Transit: No

Sausalito Beach

This is a very narrow beach at the foot of Richardson St. with nice scenery and a boardwalk. The boardwalk cuts the beach in half, making it even narrower. There are residential houses behind the boardwalk. The beach is accessible from the foot of Main or Richardson St. There is no nearby public transportation and parking is limited to street parking availability.

Amenities: scenery

Parking capacity: limited to street

Mass transit: no

McNears

McNears Beach Park is a 55-acre regional park along the shores of San Pablo Bay in San Rafael. There is a day use fee of $8-10 which gives visitors access to the swimming pool, seasonal snack bar, volleyball courts, several picnic areas, big lawns, tennis courts, restrooms and showers. Most visitors lounge on the lawn looking out at the beach, while mostly children play on the actual beach. The beach is mostly cobble and is not the main attraction. On a sunny day, the pool gets crowded. Behind the pool, there are additional barbeque sections. While there are lifeguards on duty at the pool, there are none at the beach. There is an exceptionally popular fishing pier. Kayaking and canoeing are also recreational activities at this site. Dogs are not allowed. There is a large parking lot with additional lots for overflow. Golden Gate Transit travels to San Rafael although to get to McNears, a 15 minute cab ride is necessary.

Amenities: BBQs, Benches, Drinking Fountain, Fishing Pier, Group Picnic Areas, Parking, Picnic Tables, Playfields, Restroom, tennis courts, pool and snack bar (only during summer season).

Parking capacity: 160

Mass transit: Golden Gate Transit to San Rafael then a 15 min cab ride from station to McNears Beach

Candlestick Point State Recreational Area

This is a state park located off highway 101, on the western shoreline of the San Francisco Bay with views of the East Bay Hills and the San Bruno Mountain. There are trails next to the water and many picnic tables scattered along the trail. Wind shelters are around the group picnic areas. There is one small beach in front of a large picnic area. There are two fishing piers; one is closed due to rehabilitation while the other one is open for use. Mostly families with children, joggers, or site-seers visit the beach. The area also offers a fitness course along the shoreline walking trails for those who choose to use them. In the spring and summer, wind surfers enjoy the wind and waves. This is a popular destination for bird watching, especially during the winter months. There is a large parking lot. Two Muni lines, the 29 and 8BX, provide access to this beach.

Amenities: trails, picnic benches, wind sheltered picnic areas with barbeques, restrooms, two piers, fitness course

Parking capacity: 170

Mass transit: Muni 29 or 8BX, 20 minute walking distance

China Beach

This is a small beach located at the end of Seacliff Ave. in between Lands End and Baker Beach. Access to the beach is either a stairway down from the parking lot or a paved ramp. Views of the Golden Gate Bridge and Marin headlands are spectacular. The sand is somewhat coarse. There are restrooms and cold-water showers. Fishermen use the western section of the beach while the other side is used recreationally. Above the beach, there are grills and a picnic area.

Also above the beach there is a large structure, which used to be a lifeguard station but is now used for equipment storage. Currently there are no lifeguards. Dogs are not allowed. Mainly locals visit the beach because it is not well known, tourists will flock to Baker Beach, which is directly east of China Beach. The Muni lines 1 and 29 stop at 30th avenue, which requires a few blocks walk.

Amenities: trail, views of Golden Gate and Marin Headlands, picnic area

Parking capacity: roughly 37

Mass transit: Muni 1, 2, 29. Closest stop is 30th and California on the 1; 5-10 minute walk to the beach.

Black Sands Beach

This is a small beach in the Marin Headlands. A moderately challenging hike is required to get down to the beach. The trail begins off Conzelman Road in the small parking lot, where there is a restroom. At the beach people enjoy fishing, sunbathing, and relaxing. People are attracted to this beach because of the unusual black sand and its stunning views of the Golden Gate with the city skyline as the backdrop. This beach is relatively unknown and sparsely visited, mostly by locals. Public transportation is feasible; the Muni line 76X travels across the bridge but a 20+ minute walk is required to walk down to the beach.

Amenities: trail, views of Golden Gate

Parking capacity: 14

Mass transit: Muni 76X must walk 20+ min to beach

Point Pinole Regional Shoreline

Point Pinole is a 2,315 acre park built on land previously owned by Bethlehem Steel, on the western edge of the cities of Pinole and Richmond adjacent to San Pablo Bay. This shoreline park includes habitat for Monarch butterflies, deer and over 100 species of birds. Views from the shoreline include Mt. Tamalpais and the Marin coast. Visitor activities include bird watching, hiking, bicycle and horse riding, fishing for sturgeon, striped bass, perch, kingfish, and flounder from the 1,250 foot fishing pier. Within the park, amenities can be accessed by foot, bicycle, horseback and a limited-stop shuttle bus. Dogs, on-leash, are permitted within certain areas.

Photograph 3. Point Pinole

Amenities: scenery, wheelchair accessible restrooms, volleyball courts, open lawn areas, picnic tables, benches, grills, trash cans, water fountains, children's playground, camp sites and maintained horse and hiking trails

Parking capacity: approximately 72 parking spaces

Mass transit: AC Transit lines 71 and 376 available to the general public and through Parks Express (an East Bay Regional Park District program that provides low-cost transportation to groups serving seniors, people with disabilities and low-income children).

Miller/Knox Regional Shoreline

Miller/Knox Regional Shoreline Park is part of the East Bay Regional Park system and is located on the western edge of the city of Richmond, CA. Portions of the park afford views of San Francisco, Mt. Tamalpais, and the Richmond San Rafael Bridge. Jogging and bicycling trails are available, along with some picnic facilities on the lawn which surrounds a saltwater lagoon, several of which are reservable for group parties. No lifeguards are on duty at the beach and dogs must remain of leases while on the trails.

Amenities: scenery, a picnic area adjacent to the saltwater lagoon, a swimming cove with a small beach, picnic tables and showers, a mile-long paved trail for pedestrians and bicyclists, a horse trail, a children's playground, and a fishing pier. Public restrooms and water fountains are scattered throughout the park

Parking capacity: approximately 230 parking spots

Mass transit: AC Transit Bus #72M) and through the East Bay Regional Park District Parks Express program.

Barbara and Jay Vincent Park

Barbara and Jay Vincent Park is owned and operated by the city of Richmond, CA. The park is located on the tip of a small peninsula, at the entrance to the Marina Bay. The park includes 6 acres of land and offers views of Marina Bay, downtown San Francisco and the Bay Bridge. A small sandy beach includes a ramp for kayak and other small watercraft access to the SF Bay and the Marina. Dogs are allowed although it is unclear whether leashes are required at the beach.

Photograph 4. Barbara and Jay Vincent Park

Amenities: children's playground, launch site for small watercraft, scenery, paved trail, benches, picnic areas with BBQ facilities, open lawn area, portable restrooms

Parking capacity: approximately 36 spots

Mass transit: AC Transit #74

Point Isabel Regional Shoreline

Point Isabel encompasses 23 acres on the western edge of the city of Richmond. The park provides panoramic views of the San Francisco skyline, the Bay and Golden Gate Bridges and the Marin bay shoreline. Park activities include bird watching, fishing for a variety of fish including striped bass, sturgeon and flounder, jogging, bicycling, kite-flying and picnicking. Point Isabel is one of the largest public off-leash dog parks in the country. Several park amenities support the dog-walkers who visit the park, including dog-height water fountains, kiosks with plastic bags for the removal of dog waste and community bulletin boards with dog-related information. A popular amenity is Mudpuppy's Tub & Scrub and the adjacent Sit & Stay

Café. Mudpuppy's includes a dog-washing station and sells dog treats and toys. The Sit & Stay Café offers coffee, sandwiches and other portable treats. The café provides customers with several umbrella-shaded picnic tables.

Photograph 5. Point Isabel

Amenities: scenery, paved trail, open lawn space, water fountains, dog-height water fountains, kiosks with plastic bags for removal of dog-waste, trash cans, community bulletin board with dog-related information, dog-bathing services, café, picnic tables, benches, public restrooms

Parking capacity: approx. 108 parking spots plus additional street parking

Mass transit: AC Transit Bus #25) and through the East Bay Regional Park District Parks Express program.

Albany Bulb

The Albany Bulb is a converted landfill-turned-park that is owned and operated by the city of Albany. The Bulb is adjacent to Eastshore State Park, on the western edge of the city of Albany.

The Bulb is so named due to its location on the bulbous tip of a small peninsula located behind the Golden Gate Fields horse-race track. The Albany Bulb is known as an outdoor exhibit for "urban art" including large murals, graffiti and sculptures. Since the Fall of 2013, the City of Albany began the process of discouraging overnight campers and dismantling the current homeless encampment. As this process takes place, including legal attempts by campers to halt the eviction process, it is not clear how this change will impact usage of the Bulb area. The Bulb is popular destination for local dog-owners and dog-walkers who use the wide trails and small sandy beach.

Amenities: scenery, hiking trail, benches, trash cans

Parking capacity: approximately 41 spaces

Mass transit: no

Berkeley Marina – Shorebird Park

Shorebird Park is an approximately 6 acre park located on the western edge of the City of Berkeley on the southern portion of the Berkeley Marina. The park is near the popular Berkeley Adventure Playground and the U. C. Berkeley Cal Sailing Club. The park also includes a small sandy beach area on which dogs can play along with a newly renovated Nature Center that features child-friendly exhibits on the ecology of the SF Bay. The park is frequently used by Berkeley residents and Berkeley school groups and children's recreational programs.

Photograph 6. Shorebird Park

Amenities: scenery, a children's playground, Nature Center, open lawn area, picnic tables with BBQ facilities, trash cans, benches, hiking trails, water fountains and public restrooms

Parking capacity: the park is adjacent to several Berkeley Marina parking areas providing over 125 parking spaces and several bike stands

Mass transit: AC Transit 51B

Berkeley Beach

Berkeley Beach is a narrow strip of sandy coastline on the western edge of the City of Berkeley. Berkeley Beach extends from near the Ashby Ave. and Frontage Road intersection north to the Brickyard Cove area south of University Ave. Accessibility to the sandy area is limited by the tides; at high tide most of the sand is submerged. Parking is limited to street parking along the frontage road. There are no restrooms, water fountains or picnic facilities.

Photograph 7. Berkeley Beach

Amenities: scenery

Parking capacity: Parking along frontage road.

Mass transit: no

Point Emery

Point Emery is a very small peninsula about 1 mile south of the Berkeley Marina, on the SF bay. Point Emery offers expansive views of the San Francisco Bay Bridge, and the Berkeley Marina and has a small sandy beach that is popular with dog walkers and families taking a break from walking or biking the SF Bay Trail. This park is used as a launch site for kayakers, windsurfers and kite sailors and serves as an access point for the San Francisco Bay Trail. There are no restrooms, water fountains or picnic facilities.

Photograph 8. Point Emery

Amenities: scenery, trash cans

Parking capacity: 13 parking spaces

Mass transit: no

Emeryville Marina Park

Marina Park is an approximately 7.5 acre space owned by the city of Emeryville, CA, located at the western edge of Powell St. on the SF bay. Marina Park has spectacular views of the SF Bay Bridge and downtown San Francisco. There is a rocky shoreline as well as a few hiking trails on which leashed dogs can be walked.

Amenities: scenery, paved hiking trail along the park's rocky shoreline, picnic tables, BBQ facilities, trash cans and public restrooms

Parking capacity: approximately 100 adjacent parking spaces

Mass transit: no

Encinal Boat Ramp Park

Encinal Boat Ramp Park is a small park located on the north western edge of the city of Alameda. The park and boat ramp are owned and operated by the City of Alameda. The park offers a boat ramp for launching into SF bay, a fishing pier, a small sandy beach and broad views of downtown San Francisco and the SF Bay Bridge. The park and boat ramp are owned and operated by the City of Alameda. The park's walking trail forms part of the SF Bay Trail which is maintained by East Bay Regional Parks.

Amenities: scenery, picnic benches, trash cans, walking trail, boat ramp and public restrooms

Parking capacity: approximately 100 parking spaces

Mass transit: AC Transit bus #31 stops within half a mile of the park.

Crown Memorial State Beach

Crown Memorial State Beach is a park that encompasses 181 acres located along the western edge of the city of Alameda and is operated by the East Bay Regional Park District under a cooperative agreement with the State of California and City of Alameda. Crown Beach consists of two main areas: Crab Cove located on the northern portion of the 2.5 mile sandy beach and the Elsie Roemer Bird Sanctuary located in the marshy southern portion. Crown Memorial is a very popular beach with visitors from throughout the East Bay who enjoy the many beach amenities and the adjacent open grassy areas and picnic facilities. Popular year-round visitor activities include dog walking, jogging, picnicking, wind and kite surfing, frisbee, kite-flying, bicycling, and wading in the water. Crown Memorial hosts an annual sand-castle building contest that draws hundreds of visitors to view the elaborate sand sculptures. The grassy area near Crab Cove is used for a series of free summer concerts, which also draw hundreds of picnickers. Sand is periodically added to the beach to maintain the shoreline. More Information: Crown Memorial State Beach Sand Project

Photograph 9. Crown Beach

Photograph 10. Crab Cove

Amenities: scenery, Crab Cove Visitor Center which offers educational exhibits and naturalist-guided programs, large open lawn areas, beach volleyball court, public restrooms and showers, water-fountains, water sprays for removal of sand from body and feet, picnic benches and BBQ facilities, trash cans, interpretive nature signs, paved biking and pedestrian trails, and concessions such as wind and kite-surfing rentals, bicycle and canoe rentals and snacks. Beach-capable wheel chairs are available for free from the Crab Cove Visitors Center.

Parking capacity: approximately 330 parking spaces

Mass transit: AC Transit lines #21 and W and the East Bay Regional Park District's Park Express program

Bay Farm Shoreline Park

Bay Farm Shoreline Park is a small, narrow park located on the northern and western rocky shoreline of the City of Alameda's Bay Farm Island. The park is adjacent to the Harbor Bay Ferry Terminal. The park offers views of the bay and South San Francisco. Visitor amenities include picnic benches, a small grassy open area and a paved hiking/biking trail that includes a portion of the SF Bay Trail upon which dog-walking is popular.

Amenities: scenery, picnic benches, trash cans, small open lawn area area, hiking trail

Parking capacity: limited to street

Mass transit: AC Transit buses #631 and #21

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Summary of Central Bay Area Beaches

Table 1 (below) provides a summary of the beaches and parks located within the central area of the San Francisco Bay. In addition to the 9 columns that list various amenities which may (if marked with an "x") or may not (if left blank) be found at each beach, the final column shows how many parking spots are available at each beach.

Table B. Amenities Available at Central Bay Area Beaches

Beaches in Central Bay Area	Restrooms	Showers	Pier	Hiking	Boardwalk	Picnic Area	Snack Bar	Volleyball	Campground	Parking Cap.
Angel Island	x		x	x		x	x	x	x	n/a
Baker Beach	x			x		x				200
Crissy Field	x	x	x		x	x	x			800
Paradise Beach	x		x	x		x				100
Fort Baker			x	x		x				10
Kirby Cove	x			x		x			x	21
Sausalito			x		x					n/a
McNears	x	x	x		x	x	x	x		160
Candlestick Point	x				x	x				170
China Beach				x		x				37
Black Sands Beach				x						14
Pt. Pinole	x		x	x		x		x		72
Miller/Knox	x	x	x	x		x				230
Vincent	x					x				36
Point Isabel	x			x		x	x			108
Albany Bulb				x						41
Berkeley Marina	x			x		x				125
Berkeley Beach										n/a
Point Emery										13
Encinal Boat Ramp	x			x		x				100
Crown Memorial	x	x		x		x	x	x		330
Bay Farm Shoreline				x		x				n/a

Beach Attendance and Activity Distribution

With a general familiarity with the beaches of the central bay in hand, we will now move on to discuss how many people visit each of these beaches and for what purpose. These attendance figures will then be used in the third and fourth sections in order to determine at which locations beach-nourishment will have the most positive effect on visitors.

From May of 2013 to June of 2014, research assistants traveled to the beaches within the central bay in order to collect attendance data for each beach. For each beach, the assistants performed head counts at various times throughout the year. The daily attendance for each beach was then calculated by multiplying the number of people observed at the beach during the counting by an attendance multiplier.

Attendance multipliers are numbers that are used to estimate in order to project how many people visit a beach on a given day based on how many people are counted at the beach at one particular time during the day. Given that there is so little attendance data for these central bay beaches, and given that attendance multipliers must be calculated from such attendance data, we were forced to choose a mid-level multiplier of 3 to be used as a baseline against which future studies can be measured[1].

In order to ensure both accuracy and consistency, we instructed these assistants beforehand as to the proper manner in which these counts should be performed. For example, assistants were careful to perform attendance counts during the slower weekdays as well as the busier weekends so as to gather a broad range of representative samples. From this data we were able to approximate the annual attendance at each beach. Table 2 (below) lists the estimated number of total annual visits to each beach in 2013.

[1] This number is based on the range in attendance multipliers used for Southern California beaches. Again, this should be seen as a base-line number which future data should refine.

Table C. Estimated 2013 Attendance for the Beaches of the Central Bay Area

Estimated 2013 Attendance	
Beaches:	**Attendance:**
Angel Island	< 5,000
Baker Beach	99,200
Crissy Field	461,700
Paradise Beach	30,200
Fort Baker	13,100
Kirby Cove	< 5,000
Sausalito	< 5,000
McNears	251,200
Candlestick	26,300
China Beach	29,600
Black Sands	< 5,000
Point Pinole	33,900
Miller/Knox	12,000
Vincent Marina	18,100
Point Isabel	291,300
Albany Bulb	24,700
Berkeley Marina	69,000
Berkeley Beach	8,800
Point Emery	< 5,000
Encinal	12,400
Crown Beach	426,000
Bay Farm Shoreline	18,100

During their attendance counts, research assistants also gathered data regarding how many of the visitors were engaged in various activities ranging from sun-bathing to dog-walking. Activity data was only gathered for 7 central bay beaches due to both the popularity as well as their potential for future nourishment: McNears, Crissy Field, Baker, Point Pinole, Point Isabel, Albany Bulb and Crown Beach. The data analyzed in this section will later be used in the third section so as to determine which beaches depend more upon a sandy beach for its popularity and as such make for better target for future nourishment projects. If, for example, the most popular activities engaged in at a given park involve contact with the sandy beach, we can assume that, all other things being equal, that beach is a prime candidate for nourishment. It would make little economic sense, by contrast, to nourish the beach at a park which is almost entirely used for its grassy lawns and paved bike paths.

The charts below allow us to compare the popularity of various activities at seven of the more popular beaches in the central bay. To do this, the accumulative distribution of activities for all the central bay beach visits that we documented is used as the average activity distribution within the central bay. This average in then compared with the activity distribution at each of the seven individual beaches listed below. These two distributions allow us to compare the popularity of an activity both with respect to the other activities at that same beach as well as with respect to that same activity at other beaches in the central bay. Finally, it should be noted that the vertical percentage scales in the figures below shift somewhat for purposes of visual clarity.

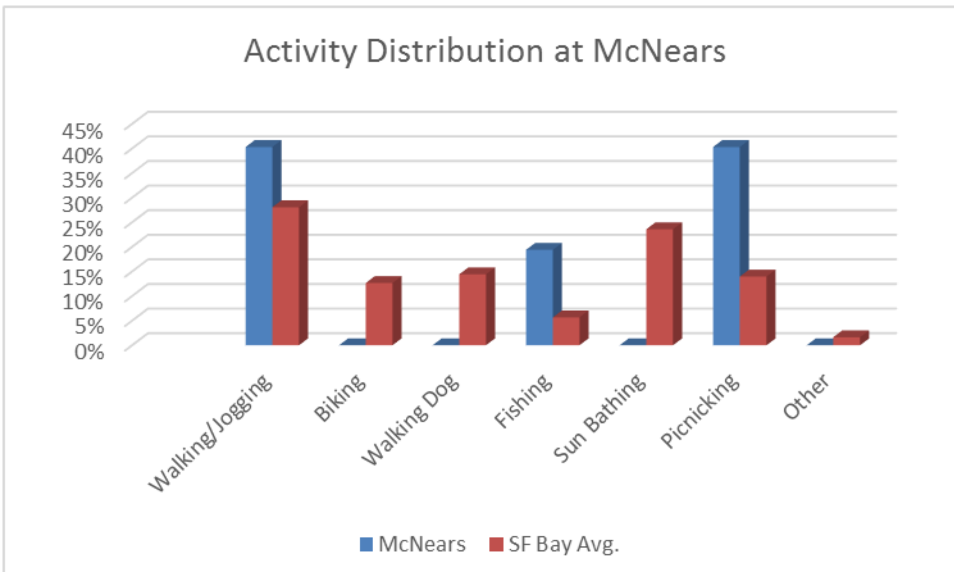


Figure 1. Activity Distribution at McNears

Figure 1 (above) shows the activity distribution at McNears beach in comparison to the average activity distribution for beaches of the central bay area. The chart clearly shows that walking/jogging and picnicking are very popular activities here, accounting for roughly 80% of its visitors. Visitors are also four times more likely to fish at McNears than they are at other beaches in the central bay. Biking, sunbathing are unpopular at McNears and dog-walking is prohibited.

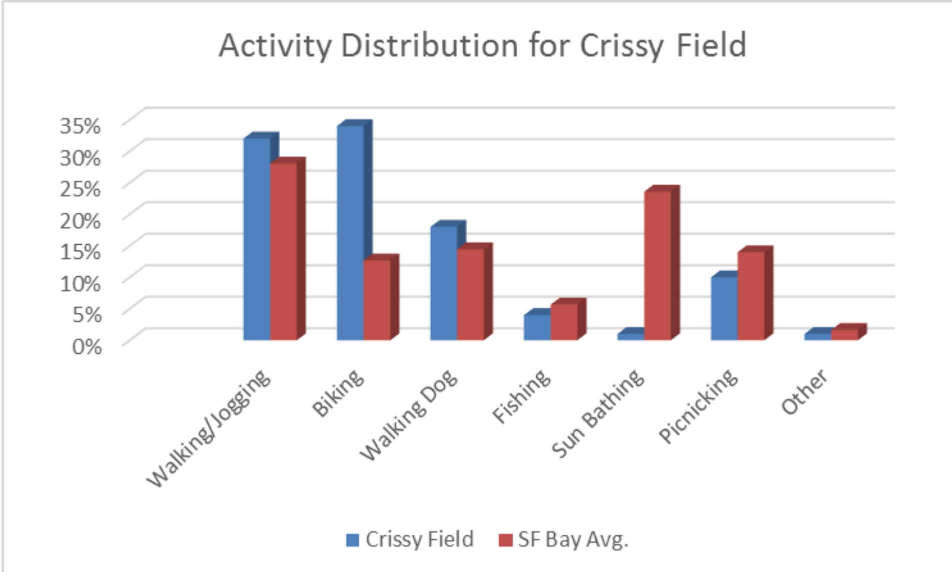


Figure 2. Activity Distribution at Crissy Field

Figure 2 (above) shows the activity distribution at Crissy Field in comparison to the average activity distribution for beaches of the central bay area. The most popular activities include walking/jogging, biking and dog walking, with a modest amount of picnicking. Biking, in particular, is far more popular at Crissy Field than it is at the other beaches in the central bay. Like McNears, sunbathing is very unpopular at Crissy Field.

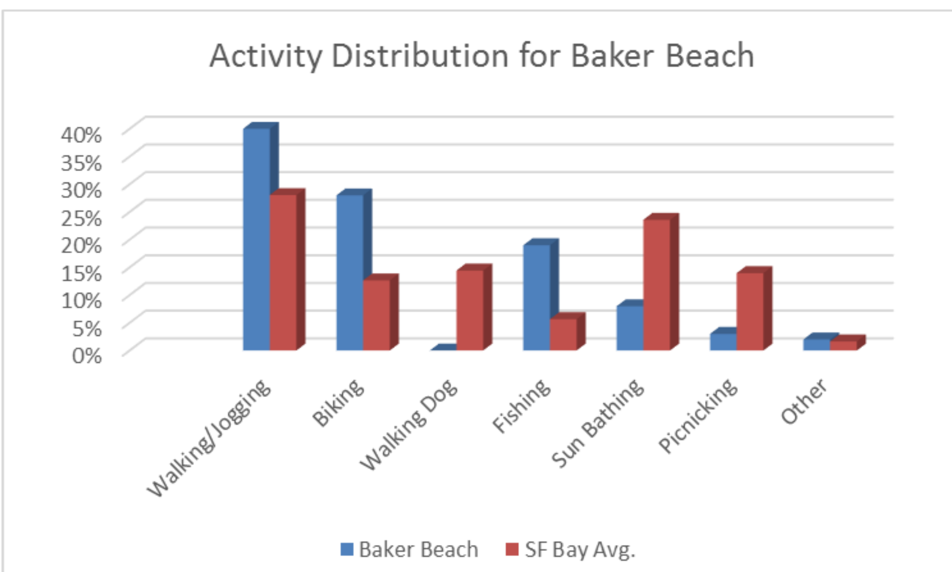


Figure 3. Activity Distribution at Baker Beach

Figure 3 (above) shows the activity distribution at Baker Beach in comparison to the average activity distribution for beaches in the central bay area. The most popular activities include walking/jogging, biking and fishing, each of these activities being significantly more popular at Baker Beach than at other central bay beaches. Baker Beach does have a small amount of sunbathing, but it along with dog-walking and picnicking are rather unpopular activities when compared to other central bay beaches.

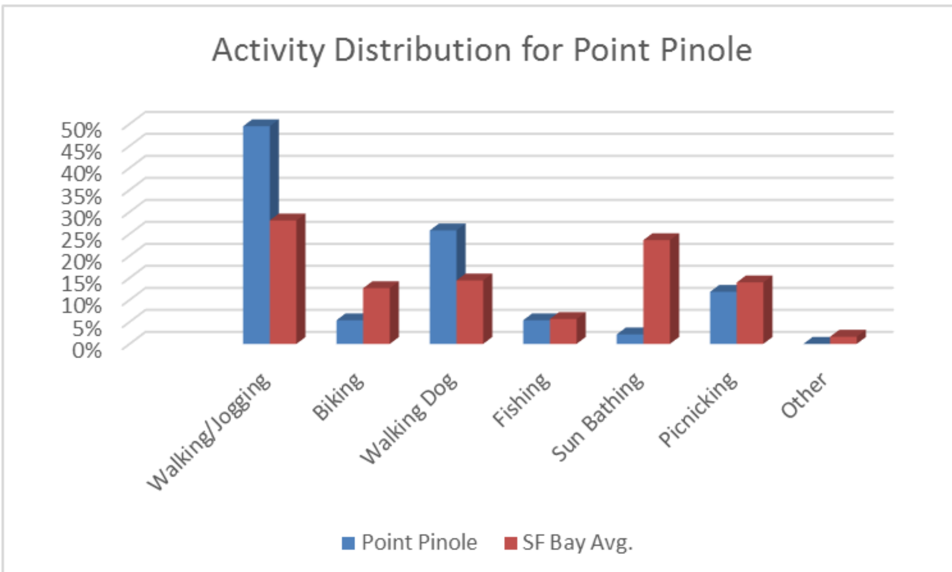


Figure 4. Activity Distribution for Point Pinole

Figure 4 (above) shows the activity distribution at Point Pinole in comparison to the average activity distribution for beaches in the central bay area. The most popular activities include walking/jogging and dog-walking, each of these activities being moderately more popular at Point Pinole than at other central bay beaches. The amount of picnicking and fishing at Point Pinole is roughly average for the central bay area, but biking and especially sunbathing are relatively unpopular.

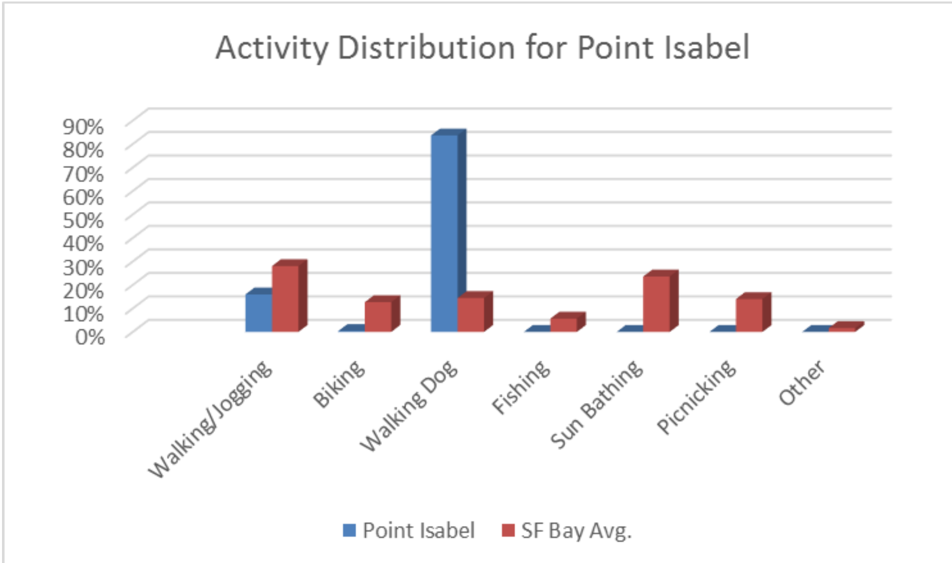


Figure 5. Activity Distribution for Point Isabel

Figure 5 (above) shows the activity distribution at Point Isabel in comparison to the average activity distribution for beaches in the central bay area. The most popular activity by far at this park is dog-walking accounting for over 80% of its visits. This has to do, first, with the absence of a sandy beach (making it an exception to the other surveyed locations) and second, with the numerous services and amenities that are available for dogs at the location. With so many people walking their dogs at this beach, the comparative frequency with which all other activities are engaged in at Point Isabel is relatively low.

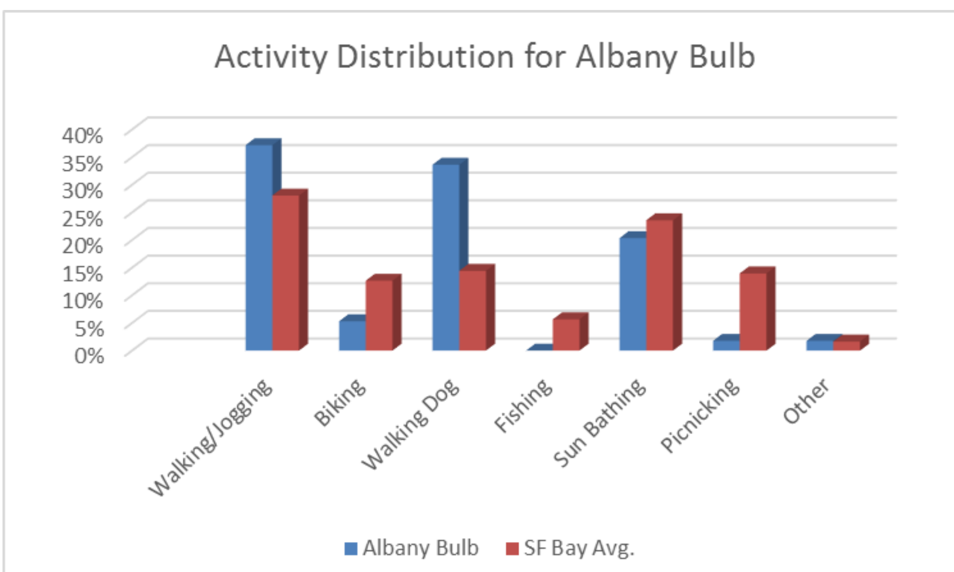


Figure 6. Activity Distribution for Albany Bulb

Figure 6 (above) shows the activity distribution at Albany Bulb in comparison to the average activity distribution for beaches in the central bay area. The most popular activities include walking/jogging, dog-walking and, to some degree, sunbathing. Biking, fishing and picnicking are all relatively unpopular activities at Albany Bulb.

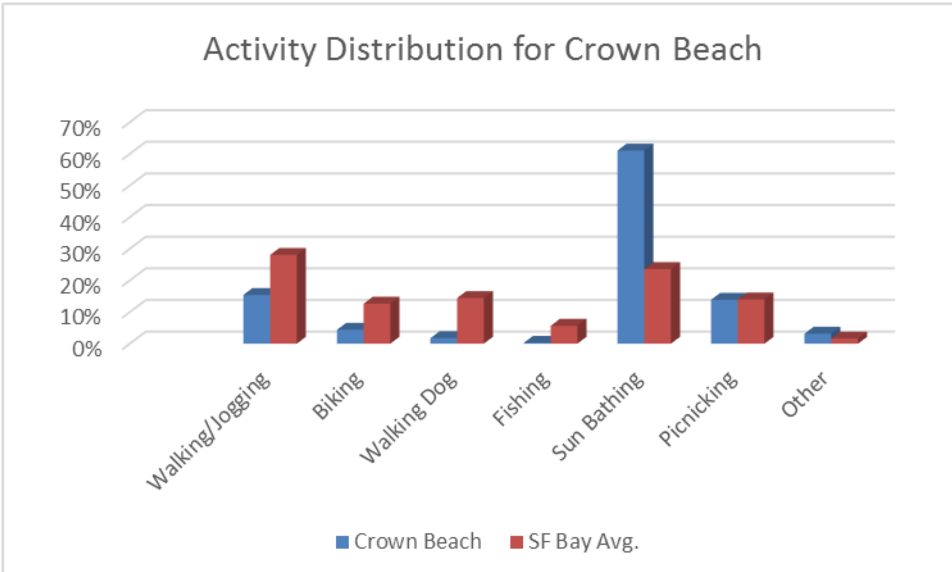


Figure 7. Activity Distribution for Crown Beach

Figure 7 (above) shows the activity distribution at Crown Beach in comparison to the average activity distribution for beaches in the central bay area. The most popular activity by far is sunbathing which accounts for 60% of the visits to this beach (at least during summer months). All other activities are at or below average popularity for central bay area beaches.

Projected Increases and Erosion to Beach-Widths

The next stage of our analysis involved gathering data regarding the effects that the beach nourishment would have on the widths of the more popular beaches as well as how these increases in beach width will effect beach attendance. For the rest of this report we will focus on the five beaches that we consider to be candidates for beach nourishment: McNears, Baker Beach, Crissy Field, Crown Beach, Albany Bulb and Point Pinole.

We were able to obtain from BCDC data regarding the width of each of these beaches prior to the proposed nourishments, as well as the projected width of the increased, post-nourishment beaches. Hypothetical nourishment specifically aimed at increasing each beach-width by 40% for smaller pocket beaches (McNears, Albany Bulb and Point Pinole) and doubling (100% increase) the existing width of the much larger beaches (Crown Beach and Baker Beach). From this we were able to calculate the post-nourishment width of each beach.

BCDC also provided us with preliminary erosion rates for each of these beaches. These erosion rates will allow us to project the width of each beach 5 years into the future. Unfortunately, the relevant erosion data for the central bay beaches is both sparse as well as very preliminary in nature. These data are long term averages as captured by google earth and as such do not account for variation or increase in these rates which might result from artificial nourishment Accordingly, even though we fully expect the post-nourishment erosion rates to surpass those which BCDC has measured, the absence of any data which is better suited to our purposes compels us to depend upon these long-term erosion rates[2]. Again, this data can usefully be taken as a baseline for future research.

Table 3 (below) shows width of each beach before and after it is nourished along with its projected erosion (or, in the case of McNears, accretion) for the next 5 years. The first two columns depict the immediate 40% increase in beach-width to McNears, Albany Bulb and Pt. Pinole as well as a 100% increase to both Baker and Crown beaches. After the immediate increase, we see erosion begin to set in as all the beaches, with the small exception of McNears, begin to erode back to their original pre-fill widths. In the case of Pt. Pinole, the erosion rate is high enough to bring the beach-width back to its original pre-fill width within 3 years' time, its 4th and 5th year width becoming less than that of the pre-fill width.

Table D. 5-Year Projection of Beach-Widths

5 Year Projection of Beach-Widths							
Fill-Site Beaches	**Pre-Fill Width**	**Immediate Increase**	**1 Year**	**2 Years**	**3 Years**	**4 Years**	**5 Years**
McNears	35.0	49.0	49.1	49.2	49.3	49.4	49.6
Baker Beach	107.0	214.0	213.8	213.6	213.3	213.1	212.9
Crown Beach	50.0	100.0	98.5	97.1	95.6	94.2	92.7
Albany Bulb	9.0	12.6	12.6	12.6	12.6	12.6	12.6
Pt. Pinole	15.0	21.0	19.0	16.9	14.9	12.8	10.8

As we discuss below, we gathered data in which we measured the increased in beach attendance that results from that beaches width being doubled, or increased by 100%. Thus, it

[2] Our treating pre-nourished beach widths as a natural equilibrium toward which the post-nourished beaches will tend to erode slightly mitigates the unrealism of our erosion rates. Were we to counter-factually assume that our unnourished beaches would erode at the same rate as our nourished beaches, this would create an absurd situation in which the larger beaches perpetually remain 50 or 107 feet wider than they would have been without nourishment. By taking the current, pre-nourished beach-widths to be the natural equilibrium toward which a nourished beach will tend, we hope to approximate tendency for an artificially nourished beach to erode faster than the rate at which an unnourished beach would erode.

will be more useful to our purposes if we reframe the data in Table 3 in terms of percentage increases in beach-width.

Table 4 (below) re-presents the same growth patterns depicted in Table 3 as percentages of each beaches original, pre-fill width. Accordingly, the first column shows the immediate 40% increase in width for the smaller beaches and a 100% increase in the width of the larger ones. These percentages, with the small exception of McNears, then begin to shrink back to the original pre-fill widths (0%). The rapid erosion of Point Pinole that we discussed above is represented by its 3rd, 4th and 5th years being less than the pre-fill width (0%).

Table E. 5-Year Projection of Relative Growth in Beach-Width

Percentage Increase in Beach-Widths						
Fill-Site Beaches	**Immediate Increase**	**1 Year**	**2 Years**	**3 Years**	**4 Years**	**5 Years**
McNears	+40.0%	+40.3%	+40.6%	+40.9%	+41.3%	+41.6%
Baker Beach	+100.0%	+99.8%	+99.6%	+99.4%	+99.2%	+99.0%
Crown Beach	+100.0%	+97.1%	+94.2%	+91.2%	+88.3%	+85.4%
Albany Bulb	+40.0%	+40.0%	+40.0%	+40.0%	+40.0%	+40.0%
Pt. Pinole	+40.0%	+26.4%	+12.8%	-0.8%	-14.4%	-28.0%

These percentages listed above in Table 4 allow us to estimate the effect that the nourishment of these beaches will have on their attendance. In 2012 we surveyed several hundred beach-goers in San Diego County, asking them how many more times they would visit that same beach within the following 12 months if the width of that beach were doubled. Our survey revealed that, on average, the beach-goer expressed the intention to visit the 30.8% more often if the beach were 100% larger[3]. Were we to assume that attendance at central bay beaches is similarly effected by increases in beach-width, projecting the increase in attendance that the nourishment will cause at each beach would then be very straightforward. We would simply multiply the hypothetical increase to each beach-width in Table 4 by this 30.8% increase in attendance.

It seems reasonable to not treat Baker and Crown beaches as being different from beaches of moderate popularity in San Diego County. They are both large and popular parks whose main attraction is quite obviously the sandy beach. We thought it unreasonable, however, to assume that McNears, Point Pinole and Albany Bulb are equally effected by an increase in the width of

[3] This data was gathered by surveying beach-goers at several beaches of moderate popularity throughout San Diego County. This data gathered in Southern California was used for this report because no such data is readily available for the beaches of Northern California. In using this data we assume that the visitation patterns for increased beach-width hold regardless of the differences in climate and beach activities that hold between San Diego and San Francisco Bay.

their small and under-utilized beaches. Accordingly, we reduced our estimate of the effect that doubling the beach-width at McNears and Point Pinole will have on attendance increases to 3%, one tenth of the 30% measured in San Diego. Since the beach at Albany Bulb is fairly popular for dog-walkers, we estimated that doubling its width would lead to a 6% increase in attendance, one fifth that of the San Diego beaches. Consequently, when we multiply these hypothetical increases in attendance to central bay beaches with the percentage increases in beach width (Table 4), we are able to predict the percentage increase in attendance from the nourishments that we consider in this report.

Table 5 (below) shows these increases in attendance as percentages of each beaches pre-nourishment attendance estimates. Both McNears and Point Pinole will experience an estimated 1.2% increase in attendance due to their 40% increase in beach-width. Baker and Crown Beach will experience an estimated 30.8% increase in beach attendance due to their 100% increase in beach-width. Albany Bulb will experience an estimated 2.5% increase from its 40% increase in beach-width. After this immediate increase in attendance, the beaches will then continue the now familiar pattern in which the attendance of begins to erode over time in proportion to its beach-width, McNears still being the small exception.

Table F. 5-Year Projection of Relative Increases in Beach Attendance

Percentage Increase in Attendance due to Beach Nourishment						
Fill-Site Beaches	**Immediate Change**	**1 Year**	**2 Years**	**3 Years**	**4 Years**	**5 Years**
McNears	+1.2%	+1.2%	+1.3%	+1.3%	+1.3%	+1.3%
Baker Beach	+30.8%	+30.7%	+30.7%	+30.6%	+30.5%	+30.5%
Crown Beach	+30.8%	+29.9%	+29.0%	+28.1%	+27.2%	+26.3%
Albany Bulb	+2.5%	+2.5%	+2.5%	+2.5%	+2.5%	+2.5%
Pt. Pinole	+1.2%	+0.8%	+0.4%	-0.0%	-0.4%	-0.9%

The increases in attendance that are expressed as percentages in Table 5 can easily be converted into numerical form by using the annual, pre-nourishment attendance figures listed in Table 2. Table 6 (below) lists the 2013 attendance for each beach in the first column, which is then used to calculate the additional visits that each beach will receive over the next 5 years due to the increase in beach-width. The final column estimates the total number of additional visits the proposed nourishment project would contribute to each beach over the next 5-years, all other things being equal.

Predictably, Baker and Crown Beach both receive a marked increase in attendance over the next 5 years (182,000 and 730,000, respectively), the magnitude of these increases being due to their large pre-fill attendances, their larger (100%) increases in beach-widths due to nourishment, and the strong effect on attendance that increases in beach-width are projected to have at those beaches (30.8%). While McNears also has large attendance prior to the nourishment, it receives a much more moderate increase in its attendance (18,900) since it receives both a smaller increase in beach-width (40%) and its attendance is not as effected by changes in beach-width (3%). Albany Bulb has neither a high pre-fill attendance, a large increase in beach-width (40%) nor a strong increase in attendance due to beach-width (6%) and as such receives a rather small increase in beach attendance over the next 5 years (3,652). Finally, Point Pinole receives a very small increase in attendance over the next 5 years (376), not only due to those same three reasons that effect Albany Bulb, but also due to its relatively high rate of erosion.

Table G. Projected Changes in Attendance Due to Beach Nourishment

Projected Changes in Attendance due to Beach Nourishment								
Fill-Site Beaches	**2013 Attendance**	**Immediate Change**	**1 Year**	**2 Years**	**3 Years**	**4 Years**	**5 Years**	**5-Year Total**
McNears	251,200	+3,095	+3,119	+3,143	+3,168	+3,192	+3,216	+18,933
Baker Beach	99,200	+30,554	+30,491	+30,428	+30,365	+30,302	+30,239	+182,379
Crown Beach	426,000	+131,208	+127,377	+123,545	+119,714	+115,883	+112,052	+729,779
Albany Bulb	24,700	+609	+609	+609	+609	+609	+609	+3,652
Pt. Pinole	33,900	+418	+276	+134	-8	-150	-292	+376

Economic Analysis

In the final stage of our analysis we took the data gathered in the previous stages and were able to provide a cost/benefit analysis of hypothetical beach nourishment activities. Although most of the beaches in the central bay area do not charge admission, there is, however, a recreational value associated with each beach that measures how much, in dollars, a visit to each beach is worth to its visitors. Consequently, if the increase in recreational value caused by a beaches nourishment exceeds the cost of that nourishment, we would say that it was worth the cost.

In modeling losses to recreational value following sandy beach erosion, we use a standard model that is reasonably tractable—a benefits transfer (BT) approach, which allows one to apply estimates from previously analyzed sites to similar beaches. In practice, BT is much less expensive than other methods to model(?) and also has the advantage of consistency over space and time. For BT to work properly, consistent methodology must be used to assess the recreational value of a particular beach. This study used the Coastal Sediment Benefits Analysis Tool (CSBAT) to value beach recreation (per user per day). CSBAT uses the following six criteria to assess the recreational value of California beaches:

- Weather;
- Water quality and surf;
- Beach width and quality;
- Overcrowding;
- Beach facilities and services; and
- Availability of substitutes

The functional form used in the CSBAT analysis is a Cobb-Douglas utility function, of the general form:

$$\text{Value of a Beach Day} = M^* \; A^{a} * A_2^{b} * A_3^{c} * A_4^{d} * A_5^{e} * A_6^{f}$$

Where:

M is the maximum value for a beach day
A_1 … A_n represent each beach amenity (rated on a scale of 0 to 1)
a … f are the weighting of each amenity value
$a + b + c + d + e + f = 1$.

The CSBAT model has been calibrated with data from existing studies. The Cobb-Douglas function exhibits diminishing marginal utility with respect to beach width. In addition, the model employed in this study caps beach width benefits at 300 feet. This is consistent with a number of studies indicating that beaches can, in fact, be too wide (Landry et al. 2003). However, wider beaches also diminish crowding, the benefits of which are taken into account in the model.

Table 7 (below) presents the results of our analysis. The first column of Table 7 (below) shows the recreational value for a visit to each beach. For example, even though one does not have to pay money to visit McNears, a visit to the beach at its pre-nourished width is worth, on average, $9.37. The second column lists the increased recreational values associated with a visit to the beaches immediate after they have been nourished. From that point forward, the figures again follow the same pattern we saw in the tables above in that, with the small exception of McNears, the recreational value of a visit to each beach erodes back to its original, pre-nourishment width. This is to be expect since all variable other than beach-width have been held constant in this model.

.

Table H. 5-Year Projection of Changes in Recreational Values (per Individual Visit) for Central Bay Area Beaches

5-Year Projection of Recreation Values per Visit							
Fill-Site Beaches	**Pre-Fill Rec. Value**	**Post-Fill Increase**	**1 Year**	**2 Years**	**3 Years**	**4 Years**	**5 Years**
McNears	$9.37	$10.19	$10.20	$10.20	$10.20	$10.21	$10.21
Baker Beach	$10.10	$11.59	$11.58	$11.58	$11.58	$11.58	$11.58
Crown Beach	$9.50	$10.90	$10.88	$10.86	$10.83	$10.81	$10.78
Albany Bulb	$6.97	$7.58	$7.58	$7.58	$7.58	$7.58	$7.58
Pt. Pinole	$7.61	$8.28	$8.07	$7.84	$7.60	$7.33	$7.04

As noted above, beach-visitors state that an increase in beach-width would lead to a corresponding increase in their annual attendance to that beach. This should come as no surprise since the increase in recreational value caused by an increase in beach-width can easily be construed as the very cause of such an increase in beach attendance. Larger recreational values for a visit to the beach express a greater desire for, and therefore a higher frequency of visits to that beach. Thus, an increase in beach-width not only contributes to an increase in the recreational value for a visit to the beach, but also contributes to an increase in the number of visits to that beach.

We can, therefore, use the projected increases in both recreational value and beach attendance to estimate the total benefits produced by beach nourishment activities. The smaller rectangle in Figure 8 (below) represents the total recreational value of a beach as the product its recreational value per visit (the vertical axis) and its number of visits (the horizontal axis). The figure also shows how nourishing a beach, thereby causing an increase in both its recreational value per visit and its number of visits, expands the beaches total recreational value to a larger rectangle. In order to calculate the economic benefits of nourishing a beach, we must find the difference between the total recreational values of the pre-nourished and post-nourished beaches (the grey area).

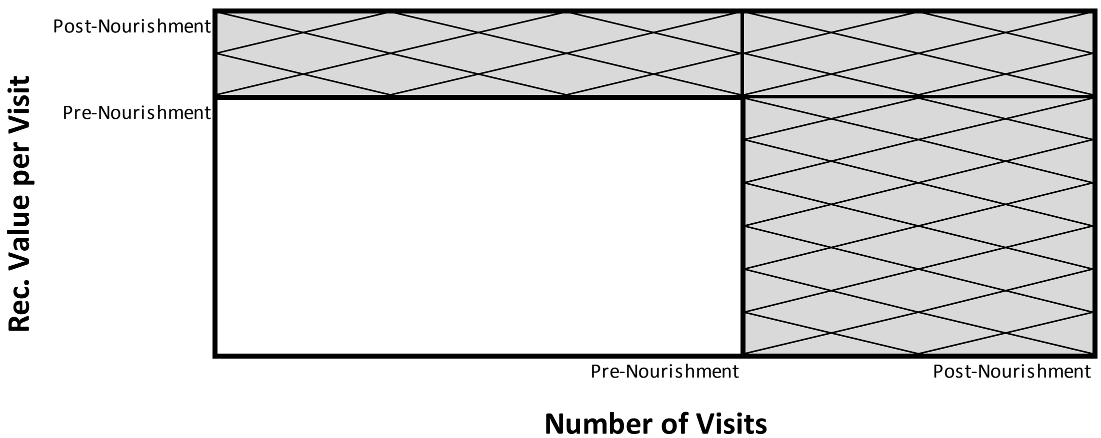


Figure 8. Measuring the Increase in Total Benefits Due to Beach Nourishment

Table 8 (below) shows the projected benefits of each beaches hypothetical nourishment over the next 5 years (with a discount rate of 5%). The final column of the table show shows the 5-year total of the present discounted increase in recreational value that could be anticipated if beach nourishment activities were undertaken at these beaches. Unsurprisingly, the nourishment of Crown Beach produces the largest benefits ($10.1 million) due in large part to its large increase in attendance. Baker Beach experiences significant benefits ($2.6 million), also due to its large increase in attendance. Perhaps surprisingly, McNears also experiences significant benefits ($1.3 million). The explanation for this is that even though its increase in attendance due to nourishment is relatively small, its large number of pre-nourishment visits are now worth more. The benefits experienced by Albany Bulb ($105,000) and Point Pinole ($24,000) are both predictably small, both having relatively low original and increases in attendance.

Table I. Discounted Increases in Total Recreational Value for Each Beach over the Next 5 Years

Discounted Benefits from Beach Nourishments (PDV = 5%)							
Fill-Site Beaches	**Immediate Increase**	**1 Year**	**2 Years**	**3 Years**	**4 Years**	**5 Years**	**5-Year Total**
McNears	+$237,671	+$227,420	+$217,605	+$208,207	+$199,210	+$190,597	+$1,280,711
Baker Beach	+$501,424	+$476,633	+$453,066	+$430,662	+$409,366	+$389,120	+$2,660,270
Crown Beach	+$2,026,919	+$1,877,956	+$1,738,598	+$1,608,268	+$1,486,420	+$1,372,539	+$10,110,700
Albany Bulb	+$19,713	+$18,774	+$17,880	+$17,029	+$16,218	+$15,446	+$105,061
Pt. Pinole	+$26,088	+$19,620	+$9,421	-$582	-$10,392	-$20,176	+$23,979

These projected benefits allow us to provide a benefit/cost ratio for each of the hypothetical beach nourishments. By dividing the total benefits listed in the final column of Table 8 by the total cost of nourishment, we arrive at the benefit/cost ratio for each beach. The total cost of nourishing each beach can easily be calculated by multiplying the amount of the sand-fill at each beach (in cubic yards) by the cost of the sand-fill ($24.00 per cubic yard). Table 9 (below) shows the total benefits of the nourishment for each beach (the fifth row) as well as the total costs of the nourishment (first row). The bottom row of the table lists the benefit/cost ratio for nourishing each beach.

The nourishment of McNears, Albany Bulb and Crown Beach are all quite cost effective, with benefit/cost ratios well above 1. The benefit/cost ratio for McNears is a very high 19.1, due both to the low cost of nourishing a comparatively small beach as well as its high attendance. The ratio for Albany Bulb is also somewhat high (8.1) due again to the small size of the beach fill. The ratio for Crown Beach is also moderately high (5.2) due, it would seem, to its large increase in attendance. The ratio for Baker Beach is only 1.1, due mostly to the large cost of the beach fill, making its nourishment barely cost effective. The ratio for Point Pinole is predictably low due to its low attendance and high erosion rate, its nourishment not quite being cost effective.

Table J. Benefit/Cost Ratios for the Hypothetical Beach Nourishment

5-Year Forecast	McNears	Baker Beach	Crown Beach	Albany Bulb	Pt. Pinole
Total Cost of Nourishment	$ 67,071	$ 2,527,597	$ 1,936,000	$ 12,963	$ 27,921
Initial Sandy Beach Width (feet)	35	107	50	9	15
Beach Fill (cy)	2,795	105,317	80,667	540	1,163
Attendance Increase Doubled	3.1%	30.8%	30.8%	6.2%	3.1%
Addition to Recreational Value (PV)	$ 1,280,711	$ 2,660,270	$ 10,110,700	$ 105,061	$ 23,979
Benefit per Cubic Yard	$ 458.27	$ 25.26	$ 125.34	$ 194.52	$ 20.61
Cost per Cubic Yard	$ 24.00	$ 24.00	$ 24.00	$ 24.00	$ 24.00
Benefit/Cost Ratio (Add'l Rec. Benefits/Project Cost)	**19.1**	**1.1**	**5.2**	**8.1**	**0.9**

Conclusion and Limitations of this Study

The economic analysis in this paper was prepared as part of the Coastal Regional Sediment Master Plan (CRSMP) for the central San Francisco Bay area. The State of California has conducted a number of these plans for other coastal areas across the state. The purpose of the economic analysis is twofold: (1) to characterize and quantify (where possible) recreational activity at beaches in the inner bay, (2) to provide a very basic analysis of the costs and benefits of nourishment at a few selected sites.

Between May, 2013 and June, 2014 we were able to catalog the accessibility by mass transit as well as the amenities available at 22 different beaches within the central area of the San Francisco Bay. We were also able to perform head and car counts at each beach in order to estimate the annual attendance at each beach. These head counts also allowed us to gather data regarding the primary activities in which people engage during their beach visits. This information will be useful in guiding the future allocation of goods and services within the central bay area.

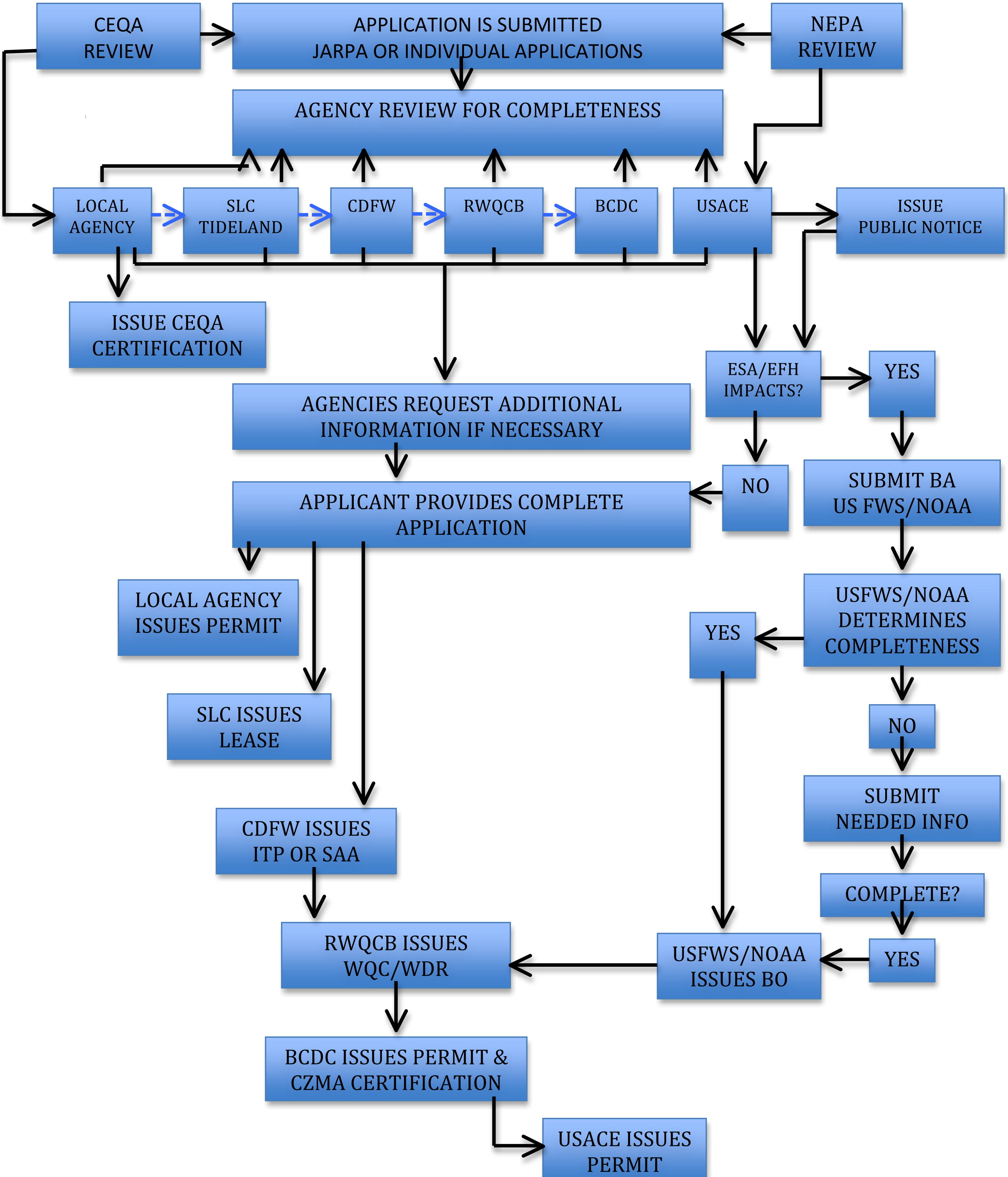
Our second task in this report involved providing a rudimentary analysis of the costs and benefits associated with the nourishment of the more popular beaches in the central bay. To this end, BCDC provided us with data regarding the pre-nourishment beach-widths, the hypothetical increase to these beach-widths and the estimated erosion rates for each of these beaches. We were then able to estimate the degree to which hypothetical nourishment of these beaches would increase both the number visits to each beach as well as the recreational value associated with any such visit. These estimates allowed us to compare the total increase in recreational value to the costs, which corresponded to the nourishment of each beach.

One challenge with this study is that there is almost no data on recreational activity at these beaches. In addition, there is little regional data collected by local or state agencies regarding shoreline changes and including erosion/accretion of beach areas. If areas of shoreline have exhibited major erosion/accretion problems, many times private consultants are hired to study the area and provide recommendations or solutions to the issues and therefore the date for these types of analyses are privately held. For the calculations performed in this study, the beach widths used in this analysis were snapshots in time and the erosion estimates provide a very simplified estimate of changes in different shoreline areas of Central Bay. These estimates assume that for larger beaches within the Bay, the nourishment would double the existing beach width and for the smaller pocket beaches, it was assumed that the existing beach width would increase by an additional 40 percent beyond the existing beach width. Erosion rates were held constant over time for these calculations as well, which does not likely represent the nature of the situation in reality.

The vast majority of these beaches have no lifeguards and no official counts, data which could potentially refine our results. Accurate attendance count multipliers that are specific to the inner bay would greatly improve the precision of our attendance estimates. Also, data regarding the effect that changes in beach-width have on visitation patterns within a climate different from that of Southern California would be extremely beneficial to any future analysis. Finally, further refinement in Bay Area erosion data and shoreline change assessments would greatly improve our ability to project future beach-width and attendance. Given these limitations, much of the effort in this study was aimed at providing a baseline analysis for each of these beaches.

Appendix C

Regulatory Setting


CEQA REVIEW
APPLICATION IS SUBMITTED JARPA OR INDIVIDUAL APPLICATIONS
NEPA REVIEW
AGENCY REVIEW FOR COMPLETENESS
LOCAL AGENCY
SLC TIDELAND
CDFW
RWQCB
BCDC
USACE
ISSUE PUBLIC NOTICE
ISSUE CEQA CERTIFICATION
ESA/EFH IMPACTS?
YES
AGENCIES REQUEST ADDITIONAL INFORMATION IF NECESSARY
NO
SUBMIT BA US FWS/NOAA
APPLICANT PROVIDES COMPLETE APPLICATION
USFWS/NOAA DETERMINES COMPLETENESS
LOCAL AGENCY ISSUES PERMIT
YES
NO
SLC ISSUES LEASE
SUBMIT NEEDED INFO
CDFW ISSUES ITP OR SAA
COMPLETE?
RWQCB ISSUES WQC/WDR
USFWS/NOAA ISSUES BO
YES
BCDC ISSUES PERMIT & CZMA CERTIFICATION
USACE ISSUES PERMIT

Appendix D

Outreach Plan

Central Bay Regional Sediment Management
Outreach Plan

Purpose: As part of the development of the San Francisco Bay Regional Sediment Management Plan (SFBRSMP; Plan) the San Francisco Bay Conservation and Development Commission will be meeting with local, state, and federal agency staff around the San Francisco Bay Area to provide education about sediment issues facing San Francisco Bay and survey/interview local managers to begin understanding the sediment needs of the different managers. Responses to both surveys and interviews will be collected and used for analysis and identification of regional areas with critical sediment issues during the creation of the SFBRSMP. After the development of the Plan, public meetings will be held to obtain comments and feedback from stakeholders regarding the Plan. These comments will be considered prior to completing the final SFBRSMP.

The mission for the Plan is to provide recommendations for coordinated regional sediment management that incorporates restoration, dredging, watershed management, recreation, and shoreline resilience to ensure safe navigation, sediment use as a resource and environmental stewardship of a balanced ecosystem.

Outreach Goal:

1. Participation of local managers in BCDC Regional Sediment Management planning process.
2. Robust and streamlined survey of current sediment resources around the Bay.
3. Educate local resource managers about San Francisco Bay sediment resources.

Objectives:

1. Educate local, state and federal stakeholders about the importance of sediment resources to coastal and estuarine ecosystems and ways that proper management can improve: quality of life for the residents of SF Bay, restore and protect natural resources, and provide economic sustainability for the whole Bay.
2. Provide a synthesis and brief summary of recent research on San Francisco Bay sediment dynamics, and current uses of sediment around SF Bay. Audience will be various local, state, and federal agency stakeholders having jurisdiction over shoreline areas that face risks of shoreline erosion or have problematic sediment accretion along portions of the shoreline.
3. Obtain feedback from local, state and federal agencies regarding the types of land uses along the shorelines within their jurisdictions and ask them to identify areas of critical erosion and accretion within their jurisdiction. Request

information about the amount of shoreline armoring and protection in their jurisdiction.

4. Understand the needs of the local resource managers regarding sediment management and the biggest hurdles and challenges these managers face.
5. Incorporate stakeholder feedback from online surveys and in-person interviews into San Francisco Bay Regional Sediment Management Plan (SFBRMP). The Plan will be developed to provide consensus-driven regional sediment management guidance and policy recommendations for managing different fractions of sediment resources in different areas of the shoreline. The development of this guidance plan will be driven by the needs of local and regional governments as well as NGOs dealing with sediment issues in the Bay. This plan will be provided to CSMW for consideration and incorporated into the California Sediment Master Plan (SMP).
6. After development of a draft SFBRMP, there will be a coordinated public review of the report. These m

Master Plan Objectives:

1. Develop a coastal "Sediment Master Plan" (SMP) to help guide political, regulatory, environmental, educational and process-related efforts anticipated when implementing RSM.
2. Currently, CSMWs main thrust for SMP development is regionally-based RSM strategy plans. We are working with regional entities towards implementation of RSM within their jurisdictional area through Coastal RSM Plans. These Plans identify how governance, outreach and technical approaches can support beneficial reuse of sediment resources within that region without causing environmental degradation or public nuisance. The outreach efforts should provide comments and local insights to the state regarding sediment issues facing the San Francisco Bay Region

The Sediment Master Plan will develop an implementation strategy for regional approaches to managing sediment up and down the state's 1000 mile coastline. The goal will be to integrate management actions for problems related to lack of sediment (e.g. beach erosion) and problems related to excess sedimentation (e.g. deterioration of habitat quality in wetlands and restrictions on shipping in harbors).

Communication:

Audience:

This education and outreach effort is mainly directed toward local/regional managers of shoreline areas around SF Bay. These managers will likely come from various local (City, County, Public Works offices), State (Coastal Conservancy, etc), and federal agencies (National Parks). Have a sign-in sheet to have a list of the meeting participants.

Challenges:

- Terminology being used to discuss sediment dynamics around the Bay area.
- Background knowledge/science education of the local resource managers
-

Materials/Media:

- Develop powerpoint presentation for educational meeting about sediment in the Bay
- Bring large scale maps (??) to the educational meetings (Have one set labeled erosion and another set labeled accretion). (Note: Maggie recommended maybe bringing preprinted numbers for the survey and passing those out as people come to write on maps. Then record the survey number on the maps. This way their online survey answers can be referred back to the actual maps they mark up).
- Online survey form. Should be limited to less than 45 minutes to complete in order to be effective in getting a number of stakeholders to take the survey. Survey will be uploaded and managed using the Qualtrics program. Need to put a particular completion time on the survey. Also provide paper copies of the surveys at the meeting for those that are interested in having a hard copy to fill out. In this case, the answers will then need to be entered into the database by one of the BCDC staff.
- Develop one-two pagers on different aspects of regional sediment management. Maybe on various topics such as: regional sediment management, sediment dynamics in SF Bay, dredging in SF Bay, etc. These quick summaries may also prove to be useful for other staff as handouts when they attend events and would like to have information to pass out while at the events.
    - Jenny working on summary of dredging activities in the Bay
    - Rosa already created a 5-page summary of sediment dynamics in SF Bay.
-

Strategy:

1. Identify the interested parties (IPs) first by subembayment and then by county. Identify the proper contacts at each agency/group to invite to the presentation/meeting on regional sediment management. (Pascale)
2. Redesign shoreline survey. When possible, phrase questions as multiple-choice answers to provide for some consistency in the answers. (Anniken & Pascale, group editing).
    a. Maggie suggested having nested question, which can kick someone to a different section of the survey based upon their responses. This way they

don't have to complete the entire survey, but only the relevant questions.
    b. Define difficult terminology at the beginning of questions.
    c. Some participants may not want to fill out the survey, but may call and someone from BCDC will need to input their answers.
    d. May want to analyze the survey for flow in Qualtrics, before publishing the survey and having people fill it out.
    e. Send out a small subset/test batch of the survey to test the survey questions and wording…this may allow us to clarify areas where the questions were ambiguous.
3. Review 2011 survey results for a particular county and gather them. Evaluate and summarize any previous survey. Put together a summary or project introduction that is specific ("personalized" for the particular region) to the different groups stakeholder groups. (Pascale)
4. Develop quick script for calls to potential meeting participants.
5. Schedule a meeting location and meeting time. Develop meeting agenda.
6. Send out an email invitation for a particular county IP list containing the personalized message for the particular region of San Francisco Bay and follow up with phone calls. (Pascale & Anniken)
7. After holding the first meeting, assess the success of the outreach materials and adjust things accordingly to maximize education and outreach to future meeting participants. Incorporate changes into the new meeting agenda.
8. Put together a presentation of relevant science on sediment dynamics in the Bay, sources/sinks of sediment. Coarse grain and fine grain dynamics. Current uses of sediment in the Bay.
9. Hold meeting. Provide the link for the online survey to the participants after the presentation. Have survey a list of survey numbers that participants can be assigned.
10. Collect any hard copies of the surveys after presentation and ask about any particular questions or clarification regarding areas of the Bay experiencing erosion. Provide large-scale maps for markup regarding erosional and accretional areas of the shoreline.
11. Maybe go and have site visits with participants to identify specific GPS coordinates for erosional areas (maybe able to purchase or rent GPS equipment for identifying these areas).
12. Identify the types of data or monitoring that participants have on the erosional/accretional areas.

Timeline for Outreach

- Four meetings with stakeholders will be held during the Plan development process

- Hold first outreach meeting with stakeholder groups around the City of San Francisco at the beginning of April 2014.
- The three additional outreach meetings will be held
- Two public meetings will be held on the draft SFBRSMP

Analysis:
-Compare responses for Regional Sediment Management surveys and differences between 2011 and 2014 shoreline surveys
-Minimal analysis of the percent return for surveys sent out.
-Identify erosional and accretional hot spots – creation of a GIS layer

Deliverables for Outreach Effort:
The SMP consists of three types of products produced during Plan development- informational reports, computer-based tools, and RSM strategies/Plans. Outreach and agency coordination provide the fourth and overarching Plan focus.

-Identify the local and regional management questions
-Map of shoreline erosion areas; including BECAs within San Francisco Bay. (This should include descriptions of the erosional areas that can be imported into a GIS layer/attribute table. Included in the general description: County, jurisdictional agencies, identification of the survey or the report discussing the issue, date of the survey, potential recommended solutions, problem assessment/general description of the area, general estimate of the length of shoreline erosion.) => Data to be incorporated into the CSMW WebMapper digital tool.
-Map of shoreline accretional areas.
-Identify "sensitive areas" around the Bay.
-Map/identification of beach sand deposits in SF Bay.
-Informational Report about the current state of the shoreline around SF Bay.
-Sediment management tools applicable to estuarine systems.

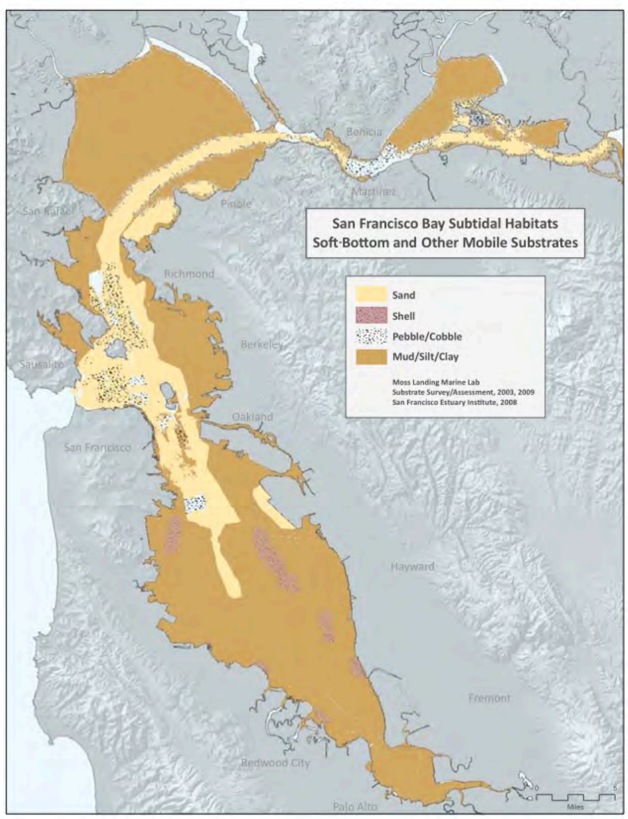
Appendix E

Potential Sediment Sources

Potential Sediment Resources in San Francisco Bay

Beach nourishment and wetland restoration require sediment either coarse or fine according to the project design. Within San Francisco Bay, there are a number of active dredging projects and active sand mining of deep water shoals. Dredging within the Bay system consists of both navigational and flood protection dredging, primarily for maintenance of existing channels, berths, and marinas, and flood protection channels, respectively. Periodically, there are deepening projects or new work projects within both categories of dredging. Sand mining is conducted primarily for construction purposes, but sand can be purchased for other purposes from the mining companies. Fine grain and coarse grain sediment is potentially available from other areas of the Bay, but would need to be permitted by a number of agencies (see regulatory setting document). Because sediment supply to the Bay from the Delta has been significantly reduced since the late 1990's[1], current regulatory programs focus on using the existing dredging projects as sources of sediment.

Sand Resources. Within the Bay, there are two general areas where the Bay sediments are coarse grain in nature: Central Bay and Suisun Bay. These two areas have high enough energy to carry heavier sediments while the remainder of the Bay consists of finer grained sediments due to the less energetic waters. Sand can be obtained through mining activities or beneficial reuse of dredged sediments from a limited number of projects that contain sand.



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1 Schoellhamer, 2003

Sand Mining. Within the Bay Area, there are three sand mining companies that together hold six subtidal lease areas, five leased from the State Lands Commission and one from a private owner. Two of the lease areas are within Suisun Bay and four are within Central San Francisco Bay.

Suisun Bay Channel Sands: The Suisun Bay lease areas contain fine-grained sand, primarily used for backfilling trenches and other fill projects, but this sand is also suitable for sand dune restoration or enhancement. Due to the fine nature of this sand (.15 - 1.2 mm), it may not be a good source for beach nourishment.

Suisun Associates Lease Area (State Lands Commission (SLC) Lease PRC 7781): 2,450,000 cubic yards (cy) of sand is authorized for mining from 936-acres of subtidal lands. There is an annual limit of 300,000 cy and mining is possible year round. Monthly limitations apply during the winter months to protect listed species. Hanson Marine Aggregates and Lind Marine hold the lease through a joint venture, Suisun Associates. As discussed above, this sand falls in the range of 0.15 - 1.2 mm in size. It is also assumed to be free of chemical contaminates due to the sandy nature of the sediments. The wastewater from mining is currently being tested for elevated levels of contaminants.

Middle Ground Shoal Lease Area (Privately owned): 1,000,000 cy of sand is authorized for mining from a limited portion of 367 acres of subtidal lands. There is an annual limit of 120,000 cy and mining is possible year round. Monthly limitations apply during the winter months to protect listed species. Lind Marine holds the lease for this area. As discussed above, this sand falls in the range of 0.15 - 1.2 mm in size. Like Suisun Associates, is also assumed to be free of chemical contaminates due to the sandy nature of the sediments. The wastewater from mining is currently being tested for elevated levels of contaminants.

Central Bay Sands: Central San Francisco Bay sands are more coarse grain in nature and vary greatly in size depending on the location of the mining activity. The sand from Point Knox and Alcatraz Shoal are more coarse grain in nature, sand from these areas range between from 0.15 – 4.75 mm, with the finer end of the spectrum mined at Presidio Shoal. All four leases in this area are held by Hanson Marine Aggregates. Hanson Aggregates is authorized to mine up to 11.41 million cy over ten years and not more than 1.141 million cy annually.

Central Bay Leases	**Annual Average Permit Volume**	**Peak Year Volume**	**Total 10-Year Total Volume**
Presidio Shoals (PRC 709)	170,000 cy	235,000 cy	
Point Knox Shoal South (PRC 2036)	360,000 cy	450,000 cy	
Point Knox Shoal (PRC 7779)	484,000 cy	550,000 cy	
Alcatraz South Shoal (PRC 7780)	127,000 cy	160,000 cy	
Central Bay Leases Total Volume	1,141,000 cy	1,395,000 cy	11.41 cy

Point Knox Shoal and the Alcatraz Shoal are located on the western side of Angel Island and Alcatraz and extend towards the Golden Gate and Treasure Island. Sand mined in these locations is generally used for concrete and can vary in size depending on the location of the mining event. The sand here ranges in size from 0.6 -2.36 mm.

Presidio Shoal is located adjacent to Crissy Field and heads southeast toward Alcatraz Island. Sand from this area is consistent with sand on Crissy Field, Lands End and Ocean Beach, and grain size ranges from 0.15 - 0.33mm. This sand is generally used as back fill sands for construction projects.

Sand mined from the Bay can be directly pumped hydraulically to beach nourishment or other sites through contractors, or can be trucked to use sites from several strategically placed sand yards, including in San Francisco, Redwood City, Oakland, Napa and Petaluma, among others. Approximately 80,000 cy of sand from Point Knox Shoal was hydraulically pumped to Crown Beach in Alameda, CA for beach nourishment in 2013. This area is nourished on an average of every 20 years.

Maintenance Dredging Projects with Sand. There are four projects that are regularly dredged that contain sand. These include two federal channels, Pinole Shoal and Suisun Bay Channel; one refinery berth in Rodeo, Phillips 66; and one municipal marina, San Francisco Marina West's entrance channel. With the exception of the marina, all are required through the Long Term Management Strategy for the Placement of Dredged Sediments in the Bay Region's (LTMS) Management Plan to dispose of or reuse eighty percent of the dredged sediment out of Bay. The options available to the project sponsors include deep ocean disposal or beneficial reuse at the San Francisco Bar to help supply sand to the outer coastal littoral cell, or beneficial reuse at a habitat restoration project, levee maintenance or construction.

Suisun Bay Channel and Pinole Shoal Channel are federal navigation channels maintained by the US Army Corps of Engineers. Suisun Channel produces between 100,000 cy and 200,000 cy of sediment (range of grain size) annually, though in drought years there has been less dredged. Pinole Shoal produces between 100,000 cy and 175,000 cy of sediment (range of grain size) annually. Both of these projects contain sand that is currently disposed at dispersive in-Bay disposal sites. At this time, the USACE does not consider beneficial uses for this sediment due to limitations of their regulations and the "federal standard." However, these sediments could be used for nourishment purposes if a partner organization was willing to provide funding for the incremental cost increase to transport and place the sediment at a nourishment site.

Phillips 66 Berth in Rodeo is dredged annually, usually in the fall. This site has consistently produced approximately 15,000 cy of fine sands (grain size) annually, though there is some variation in the volume from year to year. In an effort to increase sand in the outer coast littoral cell, the sand dredged from this birth is routinely placed at the San Francisco Bar (SF-8) disposal site with the assumption that it will work its way down coast along Ocean Beach.

San Francisco Marina West, Entrance Channel is dredged on a biannual basis, unless shoaling occurs more rapidly. Depending on funding this project produces approximately 12,000 – 15,000 cy of sand with each dredge episode. The sand from this area is often transported to San Rafael Rock quarry where it is sold to the aggregate market. It has also been placed at the San Francisco Bar site to nourish the littoral cell, Alcatraz disposal site and at a habitat enhancement project at Aramburu Island in Richardson Bay, which included a small beach. The remainder of the marina's sediments are mud.

Fine Grain Sediment Sources. San Francisco Bay is primarily a muddy bay, with fine grain sediment concentrated in the wide mudflats and shallow or deep subtidal shoals. Each year, between two and three million cubic yards of fine grain sediments are dredged from federal channels, ports and refinery berthing areas and marinas. In most cases these sediments are both physically and chemically suitable for use at wetland restoration projects in need of fine grain sediment. Each year, the number, volume and location of these dredging projects vary depending on sedimentation rates, funding and equipment availability. (See Appendix A) The exception to this statement is the annual projects, primarily the federal deep water channels, berthing areas at the Port of Oakland and the Port of San Francisco, and the refineries. With few exceptions, the sediment from these areas does not exhibit elevated levels of contaminates due in part to the frequency of the dredging activity. A noted challenge in using dredged sediment from the federal navigation channels is providing funding necessary to cover the incidiental cost of placement beyond that of in-Bay disposal. Currently the US Army Corps of Engineers is implementing a policy that does not allow federal dollars to be spent above that of the "federal standard," which they interpret to mean the least cost alternative.

The Dredged Materials Management Office (DMM0) has created and maintains a database that includes the grain size analysis, and chemical suitability of all dredging projects that have under gone testing in the last fifteen years. This database can be queried to provide project specific information for each dredge episode (www.dmmosfbay.org).

As discussed above, the LTMS program requires that maintenance dredging programs reduce in-Bay disposal volumes to twenty percent of the total dredged in any three year period, with a minimum of forty percent being beneficially reused and the remainder slated for ocean disposal. This provides the incentive for using dredged sediment at habitat restoration projects throughout the Bay Area. Currently fine grain sediments are being used at Cullinan Ranch and Montezuma Wetland Restoration Projects. These sediments have also been used at Sonoma Baylands, Inner Bair Island and Hamilton Wetland Restoration Projects, but these projects have been completed. Additional projects that have expressed an interest in using dredged sediments to restore marsh habitat, but have not yet used this resource include Bel Marin Keys Wetlands Project (an extension of Hamilton), Eden Landing, Ravenswood and Pond A8 of the South Bay Salt Ponds Restoration Project.

Deepening Projects. Over time, several deep water channels have been deepened to accommodate the ever growing international shipping fleets. As ships get larger, the US Army Corps of Engineers, ports and refineries respond by deepening berths and navigation channels.

Sediment from deepening projects is generally used as a resource for either wetland restoration or other beneficial project. These projects take multiple years to plan, permit and execute, which allows time to identify appropriate uses for the sediments that are dredged. There are three deepening projects that have been identified in the Bay Area: (1) Port of Stockton Deep Water Channel; (2) Port of Sacramento Deep Water Channel; and (3) Port of Redwood City Deepening Project. Of these three projects, Stockton and Sacramento are currently on hold. Redwood City is currently in the planning stage and has been through environmental review. This project could product 3 million cubic yards of sediment if it is undertaken. The current target sites for this sediment, which will be composed of fine grain sediment is Cullinan Ranch or Eden Landing. If this project is authorized and funded, it would likely begin in 2018.

Flood Protection Channels. There are several flood protection channels throughout the Bay Area, which are dredged regularly, both in the upstream and lower portions of their reaches. The local public works or flood protection agencies for cities and counties preform this work on an annual or semi-annual basis. A rough estimate of the amount of sediment dredged from these channels annually is a total of approximately 300,000 -400,000 cy (SFEI, in progress). However, records on the volumes dredged in each channel per year are limited and incomplete. Flood protection agencies have expressed an interest in providing sediment to projects on an as needed basis, but may need some additional funding and support. Currently sediment from these channels is reused on existing levees; provided as free soils to those who are interested in hauling it to their site; or used for daily cover or disposed of at landfills throughout the region. These sediments consist of both coarse grain riverine sediments and fines of either fluvial or estuarine origins, with the later being found primarily in the lower reaches of the channels. Work is currently being done to further connect flood protection agencies with opportunities to use these sediments for habitat and shoreline augmentation.

Other Sources of Sediment. The projects described above are generally projects that are permitted to remove sediment from the Bay and to beneficially reuse, sell or dispose of it. In addition to projects that currently remove sediment from the Bay, individual projects could also be permitted to remove sediment from other areas of the Bay. Historically there have been a few projects that removed sediment from the Bay for large construction projects, primarily for public infrastructure. Two such projects include the building of Treasure Island and the transbay tube for the Bay Area Rapid Transit (BART) system. More recently the San Francisco Airport considered the Bay as a potential source of sand for a runway extension. There was significant investigation into both removing sand from existing shoals in Central Bay and dredging sand from beneath the layer of Bay mud. Further, as described above, when deepening channels and berths, Holocene sands are often revealed under the Bay mud. Sand dredged incidental to deepening projects may be a source for beach nourishment and/or habitat restoration, but would likely be limited opportunistic project alignment.

Figure 1. Permitted sand sources of San Francisco Bay.

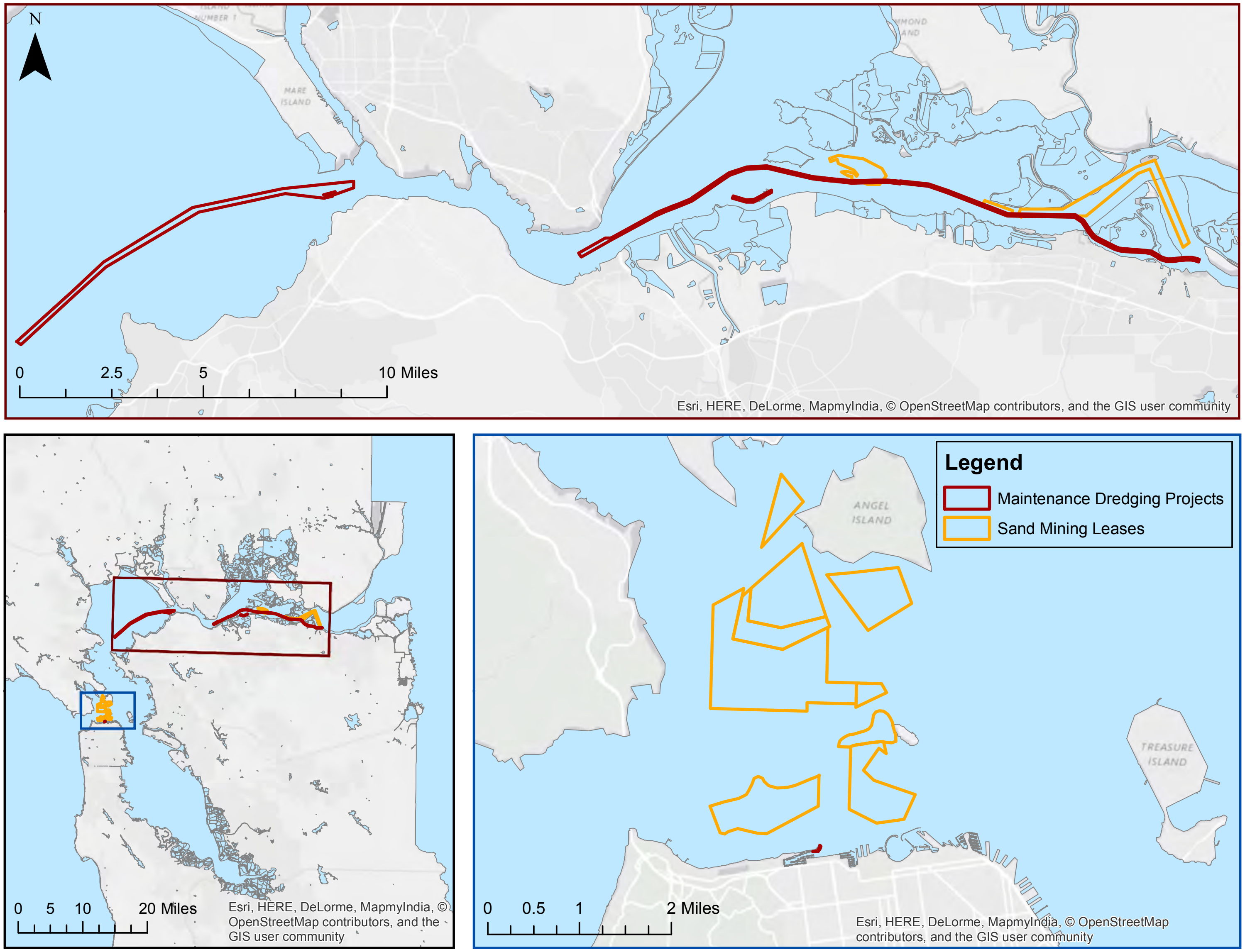


Figure 2. Permitted fine grain sediment sources in Central San Francisco Bay

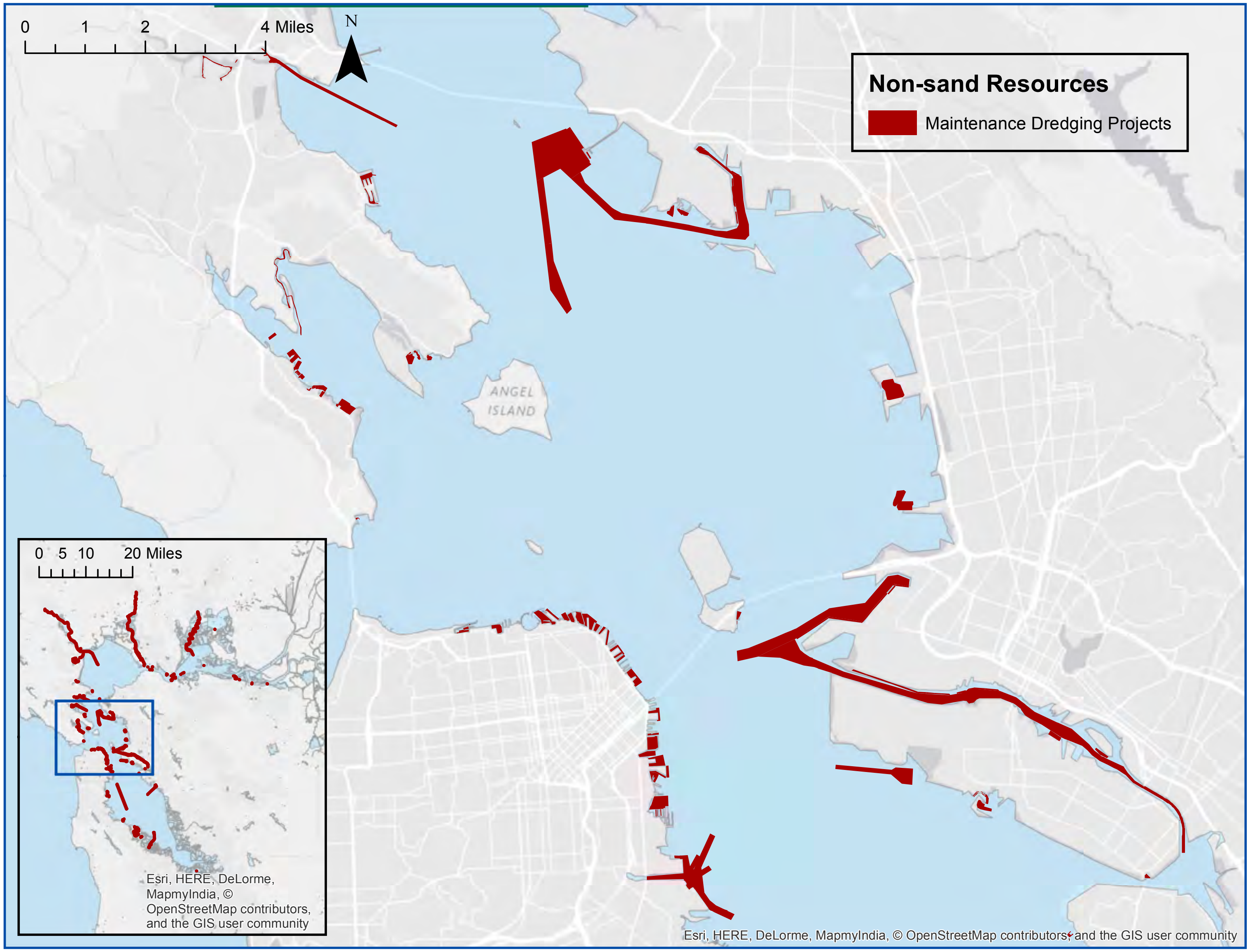


Figure 3. Permitted fine grain sediment sources in Suisun Bay

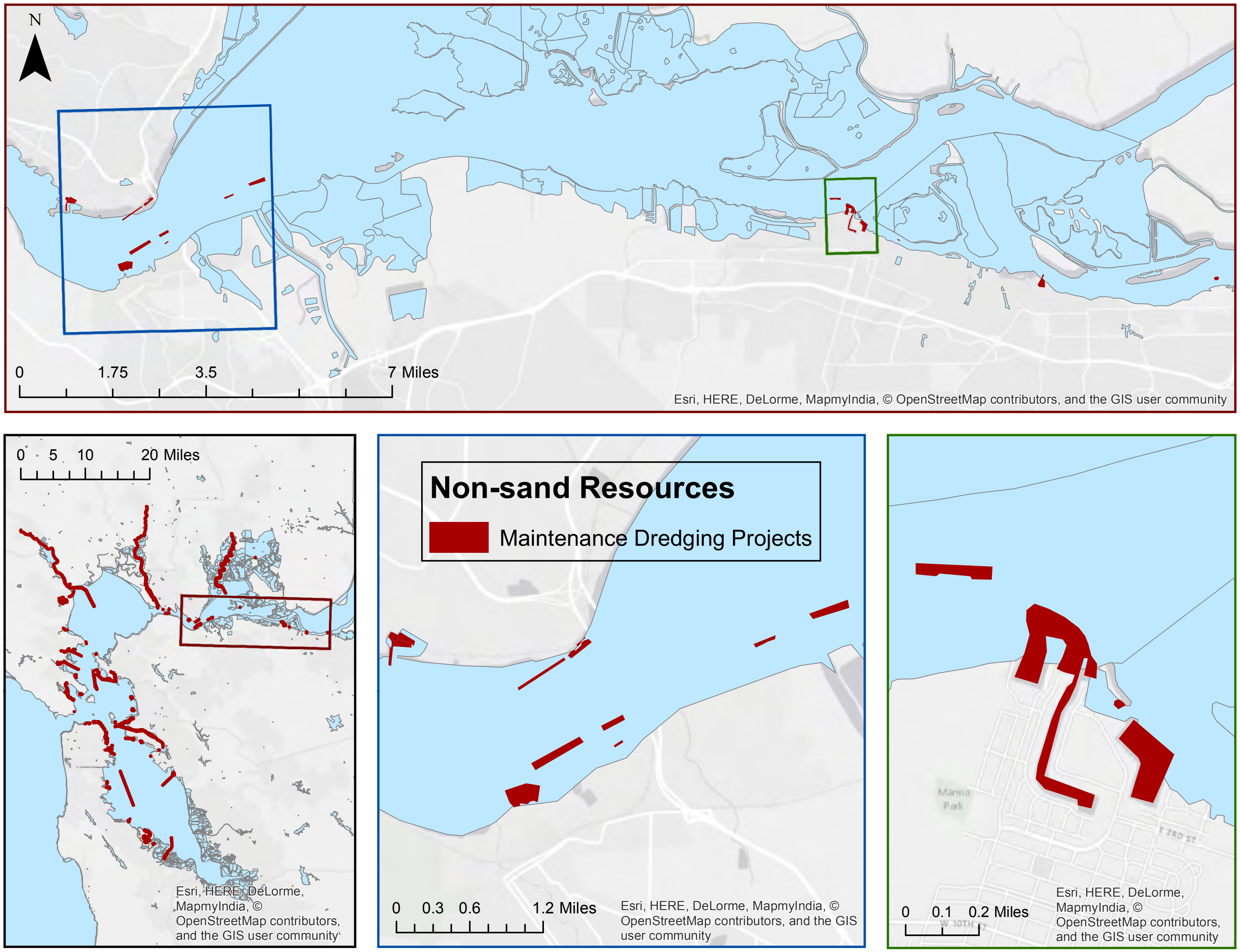


Figure 4. Permitted fine grain sediment sources in San Pablo Bay

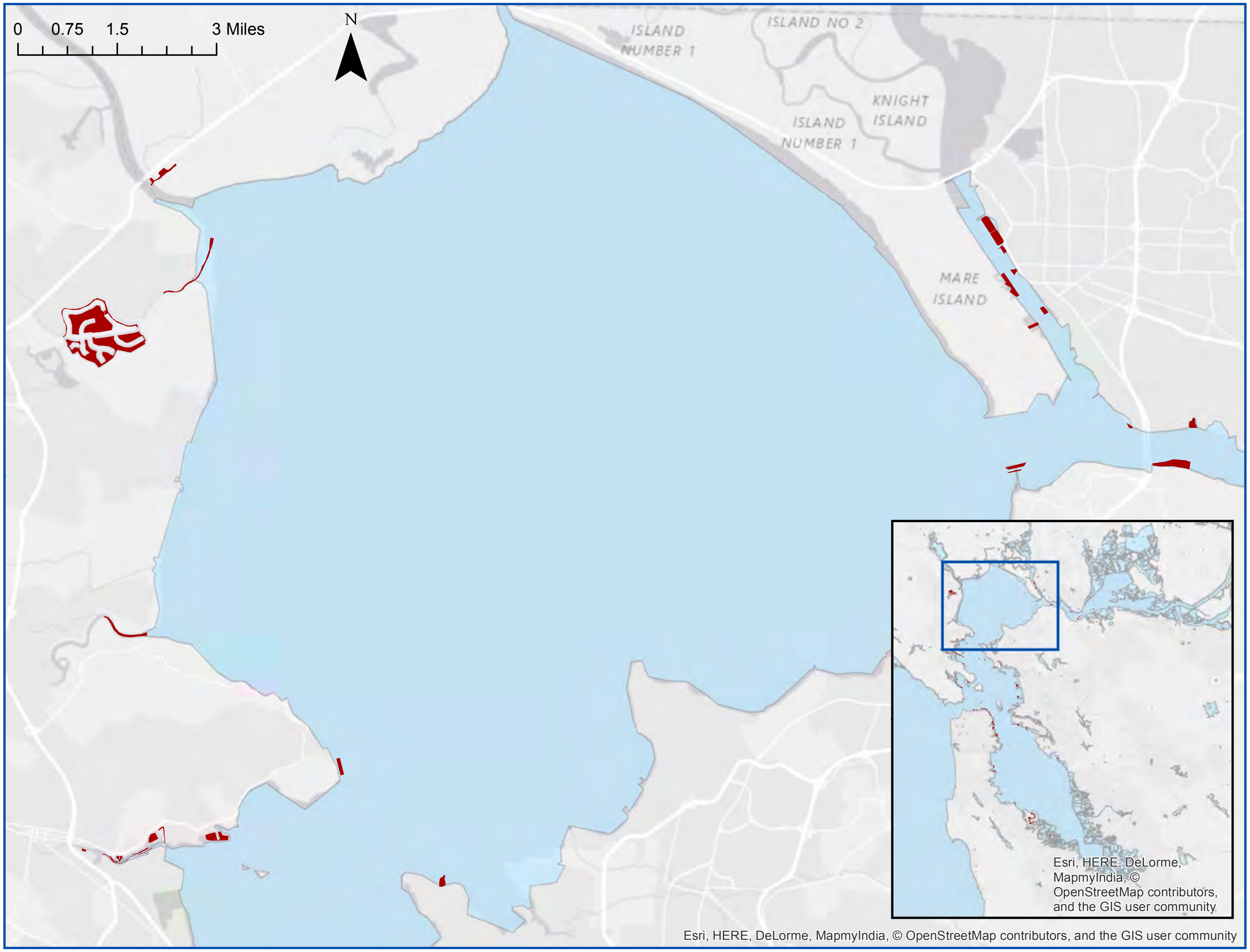
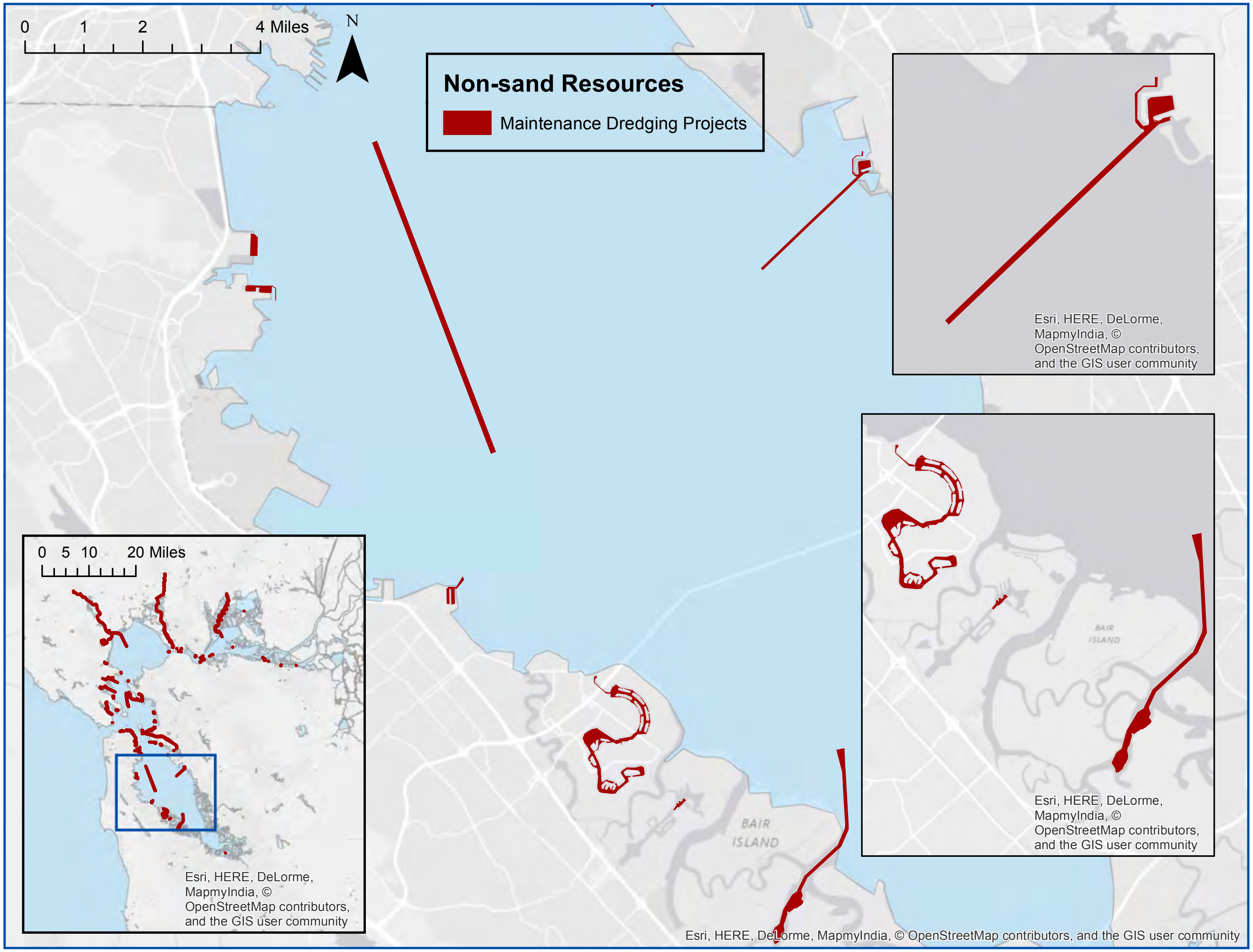


Figure 5. Permitted fine grain sediment sources in South San Francisco Bay



Other Sources of Sediment in the Bay Area

Sediment from Flood Protection Channels. As discussed previously, most of the creeks and rivers in Central Bay have either been buried or converted into storm or flood protection channels. While storm drains are regularly cleared of excess sediment, the sediment is often contaminated with urban chemical contaminants.

There are several flood protection channels throughout the Bay Area, which are dredged regularly, both in the upstream and lower portions of their reaches. The local public works or flood protection agencies for cities and counties perform this work on an annual or semi-annual basis. A rough estimate of the amount of sediment dredged from these channels annually is approximately 300,000 -400,000 cy (SFEI, in progress). Flood protection agencies have expressed an interest in providing sediment to projects on an as needed basis, but may need some additional funding and support. Currently sediment from these channels is reused on existing levees; provided as free soils to those who are interested in hauling it to their site; or used for daily cover or disposed of at landfills throughout the region. These sediments consist of both coarse grain riverine sediments and fines of either fluvial or estuarine origins, with the later being found primarily in the lower reaches of the channels.

Flood protection sediments could be used either in wetland restoration projects or as beach and shoreline nourishment if it is free of elevated levels of contaminants and site is available for its use. Distance from the flood protection channel to the placement site needs to be reasonably close as longer distances may make the reuse infeasible due to travel time and cost. Work is currently being done to further connect flood protection agencies with opportunities to use these sediments for habitat and shoreline augmentation

Cliff Erosion. As described above, much of the Bay Area topography consists of relatively flat land that gently slopes in to the Bay. Exceptions to this include Bay islands (Angel, Alcatraz, Brooks, etc.), and the step slopes of the Marin Headlands, Tiburon Peninsula, and the area from Point Lobos to Baker Beach. All of these areas have capacity to add to the sediment system and adjacent beaches through erosion and landslides. Unfortunately, data on the quantity of sediment contributed annually or even by decade was not available in this area.

Construction Projects. The Bay Area is currently going through a construction boom. During construction projects, there is often soils excavated from a site in preparation for development. Sources familiar with the construction industry report that there is clean dirt available for fill projects, and the South Bay Salt Ponds are considering using this source to create transitional habitat on the landside of the restoration project. Bair Island used 1 million cy of clean fill dirt in raising the elevations of Inner Bair Island prior to breaching the site to tidal action. The Water Board required testing of each truckload of soils brought onsite to ensure they were free of elevated levels of contaminants.

There is some concern that upland soils will be less appropriate for marsh vegetation development, but this will be borne out as this site develops. In addition, there are large development sites in the planning phase (Treasure Island, Hunters Point, etc) that require as much as 12 million cy of fill over the next several years. These projects may compete with the needs for restoration and beach nourishment projects. As a source of fill, the “dirt market” can be a viable resource, but is somewhat sporadic in availability.

Dams and Reservoirs. As briefly discussed in the watershed section, four counties surround the Central Bay study area. All have watersheds draining towards the San Francisco Bay, but not all of them have tributaries that join the Bay in the Central Bay study area. In Marin County there are nine dams, two of which drain into tributaries leading to the San Francisco Bay. Stafford Lake Dam drains into Novato Creek, which leads to San Pablo Bay and Phoenix Lake Dam drains into Corte Madera Creek, one of the creeks of the Central Bay study area. Alameda County has eight dams, two of these dams, those of San Leandro Reservoir and Lake Chabot, drain into San Leandro Creek, Alameda County’s only tributary to the Bay within the Central Bay Study Area. San Francisco County has seven dams, none of which drain into tributaries that lead to the San Francisco Bay. Contra Costa County has four dams draining to two tributaries connecting to the San Francisco Bay. San Pablo Creek and Wildcat Creek. Both of these creeks reach the San Pablo Bay, which is not within the Central Bay study area. In reviewing the readily available information on these dams and reservoirs, the sediment load data was not available. It is possible that estimates could be made with future research on this issue.

Estuarine Deposits. Fine grain and coarse grain sediment is potentially available from other areas of the Bay, but would need to be permitted by a number of agencies (see regulatory setting document). Because sediment supply to the Bay from the Delta has been significantly reduced since the late 1990’s[2], current regulatory programs focus on using the existing dredging projects as sources of sediment.

Historically there have been a few projects that removed sediment from the Bay for large construction projects, primarily for public infrastructure. Two such projects include the building of Treasure Island and the transbay tube for the Bay Area Rapid Transit (BART) system. More recently the San Francisco Airport considered the Bay as a potential source of sand for a runway extension. There was significant investigation into both removing sand from existing shoals in Central Bay and dredging sand from beneath the layer of Bay mud, since when deepening channels and berths, Holocene sands are often revealed under the Bay mud. Sand dredged incidental to deepening projects may be a source for beach nourishment and/or habitat restoration, but would likely be limited opportunistic project alignment.

2 Schoellhamer, 2003

Appendix A. Maintenance Dredging Projects 2010 through 2015. Projects highlighted in green are annual projects.

Table 1. 2010

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/SPECIES	COMMENTS
Aeolian Yacht Club	Alameda	1.8k	E	WI/Auggie's Island	8/1 - 11/30	DFG/herring NOAA/steelhead/salmon FWS & DFG/least tern	Fines, Hg
Alameda Ferry Terminal	Alameda	6	C	Winter Island	8/1 - 11/30	DFG/herring NOAA/steelhead/salmon FWS & DFG/least tern	Sand, one time project
Amports/Benicia Port Terminal	Benicia	90	C	Hamilton/SF-9	Aug 1- Nov 30	NOAA/steelhead/salmon FWS/delta smelt	Fines
Antioch Marina	Antioch		C	In coffer dam?	Aug 1- Nov 30	NOAA/steelhead/salmon FWS/delta smelt	Sand
BAE Dry Docks	South San Francisco	44	C	SFDODS	June 1- November 30	DFG/herring NOAA/steelhead/salmon	Fines, contaminant issues
Benicia Marina	Benicia	36	C	none	Aug 1- Nov 30	NOAA/steelhead/salmon FWS/delta smelt (less than 10 ft depth)	Fines
Brickyard Cove HOA	Richmond	2	C	SF-11	6/1-11/30	NOAA/steelhead/salmon DFG/herring	Fines
California Maritime Academy	Carquinez Strait	37	C	SF-9/Berth 10	8/1-11/30	NOAA/steelhead/salmon FWS/delta smelt (depth > 10 ft)	Fines
Chevron Long Wharf	Richmond	100	C	SF-11	6/1-11/30	NOAA/steelhead/salmon DFG/herring	Fines
Chevron Rod & Gun Club (Castro Cove)	Richmond	150	H	Castro Cove (onsite)	7/1-11/30	NOAA/steelhead/salmon	Fines
Coyote Point Marina	San Mateo	50		SF-11	6/1-11/30	NOAA/steelhead	Fines
ConocoPhillips	Rodeo	13	C	SF-8, SF-,9 Hamilton	6/1 to 11/30	NOAA/steelhead/salmon	Sand
Emeryville Marina	Emeryville	0.3	C	SF-11	8/1-11/30	NOAA/steelhead/salmon DFG/herring/least tern FWS	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/SPECIES	COMMENTS
Exploratorium (PoSF Berths 17/19)	San Francisco	65	C	SF-11	6/1 to 11/30	NOAA/steelhead/salmon DFG/herring	Fines
Glen Cove Marina	Vallejo	70	C	SF-9	8/1 to 11/30	NOAA/steelhead/salmon FWS/delta smelt (depth > 10 ft)	Fines
Larkspur Marina	Larkspur	18	C	SF-11/upland	6/1 to 10/31	NOAA/steelhead/salmo/coho DFG/herring/Clapper Rail/Salt Marsh Harvest Mouse.	Fines
Hanson Aggregates (at Tidewater Ave)	Alameda	1.5	C	WI	8/1 - 11/30	DFG/herring NOAA/steelhead/salmon FWS least tern	Fines
Levin Richmond	Richmond	6.5	C	Berth 10	6/1-11/30	DFG/herring NOAA/steelhead/salmon	Fines, DDT
Larkspur Ferry Terminal	San Rafael	500	C	Hamilton, SFDODs, SF-10	6/1 to 11/30	DFG/herring NOAA/steelhead/salmon	Fines
Lowrie Yacht Harbor	San Rafael	20	C	SF-10	6/1 to 11/30	DFG/ NOAA/steelhead/salmon	Fines
Montezuma Harbor	Suisun	2	C	Upland	8/1-11/30	Delta Smelt FWS/Salmonids NOAA	Fines
Mare Island Dry Dock (ADR)	Napa River	104	C	SF-9	8/1 to 11/30 (subject to change per individ. Conultant)	Delta Smelt smelt/steelhead/salmon	Fines
Marina Bay Yacht Harbor Richmond Bay LLC	Richmond	74	C	SF-11/SF-DODS	6/1 to 11/30	DFG NOAA/steelhead/salmon	Fines
Marina Vista	San Rafael	12	C	SF-10/SF-11/WI	6/1 to 11/30	DFG/herring NOAA/steelhead/salmon	Fines
Main Ship Channel (ACE)	San Francisco	500	C	SF-8	NA		Sand
Napa Yacht Club HOA	Napa	97	C	SF-9/Upland	8/1-10/15	NOAA/steelhead/salmon	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/SPECIES	COMMENTS
Oakland Inner and Outer Harbors (Corps)	Oakland	700	C	Hamilton	8/1 to 11/30	DFG/herring NOAA/steelhead/salmon FWS & DFG/least tern	Fines
Oyster Point Marina	South San Francisco	51	C	SF-11	6/1 -11/30	DFG/herring NOAA/steelhead/salmon	Fines
Paradise Cay Homeowners Association	Marin	44	C	SF-11	6/1 to 10/31	NOAA/steelhead/salmon/coho DFG/herring	Fines
Pelican Harbor	Sausalito	22	C	SF-11	6/1 to 10/31	NOAA/steelhead/salmon/coho DFG/herring	Fines
Pinole Shoal Channel (Corps)	Pinole	175	Essayons	SF-10/SF-9	6/1 to 11/30	NOAA/steelhead/salmon	Sand
Port of Oakland Berths 25, 26, 30, 32 33, 35, 37, 57, 58, 59, 60, 61, 62, and 63	Oakland	76	C	SF-11	8/1 - 11/30	DFG/herring NOAA/steelhead/salmon FWS & DFG/least tern	Fines
Port of Redwood City Berths	Redwood City	18-20	C	SF-11/SFDODs	6/1 to 11/30	NOAA/Steelhead	Fines, PCB
Port of San Francisco, Berth 35	San Francisco	52	C	SFDODS	6/1 to 11/30	NOAA/steelhead/salmon DFG/herring	Fines, Sand, PAH
Port of San Francisco, Berth 27	San Francisco	40	C	SF-11	6/1 to 11/30	NOAA/steelhead/salmon DFG/herring	Fines
Port Sonoma	Petaluma	80	H	Upland/Carneros River Ranch		NOAA/steelhead/salmon	Fines
Mallard Island	Contra Costa	33	C	SF-9	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead	Fines
Richmond Outer Harbor (Corps)	Richmond	200	C	SF-11/Hamilton	6/1-11/30	DFG/herring NOAA/steelhead/salmon	Fines
Richmond Inner Harbor (Corps)	Richmond	250	C	Hamilton	6/1-11/30	DFG/herring NOAA/steelhead/salmon	Fines
River Park Marina	Napa	17	E	Auggie's Island	6/1-10/15	NOAA/steelhead/salmon	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/SPECIES	COMMENTS
San Francisco Marina, City of SF	San Francisco	13	C/H	upland	6/1 to 11/30	DFG/herring NOAA/steelhead/salmon	Sand
San Rafael Rock Quarry	San Rafael	16	C		6/1 to 11/30	NOAA/steelhead/salmon DFG/herring	Fines
Schnitzer	Oakland	7	C	SF-11	8/1 to 11/30	DFG/herring NOAA/steelhead/salmon FWS & DFG/least tern	Fines
Suisun Bay Channel/ New York Slough (Corps)	Suisun	169	H	SF-16	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead	Sand
USCG Yerba Buena Island	San Francisco		C	SF-11	8/1 - 11/30	DFG/FWS/NOAA/longfin/ least tern/salmon/ steelhead	Fines
Valero	Benicia	80	C	Hamilton SF-DoDs, Winter Island	8/1 to 11/30	FWS/delta smelt NOAA/steelhead/salmon	Fines, dredging year round, individual consultation

Table 2. 2011

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
ADR (Mare Island Dry Dock)	Vallejo	0.5	C	Knockdown	8/1 - 10/15	DFG/FWS/NOAA/ longfin/salmon/steelhead/ least tern	Fines
Alameda Point Channel (City of Alameda)	Alameda	196	C	SF-11 & SFDODS	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
BAE	San Francisco	181.4	C	SF-11/SFDODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Contaminant issues
Benicia	Benicia	22	C	SF-9	8/1 - 11/30	DFG/FWS/NOAA/ Delta smelt/salmon/steelhead/ least tern	Fines
Chevron Long Wharf	Richmond	150	C	SF-11	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Chevron Rod & Gun Club (Castro Cove)	Richmond	46	C	Castro Cove (onsite)	7/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Fines
ConocoPhillips	Rodeo	45	C	SF-8, SF-,9 Hamilton	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Sand
Emeryville Marina	Emeryville	0.3	C	SF-11	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Levin Terminal	Richmond	1	C	Upland	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Fines, DDT
Main Ship Channel (Corps)	San Francisco	500	H	SF-8 SF-17		None	Sand
Marin Yacht Club	San Rafael	12	C	SF-10	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Fines
Marina Bay Yacht Harbor Richmond Bay LLC	Richmond	74	C	SF-11/SF-DODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Marina Vista Canal	San Rafael	12	C	SF-10/SF-11/WI	6/1 - 11/30	DFG/NOAA/ salmon/steelhead/longfin	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Napa Yacht Club HOA	Napa	76	C	SF-9	8/1 - 10/15	DFG/NOAA/longfin/delta smelt/salmon/steelhead	Fines
Oakland Inner and Outer Harbors (Corps)	Oakland	1,200	C	Montezuma. SF-11	8/1 - 11/30	DFG/NOAA/FWS/herring/longfin/salmon/steelhead/least tern	Fines
Port of Oakland Berths	Oakland	133.7	C	SF-11	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Pinole Shoal Channel (Corps)	Pinole	74		SF-10	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Sand
Point San Pablo Yacht Harbor	Point Pinole	20	C	Castro Cove	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Fines
Port of SF, Berth 27	San Francisco	109	C	SF-11/DODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Port of SF, Berth 35	San Francisco	72	C	SFDODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Sand, PAH
Port Sonoma	Petaluma	50	H	Carneros River Ranch	6/1 - 1/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Redwood City Harbor Channel Maintenance Dredging (Corps)	Redwood City	362	C	SF-11	6/1 - 11/30	USFWS/Clapper Rail	Fines
Richmond Inner Harbor (Corps)	Richmond	250	C	SF-DODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Richmond Outer Harbor (Corps)	Richmond	204	H	SF-11	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
San Rafael Canal (Corps)	San Rafael	40	C	S-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Contaminant Issues
San Rafael Yacht Harbor	San Rafael	1.8	C	SF-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Hg
Sausalito Yacht Harbor	Sausalito	93	C	SF-11/ Upland	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Suisun Bay Channel/ New York Slough (Corps)	Suisun	169	H	SF-16	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand
Sunnyvale Boat Launch Ramp	Sunnyvale	0.06	Ex	Upland	6/1 - 11/30	DFG/NOAA/ longfin/salmon/steelhead	Fines
Valero	Carquinez	80 Annual	C	SF-9/SF-11/ WI/SFDODS	NA	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Dredging year round, individual consultation
Vallejo Ferry	Vallejo	10	C	SF-9	8/1 - 10/15	DFG/NOAA/longfin/ salmon/steelhead	Fines

Table 3. 2012

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
America's Cup Pier 9S, 14, Brannan St. OWB (2012 - S of 30/32)	San Francisco	33.5	C	MWRP	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Alameda Ferry - WETA	Alameda	5	C	WI	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Amports	Benicia	29	C	WI	8/1 - 11/30	DFG/FWS/NOAA/Delta smelt/ longfin/salmon/steelhead	Fines
Benicia Marina	Benicia	15	C	SF-9	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Brickyard Cove Marina	Richmond				6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Chevron Long Wharf	Richmond	150	C	SFDODS MWRP	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Clipper Yacht Harbor, Basin One	Sausalito		C	SF-11	6/1 - 10/31	DFG/NOAA/herring/ longfin/salmon/steelhead/ coho	Fines
Phillips 66 (aka Conoco Phillips)	Rodeo	17	C	SF-8, SF-9, upland (Aramburu)	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Sand
Cove Investment	Richmond	4			6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Fines
Emeryville Marina Entrance Channel	Emeryville	44	C	SF-11	8/1-11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Levin Richmond	Richmond	6		Upland, landfill only	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Fines, DDT
Lowrie Yacht Harbor	San Rafael Canal	26.8	E	SF-10	6/1 - 11/30	DFG/NOAA/longfin/herring/ salmon/steelhead	Fines
Main Ship Channel (Corps)	San Francisco	500	H	SF-8 SF-17		None	Sand
Martinez Marina	Martinez	25	H	upland	30-Nov	DFG/FWS/NMFS/Delta smelt/salmon/steeelhead	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Napa Valley Marina	Napa	92	suction	upland/beneficial reuse	11/1 -12/31	steelhead/salmon/green sturgeon/delta and longfin smelt	Fines
Oakland Inner and Outer Harbors (Corps)	Oakland	800	C	SFDODS / beneficial reuse	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/least tern	Fines
Paradise Cay Yacht Club	Tiburon	20	E	SF-11	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Fines
Pier 39	San Francisco	100/63	C	SF-11/SFDODS/ Berth 10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, PAH
Pinole Shoal	Pinole	120	H	SF-10	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Sand
Pittsburg Marina - Lowy Basin elbow	Pittsburg	10	C	WI	8/1-11/30	NMFS/CDFG/FWS/salmon/steelhead /delta smelt	Fines
Plains Terminal	Martinez	6	C	WI	8/1-11/30	DFG/FWS/NMFS/Delta smelt/salmon/steeelhead	Fines
Port of SF, Berth 35	San Francisco	119	C	SFDODS/MWRP?	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Sand, PAH
Port of SF, Piers 80 A and D	San Francisco	84	C	upland/ SF11	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Redwood City (Corps)	Redwood City	29	knockdown	onsite	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Richardson Bay Marina	Sausalito	14	C	SF-11	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Richmond Inner Harbor (Corps)	Richmond	75	C	SFDODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Richmond Outer Harbor (Corps)	Richmond	250	H	SF-11/SF-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
City of SF Marina West Basin	San Francisco	73	C	Upland/SF-11/Aramburu Is.	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Sand, PAH
San Rafael Canal Homeowners Aqua Vista	San Rafael	2	E	SF-10	June 1-Nov 30	DFG/NOAA/longfin smelt/salmon/steelhead	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
San Rafael Canal Homeowners Mooring Rd	San Rafael	7	E	SF-10	June 1-Nov 30	DFG/NOAA/longfin smelt/salmon/steelhead	Fines
San Rafael Canal Homeowners Newport Boating Association	San Rafael	7	C	SF-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
San Rafael Canal Homeowners Porto Bello HOA	San Rafael	7	C	SF-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
San Rafael Canal Homeowners Royal Court HOA	San Rafael	7	C	SF-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Sausalito Yacht Harbor	Sausalito	38	C	SF-11/ Upland	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Suisun Bay Channel/ New York Slough (Corps)	Suisun	119	H	SF-16	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand
Tesoro	Carquinez	5	C	WI	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand
USCG Yerba Buena Island	San Francisco	22	C	SF-11, DODS, upland	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead/eelgrass	Fines
Valero	Carquinez	80	C	Montezuma, SF-9	NA	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Dredging year round, individual consultation
Vallejo Marina North and South Basins	Vallejo	79	C	SF-9	8/1 -10/15	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
West PAC Energy	Pittsburg	170	C	WI/ Montezuma	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand

Table 4. 2013

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
America's Cup- Piers 30/32	San Francisco	33.5	C	MWRP	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Benicia Marina	Benicia	15	C	SF-9	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Chevron Long Wharf	Richmond	150	C	SFDODS MWRP 80%; SF-11 20%	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Clipper Yacht Harbor, Basin Three	Sausalito	1,184 cy + 356 cy soil	C	Berth 10, upland landfill	6/1 - 10/31	DFG/NOAA/herring/ longfin/salmon/steelhead/ coho	Fines
Phillips 66 (aka Conoco Phillips)	Rodeo (San Francisco Refinery)	8.2	C	SF-8, SF-9, upland	8/1 - 11/30	DFW/NOAA/FWS/longfin/delta smelt/ salmon/steelhead	Sand
Main Ship Channel (Corps)	San Francisco	500	H	SF-8 SF-17		None	Sand
Oakland Inner and Outer Harbors (Corps)	Oakland	700	C	MWRP/SF-11/SFDODS / beneficial reuse	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Pinole Shoal	Pinole	101	C	SF-10/SF-9	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Sand
Port of Oakland Berths 24 - 26, 30, 32, 35-37, 55 - 59	Oakland	150	C	SF-DODS	8/1 - 11/30	DFW/FWS/NOAA/herring/ longfin/salmon/steelhead	Fines
Port of SF, Berth 35	San Francisco	79	C	SFDODS	6/1 - 11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines, Sand PAH
Richardson Bay Marina	Sausalito	14	C	SF-11	6/1-10/30	NMFS/DFW/herring,longfin,least tern/eelgrass, salmonids	Fines
Richmond Inner Harbor (Corps)	Richmond	150	C	SFDODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Richmond Outer Harbor (Corps)	Richmond	156	C	SF-11/SF-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
City of SF Marina West Basin	San Francisco	13.4	C	Upland	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Sand
San Rafael Canal Homeowners Mooring Rd	San Rafael	7	E	SF-10	June 1-Nov 30	DFG/NOAA/longfin smelt/salmon/steelhead	Fines
Suisun Bay Channel/ New York Slough (Corps)	Suisun	156	H	SF-16/SF-9	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand
US Coast Guard Station Vallejo	Vallejo	11	C	SF-9	8/1-10/15	NOAA/DFW/delta smelt/steelhead	Fines
Valero	Carquinez	80	C	Montezuma, SF-9	NA	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, year round dredging, individual consulation

Table 5. 2014

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Aeolian Yacht Club	Alameda	25	C	SF-11	8/1-11/30	NOAA/steelhead/salmon DFG/herring USFWS/least tern	Hg
Alameda Lagoons	Alameda	12,000	C	Upland at Naval Airstation Alameda	NA	No EFH or ESA	Fines
BAE Systems/SF Drydock - DD2	San Francisco	2011	C	SF-11/Montezuma	3/1 to 11/30	DFG/herring	Contaminant Issues
Benicia Marina	Benicia	15	C	SF-9	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Brickyard Cove Marina	Richmond	2	C	SF-11	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
BP Terminal	Richmond	11.2	C	SF-11	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Chevron Long Wharf	Richmond	150	C	SFDODS MWRP 80%; SF-11 20%	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Corinthian Yacht Club	Tiburon	22	C	SF-11	6/1-10/31	NOAA/Steelhead/salmon DFG/herring	Fines
JFK Boat Ramp	Napa				8/1 - 10/15	DFW/NOAA/FWS/steelhead/sal mon/delta/ longfin smelt and clapper rail	Fines
Loch Lomond Marina	San Rafael		4-5 years	WD	1/1 to 12/31	NOAA/steelhead/salmon	Fines
Main Ship Channel (Corps)	San Francisco	500	H	SF-8 SF-17	NA	None	Sand
Mare Island Dry Dock MIDD	Napa River	104	C	SF-9	8/1 to 11/30	Delta Smelt smelt/steelhead/salmon	Fines
Marin Yacht Club	San Rafael	7	C	SF-10	6/1 - 11/30	NOAA/steelhead/salmon	Fines
Marina Vista HOA	San Rafael	6.5	C	SF-10	6/1 - 11/30	NOAA/steelhead/salmon	Fines
Napa Flood Control	Napa River				8/1 - 10/15	DFW/NOAA/FWS/steelhead/sal mon/delta/ longfin smelt and clapper rail	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Napa Valley Marina	Napa	11.6	suction	upland/beneficial reuse	8/1 - 10/15	DFW/NOAA/FWS/steelhead/salmon/delta/ longfin smelt and clapper rail	Fines
Oakland Inner and Outer Harbors (Corps)	Oakland	700	C	MWRP/SF-11/SFDODS / beneficial reuse	8/1 - 11/30	DFG/FWS/NOAA/herring/ longfin/salmon/steelhead/ least tern	Fines
Paradise Cay Homeowners	Tiburon	26.6	C	SF-!!	6/1-11/30	DFG/herring, NOAA/steelhead/salmon	Fines
Phillips 66 (aka Conoco Phillips)	Rodeo (San Francisco Refinery)	8.2	C	SF-8, SF-9, upland	8/1 - 11/30	DFW/NOAA/FWS/longfin/delta smelt/ salmon/steelhead	Sand
Phillips 66 (aka Conoco Phillips)	Richmond		C	SF-11/Montezuma	8/1 - 11/30	DFW/NOAA/FWS/longfin/delta smelt/ salmon/steelhead	Fines
Pinole Shoal	Pinole	101	C	SF-10/SF-9	6/1 - 11/30	DFG/NOAA/longfin/ salmon/steelhead	Sand
Port of Oakland Berths 22,25,26,57,58,59	Oakland	15	C	SF-11, SF-DODS, Upland	8/1 - 11/30	DFW/FWS/NOAA/herring/ longfin/salmon/steelhead	Fines
Port of Oakland Berths 23, 30, 32, 35, 37, 55 and 56	Oakland	42.7	C	SF-11, SF-DODS, Upland	8/1 - 11/30	DFW/FWS/NOAA/herring/ longfin/salmon/steelhead	Fines
Port of Redwood City Berths	Redowood City	50	C	SF-11/SFDODS	6/1 to 11/30	DFG/herring NOAA/steelhead/salmon	Fines
Port of San Francisco, Berth 27	San Francisco	2008	D	C	6/1 to 11/30	DFG/herring NOAA/steelhead/salmon	Fines
Port of San Francisco, Berths 80/92/94/96 &Islais Creek	San Francisco	2008	D	C	6/1 to 11/30	NOAA/steelhead/salmon	Fines
Port of SF, Berth 35	San Francisco	62	C	SFDODS	6/1 - 11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Sand and Fines, PAH
Redwood City (Corps)	Redwood City		knockdown	SFDODS	6/1 to 11/30	DFG/herring NOAA/steelhead/salmon	Fines, PCB in Turning Basin

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Richmond Inner Harbor (Corps)	Richmond	150	C	SFDODS	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
Richmond Outer Harbor (Corps)	Richmond	156	C	SF-11/SF-10	6/1 - 11/30	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines
San Rafael Rock Quarry	San Rafael	45	C	Montezuma, SF-10, SFDODS	6/1-11/30	NOAA/steelhead/salmon DFG/longfin	Fines
Strawberry Channel/Cove Apts	Mill Valley	2007	SRC	C/H	6/1-11/30	NOAA/steelhead/salmon DFG/herring	Fines
Suisun Bay Channel/ New York Slough (Corps)	Suisun	156	H	SF-16/SF-9	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand
Sunnyvale Boat Launch Ramp	Sunnyvale	0	E	Upland	NA		Fines
Tesoro	Carquinez	5	C	WI	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Fines
Valero	Carquinez	80	C	Montezuma, SF-9	NA	DFG/NOAA/herring/ longfin/salmon/steelhead	Fines, Can dredge year round due to individual consulations
Vallejo Marina North and South Basins	Vallejo	79	C	SF-9	8/1 -10/15	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead	Fines
Vallejo Yacht Club	Vallejo	2008	WD	C	8/1 to 10/31	FWS/Delta smelt NOAA/steelhead/salmon	Fines
West PAC Energy	Pittsburg	170	C	WI/ Montezuma	8/1 - 11/30	DFG/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand
WETA SF Bay	Alameda	47.1		Montezuma,SFDOD S	8/1 - 11/30	DFG/FWS/NOAA/longfin/ least tern/salmon/ steelhead (depth > 10 ft)	Fines

Table 6. 2015

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Aeolian Yacht Club	Alameda	22	C	SF-11, SFDODS	8/1 -11/30	NOAA/steelhead/salmon DFW/herring USFWS/least tern	Fines, Hg
Amports	Benicia	18	C	SF-9, Upland	8/1 -11/30	Delta smelt/steelhead/Chinook salmon	Fines
Benicia Marina	Benicia	15	C	SF-9	8/1 -11/30	DFW/FWS/NOAA/herring/ longfin/salmon/steelhead/	Fines
BP Terminal	Richmond	11.2	C	SF-11	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
Brisbane Marina	Brisbane	109	C	SF-11,	6/1 -11/30	DFW/NOAA/herring/longfin/sal mon/steelhead	Fines
Chevron Long Wharf	Richmond	150	C	SFDODS MWRP 80%; SF-11 20%	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
Clipper Yacht Harbor, Basin Two, Three, Four	Sausalito		C	SF-11	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead/coho	Fines, Hg, Cd
Corinthian Yacht Club	Tiburon	22	C	SF-11	6/1 -11/30	NOAA/Steelhead/salmon DFW/herring	Fines
Ferro Property	San Rafael		C	SF-11, 10	6/1 -11/30	NMFS/CDFW/herring /longfin/salmon/steel head	Fines
Greenbrae Marina - Larkspur Marina	Larkspur	48	C	SF-11, SF-10, upland	6/1 -11/30	NOAA/steelhead/salmon/coho; DFW herring/Clapper Rail/Salt Marsh Harvest Mouse	Fines, Hg
IMTT	Richmond	6	C	upland (MWRP)	6/1 -11/30	CDFW/NOAA/herring/ longfin/salmon/steel head	Fines, DDT
Kiewit Pacific	Vallejo	13	C	SF-9, Cullinan	8/1 -10/15	CDFW/USFWS/Delta smelt	Fines
Larkspur Ferry Terminal	Larkspur	602 for 2015; 602 for 2019	C	SF-9/SF-10/SF-11/SF-DODS/MWRP/CR/W I	6/1 -11/30 (9/30 for SMHM)	NOAA/steelhead/salmon/coho; CDFW/USFWS/herring/Clapper Rail/Salt Marsh Harvest Mouse	Fines
Loch Lomond Marina	San Rafael	100	C	SF-11, SFDODS, Upland	6/1 -11/30	NOAA/steelhead/salmon	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Main Ship Channel (Corps)	San Francisco	500	H	SF-8/SF-17	NA	None	Sand
Mare Island Dry Dock MIDD	Napa River	70	C	SF-9	8/1 -10/15	Delta Smelt smelt/steelhead/salmon	Fines
Marin Yacht Club	San Rafael	29	c	SF-10	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
Marin Rowing Association	Greenbrae	3	C	SF-10	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
Marina Vista HOA	San Rafael	6.5	c		6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
Oakland Inner and Outer Harbors (Corps)	Oakland	400	C	MWRP/beneficial reuse	8/1 -11/30	DFW/FWS/NOAA/herring/ longfin/salmon/steelhead/least tern	Fines
Paradise Cay Yatch Club	Tiburon	26.6	C	SF-11	6/1 -11/30	DFW/herring, NOAA/steelhead/salmon	Fines
Paradise Cay HOA	Tiburon		C	SF-11	6/1 -11/30	DFW/herring, NOAA/steelhead/salmon	Fines
Phillips 66 (aka Conoco Phillips)	Rodeo (San Francisco Refinery)	6	C	SF-8	6/1 -11/30	DFW/herring, NOAA/steelhead/salmon	Sand
Pinole Shoal	Pinole	150	C	SF-10/SF-9	6/1 -11/30	DFW/NOAA/longfin/ salmon/steelhead	Sand
Port of Oakland Berths	Oakland	143	C	Upland (MWRP)	8/1 -11/30	DFW/FWS/NOAA/herring/ longfin/salmon/steelhead	Fines
Port of Redwood City Wharves 1, 2, 3, & 4	Redwood City	50	C	SF-11/SFDODS	6/1 -11/30	CDFW/NOAA/herring /longfin	Fines, Some PCB
Port of Richmond	Richmond	23	C		6/1 -11/30	CDFW/NOAA/herring /longfin/least tern	Fines, DDT
Port of San Francisco, Berth 27	San Francisco	knockdo wn	C	BRU/ SFDODS	6/1 -11/30	DFW/herring NOAA/steelhead/salmon	Fines

PROJECT NAME	CITY/ LOCALE	VOLUME (Range in 1000 CYS)	EQUIPMENT	DISPOSAL SITE	WORK WINDOW	CONSULT AGENCIES/ SPECIES	COMMENTS
Port of SF, Berth 35	San Francisco	90	C	SFDODS	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Sand, Fines
Port of San Francisco, Berth 94/96	San Francisco	18.5	C	SF-11	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
Redwood City (Corps)	Redwood City	350	C	SFDODS	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines, PBC in Basin
Richmond Inner Harbor (Corps)	Richmond	250	C	BRU/SFDODS	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
Richmond Outer Harbor (Corps)	Richmond	250	C	SF-11/SF-10	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Fines
San Francisco Marina West	San Francisco	10	C	San Rafael Rock Quarry	6/1 -11/30	DFW/NOAA/herring/ longfin/salmon/steelhead	Sand, Fines
San Rafael Rock Quarry	San Rafael	45	C	BRU/ SFDODS	6/1 -11/30	NOAA/steelhead/salmon DFW/longfin	Fines
Strawberry Channel/Cove Apts	Mill Valley	7	C	SF-11/SF-10	6/1 - 11/30	NOAA/steelhead/salmon CDFW/herring USFWS/clapper rail	Fines
Suisun Bay Channel/New York Slough (Corps)	Suisun	150	H	SF-16/SF-9	8/1 - 11/30	DFW/FWS/NOAA/longfin/ delta smelt/salmon/ steelhead (depth > 10 ft)	Sand
Sunnyvale Boat Launch Ramp	Sunnyvale	0	E	Upland	NA		Fines
Valero	Carquinez	56	C	MWRP, SF-9, SF-DODS, Beneficial reuse/WI	NA	CDFW/NOAA/longfin/salmon/steeelhead	Fines, Dredging year round - individual consultation
Vallejo Ferry	Vallejo	7	C	SF-9	8/1 -10/15	CDFW/NOAA/herring/longfin/salmon/steeelhead	Fines