AECOM

Regional Beach Sand Project III Feasibility Study

San Diego Association of Governments

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Delivering a better world

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The Regional Beach Sand Project III (RBSP III) Feasibility Study prepared for the San Diego Association of Governments (SANDAG) aims to address ongoing beach erosion issues in the San Diego region by replenishing sand on highly eroded beaches. This Feasibility Study evaluates the potential strategies, site conditions, lessons learned from previous projects, and economic considerations for implementing RBSP III. The proposed project involves a programmatic long-term beach nourishment approach of dredging beach-quality sand from offshore borrow sites and placing it on receiver sites along the San Diego coastline. The purpose of this Feasibility Study is to evaluate potential strategies to address ongoing beach erosion issues in the Oceanside, Mission Bay, and Silver Strand littoral cells and assess the economic feasibility of regional nourishment through a Benefit-Cost Analysis (BCA). This Feasibility Study also includes an individual section addressing the same issues for southern Orange County.

Site Conditions

The Feasibility Study provides a comprehensive analysis of various factors affecting beaches, including sea-level rise, sediment budgets, longshore sediment transport rates, wave climate, beach profiles, sediment grain size, shoreline position, and nearshore biological inventory. Understanding these dynamics is crucial for effective coastal management and for determining the necessary steps for RBSP III.

Lessons Learned and Recommendations

Key lessons learned from previous projects are highlighted, along with recommendations for improving efficiency. These include emphasizing both economic and ecological benefits, identifying larger or new borrow sites, considering sand retention features, optimizing receiver site footprints, streamlining federal and state environmental review and permitting processes, early coordination with regulatory agencies, and determining optimal renourishment intervals. Additionally, the Feasibility Study discusses the potential benefits of regional collaboration or contracting with USACE contractors to reduce costs.

Project Components

RBSP III proposes placing up to 4.8 million cubic yards of sand on 15 receiver sites in San Diego County from Oceanside to Imperial Beach, and up to 1.6 million cubic yards of sand on 3 receiver sites in southern Orange County. Detailed locations and volumes for each receiver site are provided, along with proposed offshore borrow sites for dredging sand. The Feasibility Study also outlines potential opportunities for a programmatic nourishment regime over a timeframe of 50 years with periodic renourishment cycles to maintain beach-width, a cost-effective feeder beach concept, and a pilot retention feature to improve project success.

Economic Considerations

Economic considerations are addressed through a BCA, which quantifies the economic benefits of RBSP III. The estimated project cost of San Diego sites only is approximately $180 million, with a Benefit-Cost Ratio (BCR) of 7.7, indicating significant economic justification. The estimated project cost including both San Diego and Orange County sites is approximately $278 million with a BCR of 5.5. The primary benefit accrued from the proposed project consists of recreational usage and associated revenue.

Conclusions and Decisions to be Made

In conclusion, the Feasibility Study demonstrates that RBSP III is technically and economically viable, with substantial benefits for both the San Diego and Orange County region. Key decisions and next steps include determining the preferred approach for programmatic nourishment and length of overall program (in years), evaluating the inclusion of a feeder beach and pilot retention project, confirming receiver site locations and volumes, securing funding, and coordinating with regulatory agencies.

1. Introduction

The beaches of the San Diego region have eroded to the point that some have disappeared, and others are often inaccessible losing recreational and ecological value. The region is experiencing a net loss of sand at numerous beaches along its coastline. Beach sand is a product of weathering of the land, and the primary natural source for the region's beaches is sediment carried from inland areas by rivers and streams. Human actions have had major positive and negative impacts on the San Diego coast since the 1880's. Through urban development activities, including water reservoir and dam building, flood control systems and sand mining, natural sediment delivery to the coast has been hindered or eliminated. Due to this, the volume of sand within the active zone of sand movement and deposition, termed the "littoral cell," is progressively decreasing and beaches are narrowing. A littoral cell is a coastal reach bounded by physical features (e.g., submarine canyons, coastal headlands, harbors) where sediment flows in and out from the ocean. It is the dynamic interface between the ocean and the land. Insufficient sediment or sand volumes along the San Diego County shoreline has led to further coastal erosion, damage to infrastructure, habitat degradation, threats to public safety, and reduced recreational and economic benefits. Sand replenishment projects help offset the gradual narrowing and disappearance of the region's beaches, loss of environmental, recreational, economic, and aesthetic benefits, and the increasing destruction of coastal access, infrastructure, and other properties.

The San Diego region has 18 jurisdictions, 8 of which are beachfront jurisdictions, and includes approximately 70 miles of coastline that can be accessed via transit, highways, roadways, and bicycle and pedestrian facilities. A number of these facilities are at risk from the impacts of rising seas, high tides, and strong storms. In addition to the beaches, these access routes to beaches, residences, and public facilities may also be impacted. San Diego Association of Governments (SANDAG) is the Metropolitan Planning Organization for the San Diego region and plays a key role in the regional coordination of a variety of projects. To help implement regional solutions to coastal erosion problems, SANDAG has an established regional forum, the Shoreline Preservation Working Group (SPWG), where elected officials are engaged in regional adaptation projects, such as beach nourishment. Collaboration has resulted in the identification of beach sand replenishment as the preferred approach to this regionwide problem. This approach is presented in the Shoreline Preservation Strategy (SPS) adopted by the SANDAG Board in 1993. The SPS noted that approximately 30 million cubic yards (cy) of sand would be required to widen beaches in the entire region sufficiently to protect against the 100-year coastal storm wave event. That buffer is generally 200 feet (ft) wide with an additional 50-foot buffer to account for seasonal beach-width changes in summer and winter. Once accomplished, the region would also need approximately 300,000 cy of sand annually as maintenance of those beaches.

Following the SPS, SANDAG completed two regional beach sand projects (RBSPs) in 2001 and 2012 (RBSP I and RBSP II, respectively), adding approximately 3.6 million cy of sand to the San Diego region's local beaches. Implementation of these projects involved dredging beach-quality sand from offshore borrow sites for placement at identified receiver sites. The RBSP I and RBSP II efforts accomplished approximately 10 percent (%) of the initial total amount of required sand identified in 1993. Table 1-1 presents a detailed breakdown of placement amounts and borrow sources from those two prior projects. These projects were proof of the concept, representing the first major steps in addressing the severe sand deficit on the region's beaches and identifying a long-term approach to managing the region's shoreline. Beach nourishment is considered a sea-level rise adaptation strategy by a number of cities in the San Diego region which have updated their Local Coastal Programs to align with the California Coastal Commission's (CCC's) Guidance on sea-level rise. Wide beaches can help protect coastal infrastructure and facilities, as well as communities and access, by acting as a buffer to alleviate some of the impacts from sea-level rise, strong storm events, and high tides. Beaches also represent a regional resource that drives much of the economy and provides benefits to a range of sensitive species along the San Diego coast.

Table 1-1. RBSP I and RBSP II Total Volumes Placed

Littoral Cell	Receiver Beach	RBSP I[1]		RBSP II[1]	
		Borrow Source	Volume (cy)	Borrow Source	Volume (cy)
Oceanside	Oceanside	SO7	421,000	MB1 (4,700 cy), SO6 (288,300 cy)	293,000
	North Carlsbad	SO5 (146,700 cy), SO6 (5,100 cy), SO7 (46,500 cy), SO9 (26,700 cy)	225,000	SO5	219,000
	South Carlsbad	SO7	158,000	SO5 (9,000 cy), SO6 (132,000 cy)	141,000
	Batiquitos	SO7	117,000	SO5	106,000
	Leucadia	SO7	132,000	Not included.	Not included.
	Moonlight Beach	SO6 (6,500 cy), SO7 (98,500 cy)	105,000	SO5	92,000
	Cardiff	SO6	101,000	SO5	89,000
	Solana Beach	SO5	146,000	SO5	142,000
	Del Mar	SO5	183,000	Not included.	Not included.
	Torrey Pines	SO5	245,000	Not included.	Not included.
Mission Beach	Mission Beach	MB1	151,000	Not included.	Not included.
Silver Strand	Imperial Beach	SS1 (7,500 cy), MB1 112,500 cy)	120,000	MB1	450,000
Total Volume	**Not applicable**	**Not Applicable**	**2,104,000**	**Not Applicable**	**1,532,000**

Notes:
[1] RBSP I nourishment activities were conducted in 2001. RBSP II nourishment activities were conducted in 2012.
[2] Actual volumes placed may be less than volumes permitted for each site.
Source: Noble Consultants, Word Dredging Mining & Construction, 2002

As discussed above, the SPS (SANDAG 1993) stated 30 million cy of sand was needed in the region; while SANDAG has placed about 10% of that, a deficit in the littoral system still exists. Because of this, repeated and consistent replenishment is necessary to maintain the region's beaches and the recreational, economic, habitat, and protective benefits they provide. This Regional Beach Sand Project III Feasibility Study document (Feasibility Study) evaluates the feasibility for SANDAG to conduct a third RBSP (RBSP III), as well as opportunities for addressing regional beach nourishment in a more efficient programmatic way with renourishment intervals proposed over a timeframe of 50 years.

Implementation of RBSP III (or proposed project) would involve dredging beach-quality sand from offshore borrow sites and placing it on highly eroded beaches in the San Diego region, similar to past projects. Figure 1-1 depicts the location of the region's littoral cells, offshore borrow sites, and receiver sites proposed for RBSP III. The potential to implement retention strategies as a pilot project is also incorporated into the RBSP III approach to enhance the effectiveness of regional nourishment. RBSP III would expand nourishment to encompass the entire Oceanside Littoral Cell and extend to include the evaluation of nourishing southern Orange County beaches in the cities of Dana Point and San Clemente. This is the first time beaches outside of San Diego County would be included as part of a RBSP, but it reflects a more system-wide approach based on littoral cells rather than jurisdictional boundaries. The Feasibility Study addresses topics including site conditions, potential project components (receiver sites and borrow locations), preliminary costs and economic benefit, as well as possible efficiencies, related to components in the San Diego region. Technical studies related to borrow sites (Appendix A) and costs/benefits (Appendix B) are attached specific to San Diego elements. Section 6 provides similar information regarding

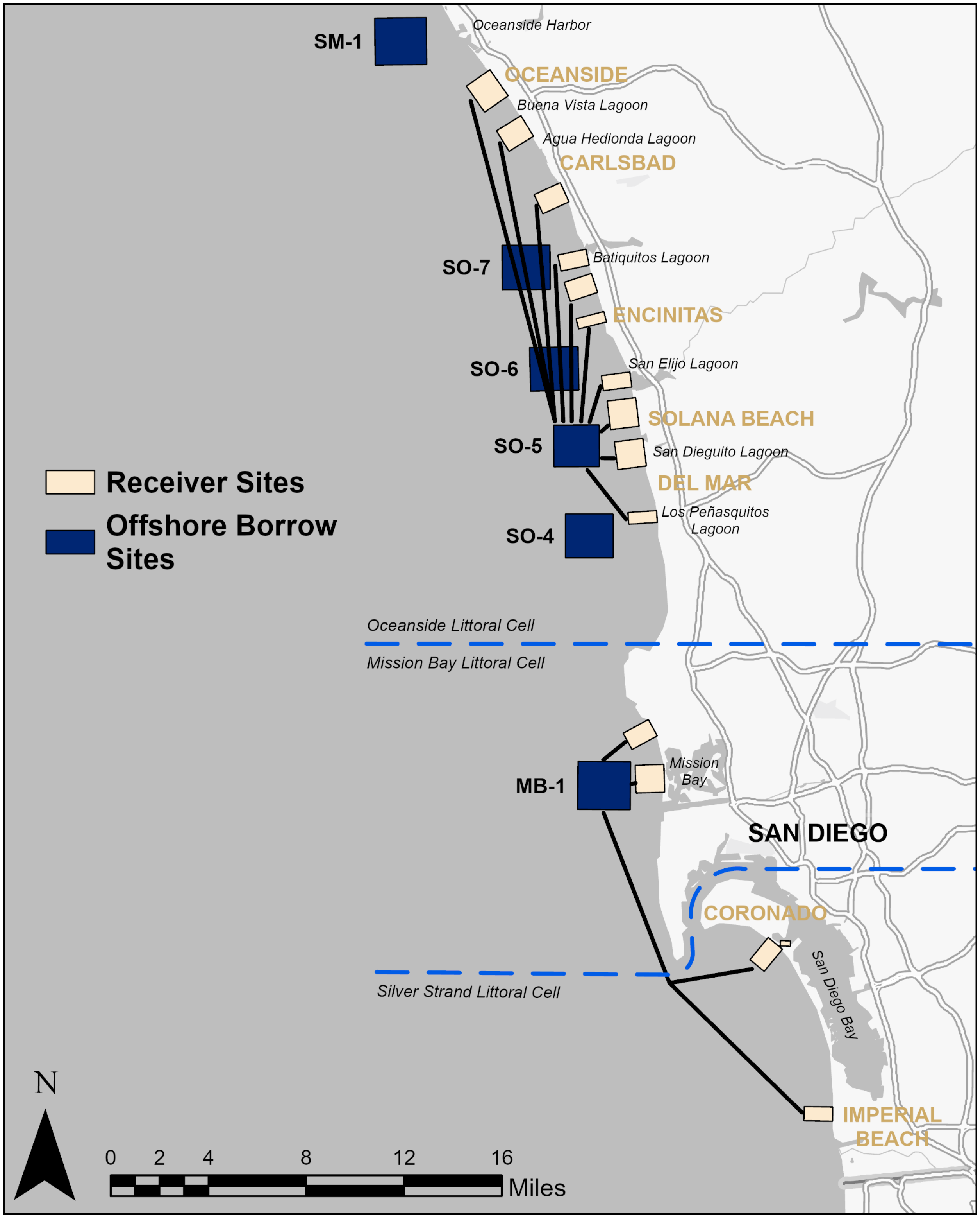


Figure 1-1. RBSP III San Diego County Proposed Borrow and Receiver Sites

site conditions, project components, costs/benefits, as well as efficiencies associated with the elements of RBSP III in Dana Point and San Clemente. Technical studies related to borrow sites and cost/benefits specific to Orange County beaches are included as Appendix C and D, respectively.

1.1 Purpose

The purpose of this Feasibility Study is to evaluate potential strategies to address ongoing beach erosion issues in the Oceanside, Mission Bay, and Silver Strand littoral cells and assess the economic feasibility of regional nourishment through a Benefit-Cost Analysis. Nourishment strategies evaluated for economic feasibility are informed by lessons-learned from past efforts, as well as current conditions in various jurisdictions in each littoral cell. This Feasibility Study will be used by SANDAG and/or others to secure funding to complete this proposed effort of a third RBSP and will provide the basis for future implementation strategies.

2. Site Conditions

The following section provides an overview of the existing RBSP III site conditions, including sea-level rise, sediment budgets and longshore sediment transport rates, wave climate, beach profiles, sediment grain size, shoreline position, nearshore inventory, and other ongoing and planned projects in the region. By analyzing the dynamics of these various aspects along the coast, this section aims to present an understanding of the current site conditions of the beaches in the RBSP III area. Understanding these factors would help determine the necessary next steps for RBSP III, by highlighting the existing sediment deficits or surpluses, shoreline changes, and the status of other past and ongoing sand management efforts that may affect future implementation.

2.1 Sea-level Rise

Climate change and sea-level rise are inherently considered in the design of beach nourishment projects. Global sea levels have steadily risen over the 20th century at an average rate of 2 millimeters per year, with relative sea level trends in the San Diego region following approximately the same rate. Recent scientific consensus suggests that climate change will cause sea level rise to greatly accelerate over the next century, leading to a need for higher sand quantities in order to maintain wide beaches. Nonetheless, RBSP III would likely be implemented within the next 5 to 10 years, where sea-levels are only projected to revise approximately 0.3 to 0.5 ft in the San Diego region according to state sea level rise guidance (OPC 2024). OPC issues mean sea level rise (MSLR) guidance about every five years that is adopted by state agencies and must be considered as part of costal development permit applications. OPC (2024) is the latest and contains a set of MLSR projections through 2150 relative to 2000 at every tide gauge location along the California coast. If programmatic efforts are implemented as part of RBSP III beyond the next 10 years, then future placements cycles should consider larger sand volumes and sand retention strategies to maximize performance with more substantial sea-level rise. Authors such as Flick and Ewing (2009) recommend beach nourishment as a strategy to be able to keep pace with sea-level rise. These authors examined the projected sand volume requirements for southern California beaches based on anticipated future sea-level rise rates and showed a need for sand volumes higher than that proposed for this discrete RBSP III effort. Ultimately, as sea levels continue to rise more rapidly, programmatic and repeated sand nourishment efforts, as well as effective sand retention strategies, would be essential to maintain beach-widths long-term.

2.2 Sediment Budgets and Longshore Sediment Transport Rates

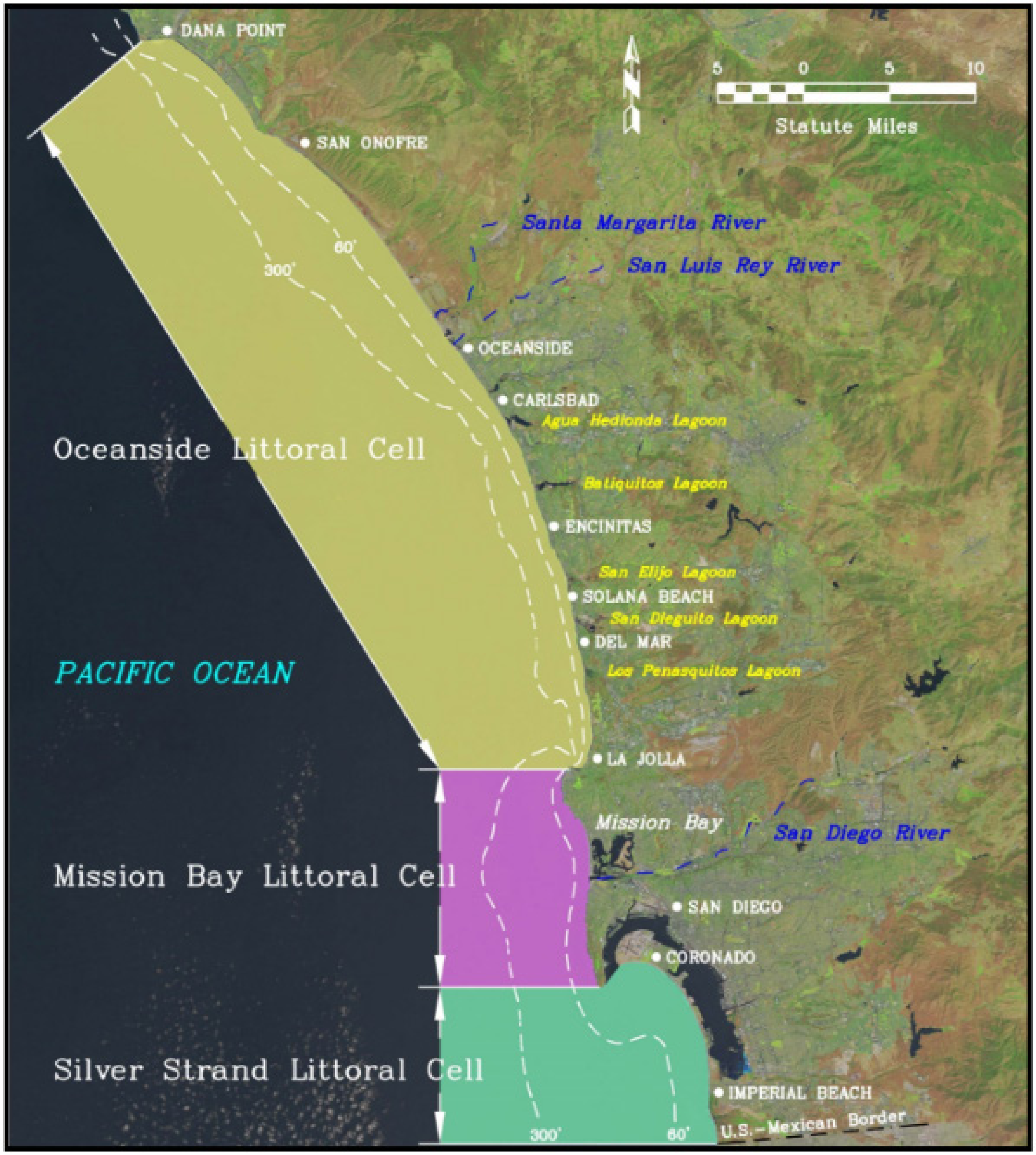
Understanding the dynamics of sediment budgets and longshore sediment transport rates is important for effective coastal management. Two complementary studies put forth by University of California, Santa Cruz titled *Littoral Cells, Sand Budgets, and Beaches: Understanding California's Coastline* (Patsch and Griggs 2006) and *Development of Sand Budgets for California's Major Littoral Cells* (Patsch and Griggs 2007) remain a major source of information on understanding sediment budgets and longshore sediment transport rates for the three littoral cells in the RBSP III area. Information presented in this section was also taken from technical reports, including the 2007 Preliminary Engineering Study for RBSP II (Moffat & Nichol [M&N] 2007), 2009 SANDAG's *Coastal Regional Sediment Management Plan for the San Diego Region* (M&N 2009a), and United States Army Corps of Engineers (USACE) 1991 *Coast of California Storm and Tidal Wave Study, San Diego Region* (USACE 1991). Additionally, more recent studies, such as Kahl et al. (2024) and O'Reilly (2023), have provided updated insights into coastal erosion and sediment transport dynamics specifically in the Oceanside Littoral Cell. Although some of these studies were developed earlier in time than more recent ones, they make use of valuable historic data and trends that are needed to make long-term estimates of sediment budgets and longshore sediment transport rates and directions. Coastal systems have seasonal and even decadal fluctuations making the use of these historic datasets important to understand trends on a larger timescale. It is also worth noting these prior studies indicate the potential to underestimate northward sediment transport due to limitations associated with representing Southern Ocean swell.

The sediment budget concept was developed to understand coastal processes and shoreline change. The sediment budget conceptually accounts for inflows (sources), outflows (sinks), and storage of sediment in a geographic unit referred to as a littoral cell. According to Inman and Chamberlain (1960) and the USACE (1991), a littoral cell is a coastal reach bounded by physical features (e.g., submarine canyons, coastal headlines, harbors) where sediment enters, moves along, and leaves the coastal zone into the ocean. It is the dynamic interface between the ocean and land. Littoral cell sediment sources commonly include river or stream sediment discharge, bluff erosion, onshore migration of sand bars, and artificial nourishment. The sediment sinks are commonly offshore losses at submarine canyons, offshore areas during storms or from deflection by structures, inland losses via wind transport, and capture in lagoon mouths and harbors. Beaches and the nearshore zone represent storage areas in a littoral cell. Sand either moves through a littoral cell along the beach and/or nearshore zone from source to sink, or sand is stored in the cell if the cell is closed. Bounded on one side by the landward limit of the beach and extending seaward beyond the area of breaking waves, the seaward edge of an active littoral cell is defined as its depth of closure[1]. Substantial quantities of sand from coastal littoral cells do not usually travel outside of this depth and into the deeper ocean in large quantities, except during severe coastal storm wave events. Typically, insufficient shoreward energy exists to move sand from outside of the depth of closure back into the littoral cell. Sand located or carried outside of the depth of closure essentially, exits the littoral cell and is no longer available to naturally replenish beaches during the summer.

Ultimately, the sediment budget of a littoral cell is either in balance with stable beaches, in a surplus with growing beaches, or in a deficit with narrowing beaches. Sediment budgets are also time-period specific, particularly when it comes to artificial nourishment contributions; therefore, it should be noted the numbers presented below will continue to change, and planning for RBSP III would continue to use the most up-to-date information available in future phases.

Understanding sediment budget information clarifies whether beaches in the littoral cell are eroding (getting smaller), accreting (getting larger), or stable, and yield information useful in determining the longshore sediment transport rate for characterization of a specific beach site. Longshore sediment transport (aka "littoral drift") reflects the volume and rate of sand moving through a coastal reach over time and occurs in both upcoast (north) and downcoast (south) directions. The direction of sand movement varies seasonally and depends on wave conditions. The total amount of sediment movement over a year is referred to as the gross transport rate, and the difference between the upcoast and downcoast sediment transport rates is referred to as the net transport rate. The volume and direction of net sediment transport represents the effective or predominant littoral drift used in sediment budget calculations. Both aspects of coastal processes (i.e., sediment budgets and longshore sediment transport rates) are summarized below for each of the three littoral cells in the proposed RBSP III area (San Diego County region): Oceanside, Mission Bay, and Silver Strand. The extents of these littoral cells are shown on Figure 2-1. The sediment budget data presented rely on USACE (1990 and 1991) and Patsch and Griggs (2006 and 2007), while longshore sediment transport data rely solely on USACE data.

[1] The depth of closure refers to the water depth at the outer limit of seasonal sand movement, which is the seaward edge of an active littoral cell.



Source: (Coastal Frontiers Corporation [CFC] 2023)

Figure 2-1. Littoral Cells in RBSP III Area

2.2.1 Southern Oceanside Littoral Cell

The Oceanside Littoral Cell extends from Dana Point to Point La Jolla. The Oceanside Harbor North Jetty represents an effective, artificial barrier to sediment transport from the northern to southern portion of the littoral cell; therefore, this littoral cell can be sub-divided into two separate overall sub-cells. This text focuses on the San Diego County portion of the RBSP III area, which occupies most of the southern sub-cell of this littoral cell, from approximately the northern jetty near Oceanside Harbor to La Jolla. The southern Orange County portion of the RBSP III area is in the northern sub-cell. Details regarding the sediment budget and longshore sediment transport rate for the northern Oceanside Littoral Cell specific to southern Orange County are discussed in Section 6.0.

Sediment Budget

Defining sediment budgets for coastal reaches, such as the southern Oceanside Littoral Cell, is very difficult and, at times, can be less than accurate. As stated in Patsch and Griggs (2007), “attempting to average out the often very large year-to-year fluctuations and produce a quantitative budget is extremely difficult.” The information relayed in Patsch and Griggs (2007) is referred to herein but is intended to convey the message that the cell is likely in a deficit condition, as evidenced by observations and data, regardless of the best numeric estimates. Patsch and Griggs (2007) further state, “any littoral cell budget needs to be seen as a work in progress that is complicated and made more difficult by annual variations, uncertainties in measuring and/or quantifying each of the individual components, and human impacts.”

Patsch and Griggs (2007) developed a sediment budget for the southern reach of the Oceanside Littoral Cell and estimated the following inputs: fluvial sources (mainly the San Luis Rey and San Dieguito rivers) are estimated to supply 50,000 cy per year (cy/year), bluff erosion supplies an additional 44,000 cy/year, and on average 220,000 cy/year of material is dredged from the Oceanside Harbor annually. It is estimated that 74,000 cy/year is transported upcoast back into the harbor by littoral drift, while 146,000 cy/year heads south. The sum of each of these inputs is 240,000 cy/year. The 74,000 cy/year sand volume estimated to return to the harbor is not a measurement but rather a result of balancing the assumed sediment budget. Estimates are for the long-term average condition over time and space. More recent data suggest shorter-term and smaller-scale shifts in longshore sediment transport. These are presented in subsequent sections. An attempt is made to present a balanced discussion of sand movement to consider for planning.

Approximately 226,000 cy/year of the 240,000 cy/year total is eventually lost into Scripps Submarine Canyon or offshore. Therefore, the net accretion in the southern Oceanside Littoral Cell may be approximately 14,000 cy/year, which is considered negligible. According to this logic, the Cell would nearly be in balance with inputs being very similar in magnitude to outputs. However, observations and monitoring data indicate otherwise, that the cell is in a deficit of increasing magnitude. Much of the sand moving alongshore may be lost offshore during storms and is stored in the lagoon shoals from Agua Hedionda to Los Peñasquitos. Thus, the implied sediment budget balance may be distorted and not reflected on the beaches due to sand being lost or confined to other areas outside of the beaches.

The information above does not consider the nourishment to the southern Oceanside Littoral Cell by SANDAG in 2001 and 2012, and USACE in 2024, and from restoration of Batiquitos in 1993, San Elijo in 2020, and San Dieguito Lagoon in 2011. Additional detail on more recent nourishment projects is presented in Section 2.8. Each project contributed sand to the littoral cell. SANDAG’s regional shoreline monitoring program[2] has occurred since 1996, is ongoing, and is instrumental in showing shoreline evolution over time. While beaches have continued to narrow after nourishment events, according to the monitoring, the effects of the most recent nourishment by USACE is yet to be reported. It is highly probable that beaches would temporarily widen after nourishment and then progressively narrow again over time unless renourished.

Analysis of regional beach monitoring data support shows an overall average shorezone volume loss since RBSP I in 2001 (CFC 2023). Advances in satellite imagery allow for the remote sensing of beach-widths on a regional scale using data from CoastSat (Vos et al. 2019). Beach-width trends from 2000 and 2021 also support a sediment deficit in the southern Oceanside Littoral Cell, with many beaches retreating at rates greater than 3 ft per year. Since these numbers have been calculated, different nourishment events have occurred in this littoral cell which would affect the overall sediment budget. As discussed above, these numbers will continue to change, and planning for RBSP III will continue to use the most up-to-date information in future phases.

Longshore Sediment Transport Rates

As discussed above, longshore sediment transport consists of gross and net transport components. Various estimates for longshore sediment transport in the southern Oceanside Littoral Cell (USACE 1990 and 1991) show a wide range depending on the calculation method. Generally, the maximum estimate of gross transport is 1,400,000 cy/year, and the minimum estimate is 400,000 cy/year, with an average near

[2] Additional information on SANDG’s regional monitoring program can be found here SANDAG - Monitoring Program.

1,000,000 cy/year. Net sediment transport ranges from 0 cy/year to 550,000 cy/year to the south, with the average being approximately 275,000 cy/year to the south.

Reversals in sediment transport occur seasonally and over certain years. Summer and fall seasons are typically dominated by southern hemisphere swells that generate currents and sediment transport to the north. This is evidenced by the 74,000 cy/year of sand transported upcoast back into Oceanside Harbor after annual maintenance dredging (Patsch and Griggs, 2007). Over certain years, the southern hemisphere swell component can dominate, causing net sediment transport to be northward rather than southward. Most researchers consider the long-term net sediment transport condition to be southward (USACE 1991), although there is uncertainty regarding Southern Ocean swell and potential northward sediment transport.

A recent study from University of California, Irvine (Kahl et al. 2024), suggests that longshore sediment transport direction and magnitude is temporally and spatially variable, and in some areas the dominant direction is northward. The results of this Feasibility Study indicate numerous inflection points along the Oceanside Littoral Cell where dominant net sediment transport direction changes from north to south, suggesting a more spatially fragmented coastline than previously thought. Additionally, Dr. William O'Reilly of Scripps Institution of Oceanography (O'Reilly 2023) has presented on mini-cells in the southern Oceanside Littoral Cell. These mini-cells are influenced by the presence of lagoons, tidal inlets, deltas and other bathymetric/topographic variations along the coast, contributing to variabilities in sediment transport. O'Reilly's findings indicate that the sand transport rate varies along the coast near lagoon mouths. Specifically, that transport is highest just downcoast of a lagoon mouth where beaches are narrow, and drops in magnitude as sand approaches a lagoon mouth and beaches become wider. Also, while sand transport is generally estimated to be from north to south (with some uncertainties), transport reverses to be from south to north during non-El Niño winters around lagoon and creek mouths. El Niño winters and atmospheric river conditions support sediment flowing offshore and southward (i.e., more like the traditional understanding of the southward migrating river of sand). Non-El Niño winters have observed transport reversals around lagoon and creek mouths where sediment flows northward (O'Reilly 2023). These findings show the complexity and evolving understanding of sediment transport dynamics within the Oceanside Littoral Cell, highlighting the need for monitoring, ongoing research, and adaptive coastal management strategies.

2.2.2 Mission Bay Littoral Cell

The Mission Bay Littoral Cell extends from Point La Jolla to Point Loma and is divided into several sub-cells. The sub-cells relevant to the RBSP III study include the sub-cells from La Jolla to Pacific Beach (PB) Point and from PB Point to Mission Beach Jetty.

Sediment Budget

A sediment balance exists from La Jolla to PB Point, with no sand entering the sub-cell at La Jolla and no sand passing PB Point. According to Patsch and Griggs (2007), the sub-cell from Point La Jolla through Mission Beach receives an annual sediment inflow of 3,000 cy/year from artificial beach nourishment sourced from dredging the interior of Mission Bay, 9,000 cy/year from bluff erosion, and 34,000 cy/year backpassed from the Mission Bay entrance channel. This sediment flow results in an average annual sand supply of 46,000 cy/year for the northern Mission Bay Littoral Cell. However, this scenario may not accurately reflect the history of sediment management within this littoral cell, as regular backpassing of sand from the Mission Bay Entrance Channel is not a recurring practice but has occurred only once in time in 2010 and cannot be depended upon to provide sand backpassing benefits in the future. Therefore, the planning and design of projects in the Mission Bay Littoral Cell will not be based on sand backpassing as a sediment budget component, and the sediment supply to this cell may be significantly lower than stated in the referenced document.

The southern sub-cell of the Mission Bay Littoral Cell is characterized by wide sandy beaches held in place by the Mission Bay jetties. Beginning as early as 1921 (Patsch and Griggs 2007), Mission Bay was extensively modified to create an aquatic park for boating and tourist activities. In 1949-1950, three jetties were constructed to separate the Mission Bay entrance and the San Diego River outlet. The northern jetty currently act as sand retention structures that helps create the existing wide beach at Mission Beach. It is estimated that approximately 12,000 cy/year of sand is stored behind retention structures or lost offshore along this reach. Additionally, there is an estimated 18% reduction in the natural sediment supply due to damming of the rivers and seacliff armoring throughout the entire Mission Bay Littoral Cell.

Beach monitoring efforts (CFC 2023) indicate that the shoreline position in the Mission Bay Littoral Cell has not significantly changed (less than 1 foot) since RBSP I in 2001. However, shorezone volumes have on average increased, suggesting that the littoral cell may be balanced or have a sediment surplus.

Longshore Sediment Transport Rates

The gross sediment transport rate in the Mission Bay Littoral Cell is 200,000 cy/year, while the net longshore sediment transport along Mission Beach and PB ranges from 20,000 cy/year to 90,000 cy/year towards the south (USACE 1991).

2.2.3 Silver Strand Littoral Cell

The Silver Strand Littoral Cell extends from Point Loma to the Coronado Canyon located in Mexico. There are two relevant sub-cells in this littoral cell for RBSP III: the Strand sub-cell which extends from the San Diego Bay entrance channel to the Tijuana River Delta, and the Tijuana River Delta sub-cell which extends from the Tjuana River Delta to the Coronado Canyon. The RBSP III study area is nearly contiguous with the Strand sub-cell.

Sediment Budget

According to Patsch and Griggs (2007), the Tijuana River is the only natural sediment source in this littoral cell, supplying an estimated 42,000 cy/year of sand to the system. It is assumed that this sand supplied by the Tijuana River is divided equally by the northern and southern littoral drift, with 21,000 cy/year traveling south to supply sand to Imperial Beach and Silver Strand. This sand eventually makes its way north and is either deposited at Zuniga Shoal, lost offshore, or accumulated in the entrance channel of San Diego Bay. Historically, very large quantities of sand removed from the dredging of San Diego Bay were placed on the beaches of Silver Strand, Coronado, and Imperial Beach, averaging to approximately 256,000 cy/year between 1967 and 2005. The Silver Strand Littoral Cell is one of the most highly nourished cells in all of southern California. Large quantities of sand were dredged from San Diego Bay and placed on the beach here to make the Bay navigable for naval vessels (Everts 1987). From 1941 - 2005, almost 40 million cy of sand was dredged from San Diego Bay and placed on beaches along the Silver Strand Littoral Cell, widening the beaches by up to 1,000 ft from Silver Strand State Beach to Zuniga Jetty (Patsch and Griggs 2007). However, CFC (2023) suggests this quantity has since decreased, with the littoral cell receiving 44,000 cy/year since RBSP I in 2001.

Beach monitoring in this littoral cell suggests that the shorezone has been losing sand volume at an average rate of 42 cy/year per ft of shoreline since RBSP I. Despite this information, shoreline positions have not significantly changed and remain stable (CFC 2023). Beaches are still wide north of Coronado Shores due to their extreme historical width toward North Island; however, the beach is narrow at the Coronado Shores and to the south along the north end of the Navy Seal Training area. Coronado Shores varies in width over its length and narrow areas are a concern and warrant consideration for nourishment due to a lack of natural sand sources in the area.

Longshore Sediment Transport Rates

The gross sediment transport rate is 740,000 cy/year, while the net longshore sediment transport rate ranges from 120,000 cy/year to 200,000 cy/year towards the north (USACE 1991). Patsch and Griggs (2007) indicate that there may be an inflection point in transport direction at the Tijuana River delta (i.e., sediment moves north, north of the delta and south, south of the delta).

2.3 Wave Climate

Waves are the driving force in generating longshore currents, sediment transport, and shoreline changes. The waves climate in the RBSP III area is described below.

Four main categories of ocean waves occur off the coast of southern California: 1) northern hemisphere swell, 2) tropical swell, 3) southern hemisphere swell, and 4) seas generated by local winds. Each wave type is described below (Moffatt & Nichol 1988).

1. Northern hemisphere swell represents the category of the most severe waves reaching the California Coast. Deepwater significant wave heights rarely exceed 10 ft, with wave periods ranging from 12 to 18 seconds. However, during extreme northern hemisphere storm events, wave heights may exceed 20 ft with periods ranging from 18 to 22 seconds.

2. Tropical storms develop off of the west coast of Mexico during the summer and early fall. The resulting swell rarely exceeds 6 ft, but a strong hurricane in September 1939 passed directly over the southern California area and generated waves recorded at 26.9 ft.

3. Southern hemisphere swell is generated by winds associated with winter storms in the South Pacific and Southern Ocean. Typical southern hemisphere swell rarely exceeds 4 ft in height in deep water, but with periods ranging up to 18 to 21 seconds, they can break at over twice that height.

4. Sea is the term applied to steep, short-period waves which are generated either from local storms, strong pressure gradients over the area of the Eastern Pacific Ocean (Pacific High), or the diurnal sea breezes. Wave heights are usually between 2 and 5 ft with an average period of 7 to 9 seconds.

A southern California wave exposure diagram is shown on Figure 2-2. The region from Dana Point to San Diego is directly exposed to ocean swell entering from three main windows (Moffatt & Nichol 1988). The northernmost window extends from approximately 310 to 280 degrees (relative to true North) where wind waves cause local seas in the Santa Barbara Channel that can travel to San Diego County. The northwestern window, where severe northern hemisphere storms enter, extends from 290 to 250 degrees. The Channel Islands (San Miguel, Santa Rosa, Santa Cruz and Anacapa) and Santa Catalina Island provide some sheltering from higher waves associated with these two windows, depending on the approach direction. The third major exposure window opens to the south from 250 to 150 degrees, allowing swell from southern hemisphere storms, tropical storms (hurricanes), and pre-frontal seas caused by onshore southwest winds ahead of approaching cold weather or storm fronts.

With the predominance of wave energy reaching this coastline from the northern hemisphere, wave-driven currents typically run from north to south throughout winter and spring, causing most of the longshore sediment transport. As this coast is also significantly exposed to the southern swell (from both the southern and northern hemispheres), seasonal reversal in littoral drift and longshore sediment transport occurs. Variable climatic cycles result in a range of conditions, with periods of dominant southward sediment transport, followed by periods of more balanced sediment transport. The shoreline morphology adjusts to predominant conditions and over the long-term is oriented to southward sediment transport, with sediment inputs to the littoral cell typically from the north and outputs from the littoral cell typically to the south.

As mentioned previously, O'Reilly (2023) has presented evidence from wave data and sediment transport estimates that indicate the long uniform trend of sediment transport along northern San Diego County may actually be quite variable and split into mini-cells. Southward sediment transport can be interrupted at each mini-cell with an offshore flow component just downcoast of a lagoon mouth. This interruption suggests that longshore sediment transport is near zero just south of a lagoon mouth, with the rate gradually increasing toward the south and reaching a maximum at the next lagoon mouth. There are six lagoons in northern San Diego County, and they are spread between 2 and 5 miles apart. Therefore, the longshore sediment transport rate can vary tremendously over a relatively short reach of coast. The cause of the mini-cells is yet to be entirely clear but is likely related to lagoon tidal ebbs and floods, tidal ebb deltas, and wave refraction and diffraction over bathymetric variations along the coast. Figure 2-3 shows the concept of coastal lagoon littoral sub-cells.

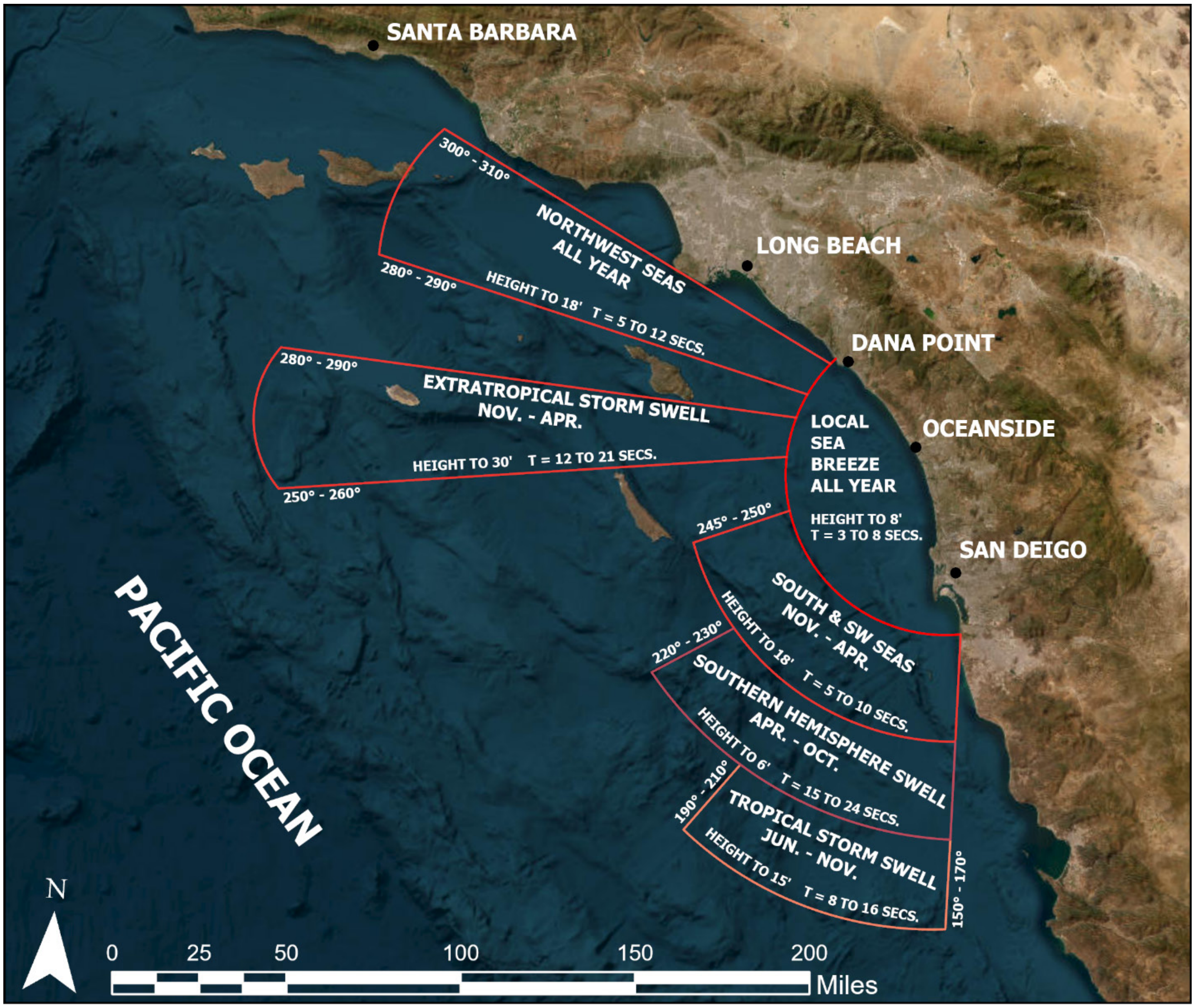
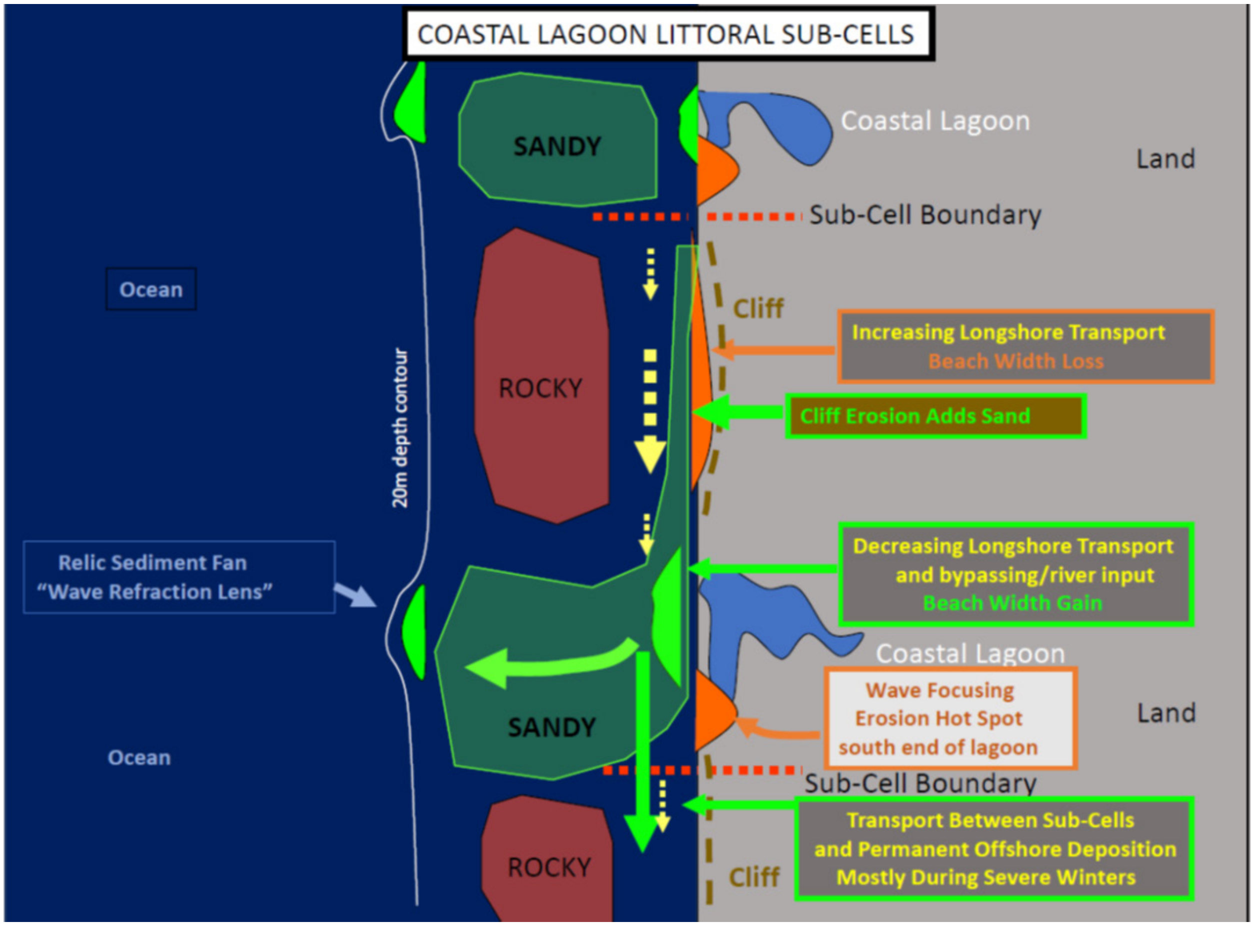


Figure 2-2. Southern California Wave Climate

In addition, the longshore sediment transport rate and direction are both significantly affected by El Niño events, Pacific Decadal Oscillation, and other global climatic phenomena. Reverses in the global oceanic and atmospheric circulation can trigger different storm patterns and variable wave conditions, which can directly affect longshore sediment transport patterns along the southern California coast and cause reversals in patterns over time and space. Global climate change may further complicate this situation and lead to long-term changes that are not yet evident. Predictions include increased southern hemisphere storm activity and wave generation in the future, leading to increased northward sediment transport over time.



Source: O'Reilly 2023

Figure 2-3. Coastal Lagoon Littoral Sub-Cells

2.4 Beach Profiles

SANDAG has managed a regional beach monitoring program since 1996 (CFC 2024) and coastal sandy shoreline cities proportionately pay a share to sponsor the program. This effort is augmented by similar programs undertaken by several coastal cities (i.e., Oceanside, Carlsbad, Encinitas, and Solana Beach). Scripps Institution of Oceanography (SIO) also conducts long-term beach change monitoring and detailed studies of regional coastal change (SIO-UCSD 2024). In recent years, there has been increased coordination between the SIO-UCSD and SANDAG CFC programs. The general objective of the program is to obtain a quantitative understanding of coastal changes in the region. The results also are used to monitor the fate of nourishment material and inform future sea-level rise adaptation strategies.

The program consists primarily of semi-annual (spring and fall) beach profile surveys conducted along shore-perpendicular transects with a typical alongshore spacing between transects of less than 0.5 miles. The program study area extends from Oceanside Harbor to the United States-Mexico border and includes the southern half of the Oceanside Littoral Cell, Mission Beach Littoral Cell, and northern portion of the Silver Strand Littoral Cell. The number of transects included in the program has varied from 24 to 61 (Figure 2-4).

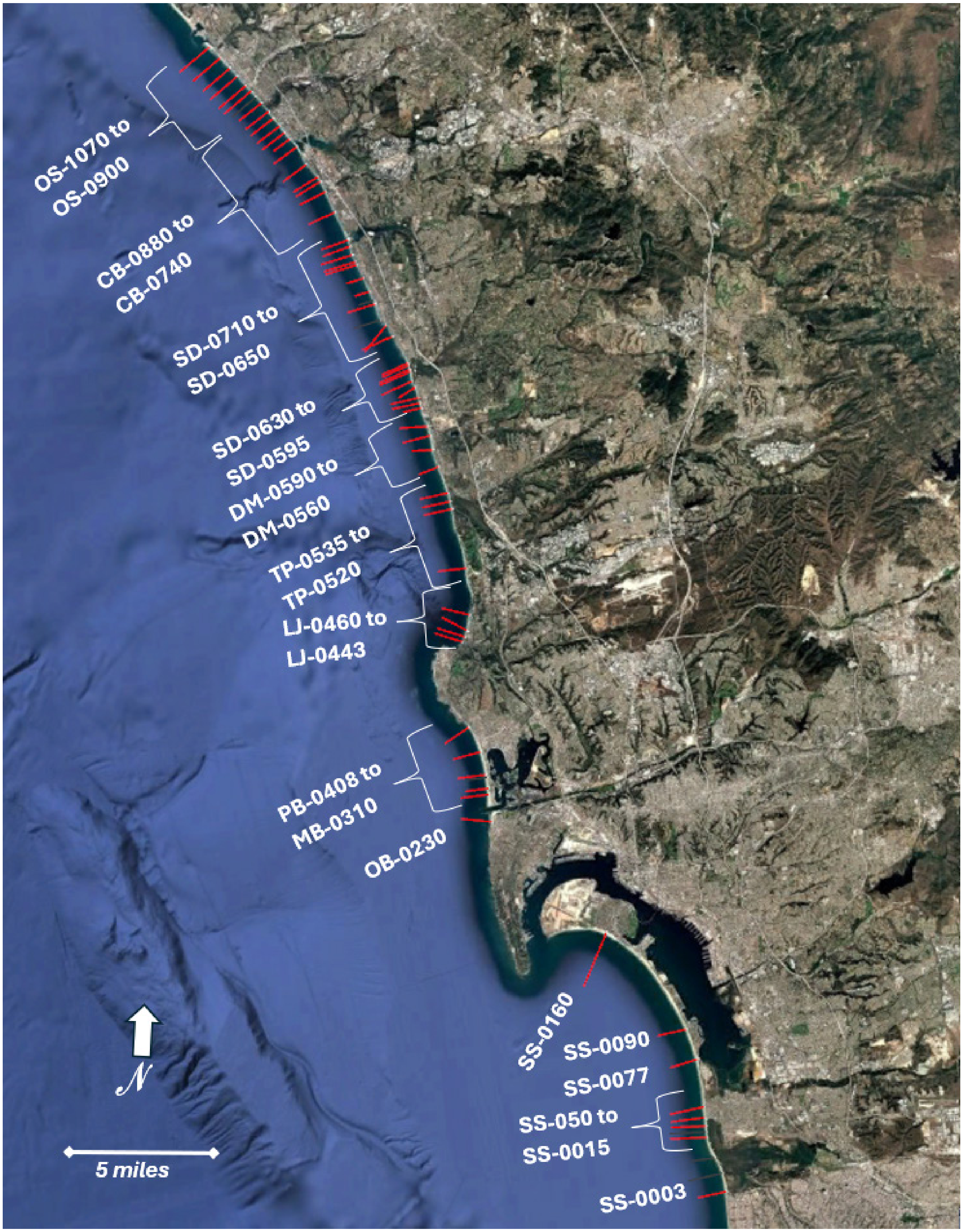


Figure 2-4. SANDAG Shoreline Monitoring Program, Beach Profile Transect Location Map

Beach profile data are obtained along each transect from the back beach to a location beyond the estimated depth of closure. The surveys are conducted in the spring and fall, corresponding with the beginning and end of the winter and summer wave seasons, and the results are used to assess the shorezone changes and evaluate the impact of natural events (e.g., El Niño) and human intervention (e.g., beach nourishment). Comparison of the spring and fall profiles provides an indication of seasonal changes, while comparison of consecutive fall profiles shows the nature of inter-annual and long-term changes. Shoreline position and sediment volume calculated from the beach profiles serve as a primary analysis tool.

Table 2-1 summarizes the beach profile characteristics in the 12 sub-reaches in the program study area. The berm height was estimated from a representative transect in the sub-reach, while the depth of closure value corresponds to the deepest value among the transects in a given sub-reach. Additional details are provided in SANDAG's Annual Shoreline Monitoring Reports (CFC 2024).

Table 2-1. Beach Profile Characteristics in San Diego County Sub-Reaches

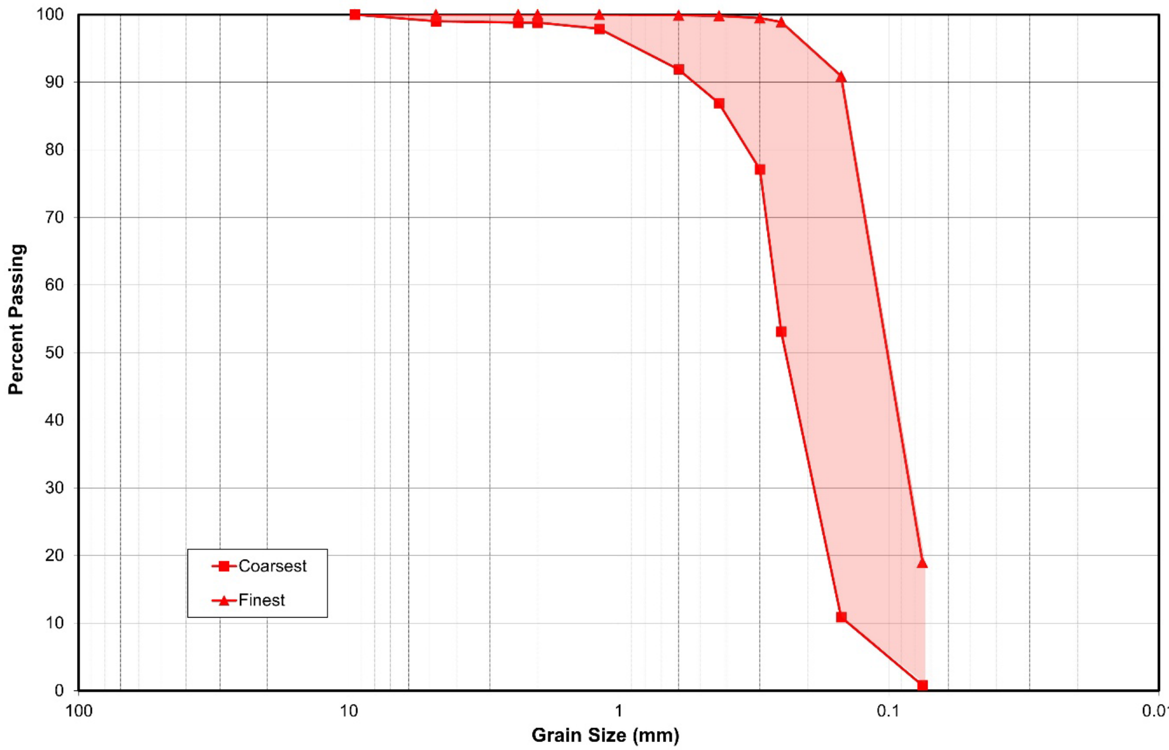
Sub-Reach	Representative Transect	Berm Height (ft MLLW)	Depth of Closure (ft MLLW)
Oceanside	OS-0930	12	-25
North Carlsbad	CB-0865	12	-20
South Carlsbad	CB-0775	10	-24
Encinitas/Leucadia	SD-0670	13	-30
Cardiff	SD-0630	12	-28
Solana Beach	SD-0600	10	-16
Del Mar	DM-0580	10	-30
Torrey Pines	TP-0520	10	-32
La Jolla	LJ-0450	9	-19
Mission Beach	MB-0340	10	-29
Coronado	SD-0160	10	-24
Imperial Beach	SS-0035	10	30

The berm height and depth of closure values in Table 2-1 can be used to estimate the loss of beach due to sea-level rise using the equilibrium beach profile concept proposed by Dean (1991). Similarly, beach-width gains from artificial sand nourishment events can be estimated using these values along with grain size information. Both the loss and gain of beach-width in these sub-reaches were taken into account to estimate the proposed nourishment volumes required to achieve a desired beach-width as part of RBSP III.

2.5 Sediment Grain Size

Sediment grain-size data are essential for analyzing the compatibility of a sand source for beach nourishment. This data is a tool to predict the longevity of a beach fill, the dispersion rate of sand from a beach fill project, and morphologic changes over time. For example, based upon the outcomes of RBSP I and RBSP II, beach fills composed of coarser material tended to persist longer than those fills composed of finer grained material.

Sand in a given littoral cell ranges in grain size along the beach profile. Typically, coarser sand sits at the upper end of the beach profile (on the beach) and into the surf zone, while finer sand sits farther off of the beach in quieter water. The coarsest sand is in the breaker zone between 0 and -6 ft mean lower low water (MLLW), where wave energy is highest, and the finest sand rests out toward the depth of closure, around -30 ft MLLW. Thus, existing sand grain sizes form an "envelope" of gradations, from fine to coarse along the beach profile. This gradation envelope represents the range of grain sizes at a particular beach and serves as the basis for comparing a sand source for beach nourishment. Source sand is generally considered compatible if it falls within the existing gradation envelope or is close to its margins. An example of a grain size envelope is shown below in Figure 2-5.



Note: mm=millimeter

Figure 2-5. Example Grain Size Envelope Based on Composite Gradation Curves of the Existing Beach at Del Mar

Several studies have documented the grain-size distribution of San Diego beaches. USACE (1989) developed a protocol for sampling beaches and preparing the gradation envelope. This method is also described in the Sand Compatibility Opportunistic Use Program (SCOUP) document (M&N 2006). This protocol involves sampling sand from the surface, starting from the top of the beach profile at +12 ft MLLW and extending to the closure depth at -30 ft MLLW at 6-foot vertical intervals. This results in eight samples being taken at +12 ft, +6 ft, 0 ft, -6 ft, -12 ft, -18 ft, -24 ft, and -30 ft. Sampling is conducted at two profiles on any one beach that are positioned 0.25 miles apart. The samples are then taken to a laboratory where they are dried and mechanically sieve-tested. The laboratory results are provided as gradation matrices and graphs with gradation curves. The results include the grain size data for each beach that can be used to develop the gradation envelopes and determine the statistical median grain size. The median grain size is the mid-point of the sand grain size range and is representative of the most commonly occurring grain size on the beach.

As part of the efforts for RBSP I and RBSP II, grain-size data were collected by several entities, including USACE (1984), Woodward-Clyde Consultants (1998), and CFC (2010) for several receiver sites throughout San Diego County. The results from each effort indicated most of the region's beach sand was fine to medium in grain size, as defined by the Unified Soil Classification System[3] (American Society for Testing Materials 1999). Northern San Diego County beaches tend to have slightly coarser sand than southern San Diego County beaches, but the difference is typically minor. In northern San Diego County, native beach sand has a median grain size (the mid-point of the gradation range of the material) between 0.25 and 0.30 millimeter (mm), whereas in southern San Diego County, the median grain size ranges from 0.20 to

[3] The Unified Soil Classification System is a widely used method in engineering for categorizing soils based on their texture and grain size.

0.25 mm. During the future planning phase of project development for RBSP III, additional analysis of grain size may be performed to ensure optimal compatibility of offshore sources for each receiver site to maximize duration of beach fills.

2.6 Shoreline Position

As discussed in Section 2.4 above, SANDAG and several coastal cities have managed shoreline monitoring programs in the RBSP III area consistently for nearly three decades. The programs include beach profile surveys conducted during each year in the spring and fall to capture seasonal, annual, and long-term changes. Beach-widths are computed from the beach profile data as the distance between the landward edge of the beach sand and the point at which the beach profile intersects the plane of the MSL Datum, which can include both wet and dry beach areas. The results are tabulated in SANDAG's Annual Shoreline Monitoring Reports (CFC 2024).

Beach-width provides an indication of recreational area as well as the protection afforded to upland facilities. Comparing fall and spring beach-widths indicates winter seasonal changes (typically erosion), while comparing spring and fall beach-widths shows summer seasonal changes (typically accretion). Additionally, comparing fall beach-widths show the nature of inter-annual and long-term changes.

Table 2-2 summarizes the beach-width changes and trends documented in 12 sub-reaches in the San Diego region between 2000 and 2023. Beach-widths are presented as average values based on the available transects in each sub-reach with consistent measurements dating back to 2000. The uneven spacing between transects was accounted for by weighting each value according to the alongshore distance associated with the corresponding transect. The 23-year period between 2000 and 2023 encompasses both RBSP I and RBSP II, as well as several opportunistic nourishment programs. Nourishment quantities placed in each sub-reach are provided for reference. Sand bypassing quantities from harbors and lagoons are not included because this process does not add new sand to the littoral system. Rather, sand bypassing returns sediment to the littoral system that has been trapped by these coastal features. While bypassing does not increase the quantity of sediment in the littoral cell, it plays a crucial role in maintaining the distribution of sediment within the system and provides a local benefit to the sand placement sites.

Table 2-2. Beach-Width Changes in San Diego Region Sub-Reaches, 2000 to 2023

Sub-Reach	Fall 2023 Beach-Width (ft)[1]	Beach-Width Change (ft)[1] Fall 2000 to Fall 2023	Beach-Width Trend (ft per year)[1,2] Fall 2000 to Fall 2023	Beach Nourishment (cy)[3] Fall 2000 to Fall 2023
Oceanside	117	-27	-2.2	714,000
North Carlsbad	107	+41	+0.9	444,000
South Carlsbad	91	-35	-1.8	299,000
Encinitas/Leucadia	121	-81	-3.0	650,000
Cardiff	184	+69	+3.9	547,000
Solana Beach	217	+109	+4.8	455,000
Del Mar	163	-21	0.0	183,000
Torrey Pines	91	-109	-3.6	245,000
La Jolla	204	-5	0.0	None
Mission Beach	239	+9	0.0	601,000
Coronado	737	-30	-3.4	56,000
Imperial Beach	134	+25	-0.1	904,000

Notes:
1 Average shoreline data derived from the 44 transects included in the fall 2000 and 2023 surveys.
2 Trends derived by linear regression (fall surveys only).
3 Includes RBSP I, RPBSP II, and opportunistic projects. Sand bypassing and backpassing quantities are not included.
4 Harbor Beach is not included in Oceanside beach-width trend analysis and rationale.

The average beach-width among the 12 sub-reaches at the time of the fall 2023 survey ranged from 737 ft at Coronado to 91 ft at both South Carlsbad and Torrey Pines. The latter were the only two sub-reaches where the average beach-width fell below 100 ft. The average beach-width exceeded 200 ft at four sub-reaches (Solana Beach, La Jolla, Mission Beach, and Coronado). Over the 23-year period between the fall 2000 and fall 2023 surveys, net beach-width gains were observed at five sub-reaches (North Carlsbad, Cardiff, Solana Beach, Mission Beach, and Imperial Beach). Net beach-width losses occurred at the remaining seven sub-reaches (Oceanside, South Carlsbad, Encinitas/Leucadia, Del Mar, Torrey Pines, La Jolla, and Coronado). This outcome reflected shoreline change rates ranging from accretion of 4.8 ft per year (Solana Beach) to erosion of 3.6 ft per year (Torrey Pines). Ultimately, the shoreline position data are used to evaluate the need for beach nourishment, likely performance of beach fills, and optimum renourishment intervals.

2.7 Nearshore Biological Inventory

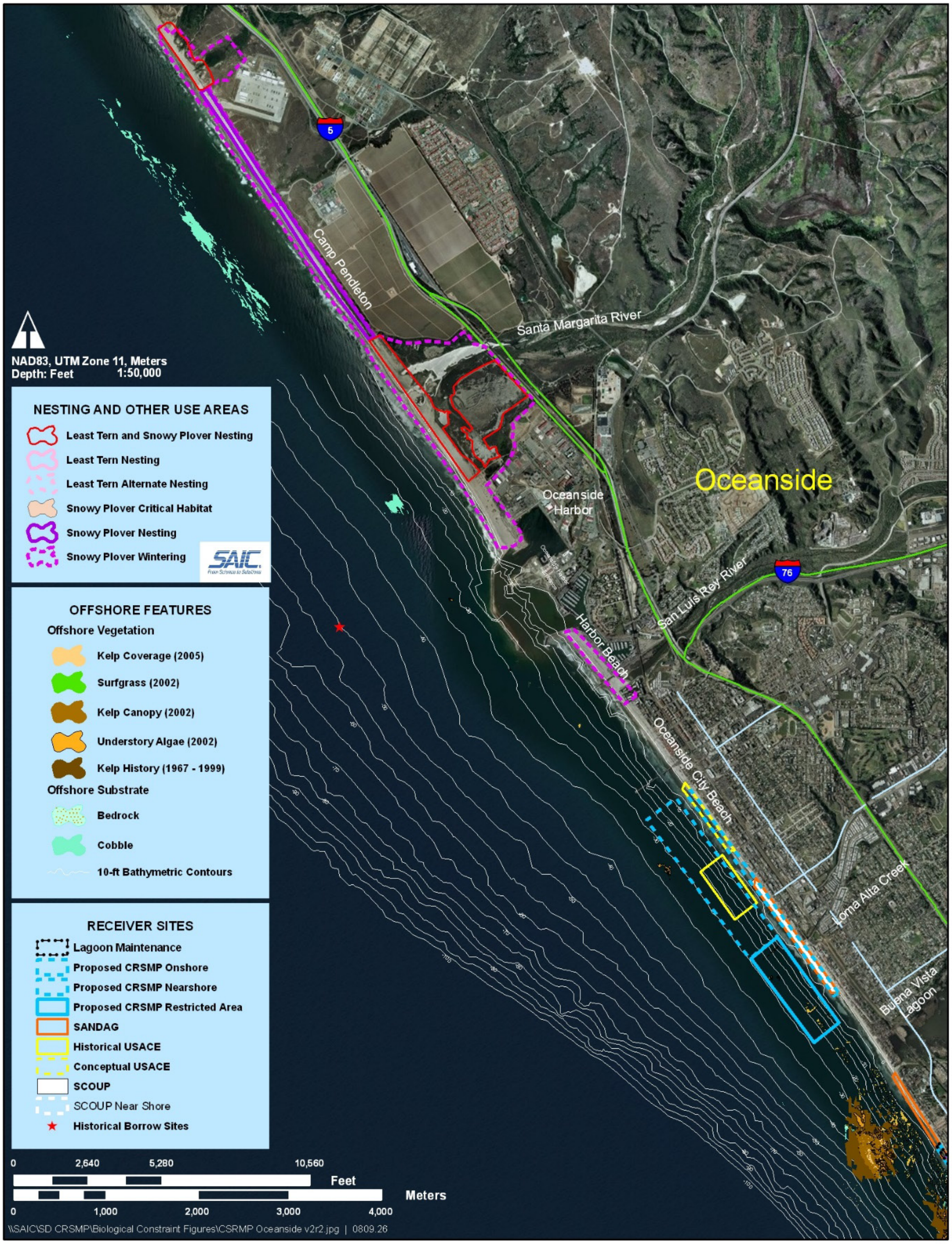
A wide variety of marine ecosystems and nearshore biological habitats occur in the proposed RBSP III area and include sandy beaches, sandy offshore habitat, rocky reefs, kelp forests, and seagrass beds. Sandy beach habitat supports shorebirds, including the threatened western snowy plover, and provide spawning habitat for the California grunion, a state-managed fish. Additionally, pismo clam beds occur in some locations in sandy substrate extending from intertidal to nearshore depths. Soft-bottom habitats also support eelgrass beds and diverse invertebrate populations, which provide a food source for various demersal fishes that live on or near the bottom. Nearshore reefs and kelp beds support a diverse community composed of a variety of macroalgae, invertebrates, and fishes, while marine mammals forage on invertebrates and fish throughout the water column over hard or soft bottoms and within kelp beds. These marine biological resources support important commercial fisheries are the target of recreational fishing and diving, and are the subject of educational research. In addition, federally designated habitat areas of particular concern include canopy kelp beds, seagrasses, and rocky reefs. Several marine protected areas also occur within or in close proximity to the proposed project area and include (from north to south): Batiquitos Lagoon State Marine Conservation Area (SMCA), Swami's SMCA, San Elijo Lagoon SMCA, Scripps Coastal SMCA, Matlahuayl State Marine Reserve, South La Jolla SMCA, Cabrillo State Marine Reserve, and Tijuana River Mouth SMCA.

Comprehensive reports have been prepared that summarize known resources in both San Diego and Orange counties (M&N 2009a; 2011; Tierra Data Inc. 2016); however, these studies are old, and digital spatial data are unavailable due to the inability to obtain the original data files from the appropriate sources. Table 2-3 lists known potential data sources, year of most recent surveys, and an assessment of whether those data are dated and/or available. Figures 2-6 through 2-14 graphically present the nearshore marine biological resources from Oceanside to Imperial Beach, using available data from 2011 and 2020. Table 2-3 indicates where existing conditions information would need to be updated to evaluate potential impacts to marine habitats from the proposed RBSP III. New studies or reports will be taken into consideration when planning for future phases of RBSP III.

Table 2-3. Spatial Habitat Data in the RBSP III Area

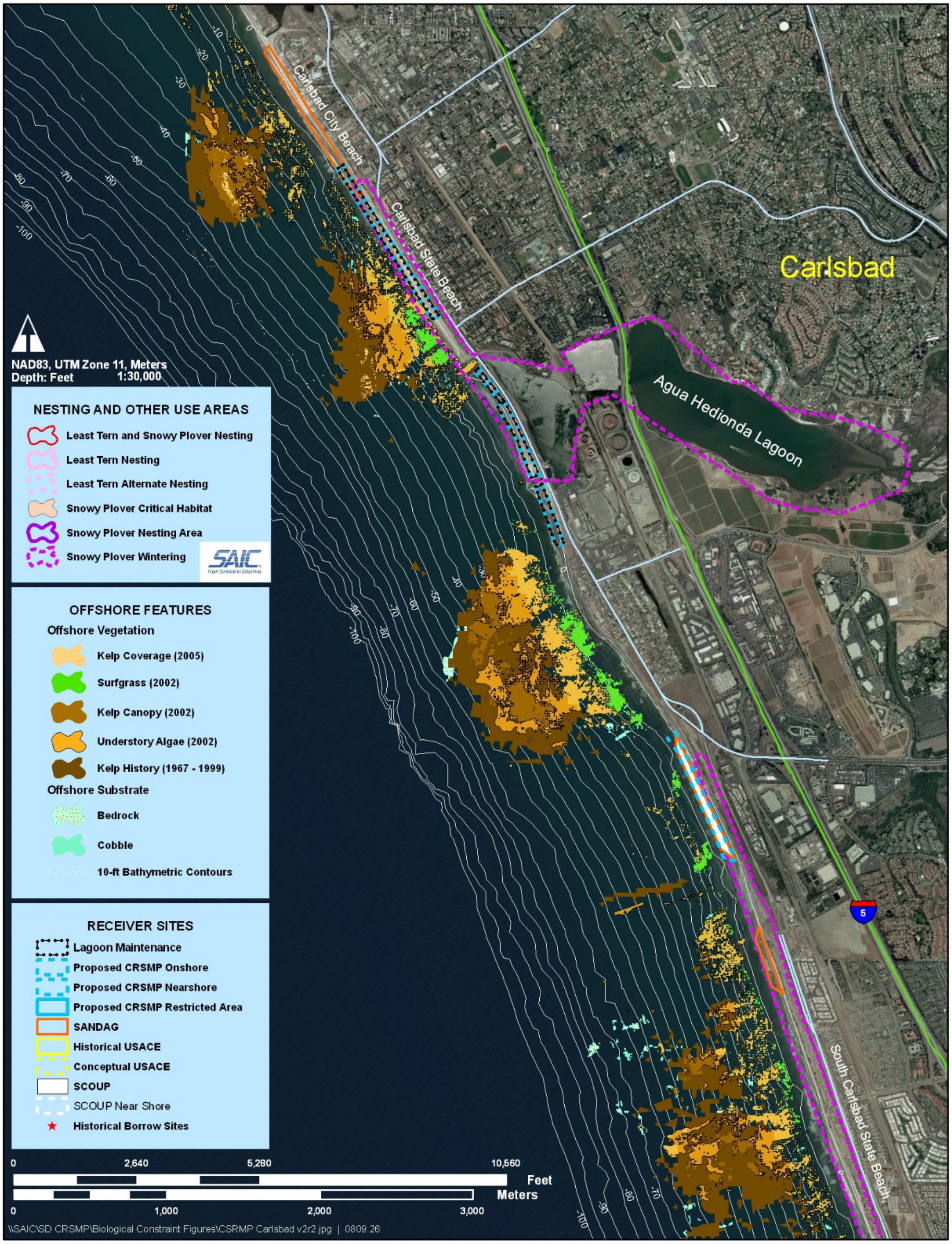
Receiver Beach	Existing Known Data Sources	Spatial Data Available?	Requires Updating Prior to Project Implementation (Year Surveyed)
Oceanside	M&N 2009a Tierra Data Inc. 2016	Yes No	No*
North Carlsbad	M&N 2009a M&A 2023	Yes	No** (2023)
South Carlsbad	M&N 2009a	Yes	Yes
Batiquitos	M&N 2009a M&A 2024	Yes	No** (2022)
Leucadia	M&N 2009a M&A 2024	Yes	No** (2022)
Moonlight Beach	M&N 2009a M&A 2024	Yes Yes	No** (2022)
Cardiff	M&N 2009a M&A 2024	Yes Yes	No** (2022)
Solana Beach	M&N 2009a M&A 2024	Yes Yes	No** (2022)
Del Mar	M&N 2009a	Yes	Yes
Torrey Pines	M&N 2009a	Yes	Yes
Tourmaline	M&N 2009a	Yes	Yes
Mission Beach	M&N 2009a	Yes	No*
Coronado	M&N 2009a	Yes	Yes
Glorietta Bay	M&A 2020	Yes	No** (2020)
Imperial Beach	M&N 2009a	Yes	Yes

Notes:
M&A = Merkel & Associates
*Historical data indicates few sensitive resources of concern; therefore, updated information is not necessary.
**Assumes RBSP III implementation is initiated within 5 years of the last survey and may require an update if RBSP III is initiated beyond 5 years of the last survey.



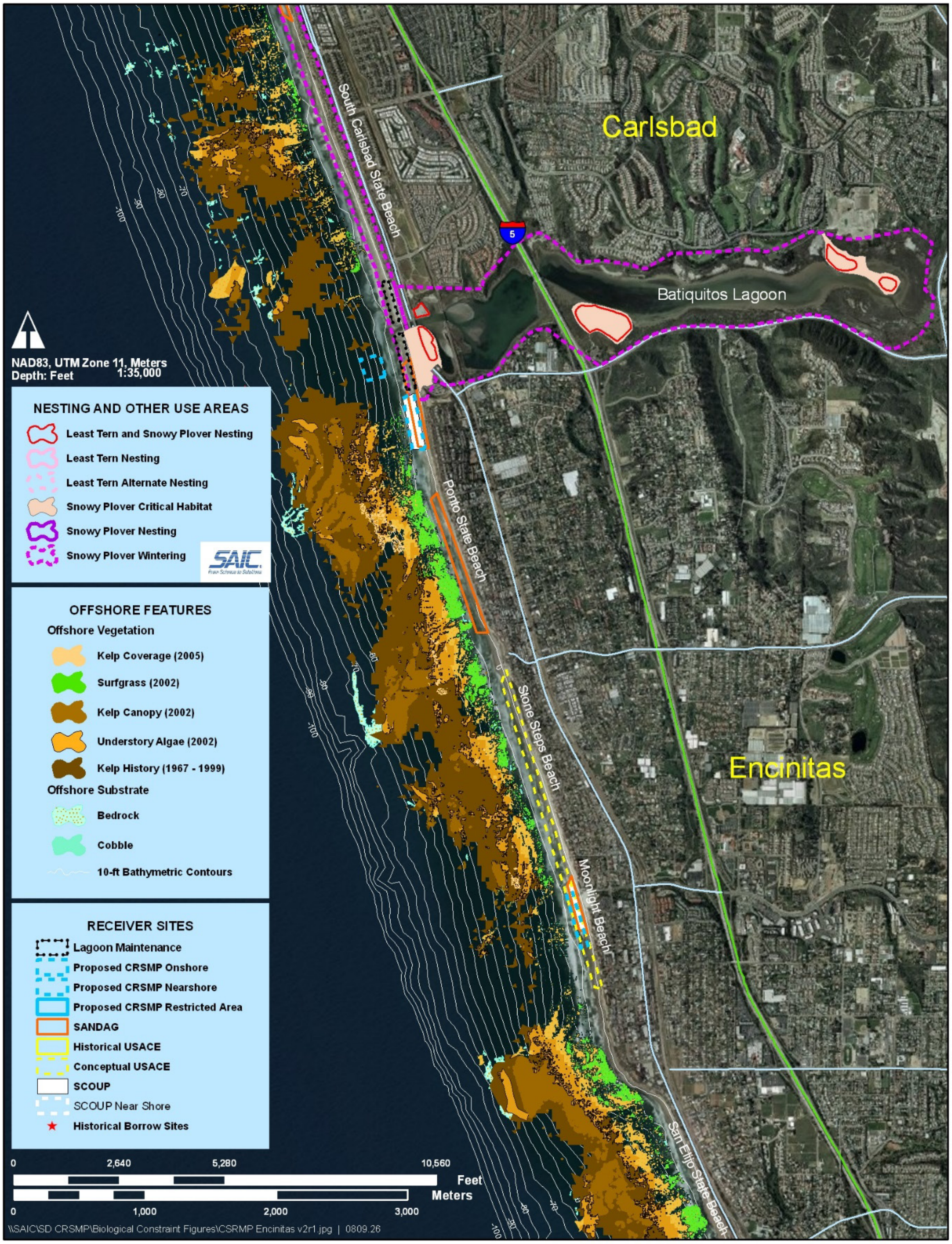
Source: M&N 2011
Notes: CRSMP = Coastal Regional Sediment Management Plan

Figure 2-6. Sensitive Biological Resource Areas in the Vicinity of Oceanside



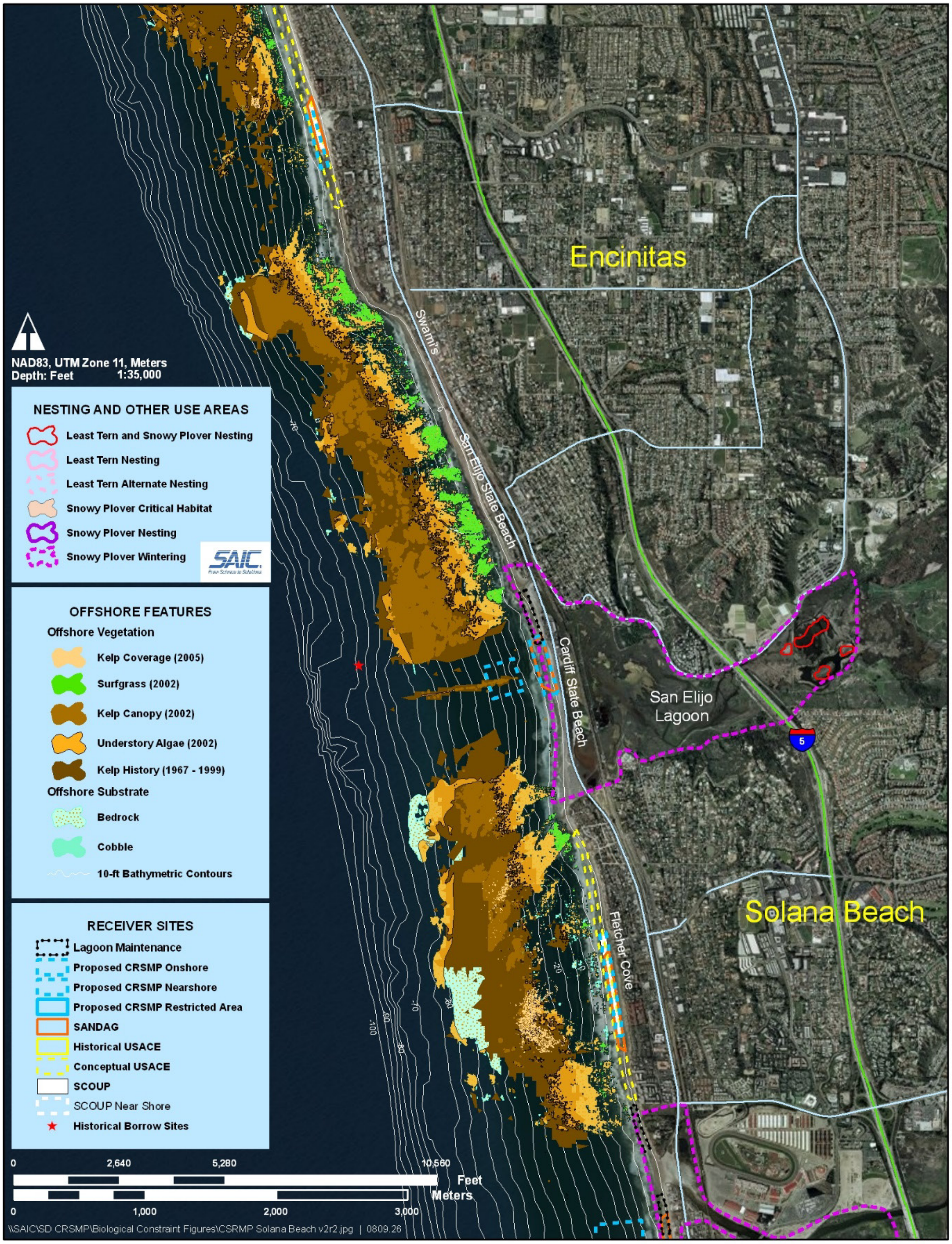
Source: M&N 2011

Figure 2-7. Sensitive Biological Resource Areas in the Vicinity of Carlsbad



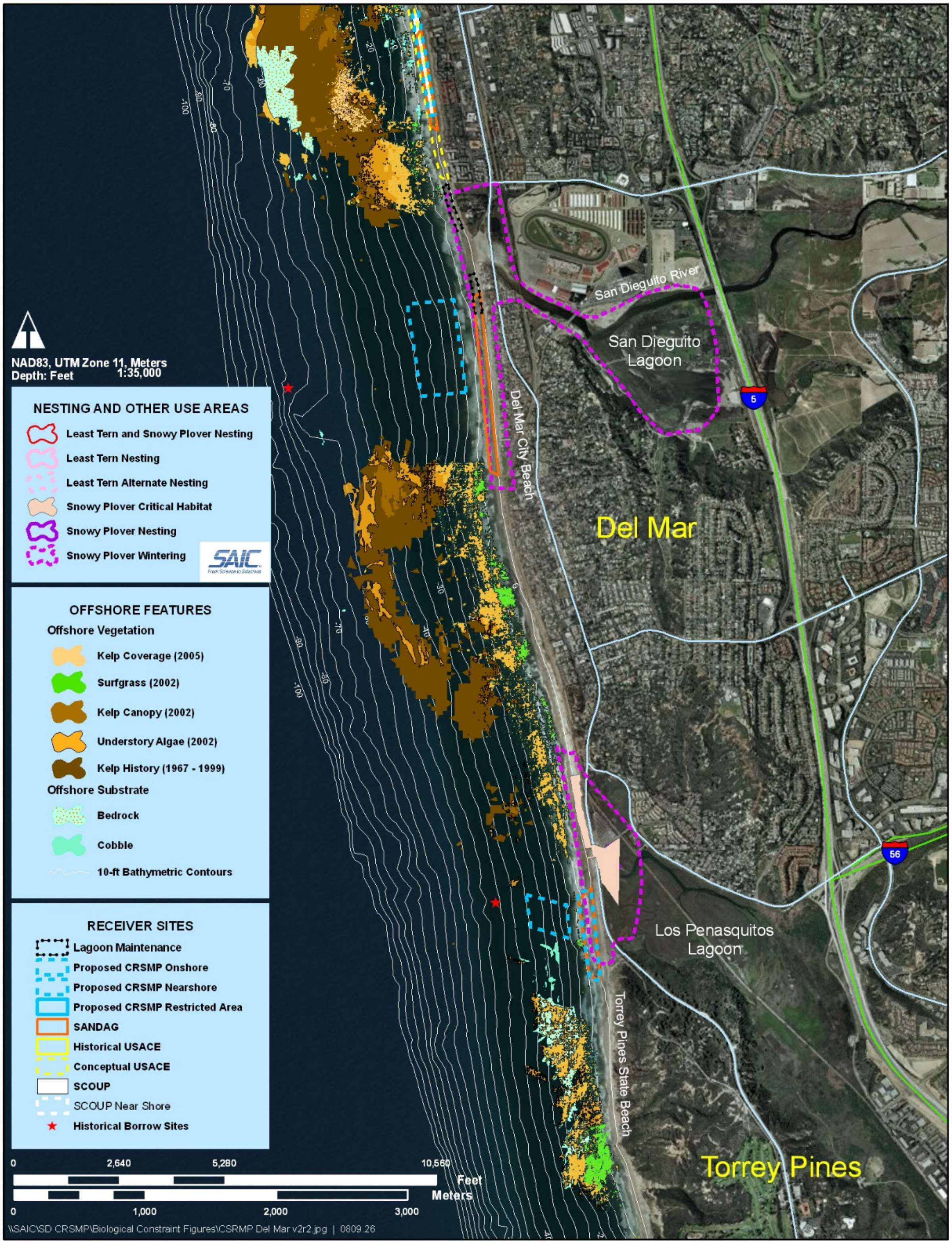
Source: M&N 2011

Figure 2-8. Sensitive Biological Resource Areas in the Vicinity of Carlsbad and Encinitas



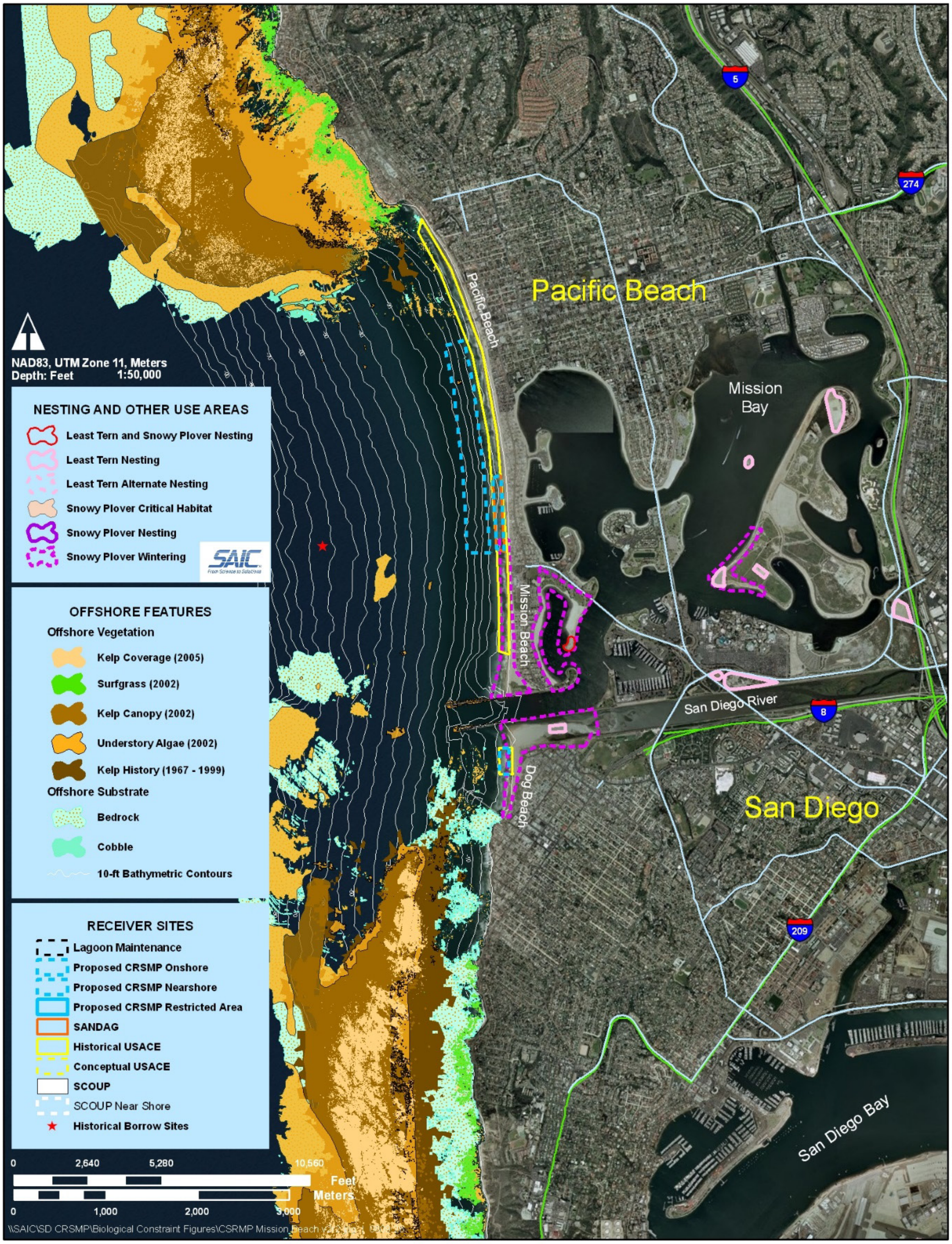
Source: M&N 2011

Figure 2-9. Sensitive Biological Resource Areas in the Vicinity of Encinitas and Solana Beach



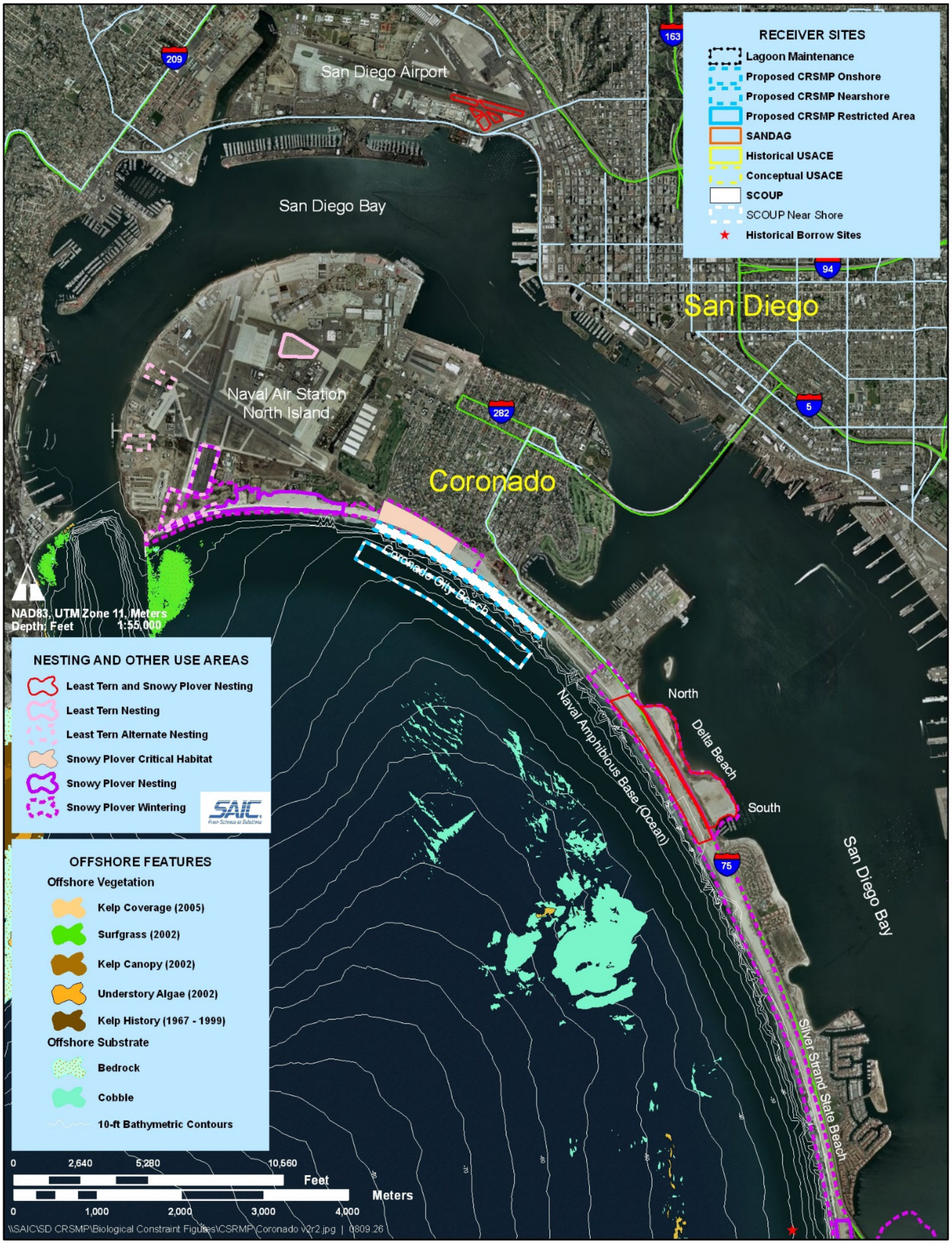
Source: M&N 2011

Figure 2-10. Sensitive Biological Resource Areas in the Vicinity of Del Mar and Torrey Pines



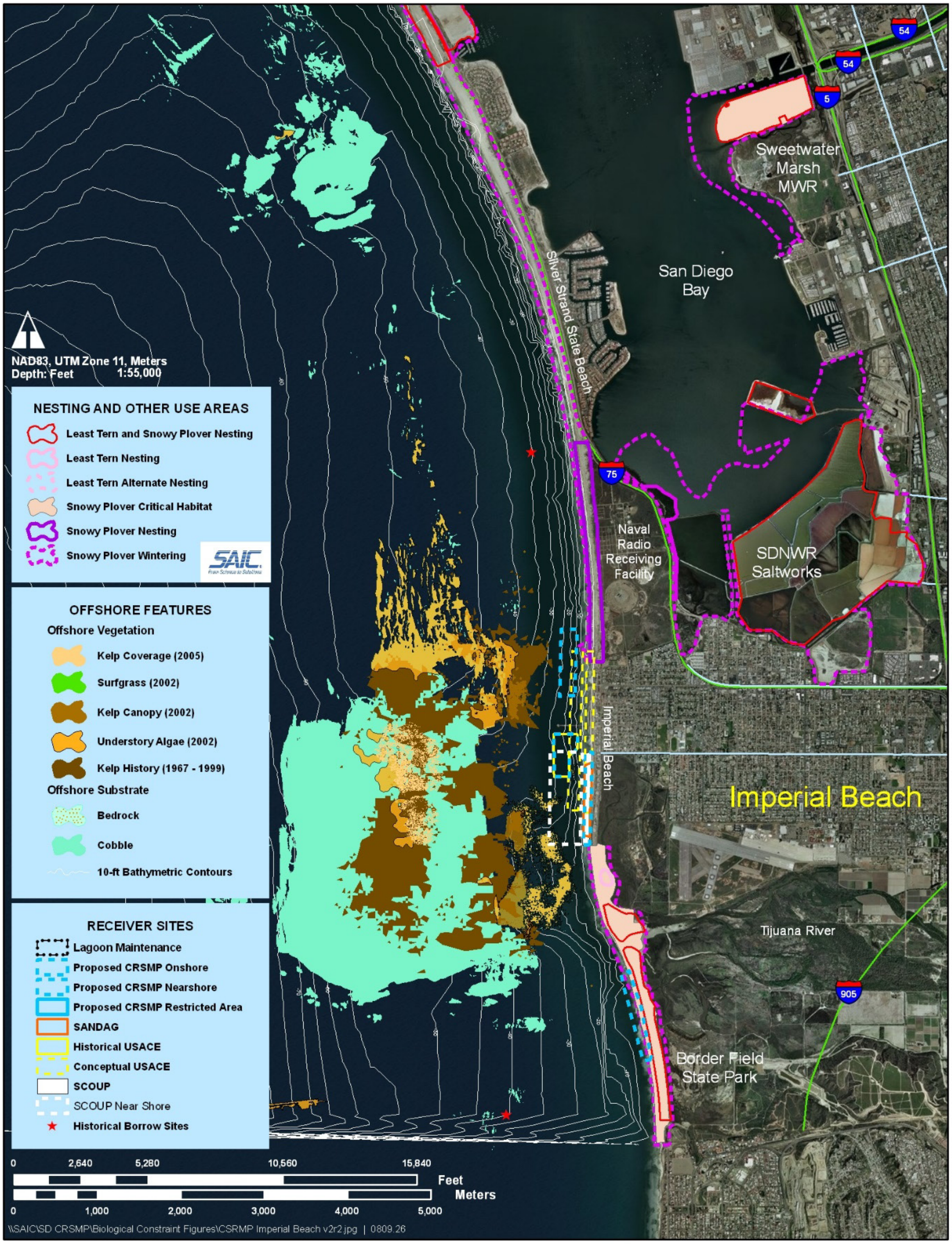
Source: M&N 2011

Figure 2-11. Sensitive Biological Resource Areas in the Vicinity of Mission Beach



Source: M&N 2011

Figure 2-12 Sensitive Biological Resource Areas in North San Diego Bay in the Vicinity of Coronado



Source: M&N 2011

Figure 2-13. Sensitive Biological Resource Areas in the Vicinity of Imperial Beach

Source: M&A 2020

Figure 2-14. San Diego Bay 2020 Eelgrass Distribution

2.8 Other Related Projects (ongoing, planned, and potential)

Sand management activities have been conducted in the San Diego region for decades. Beach replenishment efforts have included large-scale beach restoration projects (e.g., RBSP I and RBSP II), projects placing sand from dredging of lagoons (e.g., Batiquitos Lagoon Restoration, San Elijo Lagoon Restoration Project [SELRP]), and small-scale maintenance dredging of harbors (e.g., Oceanside Harbor bypassing). Several jurisdictions have also adopted the SCOUP concept to capture smaller-scale sand sources that would otherwise be landfilled or disposed of (M&N 2006). A SCOUP allows jurisdictions to implement individual nourishment projects, typically over a 5-year period restricted by the regulatory permits. Sand placed at specific locations as a result of these activities disperses throughout the littoral system over time, eventually becoming too dispersed to be measurable in a single location. Specific detail is presented below by project type.

Large-scale Placement Projects

Prior to implementation of RBSP I in 2001, sand nourishment projects placed 3.3 million cy of sand along the coastline between 1994 and 2000 (CFC 2010). Between 2001 and 2023, a majority of sand placed in the region was from RBSP I and RBSP II (3.6 million cy in 2001 and 2012). Most of the non-RBSP nourishment has derived from activities whose primary motive was not beach replenishment, such as dredge spoils associated with lagoon restoration. Notably, the Batiquitos Lagoon Restoration between 1994 and 1997 contributed over 1.8 million cy, Agua Hedionda Lagoon functional improvements added another 560,000 cy in 1998, and SELRP added 446,000 cy in 2018. The sand from SELRP was beneficially reused to restore a historic dune system as part of the Cardiff State Beach Living Shoreline Project. Future sources of opportunistic nourishment are expected to include lagoon restoration at Buena Vista Lagoon, and potentially at Los Peñasquitos Lagoon. Enhancement at Buena Vista Lagoon is anticipated to yield up to 1,000,000 cy of beach sand, but the implementation schedule is currently unknown.

The most recent large-scale beach nourishment project has been the USACE Encinitas/Solana Beach Coastal Storm Damage Reduction Project (Encinitas/Solana Beach Project), which is a 50-year project in the Oceanside Littoral Cell conducted by USACE Los Angeles District, City of Encinitas, and City of Solana Beach. The purpose is to effectively reduce life safety risks and economic damages associated with the bluff and beach erosion along the shorelines of the two cities. A secondary purpose is to reduce erosion and shoreline narrowing to improve coastal access and recreational opportunities for the public. The authorized plan consists of sand nourishment in the Encinitas/Leucadia sub-reach and the Solana Beach sub-reach. The initial phase of the 50-year project was completed in May of 2024 with placement of 1,040,000 cy of sand dredged from the SO-5 borrow site. The initial placement in the Encinitas/Leucadia sub-reach totaled 340,000 cy of sand, with renourishment placement of 220,000 cy per event planned at 5-year intervals. At the Solana Beach sub-reach, the initial placement totaled 700,000 cy, with renourishment placement of 290,000 cy per event planned at 10-year intervals.

Routine Maintenance Placement Projects

Regular sand bypassing has been conducted at Oceanside Harbor and several lagoon entrances in the Oceanside Cell to return sediment to the littoral system that has been otherwise trapped. In the Oceanside Cell, bypassing operations occur at Oceanside Harbor, Agua Hedionda Lagoon, Batiquitos Lagoon, San Elijo Lagoon, San Dieguito Lagoon, and Los Peñasquitos Lagoon (CFC 2024). Sand backpassing also occurs at Agua Hedionda Lagoon and sand is retained effectively to establish beaches adjacent to the four jetties along the beach, particularly at Tamarack Beach. Bypassing is not regularly undertaken in the Silver Strand and Mission Beach cells but has occurred episodically. Because sediment trapping is a continuous process, bypassing operations typically are conducted at periodic intervals. Between 2001 and 2023, 225,000 cy/year were removed from Oceanside Harbor and placed on adjacent beaches, with a portion of that sand returning north to the harbor over time. At Agua Hedionda, bypassing operations yielded 122,000 cy/year to Carlsbad-area beaches. More sporadic bypassing at Batiquitos Lagoon resulted in 15,000 cy/year placed on adjacent beaches. At the unstabilized[4] entrances of San Elijo, San Dieguito, and Los Peñasquitos Lagoon, the annualized bypassing rates were 19,000 cy/year, 7,000 cy/year, and 25,000

[4] An unstabilized lagoon entrance is natural, dynamic opening between the lagoon and the ocean that has not been engineered or reinforced to maintain a fixed location, shape, or depth.

cy/year, respectively. Sand bypassing at Oceanside Harbor, Agua Hedionda Lagoon, Batiquitos Lagoon, San Elijo Lagoon, San Dieguito Lagoon, and Los Peñasquitos Lagoon is expected to continue at comparable rates in the future; however, it also is noteworthy that the historical bypassing rates at the unstabilized lagoons (San Elijo Lagoon, San Dieguito Lagoon, and Los Peñasquitos Lagoon) are dependent on available funding at each location. As such, future bypassing rates may vary if funding levels change. Although bypassing does not increase the quantity of sediment in the littoral cell, it plays a crucial role in maintaining the distribution of sediment within the system.

Opportunistic Placement Projects

Opportunistic sand nourishment is also expected to continue in the future on an as-available basis, with several jurisdictions maintaining active permits under a SCOUP. The cities of Encinitas and Solana Beach have placed approximately 174,000 cy under SCOUP permits as part of six projects (five in Encinitas, consisting of 151,600 cy, and one in Solana Beach, consisting of 22,400 cy). Both the City of Encinitas and Solana Beach have pursued amendments or extensions of their SCOUP permits every five years since they originally secured their permits in 2009 and 2018, respectively, and increased to 10-year terms more recently in 2024. The City of Del Mar also secured permits for a SCOUP in 2024 to place up to 180,000 cy in placement envelopes north and south of the San Dieguito river inlet. No specific project under the Del Mar SCOUP is planned at this time, but is likely to take place within the next 5 years. Other potential future sources may include inland construction projects, flood control projects, or harbor dredging (e.g., San Diego Harbor). The City of Oceanside is also in the process of developing their own SCOUP.

Planned Projects

Additionally, the City of Oceanside is actively pursuing a shoreline restoration pilot program. The project, termed “RE:BEACH”, consists of sand nourishment and retention. As currently envisioned, the concept proposes one multi-purpose offshore artificial reef and two headlands acting as groin-like structures, supported by approximately 1,000,000 cy of nourishment, with renourishment of 300,000 to 500,000 cy occurring at 5-year intervals. RE:BEACH is currently still in the design and funding stage.

The Los Peñasquitos Lagoon Foundation and California State Parks are planning the Torrey Pines Living Shoreline Project. This project is in the preliminary planning phases but should be considered in future phases of RBSP III for the potential to collaborate.

The above events are not intended to be an exhaustive list of past and ongoing beach nourishment and related maintenance projects. However, included efforts were considered and taken into account when determining the proposed receiver site locations and volumes for RBSP III. The proposed project would complement or build upon these efforts. Analysis of potential cumulative impacts as a result of RBSP III would be completed as part of the planning phase as required by federal and state environmental regulations.

3. Lessons Learned and Recommendations for Efficiencies

Beach and littoral cell nourishment has become a recognized strategy to combat beach erosion and damage that can occur along eroded shorelines to structures and facilities. Beach nourishment is a nature-based climate solution to adapt to future sea level rise, while promoting recreational opportunities. As discussed in Section 2.8 above, there is a long history of beach nourishment projects in the San Diego region, including RBSP I and RBSP II, as well as a number of more localized opportunistic nourishment efforts. Each of the efforts can inform future projects and help identify strategies to enhance the efficiency and/or cost-effectiveness of project design, approval, and implementation. Specific lessons-learned or recommendations for efficiencies are presented below by project phase and should be considered for incorporation into future efforts. These potential streamlining opportunities build on previous projects and nourishment efforts. These streamlining strategies may not be as effective if future efforts propose expanded or newly identified receiver sites and/or volumes.

3.1 Project Goals

Beach nourishment not only provides economic benefits but also restores sandy beach conditions critical to many sensitive species. To qualify for funding, economic benefit compared to project cost is prioritized. Emphasizing the restoration component of future projects, along with economic benefits, would provide a broader context for regulatory and resource agency coordination and permit approvals. The loss of beach habitat threatens foraging and spawning support functions for multiple species, and short-term impacts from sand placement are typically more than offset by the long-term gain in ecological function resulting from beach nourishment. Highlighting the importance of sensitive species support that results from implementation of such nourishment projects should be emphasized as a key project objective. This would be in addition to the objectives of prior projects, which were protection of infrastructure, public property, and recreational opportunities with corollary economic value.

As stated in the introduction to this Feasibility Study, sand replenishment projects help offset the gradual narrowing and disappearance of the region's beaches or rapid more catastrophic beach loss associated with severe winter storms, loss of environmental, recreational, economic, and aesthetic benefits, and the increasing destruction of coastal access, infrastructure, and other properties. The first two RBSPs were implemented out of necessity as individual pilot projects, focused on sand placement only. The previous projects were not able to holistically address shoreline needs or solutions. This project looks to include more beaches and address a potentially larger geographic area. It also may include other measures, such as sand retention to test the efficacy of this approach to improve the cost-effectiveness of nourishment.

3.2 Design

With two significant regional beach nourishment efforts complete (i.e., RBSP I and RBSP II), SANDAG has gained valuable insight that could be applied to future project design. The first two RBSPs were specifically designed to avoid causing significant permanent environmental impacts. The goal of nourishment is to accomplish positive benefits to the coast while maintaining environmental sensitivity to the greatest degree feasible. Based on experience from both RBSP I and RBSP II, this section includes lessons learned regarding project design for future beach nourishment.

Additional and larger suitable borrow sites should be identified to provide flexibility and redundancy during construction. Increasing the number of suitable borrow sites is crucial to ensure there is enough suitable sand to accommodate the region's need for beach nourishment. Borrow sites with a larger area would also allow the dredging contractor more room for mobility and efficiency of movement. Specific borrow sites proposed for RBSP III are discussed in Section 4.2 below.

As compared to other sites, retention devices should be evaluated for areas that are known for limited beach fill lifespans or longevity to help maintain or increase the width of the beach over longer reaches of the coast. The beach fill performance data from Section 3.6 below show which areas had the shortest sustained period of beach-width gain post-RBSP I and RBSP II and are the areas likely to benefit most from retention devices. Retention opportunities could include the proposed RE:BEACH project in Oceanside or other approaches such as groins discussed further in Section 4.5 below. Retaining sand for extended periods reduces the frequency of required nourishment, thereby enhancing project success and achieving cost savings. Sand retention devices are already widely used in southern California and all over the world to maintain beach width on coasts with critical sand deficits, or natural or artificial barriers to sand movement. The idea of expanded envelopes for specific receiver site footprints should also be evaluated for RBSP III. Instead of increasing the proposed placement volume, a maximum envelope approach for placement would increase the proposed placement area to allow some additional flexibility during sand placement. A larger envelope would be analyzed for a conservative maximum, but placement would ultimately occur within the envelope area for what would perform best depending on conditions at the time of placement. For example, longer and narrower fill footprints are typically longer-lived.

Access routes to receiver sites should be analyzed and designed to ensure efficient delivery of equipment such as pipelines, bulldozers, fuel trucks, and lighting. Sensitive habitat, traffic, recreational use of parks, and other ongoing project construction, needs to be considered when planning access routes. For example, based on experiences from RBSP I, access points for RBSP II were refined at Solana Beach, South Carlsbad, Moonlight, and Cardiff beaches.

The location strategy for the dredge discharge line from the sea to the shoreline (i.e., the subline) should also be analyzed to realize cost efficiencies and avoid potential impacts based on past projects. The subline is typically positioned to pass through areas clear of subtidal rocky habitat areas and kelp beds. As such, it may not necessarily be located as close as possible to a particular receiving beach. Positioning the subline to avoid potential impacts reefs and to be as close as possible to receiver site(s) may decrease the cost of delivery (due to shorter pump distances) and shorten construction periods, thus rendering the project more environmentally sensitive.

Design of beach fills near homes or popular surfing areas should also take into consideration past experiences. After RBSP II placement in Imperial Beach in 2012, concerns were raised regarding ponding on the beach near homes and wave reflection off of the beach. Placement of the beach fill with a level surface (beach berm) resulted in water ponding on the beach in front of homes during a combined condition of king tides and high waves. The water ponding condition may have exacerbated preexisting water seepage into underground parking garages, associated nuisances and "damages." One potential approach to reduce this concern would be to design the berm to include a subtle and gradual slope from the rear of the beach towards the water to prevent ponding. This could be achieved by sloping the beach fill from an elevation of +13 ft MLLW at the landside of the beach to +11 ft MLLW at the seaward edge before dropping towards the water, ensuring drainage of ponded water from the beach to the sea. One other consideration is that even if sand is placed with a seaward slope, the ocean may build up a small "lip" along the seaward edge of the berm during the conditions in which water is held on the berm. That lip may need to be periodically knocked down by the local City Public Works Department with a bulldozer or front-end loader to maintain drainage off of the berm.

Additionally during RBSP II in 2012, the Imperial Beach fill was constructed with a seaward slope of 2:1, while the design showed a desired slope of 10:1. The steeper slope was installed in order to keep the beach fill footprint within the seaward boundary of the template that was shown in the permits and final environmental document for the project; nevertheless, the quantity of sand placed was more than that anticipated south of the pier. The original proposal showed 450,000 cy to be placed over a longer reach extending from south Imperial Beach to north of the pier; however, pismo clams were identified north of the pier so the footprint was compressed to avoid placement north of the pier. More sand was placed within a smaller envelope area, necessitating steepening of the seaward slope.

Surfing at south Imperial Beach in 2012 was compromised for approximately one climate season by wave reflection off the steeper beach fill. The ocean reworked the seaward slope after placement, acting to flatten and lengthen it to be more natural and energy absorbing, rather than energy reflecting. This process occurred over several months, and surfers were less able to complete rides without having to navigate the reflected wave known as "backwash." Accordingly, in popular surf areas, the designed shoreline should be sloped from the seaward side of the berm towards the water at a minimum ratio of 5:1, or flatter, to prevent backwash near surfing locations. Careful consideration of beach fill design is essential to avoid potential impacts to drainage needs and recreational use, as well as other concerns.

Potential impacts to the San Diego region's lagoons would also be considered when designing the project based on past experience. SANDAG met with each lagoon manager in 2011 prior to the RBSP II project to determine potential impacts. Lagoon sedimentation was estimated for each lagoon and agreements on financial compensation for increased maintenance dredging were developed. For RBSP III, revised and updated agreements would need to be developed considering results and impacts of RBSP II. Certain lagoons (e.g., Los Peñasquitos and Tijuana) were observed to be more affected than others for various reasons. In the next phase of this project, designs should be done to factor in potential lagoon impacts and mitigation if needed in the form of increased lagoon excavation. Funding mechanisms for increased maintenance burdens would be determined at a later phase of the project.

The lessons learned presented above from RBSP I and RBSP II provide a foundation for improving the design of RBSP III. By applying these insights and recommendations, SANDAG could enhance project design and contribute to the long-term sustainability of the region's beaches.

3.3 Environmental Review

California Environmental Quality Act[5] (CEQA) requires a "project" that may result in a change in the environment to evaluate its environmental impacts and develop measures to reduce these impacts. Under National Environmental Policy Act[6] (NEPA), if a federal agency has an approval decision or provides funding for an "action", that action must be evaluated for environmental and related social and economic effects. Historically, beach nourishment in the San Diego region has been addressed at the individual project level, with the exception of jurisdiction-specific SCOUPs, which are programmatic and typically include limited placement amounts and extend for 5 years or more per regulatory limits. Previous regional efforts, including RBSP I and RBSP II, each addressed compliance with CEQA and NEPA through preparation and certification/approval of an Environmental Impact Report (EIR) and Environmental Assessment (EA)/Finding of No Significant Impact (FONSI) that addressed a single proposed placement event. As previously mentioned, both RBSP I and RBSP II were designed to minimize the potential for impacts based on existing resource presence and modeling, and the environmental documents for both projects ultimately identified no significant impacts. Additionally, after implementation of RBSP I and RBSP II, no significant impacts were realized throughout San Diego County. Various strategies exist to streamline the CEQA/NEPA process, but ultimately the level of analysis and documentation required for compliance with CEQA and NEPA would depend on the potential for significant impacts associated with the proposed project. If RBSP III is also designed to avoid significant impacts, a lower level CEQA document than an EIR may be more appropriate. The CEQA and NEPA lead agencies would confirm the appropriate level of documentation after confirmation of the proposed project.

The receiver sites and volumes proposed for RBSP III would likely influence the level of environmental documentation required. Three example scenarios for RBSP III, based on site locations and volumes, are presented below.

- Scenario 1: If RBSP III were to place similar amounts of sand in previously used receiver site footprints (i.e., an RBSP I/RBSP II rebuild), then CEQA and NEPA may be streamlined. Monitoring conducted after the construction of both projects confirmed a lack of significant impacts to resources. Therefore, CEQA documentation may be addressed through the preparation of a Negative Declaration or Mitigated Negative Declaration (MND), while NEPA would likely require an EA and FONSI.

- Scenario 2: In addition to RBSP I and RBSP II, if RBSP III were to rely on other projects that have taken place, then this could allow for streamlined CEQA/NEPA documentation if monitoring associated with those other projects confirmed no significant impacts occurred to sensitive resources. In this scenario, project volumes similar to RBSP I and RBSP II would be primarily

[5] CEQA is a statute enacted in 1970 to ensure that state and local agencies in California consider the environmental impacts of their actions before making decisions. CEQA requires these agencies to analyze and publicly disclose the potential environmental effects of proposed projects and to adopt feasible measures to mitigate those impacts (California Governor's Office of Land Use and Climate Innovation 2025).

[6] NEPA was signed into law in 1970. NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions (U.S. Environmental Protection Agency 2025).

proposed, with increased volumes potentially at sites that were used for larger individual projects (such as Cardiff State Beach volumes used for SELRP, Encinitas and Solana Beach volumes used for the Coastal Storm Damage Reduction Project, or Mission Beach volumes placed by the USACE San Diego River and Mission Bay Maintenance Dredging Project). In this instance, an MND/EA/FONSI may also be sufficient because the analysis could rely on previous project results.

- Scenario 3: RBSP III expands receiver site footprints and/or placement volumes in locations that have not been previously nourished and/or monitored for impacts from nourishment. This approach may require additional environmental analysis and/or documentation, since the potential for significant impacts is more uncertain. If a similar strategy is utilized from RBSP I and RBSP II modeling, and updated/refined mapping of sensitive marine resources is taken into consideration to design a project with volumes that would not trigger significant impacts, it may be possible to address the project with a streamlined MND/EA/FONSI. However, the lead agencies would have to make that determination after modeling and mapping is complete. Substantial increases or use of new receiver sites in proximity to sensitive marine or coastal resources is likely to result in the need for additional documentation, such as an EIR for CEQA, while an EA/FONSI may still be appropriate for NEPA.

Nourishment frequency also would likely influence the level of environmental documentation needed. A project that includes a programmatic approach for placement rather than a single placement event would likely include more up-front work in terms of analysis required for the environmental document but would be more streamlined and cost-effective in the future if the proposed project could confirm long-term suitability of sites and volumes. A programmatic approach could implement more flexibility to utilize maximum envelopes for placement rather than specific footprints, as discussed in Section 3.2 above. The inclusion of programmatic events is likely to result in the need for additional environmental documentation, such as an EIR, although an EA/FONSI may still be appropriate. In this case, it may be advantageous to expand the environmental clearance at the program level and prepare a program EIR for CEQA. A program EIR may be prepared if the project consists of a series of actions that could be characterized within a larger program. A program EIR would be appropriate for a programmatic replenishment approach if the program EIR includes a description of planned activities as comprehensively as possible. If future RBSP III programmatic placement events were consistent with the project described in the program EIR, and sufficient detail has been included in the analysis to allow for adequate evaluation, then no further documentation may be required.

The inclusion of retention structures also likely would require additional documentation. A project that includes retention as a component may require more up-front work in the planning phase for the analysis required in the environmental document and permitting constraints; however, it could extend the timeline to need future nourishment if sand was retained for longer durations on beaches. This could result in more effective placement events and longer internals between individual placements needed, which may result in future cost savings for implementation. The inclusion of retention features is likely to result in preparation of an EIR and EIS depending on the scope of the program.

Inclusion of a programmatic approach and retention features as part of RBSP III, despite the need for additional documentation, is worthwhile for several reasons. These elements provide long-term benefits by enhancing the effectiveness of beach nourishment efforts. A programmatic approach allows for greater flexibility and efficiency in future nourishment activities, reducing the need for frequent, individual environmental reviews. Additionally, retention features help maintain sand on beaches for longer periods, enhancing the project's success and reducing the frequency of future nourishment. Ultimately, these strategies contribute to the overall cost-effectiveness and success of the project, aligning with the lessons learned from previous efforts and guiding decisions for future projects.

3.4 Permitting

Future beach nourishment projects will require extensive permitting from various federal, state, and local jurisdictions. Based on lessons learned from previous large-scale beach nourishment projects in San Diego County including RBSP I, RBSP II, and SELRP, as well as, smaller, local opportunistic projects, it is imperative that coordination with permitting agencies be initiated as soon as possible once it appears that the project will move forward. This would involve coordination with permitting and regulatory agencies, including, at a minimum, USACE, United States Environmental Protection Agency (EPA), United States Fish and Wildlife Service (USFWS), National Oceanic and Atmosphere Administration (NOAA), CCC, Regional Water Quality Control Board (RWQCB), California State Lands Commission, and California Department of Fish and Wildlife. As an example, for RBSP II and SELRP, agency coordination and meetings started over a year prior to construction. The early coordination with agencies provided an opportunity to discuss the project as well as potential agency concerns. This also provided an efficient opportunity to find resolutions or consensus. The meeting outcomes were used to develop and anticipate permit conditions which were invaluable for project planning and implementation. This information could be used to anticipate overall project costs that could be included in contractor solicitations (e.g., construction or monitoring requirements), which allowed the project proponent to plan and account for possible unaccounted expenses or cost-savings.

If increased sediment volumes, as well as new receiver sites, are moved forward as part of RBSP III, it would require an intensive and expensive post-construction monitoring program (approximately $2 million [United States dollars]), with the possibility of future mitigation (which can be on the order of tens of millions of dollars) may be required. Implementing the practice of early coordination with permitting agencies will be crucial. Other early coordination efforts could include, working with regulatory agencies to maintain similar monitoring requirements for construction as were required for RBSP I and RBSP II, and request to exclude nearshore biological monitoring if sediment volumes are similar or less than RBSP I. Additionally, recent regulatory changes for some species (e.g., designated critical habitat for green sea turtles) may require additional coordination and implementation of avoidance and minimization or mitigation measures during construction. Proposed critical habitat for green sea turtles includes nearshore areas from the mean high-water line to 20 m depth, from the Mexico border, including San Diego Bay, to Santa Monica (excluding the area between Oceanside and San Onofre). Since the proposed project area encompasses this proposed green sea turtle critical habitat, and assuming it would be finalized prior to RBSP III, the project proponent would need to consult with USFWS and NOAA. Based on the project scope, it may be an informal consultation; however, it may require formal consultation and preparation of a Biological Opinion. In addition, there could be additional construction monitoring requirements associated with the project which may range from simple beach surveys to full-time monitoring on the beach and/or dredge. The only requirement for RBSP II included the preparation and implementation of a Marine Mammal and Turtle Contingency Plan. Implementing early coordination efforts is essential for the successful planning, implementation, and cost management of RBSP III.

3.5 Construction

Similar to the experience with other project phases presented above, the actual implementation of each prior project has revealed various lessons that could be applied to RBSP III. The section includes lessons learned regarding construction activities for future beach nourishment based on previous large-scale beach nourishment projects in San Diego County including RBSP I, RBSP II, and SELRP.

Early and proactive coordination with cities and other local stakeholders, such as Surfrider and commercial fisherman, is key to identify potential issues and address concerns for what may occur during construction. Weekly meetings should occur, starting one month prior to construction, to ensure effective communication and coordination with potentially affected parties.

Regarding the construction season, RBSP I and SERLP were implemented during the spring and summer, while RBSP II construction started in September due to a late arrival date for the dredge. The later construction start for RBSP II resulted in a significant reduction in environmental monitoring requirements for grunion, birds, and public safety, amounting to cost savings of several hundred thousand dollars. Additionally, this timing also minimized potential construction delays and change orders from the contractor which could have arisen if environmental monitoring had necessitated changes to the receiver site footprints. Therefore, a start date later in the summer season should be considered for RBSP III to replicate these benefits.

For RBSP II, some concerns arose with lobster fisherman regarding transit routes for the dredge. The concerns centered around interruption of lobster fishing operations if the dredge passed by too close, which would cause fishermen to be forced to abandon their work and move out of the way, or to cause large wakes that make the fishing operations more difficult. Their request was to have the dredge transit a predictable path in both directions that was outside of the lobster fishing grounds to enable lobster fishing to continue unabated throughout their typical hours. The issue was ultimately resolved with agreed upon routes. If construction were to occur during the lobster season (i.e., generally October through March) for RBSP III, transit routes established for RBSP II should be applicable to minimize potential concerns, after being verified with the lobster fisherman. Even if construction were to occur in the non-lobster season, transit routes would still need to minimize potential impacts to sensitive habitats (e.g., kelp beds) and avoid conflicts with recreational boaters that may be more common in the summer months. While established dredge routes may not be necessary for support vessels (i.e., crew boat and tugs), it is still beneficial to reinforce a “good neighbor” philosophy to avoid issues similar to those that arose during RBSPs I and II.

Regarding access routes planned for construction, the contractor should be prepared to use potential alternative routes if unknown issues arise. During RBSP II, the access routes to several receiver sites had to be adjusted during construction due to issues such as traffic concerns, other project construction, or potential impacts to sensitive habitat. Incorporating flexibility into design and during construction is crucial to effectively address unforeseen challenges and ensure the project's success.

Subline installation is also critical during construction to ensure beach berms are built efficiently. The subline position would be designed to reach the shoreline from the ocean and is oriented perpendicular to shore. During construction, extensions from the subline are then laid out on the beach oriented at 90 degrees to the subline (parallel to shore). These extensions allow the sand slurry to be pumped up and/or downcoast to the precise receiver sites. These discharge sublines are extended alongshore to deliver sand to the receiver sites, and are lengthened as the fill is placed to extend along the length of the beach receiver footprints. Sand pumped out from the discharge subline onto the beach is used to create a containment dike parallel to shore. This process leaves the sand behind on the beach while allowing the water to drain off.

For RBSP II, the cost of mobilization of a dredge from the east coast was $9 million in 2012, which would only be an increased cost in the future. Implementing regional collaboration to coordinate large-scale nourishment on the west coast could increase opportunities to provide incentive for dredging firms to keep equipment on the west coast to reduce this cost. Alternatively, west coast jurisdictions could consider purchasing and sharing a dredge. If projects were on a consecutive schedule, having a dedicated dredge available to regularly conduct the work could be a cost savings. Additional discussion on the concept of purchasing a dredge is included in Section 3.7 below.

By applying these lessons learned during construction from previous projects, RBSP III can benefit from improved coordination, strategic construction timing, and flexible planning, ultimately leading to a more efficient and successful beach nourishment project.

3.6 Beach Fill Performance

The post-RBSP I and RBSP II outcome for selected sub-reaches is summarized in this section. The performance of beach fills in RBSP I and RBSP II varied across the littoral cells. The sub-reach assessment quantifies the impact of the RBSP fills beyond the receiver sites by accounting for the redistribution of the nourishment material over a broader area. As such, the sub-reach outcome provides a more appropriate indication of overall success and longevity of the nourishment programs than the receiver site changes. The RBSP I and RBSP II fill characteristics by sub-reach are summarized in Table 3-1. The beach-widths changes and trends are presented as average values based on the available transects in each sub-reach with consistent measurements dating back to 2000. The uneven spacing between transects was accounted for by weighting each value according to the alongshore distance associated with the corresponding transect. The beach-width trends are derived by linear regression plots, which is why the trends may not directly correspond to the magnitude of beach loss during the given period. Coronado and La Jolla did not receive direct nourishment as part of the RBSP I, while Torrey Pines, Del Mar, La Jolla, Mission Beach and Coronado did not receive direct nourishment as part of RBSP II.

Table 3-1. 5-Year Outcome for RBSP I and RBSP II

Sub-Reach	RBSP I 5-Year Outcome			RBSP II 5-Year Outcome		
	Immediate RBSP I Beach-Width Change (ft) [1] 2000 to 2001	Post-RBSP I Beach-Width Change (ft) [1] 2001 to 2006	Post-RBSP I Beach-Width Trend (ft per year) [2] 2001 to 2006	Immediate RBSP II Beach-Width Change (ft) [1] 2011 to 2012	Post-RBSP II Beach-Width Change (ft) [1] 2012 to 2017	Post-RBSP II Beach-Width Trend (ft per year) [2] 2012 to 2017
Oceanside	36	-9	-5.3	37	-44	-8.8
North Carlsbad	24	35	3.2	61	-33	-5.2
South Carlsbad	-9	-6	-4.9	1	-18	-3.9
Encinitas/Leucadia	20	-4	-3.9	-5	-32	-4.7
Cardiff	35	30	3.0	35	-23	-4.5
Solana Beach	63	-14	-3.1	76	-31	-3.2
Del Mar [4]	7	-14	-6.9	-	-	-
Torrey Pines [4]	52	-66	-15.2	-	-	-
La Jolla [3,4]	-	-	-	-	-	-
Mission Beach [4]	12	14	2.1	-	-	-
Coronado [3,4]	-	-	-	-	-	-
Imperial Beach [4]	70	-10	-2.1	129	-106	-15.9

Notes:
1 Average shoreline data derived from the 44 transects included in the fall 2000 and 2023 surveys.
2 Trends derived by linear regression (fall surveys only).
3 Sub-reach not included in RBSP I.
4 Sub-reach not included in RBSP II.
5 Post-RBSP I outcome includes nearshore placement of 300,000 cy of opportunistic nourishment in nearshore.

In the Oceanside Littoral Cell, where material was placed at multiple receiver sites, the outcome differed by sub-reach. This variation was due to the individual fill characteristics and the relative locations of the receiver sites. Larger fills tended to last longer than smaller fills, and fills comprised of coarser sand generally persisted longer than those with finer material. Closely spaced fills tended to merge and enhance larger areas. Additionally, oceanographic conditions also played a significant role in the performance outcome.

Initial average beach-width gains immediately following RBSP I ranged from 7 ft at Del Mar to 70 ft at Imperial Beach. In the case of South Carlsbad, the RBSP I nourishment did not produce an immediate beach-width gain in the sub-reach. According to the monitors, this outcome is attributable in part to the omission of the one beach profile transect at the fill placement site in the weighted average due to lack of a pre-nourishment survey. The net beach-width change during the 5-year period following RBSP I (2001 to 2006) ranged from loss of 66 ft at Torrey Pines to a gain of 35 ft at North Carlsbad. Shoreline change rates varied from retreat of 15.2 ft per year (Torrey Pines) to advance of 3.2 ft per year (North Carlsbad).

When the 5-year post-RBSP II outcome is considered, initial post-nourishment beach-width changes ranged from a loss of 5 ft (Encinitas/Leucadia) to a gain of 129 ft (Imperial Beach). The net beach-width loss during the 5-year period following RBSP II (2012 to 2017) ranged from losses of 18 ft at South Carlsbad to 106 ft at Imperial Beach. These changes yielded shoreline retreat rates varying from 3.2 ft per year (Solana Beach) to 15.9 ft per year (Imperial Beach). This magnitude of the losses is partly attributable to the initial cross-shore equilibration of the fill material that was placed on the above water beach. There was also a strong El Niño in 2016, 4 years after RBSP II placement.

Table 3-2 summarizes the consecutive years with sustained beach-width gain relative to the pre-nourishment conditions following both RBSP I and RBSP II, which provide a measure of fill longevity in each sub-reach. It is important to note that opportunistic nourishment projects were conducted in the period following both RBSP I and RBSP II. As indicated previously, the longevity of benefits in each reach is influenced by numerous factors, including the individual fill characteristics (quantity and grain size of fill material), the relative location of the receiver sites (migration of nourishment material between sub-reaches), and the oceanographic conditions that prevailed following fill placement. Factors that contributed to better beach fill performance should be replicated for RBSP III to the extent feasible. Additionally, this data can be used to support evaluation of how frequent renourishment intervals should be if a programmatic project was implemented. Based on the outcome in each sub-reach, the ideal renourishment interval for a regional project of comparable scale and scope to RBSP I or RBSP II is about 5 years. Longer renourishment intervals could likely be accommodated at locations such as North Carlsbad, Cardiff, Solana Beach, and Imperial Beach depending on the circumstances (e.g., notably fill size and prevailing oceanographic conditions). Specific proposed renourishment cycles for RBSP III are presented in Table 4-2 in Section 4.3 below.

Table 3-2. Beach-Width Changes in San Diego Region Sub-Reaches, 2000 to 2023

Sub-Reach	Consecutive Years with Average Beach-Width Gain Relative to Pre-Nourishment Condition [1,2]	
	RBSP I	RBSP II
Oceanside	4 years	4 years
North Carlsbad	11 years	10 years
South Carlsbad	0 years	2 years
Encinitas/Leucadia	4 years	0 years
Cardiff	11 years	6+ years [5]
Solana Beach	11 years	6+ years [5]
Del Mar [4]	2 years	-
Torrey Pines [4]	2 years	-
La Jolla [3,4]	-	-
Mission Beach [4]	6 years	-
Coronado [3,4]	-	-
Imperial Beach	5+ years [6]	12 years

Notes:
1 Average shoreline data derived from the 44 transects included in the Fall 2000 and 2023 surveys.
2 Consecutive year counted if average beach-width at the time of the fall survey exceeds pre-nourishment condition by 1 foot or more.
3 Sub-reach not included in RBSP I.
4 Sub-reach not included in RBSP II.
5 Consecutive years accounting stopped when opportunistic nourishment from San Elijo Lagoon Restoration Project was placed on the beach.
6 Consecutive years accounting stopped 1 year after opportunistic nourishment from San Diego Harbor dredging was placed in the nearshore.

3.7 Dredge Ownership

Both RBSP I and RBSP II required mobilizing a hopper dredge from the Gulf of Mexico and east coast, which incurred significant mobilization expenses. The mobilization cost for the dredge that constructed RBSP II in 2012 was $9.3 million of the total project cost of $25 million, which was 37% of the project cost. Additionally, the cost to mobilize the dredge that conducted the USACE Encinitas/Solana Beach Project in southern California in 2024 was $7.8 million of the total project cost of $69 million, which was 11% of the project cost. This high cost is because the dredges needed for large-scale beach replenishment projects are typically not present in California (M&N 2008). To address this significant expense, the concept of purchasing a dredge for the region, rather than relying on competitively bidding to the construction industry, has been raised by various local entities and stakeholders to support projects such as RBSP III and others. Both the State of California and the County of Orange have also independently explored this idea. Both agencies conducted studies to determine the feasibility of buying a dedicated dredge and conducting the work outside of the marine construction industry (M&N 2008; 2009b). The studies concluded that it was not economically feasible for one government body to buy and operate a dredge given lack of competition, high costs and maintenance requirements, lack of specialized expertise in open ocean marine dredging, and other challenges. The cost to own, operate, and maintain a large hopper dredge is substantial, often more than initially assumed by someone outside of the marine construction industry. The initial purchase cost can vary significantly depending on size and capabilities, but is estimated to cost up to $250 million for a dredge suitable for a project like RBSP III. Additional costs of dredge ownership would include but not be limited to maintenance and repairs, insurance, mooring fees, fuel, technical consumables (e.g., lubricants, oil, water, etc.), cleaning items, spare parts, freight costs, vessel depreciation, and crew payroll. Over fifteen crew members are required at minimum to operate these vessels, including engineers, boat operators, electrical technicians, captains, and others. Additionally, the specific technical requirements to conduct a dredging program require expertise that is relatively rare and is not sufficiently addressed by the standard construction industry. Therefore, significant investment would be required to hire, train, and retain the necessary staff. Finally, the liability associated with this type of construction is relatively high, with the risk burden shifting from the marine contractor to the region's ultimate dredge owners. Ultimately, it is not anticipated to be economically sound for an individual agency to buy and maintain a dredge rather than hire a contractor. This is due to the relative inefficiencies of a government-owned operation as compared to the competitive free market.

Another consideration is a long-term lease of a dredge rather than ownership or contracting. The dredging industry typically prefers to realize the profits rather than simply offering a lease rate for their equipment. Leasing of a dredge to complete the scale of work required for RBSP III has never been done in the local area, and it is highly unlikely to get agreement from a dredging contractor to lease their equipment.

Government agencies typically handle relatively light construction projects and manage the associated burden of liability. However, for more challenging and large-scale projects like an RBSP, which involve significantly higher levels of liability, they usually hire specialist contractors to complete the work with significantly higher levels of liability. Instead of SANDAG or southern California agencies purchasing a dredge on their own, other pathways to potentially accomplish similar objectives of lower construction costs are presented below.

Regional collaboration and coordination of beach nourishment projects schedules throughout southern California could promote efficiency. A "super-region" is being discussed among potential members and collaboration is occurring through various community forums. Regional collaboration could result in a series of projects advertised to the construction industry either annually or semi-annually from Santa Barbara and all counties to the south. Currently, typical nourishment programs in southern California are infrequent, inconsistently funded, and small in scale. To make the area a priority for competitive dredge contractors, projects need to be larger, more frequent, planned well in advance, and combined with other regions to render them a high profile. This level of organized construction activity could motivate large dredging companies to station and maintain large hopper dredges on the west coast which would reduce mobilization costs and potentially increase competition, thus lowering project costs overall.

Designing projects to be more suitable for other types of dredges, such as hydraulic cutterhead suction dredges, could open the market for more competition and attract more locally based equipment to bid on the job. Unlike hopper dredges, hydraulic cutterhead suction dredges cannot withstand high seas. Project designs could be modeled after the Surfside/Sunset Beach Project[7] in north Orange County, that was designed by the USACE. This project has been on-going since 1959 and has resulted in nearly 20 million cy of sand nourishing the area from Surfside Colony to Newport Harbor, a distance of 12 miles. The USACE designed the Surfside/Sunset Beach Project to be constructed with a different cutterhead suction dredge, which is highly efficient. Additionally, the design specified the dredging and beach fill location to be very close to a harbor entrance. This allowed the dredge to escape to quiet water as a refuge if ocean conditions became rough or stormy. Translating such a design to the San Diego region could include creating a fewer number of large “feeder” beaches near harbors, such as Oceanside to feed northern San Diego County, Mission Beach to feed San Diego, Coronado to feed southern San Diego County, and Dana Point to feed southern Orange County beaches. In these instances, each feeder beach would be close to a harbor entrance. Further offshore sand investigation studies would be needed to understand if the quantity of sand available in such locations would be sufficient to supply large scale beach nourishment projects such as RBSP III.

Additionally, combining both approaches outlined above into a hybrid strategy that includes extensive regional collaboration, feeder beaches near harbor entrances, and other measures to attract the marine construction industry could further enhance the efficiency, cost-effectiveness, and success of beach nourishment projects. While SANDAG and the region could pursue purchasing a dredge to construct RBSP III and other future projects, it would be prudent to complete more research before doing so.

3.8 USACE Contractor Building the Project

As discussed in Section 2.8 above, USACE is conducting the Encinitas/Solana Beach Project, which includes renourishment at 5- to 10-year intervals for the next 50 years. One potential opportunity to lower costs for RBSP III is to coordinate with USACE to construct the RBSP III project as part of their own when they return to conduct renourishment within the region in the next 5 to 10 years. This could reduce contractor mobilization costs; however, it would require the SANDAG project be added to the USACE Encinitas/Solana Beach Project. While this may be feasible, the time and costs required to modify the USACE project to include the proposed RBSP III beaches would be extensive (possibly decades), precluding work from occurring in the near future.

Alternatively, SANDAG could consider directly contracting with the same dredge contractor hired by USACE for implementation of RBSP III. This approach, known as “piggy-backing” could provide ready access to the contractor at the completion of the USACE project. SANDAG would need to coordinate with the contractor well in advance, as dredging companies schedule work years ahead. While there are uncertainties associated with this approach, it remains a viable option for consideration.

[7] The Surfside/Sunset Beach Project in Orange County is a beach nourishment and erosion control project managed by the USACE. The project aims to mitigate beach erosion along the coastline from San Gabriel River to Newport Bay (USACE 2025a).

4. Project Components

The proposed RBSP III would provide beach replenishment at both San Diego County and southern Orange County beaches. This section presents the scope of the proposed project, specific to San Diego County, including description of receiver sites, borrow sites, renourishment intervals, a feeder beach concept, and retention strategies. Approximately up to 4.8 million cy of dredged sediment from offshore borrow sites located outside of the depth of closure (i.e., outside of the respective littoral cell) would be placed on up to 15 receiver sites. Table 4-1 details the proposed receiver site locations and volumes, while Figures 4-1 through 4-15 show the potential receiver site envelopes. Figures 4-1 through 4-15 use base aerials from January 2024 and are not directly representative of the current beach-width condition at these sites. As described, beach-widths can vary seasonally. Also, a single photograph captures a point in time where the tide may be high (less visible sand) or low (more visible sand). These preliminary receiver site footprints and volumes were determined by incorporating lessons learned, strategies to streamline future efforts, and input from the cities and applicable stakeholders.

Table 4-1. Comparison of RBSP I, RBSP II, and RBSP III

Receiver Site	RBSP I Quantity Constructed (cy)	RBSP II Quantity Constructed (cy)	RBSP III Quantity Proposed (cy)	Receiver Site Location Compared to RBSP I/RBSP II Footprint
Oceanside	421,000	293,000	1,500,000	Extended north by approximately 3,000 ft, and extended south by approximately 1,500 ft
North Carlsbad	225,000	219,000	240,000	Southern end extended by approximately 500 ft
South Carlsbad	158,000	141,000	300,000	Consistent
Batiquitos	117,000	106,000	118,000	Consistent, but with flexibility to shift by approximately 1000 ft south
Leucadia	132,000	Not Included	132,000	Shifted south by approximately 700 ft but with flexibility to keep consistent with RBSP I
Moonlight	105,000	92,000	105,000	Consistent, but with flexibility to shift north or south by approximately 500 ft
Cardiff	101,000	89,000	300,000	Southern end extended by approximately 1,000 ft
Solana Beach	146,000	142,000	300,000	Shifted north by approximately 1,200 ft
Del Mar	183,000	Not Included	183,000	Northern end extended by approximately 1,000 ft
Torrey Pines	245,000	Not Included	245,000	Consistent
Tourmaline Beach	Not Included	Not Included	300,000	New footprint
Mission Beach	151,000	Not Included	450,000	Shifted south and southern end extended by approximately 2,000 ft
Coronado Shores	Not Included	Not Included	200,000	New footprint
Glorietta Bay Beach	Not Included	Not Included	10,000	New footprint
Imperial Beach	120,000	450,000	120,000 on beach; 300,000 nearshore	Consistent with RBSP II Alternative I which was not constructed
TOTALS	**2,104,000**	**1,532,000**	**4,803,000**	**Not Applicable**

The general process for sand dredging from a borrow site, delivery, and spreading is similar among receiver sites. After sand is dredged from a borrow site, it is conveyed via the dredge to a nearshore pipe connection, then pumped through dredge discharge lines to the shore. Existing sand is used to build a dike between the ocean and receiver site and the dredge material is placed behind the dike to help reduce turbidity. As the material deposits, it is spread along the shore via bulldozers to create a berm higher than the existing sand.

4.1 Proposed Receiver Sites

RBSP III proposes modifications to the prior SANDAG RBSP locations, receiver site, and placement quantities. This section presents the details of the RBSP III proposal and the rationale behind them. Table 4-1 presents a list of the proposed sand receiver sites and respective sand quantities for RBSP III compared to RBSP I and RBSP II.

The receiver sites and volumes proposed for RBSP III below are presented as maximum envelopes and volume as modeling and detailed analysis have not been completed. This approach provides conservative analysis to allow flexibility for sea-level rise and programmatic nourishment events. These preliminary receiver site envelopes and volumes were determined by incorporating lessons learned, strategies to streamline future efforts, and input from the cities and applicable stakeholders. As further information such as biological habitat mapping and detailed modeling becomes available and/or is completed, then additional refinements to the receiver sites and volumes may be identified.

Oceanside

The proposed placement strategy at Oceanside has been expanded compared to past RBSPs to accommodate requests from the City of Oceanside. Up to 1,500,000 cy of sand would be placed from just south of the Oceanside Pier starting near 1st Street (Seagaze), and extending for approximately 9,800 ft to the southern most public access point along South Pacific Street, as shown on Figure 4-1. The receiver site location is extended north with an increased volume compared to past RBSPs to maximize economic return from recreation. This strategy is consistent with the City of Oceanside's requests and complements the City of Oceanside's efforts for the RE:BEACH project in this area. This footprint allows for flexibility of sediment placement depending on the beach conditions at the time of RBSP III implementation, which is necessary given the uncertainty in timing of RBSP III and RE:BEACH implementation. This flexibility provides a resilient approach, supporting adaptive capacity for the City of Oceanside, as both RE:BEACH and RBSP III are programmatic efforts with their own renourishment cycles. Importantly, this footprint avoids placement directly in front of Loma Alta Creek and Buena Vista Lagoon.

North Carlsbad

The proposed placement strategy at North Carlsbad has been expanded compared to past RBSPs to extend approximately 500 ft on the southern edge of the receiver site to maximize economic return from recreation. Up to 240,000 cy of sand would be placed from just south of the Buena Vista Lagoon inlet, extending approximately 3,700 ft to Pine Street, as shown on Figure 4-2. This strategy would provide more recreational benefit by extending the receiver site to cover the beach area adjacent to the small park on the southern end.

South Carlsbad

The proposed receiver site at South Carlsbad is consistent with past RBSP placement at the site termed South Carlsbad North; however, the volume of sand placed would increase to up to 300,000 cy compared to RBSP I and RBSP II. The increase in volume is consistent with the City of Carlsbad request to consider South Carlsbad for additional sand placement. Sand would be placed just south of Manzano Drive extending approximately 3,300 ft to Sea Breeze Drive, as shown on Figure 4-3.

Batiquitos (Encinitas)

The proposed placement strategy at Batiquitos is generally consistent with past RBSPs, but with flexibility to either keep the placement consistent with past RBSPs or to shift the receiver site up to 1,000 ft south. Up to 118,000 cy would be placed just south of the Batiquitos Lagoon inlet, extending approximately 1,700 ft, as shown on Figure 4-4. This strategy is consistent with the City of Encinitas's requests and allows for flexibility during construction to place sand where it is needed most depending on current conditions. Additionally, if the Moonlight placement is not needed at the time of placement because the USACE

Encinitas/Solana Beach Project has already placed sediment at this location and/or it is determined not to need additional fill, the 105,000 cy proposed to be placed at the Moonlight receiver site has the potential to be partially added to this location within the proposed RBSP III envelope.

Leucadia (Encinitas)

The proposed placement strategy at Leucadia is similar to the Batiquitos proposal above with flexibility to keep the placement location consistent with RBSP I (from Range Street to Diana Street spanning 2,500 linear ft) or move this berm placement from the previously approved location south about 700 ft capturing Beacon's State Beach at the south end of the berm (also approximately 2,500 linear feet in total length). The proposed receiver site concept for both options is shown in Figure 4-5. The proposed volume would be up to 132,000 cy, which is consistent with RBSP I. These proposed changes are to accommodate requests from the City of Encinitas and to complement the USACE Encinitas/Solana Beach Project that is placed further south. Additionally, being that RBSP III is programmatic, each renourishment cycle and/or phase of the project may have different direct needs during placement. The proposed strategy is consistent with the City's request for flexibility during placement in order to maximize the public benefit at the time of placement. Additionally, if the Moonlight placement is not needed at the time of placement because the USACE Encinitas/Solana Beach Project has already placed sediment at this location and/or it is determined not to need additional fill, the 105,000 cy proposed to be placed at the Moonlight location has the potential to be partially added to this location within the proposed RBSP III envelope or placed at the Batiquitos location as stated above.

Moonlight (Encinitas)

The proposed placement strategy at Moonlight is generally consistent with past RBSPs, but with the flexibility to shift the receiver site north or south by approximately 500 ft. This small site extends approximately 750 ft in length at the end of B and C streets, as shown on Figure 4-6. As noted in Section 2.7 above, the USACE Encinitas/Solana Beach Project overlaps within this area; therefore, two potential scenarios for volume are proposed. Similar to Leucadia, the placement strategy at this receiver site would depend on if the USACE project moves forward with initial placement and renourishment cycles as planned (Scenario 1), or the USACE project does not move forward or stay on schedule for renourishment (Scenario 2). Under Scenario 1, Leucadia would renourish the full 132,000 cy amount using the proposed RBSP III envelope and Moonlight would either not be renourished if determined it didn't need it, or the 105,000 cy identified for Moonlight would be reduced and/or shifted and divided to be placed at the Batiquitos or Leucadia placement locations as stated above. Under Scenario 2, the proposed volume placed at Moonlight would be up to 105,000 cy, which is consistent with RBSP II.

Cardiff (Encinitas)

The proposed placement strategy at Cardiff has been expanded compared to past RBSPs. Up to 300,000 cy of sand would be placed just south of the San Elijo Lagoon inlet, extending approximately 2,150 ft, as shown on Figure 4-7. This strategy is consistent with the placement that occurred in this area in 2018, as part of SELRP, which identified no biological impacts. These findings were determined and documented through extensive monitoring over 5 years post-construction (M&A 2024). The placement within this proposed envelope (if not using the full 300,000 cy amount) could shift both north and south within the berm envelope to provide the best public benefit.

Solana Beach

The proposed placement strategy at Solana Beach has been expanded compared to past RBSPs. Up to 300,000 cy of sand would be placed just north of Solana Vista Drive, extending approximately 4,700 ft, as shown on Figure 4-8. This receiver site location has been shifted north with an increase in volume compared to past RBSPs. This strategy is consistent with requests from the City of Solana Beach and complements the placement area used by the USACE Encinitas/Solana Beach Project.

Del Mar

The City of Del Mar participated in RBSP I but was not involved in RBSP II. The proposed Del Mar receiver site has been expanded compared to RBSP I, by shifting the north end approximately 1,000 ft to the San Dieguito River, while keeping the volume consistent with RBSP I. Up to 183,000 cy of sand would be placed just south of the San Dieguito River inlet, extending approximately 4,900 ft to Powerhouse Park, as shown on Figure 4-9. The receiver site location and volume align with the City of Del Mar's request and are consistent with the City of Del Mar-permitted SCOUP footprint.

Torrey Pines (San Diego)

The proposed placement strategy at Torrey Pines is consistent with RBSP I. Up to 245,000 cy of sand would be placed in Torrey Pines State Beach with a 1,500 ft long beach fill, as shown on Figure 4-10.

Tourmaline (San Diego)

Beach replenishment at Tourmaline in the City of San Diego was not proposed as part of past RBSPs but is included for RBSP III. The proposed Tourmaline receiver site would extend approximately 3,300 ft from Crystal Drive to Diamond Street, and would place up to 300,000 cy of sand, as shown on Figure 4-11. If sand placement occurs at both the Tourmaline and Mission Beach receiver sites in the City of San Diego, the quantities of sand would need to be evaluated further, and it may be recommended to reduce volumes if both locations do move forward. The proposed volume presented here is the maximum amount for planning purposes.

Mission Beach (San Diego)

The City of San Diego participated in RBSP I with placement at Mission Beach but did not participate in RBSP II. The proposed sand volume at Mission Beach has been increased compared to RBSP I. Up to 450,000 cy of sand would be placed from San Juan Place extending 4,000 ft to San Fernando Place, as shown on Figure 4-12. This strategy is consistent with placement that occurred in this area in 2010 as part of the USACE San Diego River and Mission Bay Maintenance Dredging Project. If sand placement occurs at both the Mission Beach and Tourmaline receiver sites in the City of San Diego, the quantities of sand would need to be evaluated further, and it may be recommended to reduce volumes if both locations do move forward. The proposed volume presented here is the maximum amount for planning purposes.

Coronado Shores (Coronado)

Beach replenishment in the City of Coronado was not proposed as part of past RBSPs but is included for RBSP III. The proposed Coronado Shores receiver site would extend approximately 2,200 ft from just south of the Hotel Del Coronado to Avenida Lunar and would receive up to 200,000 cy, as shown on Figure 4-13.

Glorietta Bay (Coronado)

The City of Coronado encompasses a number of beaches located along San Diego Bay and has requested the evaluation of a potential bay-side nourishment. Glorietta Bay has been identified as a potential opportunity for nourishment through RBSP III, as shown on Figure 4-14. The Glorietta Bay receiver site extends approximately 470 ft in length. Placement of up to 10,000 cy of sand would contribute to approximately a 30- to 40-foot gain in beach-width.

This beach area is owned by the San Diego Unified Port District and presents a range of opportunities and constraints. Notably, water depths are too shallow to allow for delivery of sand to the beach with the same dredge used for ocean beaches. However, the proposed receiver site at Coronado Shores is directly across Silver Strand Boulevard, which would allow for relatively short truck trips that would avoid neighborhood streets. Up to 1,000 truck trips would be required for placement of 10,000 cy in this location. Additionally, a 2020 inventory of eelgrass distribution in San Diego Bay mapped eelgrass adjacent to the shoreline of Glorietta Bay (Naval Facilities Engineering Command Southwest 2021 and San Diego Bay 2020 Eelgrass inventory). Placement at this site would be anticipated to potentially impact eelgrass, either directly through placement on top of nearshore eelgrass beds or through the transport of material to nearby beds, which would require monitoring. Impacts would require mitigation and add uncertainty to the permitting process with the resource agencies. Additionally, regulatory and natural resource agencies such as NOAA, USFWS, and RWQCB permit and approve placement of material in bays differently than along the ocean and may characterize sand placement at this beach as fill rather than nourishment, leading to further permitting uncertainties.

Imperial Beach

The proposed placement strategy within Imperial Beach has been refined compared to past RBSPs to incorporate lessons learned discussed in Section 3 above. Sand would be placed from just south of the pier, extending approximately 2,300 ft to just north of Descanso Street, as shown on Figure 4-15. Up to 120,000 cy of sand would be placed on the beach consistent with RBSP I volumes, with an additional 300,000 cy proposed for placement in the nearshore zone. The nearshore placement strategy would provide a more gradual distribution to the beach and would be similar to placement by USACE in 2006 as part of the San Diego Harbor Maintenance Dredging Project. RBSP III would replicate the nearshore strategy with a slight shift towards shallower water (approximately 4 meters in depth or whatever depth is feasible for the contractor) to allow accelerated transport of sand to beach.

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-1. Oceanside Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-2. North Carlsbad Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-3. South Carlsbad Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

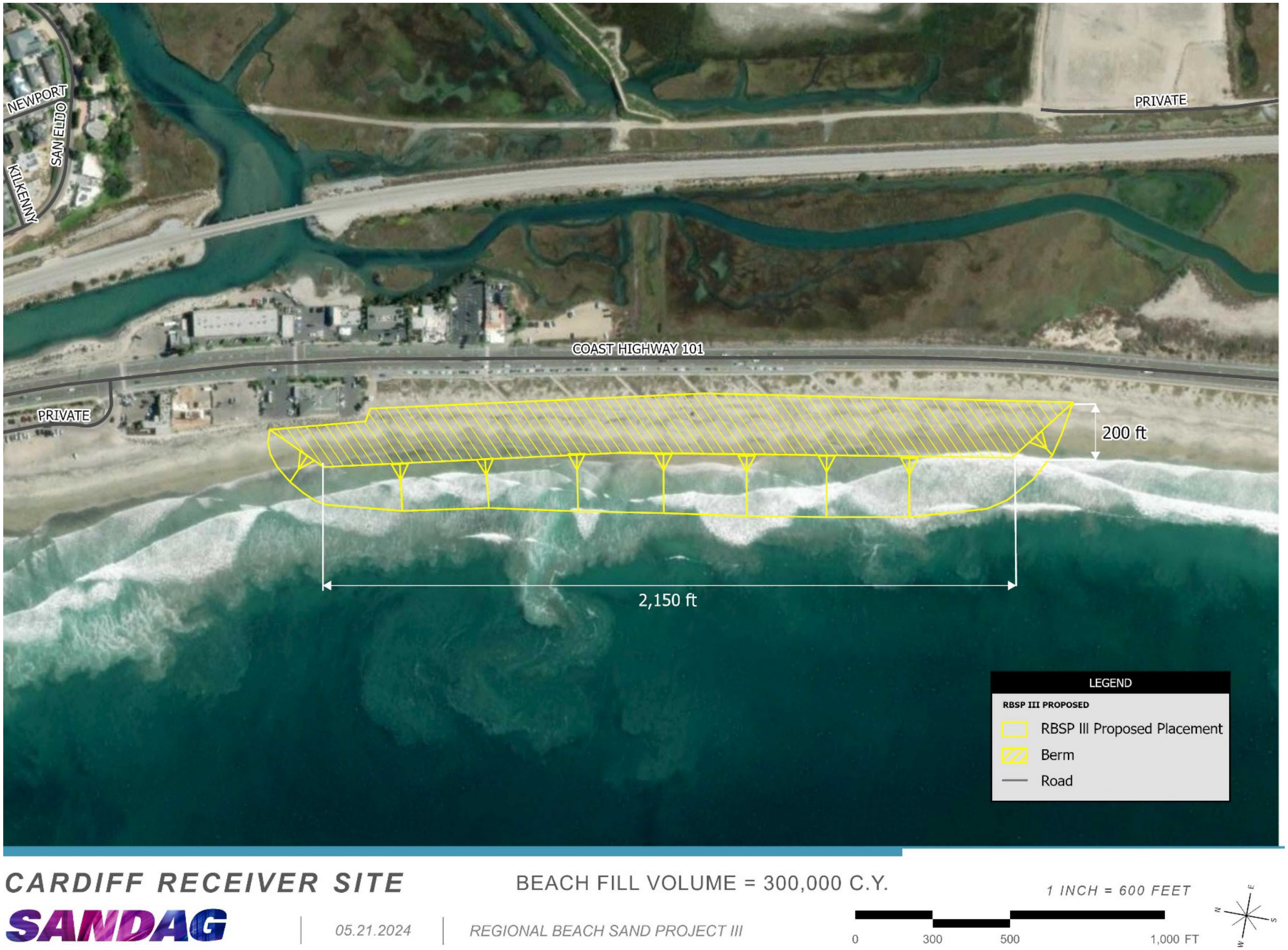
Figure 4-4. Batiquitos Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-5. Leucadia Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-6. Moonlight Receiver Site

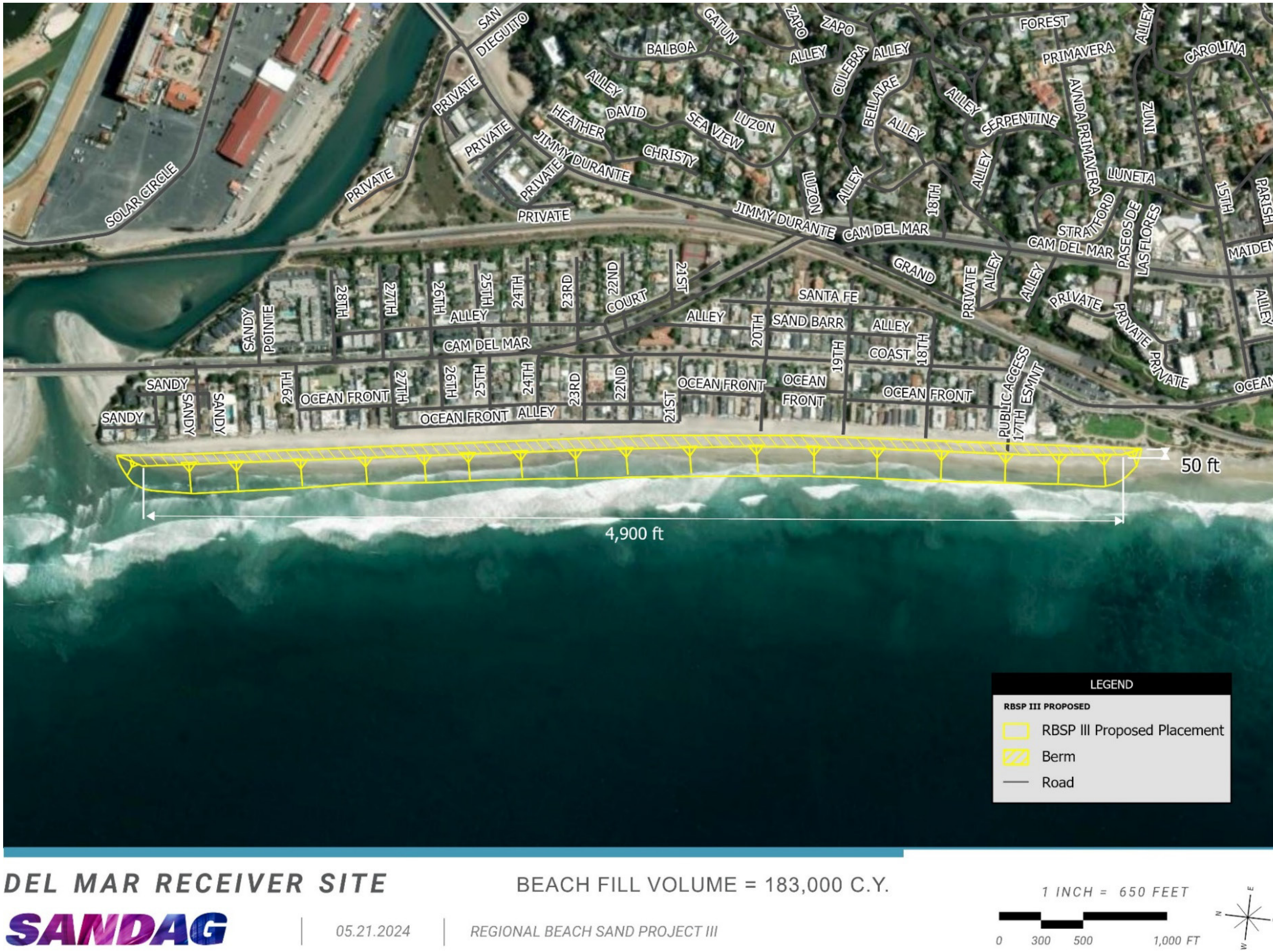


Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-7. Cardiff Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-8. Solana Receiver Site



Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-9. Del Mar Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-10. Torrey Pines Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-11. Tourmaline Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

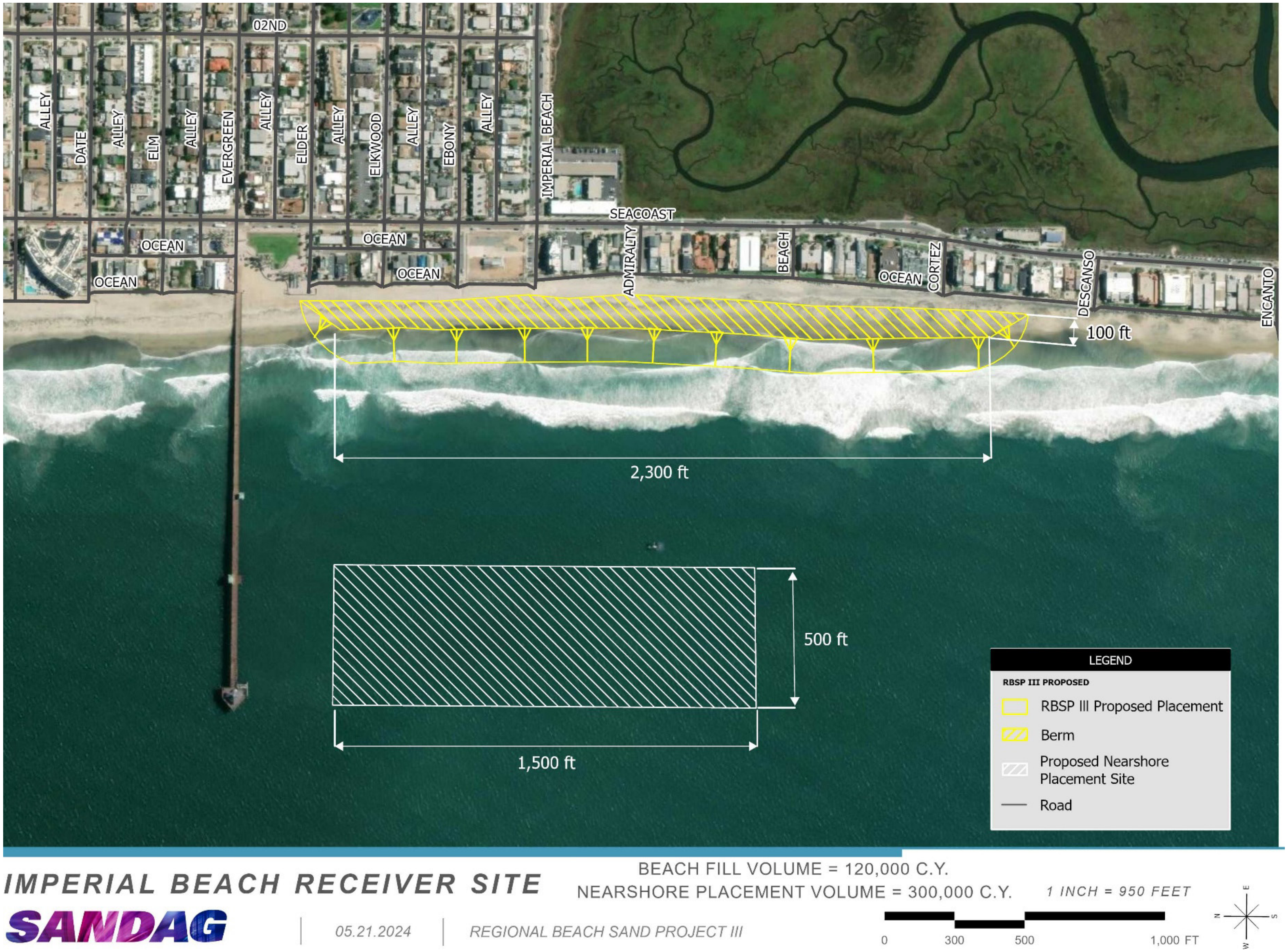
Figure 4-12. Mission Beach Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-13. Coronado Shores Receiver Site

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-14. Glorietta Bay Receiver Site



Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 4-15. Imperial Beach Receiver Site

4.2 Proposed Borrow Sites

The six borrow sites proposed for RBSP III are located offshore along the coast from Oceanside to Imperial Beach, in relative proximity to each receiver site but far enough offshore to be outside of the littoral cell depth of closure. The term borrow site refers to a location that would be investigated in terms of sediment characteristics, marine resources, and ocean surface. Within that larger area identified, a smaller dredge area would be identified in a later phase of the project where the actual material would be removed. Temporary pipelines to carry nourishment material to the receiver sites would be constructed between the ocean outside of the surf zone to the shoreline. The dredge would transport material from the borrow site to each receiver site and connect to the temporary pipelines, and then the material would be pumped up and down the coast in the approved receiver site.

Increased boundaries are being considered for RBSP III at two of the offshore borrow sites used for RBSP II, namely MB-1 (located off of Mission Beach) and SO-5 (located off of Del Mar). These borrow sites were located during previous RBSP offshore investigations and have yielded large quantities of high-quality sand that could provide additional resources for RBSP III. It is also proposed to re-explore several RBSP II borrow sites previously investigated in north San Diego County. Two of these sites (Cardiff SO-6 and Encinitas SO-7) were also used for RBSP II and RBSP I, respectively, and may still have suitable material remaining, depending on results of additional investigation. Torrey Pines (SO-4) and Oceanside (SM-1) are also proposed to be explored as potential “new” borrow areas, having not been previously sourced. The proposed borrow sites would be located offshore enough to not impact the littoral cell.

Several other candidate borrow sites were investigated previously for RBSP I and II, including potential borrow sites along Northern San Diego County, and off Imperial Beach and Coronado. These more southerly sites were determined unsuitable due to poor sand quality (i.e., the sand found was either too fine-grained, highly variable and/or gravelly). Additional details regarding previous borrow studies, physical conditions at the proposed borrow sites, and proposed borrow sites investigations are provided in Appendix A.

4.3 Programmatic Nourishment Regime

RBSP I and RBSP II were one-time efforts; however, a programmatic approach is considered for RBSP III, with proposed periodic renourishment to address long-term losses and erosion over a timeframe of 50 years. Proposed renourishment cycles are presented in Table 4-2. Renourishment quantities would be determined during the design phase of the project. These cycles are based on evaluation of performance of the RBSP I and RBSP II fills (Section 3.6 above) and the long-term shoreline change trends developed from 28 years of monitoring (Sections 2.6 above). The proposed renourishment intervals may be refined in future phases of RBSP III based on the outcome of numerical modeling. A programmatic approach provides advantages compared to a third one-time project such as: 1) having a streamlined approach to environmental review and permitting to address the same actions repeated over defined time intervals, 2) programming funding to be available to enable project progress to nourish farther into the future, 3) sets a schedule and expectation to maintain beaches based on sand needs and past performance of fills, and 4) motivating dredge contractor to station and maintain large hopper dredges on the west coast reducing costs.

While intervals are identified for Leucadia, Moonlight, and Solana Beach, RBSP III renourishment cycles for these three locations would ultimately be dependent on the USACE Encinitas/Solana Beach Project. If the USACE project moves forward with renourishment cycles as planned, then additional renourishment every cycle may not be necessary by SANDAG as part of RBSP III. The USACE renourishment schedule is shown in Table 4-3.

Table 4-2. RBSP III Proposed Renourishment Cycles

Sub-Reach	Proposed Renourishment Interval
Oceanside	5 years
North Carlsbad	5 to 10 years
South Carlsbad	2 to 5 years
Batiquitos	2 to 5 years
Leucadia	2 to 5 years
Moonlight	2 to 5 years
Cardiff	5 to 10 years
Solana Beach	5 to 10 years
Del Mar	2 to 5 years
Torrey Pines	2 to 5 years
Tourmaline	To be determined[1]
Mission Beach	5 years
Coronado Shores	To be determined[1]
Glorietta Bay	To be determined[1]
Imperial Beach	5 to 10 years

Notes:
[1] There is no history on performance of beach fills at these sites to determine a renourishment interval at this phase.

Table 4-3. USACE Encinitas/Solana Beach Project Renourishment Cycles

Encinitas[1]		Solana Beach[2]	
Renourishment Year	Renourishment Quantity (cy)	Renourishment Year	Renourishment Quantity (cy)
5	0	5	290,000
10	220,000	10	290,000
15	0	15	290,000
20	220,000	20	290,000
25	0	25	290,000
30	220,000	30	290,000
35	0	35	290,000
40	220,000	40	290,000
45	0	45	290,000
50	220,000	50	290,000
SUBTOTAL	**1,100,000**	**SUBTOTAL**	**2,900,000**

Notes:
[1] Initial nourishment quantity placed at Encinitas was 340,000 cy in 2024.
[2] Initial nourishment quantity placed at Solana Beach was 700,000 cy in 2024.

4.4 Feeder Beach

As discussed in Section 3.7 above, a cost-effective approach to increasing the sand supply to a littoral cell is by feeding sand to the upcoast end, a strategy known as a feeder beach. This approach has been successfully implemented in northern Orange County in the Surfside/Sunset Beach Project. The cost-effectiveness of a feeder beach relies on the sand source being located relatively close to the feeder site. Additionally, the approach can only succeed if there are no sensitive marine resources near the feeder beach, allowing large quantities of sand to be placed there without adverse effects. Lastly, the longshore sand transport pattern needs to be in a net direction downcoast from the feeder beach.

Sand bypassing to a feeder beach could be accomplished by dredging a large, deep pit within the depth of closure and transporting the material by hopper dredge. The pit would then backfill relatively quickly by continued longshore sediment transport over time. This process prevents or reduces the loss of sand offshore. Therefore, implementing a feeder beach concept presents a viable strategy to enhance sand supply to the northern San Diego beaches. By leveraging the natural longshore sediment transport direction and strategically placing sand from nearby sources, this approach could effectively mitigate sand loss and support coastal resilience.

4.5 Retention Feature (Pilot)

Sand retention features should be strongly considered for sites that lose sand rapidly. The 2001 SANDAG Regional Sand Retention Strategy (M&N 2001) concluded that structures that help keep sand on the beach have the potential to increase the cost-effectiveness of beach nourishment activities. Concepts considered included both onshore options such as groins and headlands, and offshore options such as reefs. As part of RBSP III, various sand retention strategies are being evaluated, and one strategy will be chosen as the pilot retention project for the region in a later phase.

The City of Oceanside has an ongoing effort to identify solutions to lessen long-term beach erosion. In 2021, the Oceanside City Council provided staff direction to move forward with a pilot project that would provide both beach nourishment and sand retention to address such issues. Since then, development of a preliminary design for a sand retention concept has been underway, known as RE:BEACH, which incorporates both onshore and nearshore concepts. The proposed concept moving forward is “Living Speed Bumps.” The Living Speed Bumps concept proposes to construct one multi-purpose offshore artificial reef and two headlands, supported by nearshore and beach nourishment (City of Oceanside 2024). In November 2024, the Oceanside City Council voted unanimously for the project location to be placed between Tyson Street Park and Wisconsin Avenue. The specific shape and size of the reef and headlands will be determined in the next phase of engineering design being led by the City of Oceanside.

Beyond Oceanside, potential sites to consider for retention features include South Carlsbad, Leucadia, and Torrey Pines State Beach. Additionally, other sand retention features, as outlined in the 2001 Regional Sand Retention Strategy, may offer more streamlined solutions compared to RE:BEACH. Other strategies for retention features are presented below.

Traditional groins are onshore features that succeed in retaining sand, depending on their design and the conditions at the site. However, groins were considered potentially less desirable than other measures due to the low net longshore sediment transport rate therefore requiring them to be relatively long. Longer groins could cause potential downcoast impacts due to their effects of shadowing downcoast beaches from receiving sand (M&N 2001).

Nearshore features could include a multipurpose reef that would sit in a water depth of 15 ft. This reef would cause waves to break over it, therefore blocking energy from reaching the shore and creating an energy shadow in its lee. A beach may form shoreward of the structure in the form of a salient. Additionally, if designed with the appropriate slopes, area, and planform (three-dimensional configuration), the reef could serve as a surfing site. It could also function as a submarine habitat for kelp and other species to colonize and as a dive site under suitable conditions.

Additionally, an empirically based sediment budget model for Cardiff State Beach assessed management strategies to maintain beach width subject to future mean sea level rise and potentially more frequent El Niño storms. Two decades (2000-2019) of surveys support the hypothesis that rocky reefs bounding the beach retain added nearshore sand from entrance dredging or beach nourishment, except during strong El Niño years with more severe storm waves (Gopala et al. 2003).

If a sand retention pilot project is pursued, the project should include a robust monitoring program with established thresholds for adaptive management that could include modification to the design to increase performance and/or lower negative impacts (if any). Ultimately, the pilot project should be built so that it could be removed if it was not successful.

5. Economic Considerations

5.1 Economic Benefit-Cost Analysis

A Benefit-Cost Analysis (BCA) was performed for RBSP III to quantify the potential economic benefits and its value to the public. The primary benefit accrued from the project consists of significantly increased recreational usage and associated revenue. Other benefits such as reducing physical damage to public facilities, emergency costs, and potential loss of roads and utilities were not considered as part of the economic analysis, though these benefits could be substantial at some sites. Additionally, some benefits such as habitat preservation and public safety are not easily quantifiable and, therefore, not included. A detailed economic analysis is provided in Appendix B.

5.1.1 Project Costs

The total cost for the proposed RBSP III Phase 2 and 3, including San Diego County sites only, is presented in Table 5-1 and Table 5-2, respectively. Phase 2 includes the environmental permitting and design efforts, while Phase 3 includes the construction implementation and 5-year post-construction monitoring. The cost and analysis of including southern Orange County sites is presented in Section 6.0. The cost presented here is a conservative estimate for purposes of the feasibility determination. The cost of both Phase 2 and Phase 3 totals to approximately $180 million, with the majority of the costs occurring during construction implementation.

Table 5-1. SANDAG RBSP III Phase 2 Preliminary Cost Estimate (San Diego County Sites Only)

Item Number	Item Description	Quantity	Unit	Unit Cost	Subtotal
Environmental, Permitting, and Design Phase					
1	Environmental (CEQA/NEPA) and Permitting	1	LS	$1,325,000	$1,325,000
2	Habitat Mapping	1	LS	$220,000	$220,000
3	Biological Technical Report	1	LS	$90,000	$90,000
4	Final Engineering (includes support on retention pilot project)	1	LS	$990,000	$990,000
5	Potential Habitat Burial Assessment	1	LS	$70,000	$70,000
6	Receiver Site Sampling (for new sites and updates to previous sites)	1	LS	$60,000	$60,000
7	Offshore Investigation	1	LS	$2,600,000	$2,600,000
8	Borrow Site and Dredge Pipeline Surveys for Final Engineering Plans	1	LS	$250,000	$250,000
1-8	**Total Phase 2 Costs**				**$5,605,000**

Notes:
LS = lump sum
Assumptions:
1. Phase 2 costs include support for one San Diego pilot retention project during the environmental, permitting, and design phase.

Table 5-2. SANDAG RBSP III Phase 3 Preliminary Cost Estimate (San Diego County Sites Only)

Item Number	Item Description	Borrow Site	Quantity	Unit	Unit Cost	Subtotal
Construction Hard Costs						
9	Mobilization & Demobilization	-	1	LS	$11,000,000	$11,000,000
10	Interim Mobilization	-	15	EA	$300,000	$4,500,000
San Diego County Sites						
11	Oceanside	SO5	1,500,000	CY	$26.22	$39,324,477
12	North Carlsbad	SO5	240,000	CY	$25.28	$6,068,194
13	South Carlsbad	SO5	300,000	CY	$23.03	$6,907,674
14	Batiquitos	SO5	118,000	CY	$21.31	$2,514,732
15	Leucadia	SO5	132,000	CY	$20.68	$2,729,207
16	Moonlight	SO5	105,000	CY	$20.26	$2,127,614
17	Cardiff	SO5	300,000	CY	$19.01	$5,703,127
18	Solana Beach	SO5	300,000	CY	$17.61	$5,283,658
19	Del Mar	SO5	183,000	CY	$17.30	$3,165,626
20	Torrey Pines	SO5	245,000	CY	$18.80	$4,604,854
21	Tourmaline	MB1	300,000	CY	$18.19	$5,455,740
22	Mission Beach	MB1	450,000	CY	$18.21	$8,195,616
23	Coronado Shores	MB1	200,000	CY	$24.15	$4,830,972
24	Glorietta Bay	MB1	10,000	CY	$39.41	$394,053
25	Imperial Beach	MB1	420,000	CY	$27.35	$11,485,152
Contingency						
26	Construction Contingency	-	1	LS	35% of construction	$43,501,744
Other Items						
27	Construction Management	-	1	LS	$1,840,000	$1,840,000
28	Construction Survey or Inspection	-	17	EA	$25,000	$425,000
26-28	**Total Construction Contingency, Management, Inspection**	**-**	**-**	**-**	**-**	**$45,766,744**
9-28	**Total Hard Costs**	-	4,803,000	CY	$35.41	**$170,057,441**
Construction Soft Costs						
29	Permit Compliance Reporting, Pre, During, and Post-Construction Biological Monitoring, and other Miscellaneous Monitoring	-	1	LS	$2,500,000	$2,500,000
30	Shoreline Monitoring (Beach Profiling After for 5 years added to base)	-	1	LS	$550,000	$550,000
31	Borrow Site Survey Support	-	1	LS	$300,000	$300,000
32	Borrow Site Post-Construction Monitoring	-	1	LS	$135,000	$135,000
33	Pre and Post-Construction Receiver Site Detailed Topography	-	1	LS	$675,000	$675,000
29-33	**Total Soft Costs**	-	-	-	-	**$4,160,000**
9-33	**Total Phase 3 Costs**	**-**	**-**	**-**	**-**	**$174,217,441**

Notes:
LS = lump sum
EA = each site
Assumptions:
1. Dredging and pumping includes land-based equipment for building the beach fill template.

2. Mobilization and Demobilization cost is taken from inflating bids from RBSP II to 2025 prices. The total cost will be approximately $15 million, excluding interim mobilizations regardless of dredge volumes and county participation. This preliminary cost estimate splits the total $15 million to each county based on their dredge volumes.
3. Maximum volumes for receiver sites are the basis of this estimate.
4. Unit costs for Glorietta Bay are calculated based on pumping to the Coronado Shores receiver site ($24.15 per cy) and trucking material to the Glorietta Bay receiver site ($15.26 per cy).
5. Sand for northern San Diego County sites comes from borrow site SO-5 off of Del Mar, and sand for southern San Diego County sites comes from borrow site MB-1 off of Mission Beach. Material quality from SO-5 and MB-1 borrow sites is excellent and similar to previous projects. Sand for the southern San Diego County sites would utilize MB-1 due to the known high-quality sand and volume. Suitable borrow sites off Imperial Beach have not been located to date and may not exist. Typically, the farther the borrow site from the receiver site is, the higher the cost.
6. Unit costs for dredging and nourishment are based on production rates of a 4,850 cy hopper dredge.
7. Material is dredged and pumped to the beach receiver sites by a hopper dredge.
8. Construction contingency is 35%. The value is based on considering the USACE estimate of 38% and SANDAG guidance of 25-40% at a 10-15% design level. Other items such as Construction Management and Construction Survey or Inspection are required services expressed as a percentage of the cost.
9. While Phase 2 costs include support for one San Diego pilot retention project during the environmental, permitting, and design phase, the Phase 3 estimate does not include costs for implementation due to the uncertainty of which concept would move forward.
10. Unit costs are not projected out to a specific year, and are representative of 2025 costs. However, the contingency percentage of 35% sufficiently covers potential cost increases, therefore this total cost accurately reflects possible conditions between now and the year 2030, and is sufficient for planning purposes.

Costs have increased substantially since RBSP II due to various factors. The most influential factor on cost is distance from the borrow site to the receiver sites, as transportation costs increase with distance. The current cost estimate in Table 5-2 assumes sand for northern San Diego County sites comes from borrow site SO-5 off of Del Mar, and sand for southern San Diego County sites comes from borrow site MB-1 off of Mission Beach. The best solution to reduce these costs is to identify suitable sand borrow sites closer to the receiver sites (e.g., closer to Oceanside and Carlsbad for northern sites, and closer to Imperial Beach for southern sites, if possible). If alternative borrow sites identified for investigation in Appendix A are determined to be suitable for use, then costs could be lower.

The second major factor contributing to high costs is construction mobilization. Currently, hopper dredges are brought from the Gulf of Mexico and the east coast to perform this work. Increasing the number of projects in the region and the overall amount of dredging on the west coast could lead to greater competition and encourage dredging companies to invest in hopper dredges dedicated to the west coast. Having hopper dredges anchored on the west coast could reduce mobilization costs. Alternatively, use of cutterhead suction dredges could be less costly as they are more common on the west coast, but this requires a different design approach, as discussed in Section 3.7 above.

Other factors that increased RBSP III costs include the unusual rate of economic inflation that has affected the United States since 2000, as well as the more normal economic escalation tied to the Consumer Price Index (CPI), which tends to rise at a rate of approximately 2% to 3% annually. Cost estimates for RBSP II were completed 13 years ago, so escalation alone at 3% annually consistent with the CPI would increase prices by nearly 40%. For example, RBSP II cost $25 million to build, not including planning and design costs, so 40% escalation in prices since 2012 would result in that same project costing $35 million in 2025.

Additionally, the overall proposed strategy for RBSP III is substantially different than RBSP I and RBSP II, including potentially expanded receiver site footprints and volumes, identification of new sites, a pilot retention location, and programmatic nourishment. These factors add significantly to the project cost. Notably, RBSP III proposes to place 4.8 million cy of sand on the beach, while RBSP II placed only 1.5 million cy. The proposed project is nearly tripled in sand volume; therefore, the cost for RBSP III should be approximately three times higher. Adding entirely new receiver sites and increased sand quantities also require more biological, physical, and numerical modeling of the sand fate. Finally, certain items (e.g., contingency) in each estimate are calculated as a percentage of the construction cost so, if the cost is high, then those items would also have a higher cost. The total cost presented in this section is a preliminary estimate and is likely to change as the project refines in future phases.

5.1.2 Benefit-Cost Ratio Results

BCA is a systematic approach for evaluating the economic value of different policy or project options by comparing their expected costs and benefits. For hazard mitigation projects, the BCA determines the future risk reduction benefits of a project and weighs those benefits against project costs (Federal Emergency Management Agency (FEMA) 2024). A BCA results in a Benefit-Cost Ratio (BCR), which is a direct comparison of expected benefits against projected costs. A BCR over 1.0 is generally considered cost-effective.

Economic benefits for RBSP III were estimated using a model developed by Dr. Phil King, combining aspects of various federal agencies' methodologies with empirical research and established practice in California to provide the most accurate estimate of the value of beach replenishment. The methodology relies on day-use value, carrying capacity, and estimating lost value. The detailed methodology approach is included in Appendix B.

The methods used for RBSP III are consistent with the core assumptions underlying federal methods and the general principles for BCA largely agreed upon in the economics profession. Crucially, the analysis used for RBSP III leverages more recent and site-specific empirical studies to generate more specific estimates for the proposed beaches. In doing so, the BCA for RBSP III employs the most current methods and studies of beaches in southern California.

The results of the analysis indicate significant economic benefits from the proposed sand replenishment. 15 beaches in San Diego County were evaluated, highlighting that replenishment would yield hundreds of millions of dollars in avoided losses in recreational value. Torrey Pines, Moonlight Beach, and Oceanside Beach are identified as having the highest potential benefits due to their high attendance and significant erosion rates. The methodology also includes a sensitivity analysis to test the robustness of the results against variations in key assumptions, such as visitor crowding tolerance and erosion rates. The findings suggest that even with conservative assumptions, the economic benefits of replenishment remain substantial. Detailed economic benefits for each San Diego County receiver site location are included in Appendix B.

Based on estimates of recreational benefits, the BCR for the proposed RBSP III is 7.7 as shown in Table 5-3. This BCR result shows the RBSP III effort is economically justified, with benefits far outweighing the costs shown in Tables 5-1 and 5-2. Overall, when considering solely the non-market recreation value of a beach day to patrons, most of the proposed RBSP III beaches show a compelling case for replenishment. Continued erosion and the concomitant loss of recreation value to beachgoers as the beach shrinks present a threat to the efforts of the CCC in its work to preserve the beaches for future public access. Additionally, a failure to maintain San Diego County's beaches would inhibit economic activity and recreational value, and place public and private infrastructure at risk. Beach replenishment offers a powerful way to maintain beaches for successive generations and should be a top priority for the region.

Table 5-3. Benefits and Costs for RBSP III San Diego County Beaches

Site	Total Cost	Total Benefit	BCR
San Diego County Beaches	$179,822,441	$1,383,729,390	7.7

It should be noted that this Feasibility Study does not include the value of the identified RBSP III beaches as buffers against storm damage. Given the high value of property in San Diego County, and the fact that coastal property is among the most highly valued property, an analysis of these additional storm damage benefits would undoubtedly yield an even higher BCR. Additionally, the BCR result is based on the cost of a singular RBSP III placement event due to the difficulty of determining specific projected costs for a 50-year project. However, the proposed programmatic approach would result in cost savings for future events as environmental review and permitting would be streamlined.

5.2 Regional Funding Options

The BCA results outlined in Table 5-3 provide the information needed to pursue grant funding opportunities to implement RBSP III. This Feasibility Study serves as a basis for funding decisions in the future. Federal, state, local, and special tax district funding opportunities are discussed below.

5.2.1 Federal

Federal agencies require BCAs for project feasibility determinations and to secure funding. Many federal agencies have climate adaptation programs which include funding for coastal resilience actions such as beach nourishment and retention features. These agencies and their programs have different focus areas, such as housing, habitat, or defense, so applicants should be aware of each program's objective, eligibility, and criteria. The list below and in Table 5-4 are not exhaustive; however, the list provides some indication of federal programs applicable to San Diego County and Orange County.

- The United States Department of Transportation's (US DOT's) PROTECT program is focused on transportation infrastructure including highways and railways, both of which are at risk from coastal erosion in San Diego County and Orange County. California Department of Transportation (Caltrans) also participates in this program.
- The National Fish and Wildlife Fund (NFWF) provides funding for projects that increase coastal resilience, as does NOAA's National Coastal Resilience program. These programs emphasize "greener" strategies such as dune restoration, which has been successfully implemented at many sites in San Diego and Orange counties.
- USACE has $17 billion for the Civil Works program "projects and activities that will provide a historic opportunity to address the nation's current and future water resources infrastructure needs for the benefit of the American public" (www.usace.army.mil). USACE has projects in a number of coastal cities in this Feasibility Study and has funded numerous nourishment programs (www.encinitasca.gov). Funding for these programs is subject to federal approval, and competition for these funds is intense.
- USFWS provides funding for coastal resilience projects that protect, restore, or enhance coastal and wetland habitat. Beaches in San Diego and Orange counties, which provide significant habitat, especially for threatened and endangered species, could be competitive applicants. While local governments are eligible for the Coastal Program, only state agencies may apply for the National Coastal Wetlands Conservation Program.
- The United States Department of Housing and Urban Development (HUD) allocates funds to geographic areas categorized as "Most Impacted and Distressed," which includes California, to reduce the impact of future disasters. Community Development Block Grant funds require a Community Development Block Grant Mitigation (CDBG-MIT) Plan for eligibility.
- The FEMA Building Resilient Infrastructure and Communities (BRIC) Program is a highly competitive grant program that supports states, local communities, tribes, and territories as they undertake hazard mitigation projects to adapt and build resilience to risks from natural disasters. The BRIC Program emphasizes capability and capacity-building; encouraging and enabling innovation, including multi-hazard resilience or nature-based solutions; promoting partnerships; enabling large, system-based projects; maintaining flexibility; and providing consistency. The program provides up to $50 million for projects funded by the national competition.
- The Department of Defense (DOD) provides funding to communities adjacent to military bases and training areas for projects that benefit the community and "Military Installation Resilience." Due to the presence of several Naval assets in the San Diego County area, and the DOD's use of San Diego County beaches, several proposed RSBP III beaches may be eligible for the Defense Community Infrastructure Program (DCIP) and Readiness and Environmental Protection (REPI) Challenge program. Proponents (e.g., local government and beach managers) should consult with the Naval base staff prior to application.

- EPA's Clean Water State Revolving Fund provides low-interest financing for projects that will protect water quality in the face of disaster. For RSBP III sites where nourishment would prevent adverse impacts to water quality, the State Revolving Fund could be an option.

Federal programs require or encourage matching funds from local and state government. Applicants should focus on the federal agencies' main interest when determining if a project is competitive. For example, the US DOT's main interest is protecting critical infrastructure, including roads and rail lines near the coast, so the project must clearly protect transportation infrastructure. Table 5-4 reflects funding opportunities as of December 2024, but it should be noted federal priorities are being re-evaluated in 2025, with funding allocations to such programs subject to change.

Table 5-4. Federal Funding Opportunities

Program	Department/ Agency	Purpose	URL	Funding
PROTECT	US DOT	Protect Transportation Infrastructure	https://www.fhwa.dot.gov/environment/protect/discretionary/	$1.4 B FY 2022 to 2026
National Coastal Resilience Fund	NFWF	Increase Resilience through Nature	https://www.nfwf.org/programs/national-coastal-resilience-fund	$140 million in FY24
Coastal Resilience	USACE	Beach Resilience	https://www.iwr.usace.army.mil/Missions/Value-to-the-Nation/Coasts/	Varies
National Coastal Resilience	NOAA	Increase Resilience	https://coast.noaa.gov/funding/bil/ncrf/overview.html	$575 million in FY23
Coastal Program	USFWS	Coastal Habitat Conservation	https://www.fws.gov/program/coastal	$6 million in FY23
National Coastal Wetlands Conservation Program	USFWS	Coastal Habitat Conservation	https://www.fws.gov/coastal/coastalgrants/	$10.8 million in FY24
CDBG-MIT Program	HUD	Increase resilience and reduce loss of life and property	https://www.hudexchange.info/programs/cdbg-mit/overview/	$12 billion
BRIC	FEMA	Community Resilience	https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	$1 billion in FY23
DCIP	DOD OLDCC	Community resilience in military supporting communities	https://oldcc.gov/defense-community-infrastructure-program-dcip	$100 million in FY24
REPI Challenge	DOD	Climate resilience in military supporting communities	https://www.repi.mil/Buffer-Projects/REPI-Challenge/	$30 million in FY25
State Revolving Funds	EPA	Water Resources	https://www.epa.gov/fedfunds/epa-state-revolving-funds-and-grants-available-water-and-wastewater-utilities	$775.5 million in FY23

Notes:
URL = Uniform Resource Locator
FY = fiscal year

5.2.2 State

The State of California has been proactive in addressing climate change and coastal resilience. The California Coastal Conservancy and CCC continue to provide funding for numerous coastal projects, promoting nature-based solutions similar to those supported by NOAA and NFWF. These agencies also encourage Local Coastal Program (LCP) development with coastal communities, which may be required to qualify for funding.

Caltrans, with a mandate similar to US DOT's, focuses on protecting transportation infrastructure. Given the proximity of the rail line and Highway 1 in both San Diego and southern Orange counties, pursuing these funds could be beneficial. Caltrans also collaborates with the US DOT's PROTECT program. Table 5-5 lists specific state funding opportunities.

Finally, the California Division of Boating and Waterways, part of California State Parks, has funding available for beach restoration through its beach restoration program. Currently, the program has $1.5 million available.

Table 5-5. State Funding Opportunities

Program	Agency	URL
LCP	CCC	https://www.coastal.ca.gov/lcp/grants/
Various	California Coastal Conservancy	https://scc.ca.gov/grants/
Protect	Caltrans/US DOT	https://dot.ca.gov/programs/local-assistance/fed-and-state-programs/protect
Beach Restoration Program	California Division of Boating and Waterways	https://www.grants.ca.gov/grants/division-of-boating-and-waterways-public-beach-restoration-program-fy26/

5.2.3 Local

In California, local governments may raise funds through taxation, levy, and assessment. Table 5-6 indicates several measures that could be utilized in California. These mechanisms, including property tax, levies sales taxes, transient occupancy taxes, and vacancy taxes (increases), require a two-thirds vote from the relevant constituency. Tax levies for school districts have a lower threshold to pass, requiring a 55% majority. Additionally, property tax levy must compete with education measures for voter approval, as voters will consider their overall tax burden when approving or rejecting a measure. It's worth noting that under California law, citizens can propose initiatives to change the law with just 50% of the vote, plus one.

Table 5-6. Local Funding Opportunities

Funding Mechanism	Pros	Cons
Tax Options		
Sales Tax	Raises funds from visitors	Requires two-thirds votes; does not include lodging and most groceries
Transient Occupancy Tax (TOT)	Local tax on overnight stays	Raises cost of hotels or short-term rentals, which increases cost to visitors
Use Tax (e.g., parking fees)	Taxes use directly	May discourage low-income households
Property Tax Levies	Consistent revenue source	Requires two-thirds vote; only taxes local residents
Vacancy Tax	Taxes vacant property on coast	Unknown; untried
Local Districts		
Climate Resilience Districts (CRDs)	Consistent revenue; geared specifically towards resilience	Requires two-thirds vote; only taxes local residents
Geologic Hazard Abatement District (GHAD)	Focuses on geologic hazards	Proposition 209 does not allow GHADs for use on public property (e.g., beaches)

A property tax provides a relatively stable source of revenue, whereas sales and transient occupancy taxes vary depending upon the business cycle and other factors that influence tourism (e.g., pandemics). When financing a large capital project, where a steady stream of revenues is required, a property tax-based scheme can be a significant advantage. However, one clear disadvantage of property tax schemes is that the burden is placed mostly or entirely on local homeowners. Many beach communities in San Diego and Orange counties welcome visitors from all over the state, and from out of state and abroad. A district that focuses on property tax revenues alone will not be taxing visitors. Alternatively, sales, use, and TOTs require visitors from out of the city or district to pay. TOTs in particular focus on visitors and TOT revenues go to local entities, typically the city, or county if unincorporated.

Finally, a vacancy tax is a less common, perhaps more radical solution to address the coastal squeeze. A vacancy tax would place a tax on homes that are vacant for a certain period of time. For example, the City of Vancouver, British Columbia, has a vacancy tax of 3% of the market value of the property per year if it is vacant (vancouver.ca).

5.2.4 Special Tax Districts

In addition to taxes levied on the entire local jurisdiction, tax districts can be created via ballot measure, such as CRDs and GHADs. Each tax district has a specific purpose. The type of tax district used will vary by city and depend on several factors, including which homeowners will pay the tax and how the tax revenues can be used. CRDs are formed by adding additional levies to existing property taxes; they require a 2/3 vote of potential members. CRDs (resourceslegacyfund.org) allow local communities to generate funding through a more targeted approach. For example, residents living close to a coastal hazard or eroded beach can form a CRD to finance projects, including capital outlays. A GHAD is similar in many ways to a CRD. However, California law treats these two entities quite differently; a GHAD is a private group and, as such, is restricted by Proposition 209 and subsequent litigation. GHADs are designed primarily to protect private property. Under Proposition 209, a GHAD can fund only private benefits that accrue directly to the members of the GHAD. This limits a GHAD's ability to fund projects that restore beaches, which are public below the mean high-tide line in California. Maintenance Assessment Districts and Facilities Benefit Assessments perform a similar function. California's Proposition 209 limits the way these funds can be spent to private property enhancements; using these districts to finance public property violates Prop 209. In practice, local authorities may want to combine potential state, federal, and local funding sources. GHADs play a unique but potentially important role since their design is to protect private property. Going forward, a combination of these mechanisms would likely be necessary.

6. Orange County

The overall RBSP III Feasibility Study addresses topics including site conditions, potential project components (receiver sites and borrow locations), preliminary costs, economic benefit, as well as possible efficiencies, related to components in the San Diego region. Technical studies related to offshore borrow sites investigations (Appendix A) and economic methodology (Appendix B) are specific to San Diego elements. This Section 6 provides similar information regarding site conditions, project components, costs/benefits, as well as efficiencies associated with the elements of RBSP III in Dana Point and San Clemente. Appendices C and D address offshore borrow site investigations proposed for Orange County and economic benefits for these two cities, respectively. To minimize repetition, this section refers to applicable sections of the RBSP III Feasibility Study for more detailed information, but it can also be read independently.

Figure 6-1 provides an overview of the applicable coastline illustrating the potential receiver sites for RBSP III in San Diego County (in three littoral cells) and the three potential sites in southern Orange County (in the northern half of the Oceanside littoral cell). Figure 6-2 illustrates the Orange County elements of RBSP III, showing the locations of three potential receiver sites and several potential offshore borrow sites (in littoral cells north and south of the receiver sites).

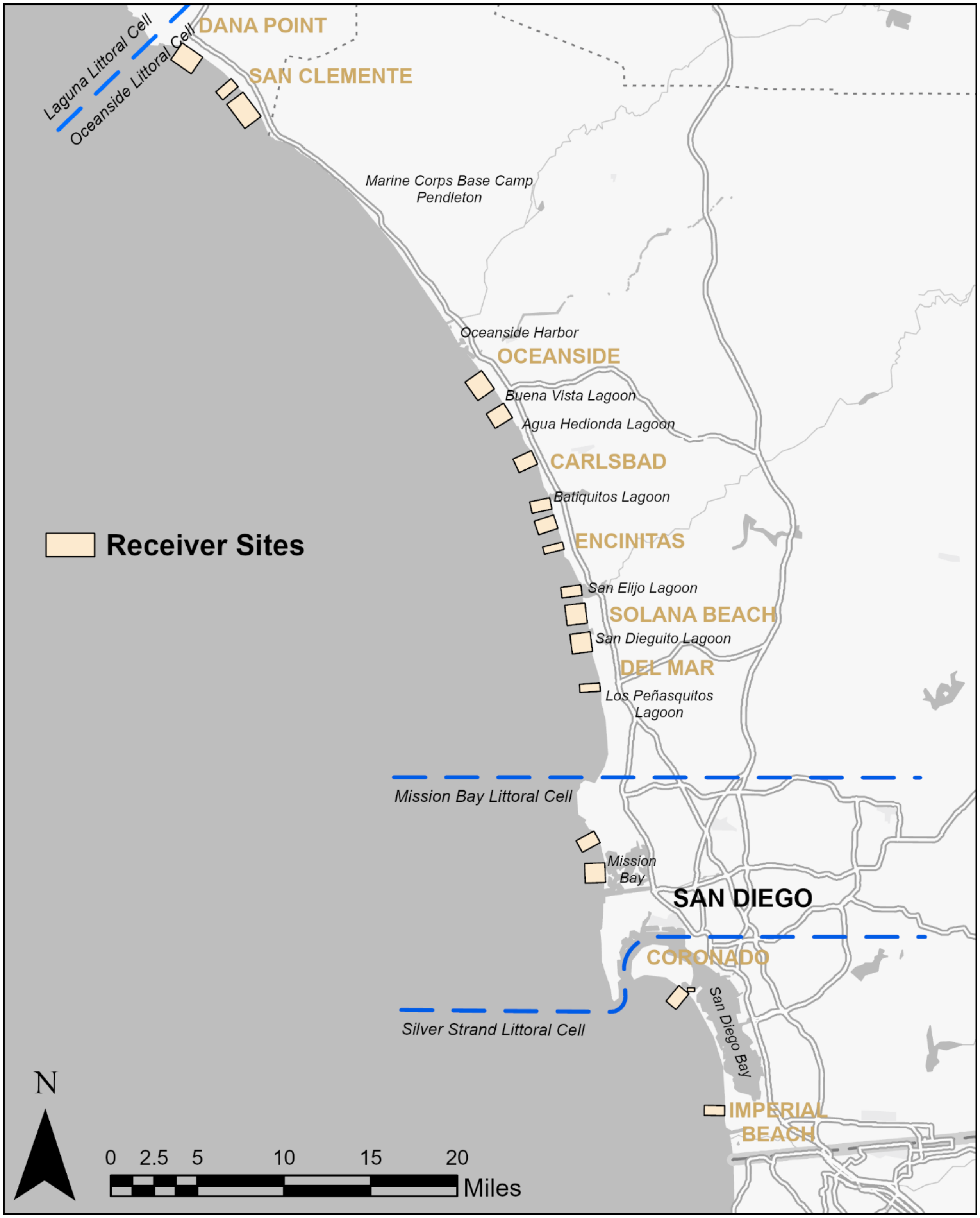


Figure 6-1. Regional Figure

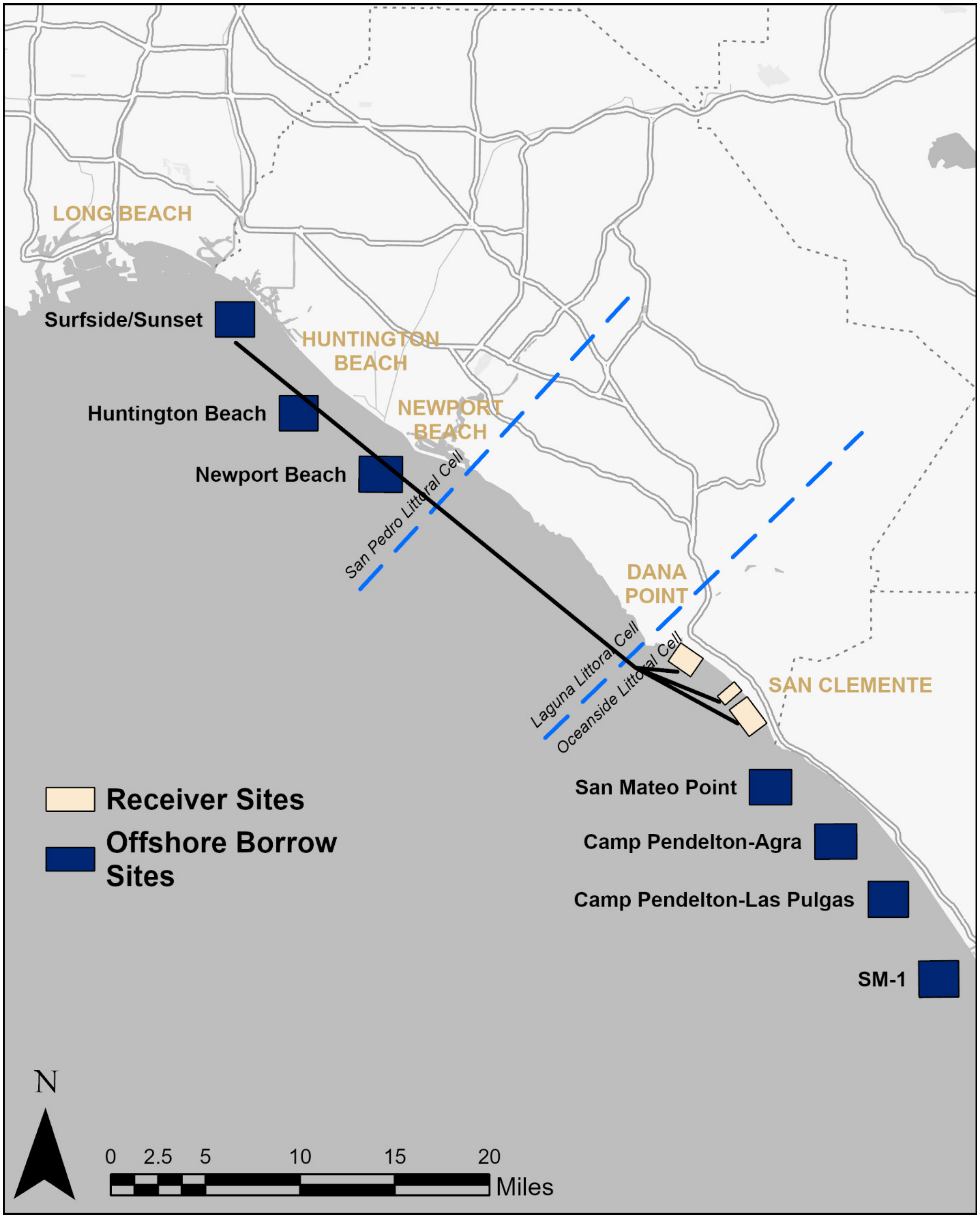


Figure 6-2. RBSP III Southern Orange County Proposed Borrow and Receiver Sites

6.1 Site Conditions

This section provides an overview of existing site conditions in southern Orange County, including sediment budgets and longshore transport rates, beach profiles, sediment grain size, shoreline position, nearshore inventory, and other ongoing and planned projects in the region. Discussion of more regional southern California site conditions, such as sea-level rise and wave climate, is included in Section 2 and applies to southern Orange County beaches as well. By describing the dynamics along the coast, this section presents current site conditions of the southern Orange County beaches in the proposed project area to help assess the feasibility of conducting RBSP III. Understanding these factors will help determine the necessary next steps for RBSP III, highlighting the existing sediment deficits or surpluses, shoreline changes, and the status of other past and ongoing sand management efforts that may affect future implementation.

6.1.1 Sediment Budgets and Longshore Sediment Transport Rates

Understanding the dynamics of sediment budgets and longshore sediment transport rates is important for effective coastal management. The sediment budget concept was developed to understand coastal processes and shoreline change. The sediment budget accounts for inflows (sources), outflows (sinks), and storage of sediment in a geographic unit referred to as a littoral cell. The littoral cell is a coastal reach that generally does not transport or receive littoral sediment from another cell in either the “upcoast” or “downcoast” direction (USACE 1991). However, a complete cycle of sedimentation exists in the cell that can include erosion of highland terrain, fluvial transport to the shoreline, and littoral transport along the shoreline. Bounded on one side by the landward limit of the beach and extending seaward beyond the area of breaking waves, the seaward edge of an active littoral cell is defined as its depth of closure. Substantial quantities of sand from coastal littoral cells do not usually travel outside of this depth and into the deeper ocean in large quantities, except during severe coastal storm wave events. Typically, insufficient shoreward energy exists to move sand from outside of the depth of closure back into the littoral cell. Sand located or carried outside of the depth of closure essentially exits the littoral cell and is no longer available to naturally replenish beaches during the summer. Sediment budgets are also time-period specific, particularly regarding artificial nourishment contributions; therefore, it should be noted the numbers presented below will continue to change, and planning for RBSP III would continue to use the most up-to-date information available in future phases.

Sediment budget information clarifies whether beaches in the littoral cell are eroding (getting smaller), accreting (getting larger), or stable, and yield information useful in determining the longshore sediment transport rate for characterization of a specific beach site. Longshore sediment transport (aka “littoral drift”) reflects the volume and rate of sand moving through a coastal reach over time and occurs in both upcoast (north) and downcoast (south) directions. The direction of sand movement varies seasonally and depends on wave conditions. The total amount of sediment movement over a year is referred to as the gross transport rate, and the difference between the upcoast and downcoast sediment transport rates is referred to as the net transport rate. The volume and direction of net sediment transport represents the effective or predominant littoral drift used in sediment budget calculations. Additional discussion of the sediment budget and longshore sediment transport rate concepts is provided in the RBSP III Feasibility Study.

The RBSP III area is composed of three littoral cells: Oceanside Littoral Cell, Mission Bay Littoral Cell, and Silver Strand Littoral Cell. This section focuses on the sediment budget and longshore sediment transport rate for the portion of the littoral cell in southern Orange County, which is the northern portion of the Oceanside Littoral Cell.

Northern Oceanside Littoral Cell

The Oceanside Littoral Cell extends from Dana Point to Point La Jolla. The Oceanside Harbor North Jetty represents an effective, artificial barrier to sediment transport from the northern to southern portion of the littoral cell; therefore, this littoral cell can be sub-divided into two separate sub-cells. The cities of San Clemente and Dana Point are located in the northern portion of the Oceanside Littoral Cell, which extends from Dana Point to Oceanside Harbor.

Sediment Budget

Defining sediment budgets for coastal reaches is challenging and can sometimes be inaccurate. Historically, research indicates the input of sediment to the Northern Oceanside Littoral Cell has been in an approximate balance with a similar quantity of sediment moving out of the system. This type of equilibrium would typically result in a relatively stable coastline. Prior to the 1970s, decreases in natural sediment supply due to anthropogenic developments were mainly offset by large influxes of artificial nourishment in the northern extent of the sub-cell. These artificial nourishment sources included sand from the construction of the San Juan Creek flood control channel, Dana Point Harbor, and the San Onofre Nuclear Power Plant. However, since the 1970s, artificial nourishment has declined, and natural sediment contributions continue to decrease. Consequently, monitoring data of historical shoreline change indicate a shift beginning in the 1980s from a stable shoreline to an average erosional trend (Moffatt & Nichol [M&N] 2019).

Patsch and Griggs (2007) estimated the sediment budget is at equilibrium with an input of approximately 290,000 cy per year balancing the loss of sediment to its sinks (approximately 290,000 cy per year), resulting in a relatively stable coastline. Beach nourishment was estimated to provide approximately 110,000 cy per year; fluvial sediment was estimated to provide approximately 80,000 cy per year; and sediment from seacliff and upland erosion was estimated to provide approximately 70,000 cy per year in this part of the littoral cell (Patsch and Griggs 2006). Sediment losses were attributed to transport into the Oceanside Harbor (146,000 cy per year) and a sandbar offshore of the Oceanside Harbor mouth (144,000 cy per year).

As part of the feasibility study for USACE's San Clemente Shoreline Protection Project, which completed construction in 2024, USACE conducted a historic sediment budget analysis for three different time periods from 1900 to 1990 (USACE 2012). The resulting sediment budget analysis indicated the shoreline was at equilibrium.

While the studies above indicate a shoreline in equilibrium, other research indicates the sub-cell is clearly in a deficit. A 2014 study on the coastal and hydraulic/hydrologic processes at Doheny State Beach assessed littoral sediment transport patterns and the sediment budget for the coast between Dana Point and San Mateo Point (Coastal Environments 2014). Data from sediment studies conducted between the 1980s and 2000s were aggregated, estimating that the sediment budget for the region is -56,000 cy per year (i.e., erosion) in dry years, and a surplus of approximately 3,000 cy per year (i.e., accretion) in wet years.

The difference in sediment yields between the 2014 Coastal Environments study and those studies mentioned earlier is likely due to comparatively little artificial nourishment taking place in the Capistrano Bight from the 1980s through the 2010s. In contrast, major beach replenishments sourced from the construction of Dana Point Harbor in the 1960s likely offset some of the net erosion that would have otherwise occurred in the cell. The discrepancy in sediment yield between wet and dry years, as calculated by the Coastal Environments 2014 study, helps explain why the prolonged drought over the late 2010s to early 2020s was correlated with significant shoreline erosion from Dana Point through San Clemente.

Since these various numbers have been calculated, different nourishment events have occurred, most recently the USACE's San Clemente Shoreline Protection Project in 2024. These numbers will continue to change and planning for RBSP III would continue to use the most up-to-date information in future phases.

Longshore Sediment Transport Rates

As discussed above, longshore sediment transport consists of gross and net transport components. In the northern portion of the Oceanside Littoral Cell; estimates for longshore sediment transport are slightly lower than those estimates for the southern portion (USACE 1990; 1991). The gross transport north of Camp Pendleton is estimated at 800,000 cy per year, while net sediment transport ranges from 0 to 150,000 cy per year to the south (USACE 1991).

Most research indicates that net littoral drift and sediment transport in both the northern and southern sub-cells in the Oceanside Littoral Cell is generally from north to south. This is supported by anecdotal data of sand accumulation in the area, such as at the northern side of Doheny Beach groin and north of T Street Reef in San Clemente. However, the northern sub-cell, particularly the zone from San Clemente through

Doheny State Beach, experiences a strong seasonal signal of northward transport from May through October due to direct exposure to southern hemisphere swells.

Kahl et al. (2024), based on wave and shoreline data from 2000 through 2021, indicate that the net littoral transport from Oceanside Harbor to San Onofre may be northward year-round, while the coastline from San Onofre to Dana Point exhibits several reversals of net transport direction throughout the year. Therefore, there is significant uncertainty about the current net direction of sand transport in southern Orange County. Additionally, if the current net direction was northward, certain signals should exist that indicate this trend, such as sand build-up on the southern side of reefs and structures, or gradual beach widening toward the north, but these signals are not observed. These findings show the complexity and evolving understanding of sediment transport dynamics in the Oceanside Littoral Cell, highlighting the need for monitoring, ongoing research, and adaptive coastal management strategies.

6.1.2 Beach Profiles

Shoreline monitoring programs have been conducted intermittently in the southern Orange County region since the early 1980s. Ten surveys were performed by USACE between November 1983 and December 1989 under the auspices of the coast of California storm and tidal waves study for the San Diego Region (USACE 1991). Between October 2001 and May 2007, eleven surveys were conducted on behalf of the City of San Clemente Beach Monitoring Program (CFC 2007). Four additional wading-depth surveys were later performed between November 2016 and November 2017, exclusively at North Beach in San Clemente to document the placement of opportunistic nourishment. Then, the City of San Clemente Beach Monitoring Program resumed in October 2022 following a nearly 16-year hiatus.

The current City of San Clemente program consists of semi-annual beach profile surveys conducted along up to 12 shore-perpendicular transects, with typical alongshore spacing between transects of less than 0.5 miles (Figure 6-3). Five of the transects were established specifically for the City of San Clemente’s program and were surveyed for the first time in the fall of 2001 (CFC 2001). Six transects had been established previously by USACE and were included in the USACE 1991 study. One additional transect was established in May 2005 to monitor the fate of sand nourishment material placed at North Beach (CFC 2005).

Beach profile data are obtained along each transect from the back beach to a location beyond the estimated depth of closure, which is defined as the seaward edge of an active littoral cell. The surveys are conducted in the spring and fall, corresponding with the beginning and end of the winter and summer wave seasons, respectively. The beach profile survey results are used to assess the shorezone changes and evaluate the impact of natural events (e.g., El Nino) and human intervention (e.g., beach nourishment). Comparison of the spring and fall profiles provides an indication of seasonal changes, while comparison of consecutive fall profiles shows the nature of inter-annual and long-term changes.

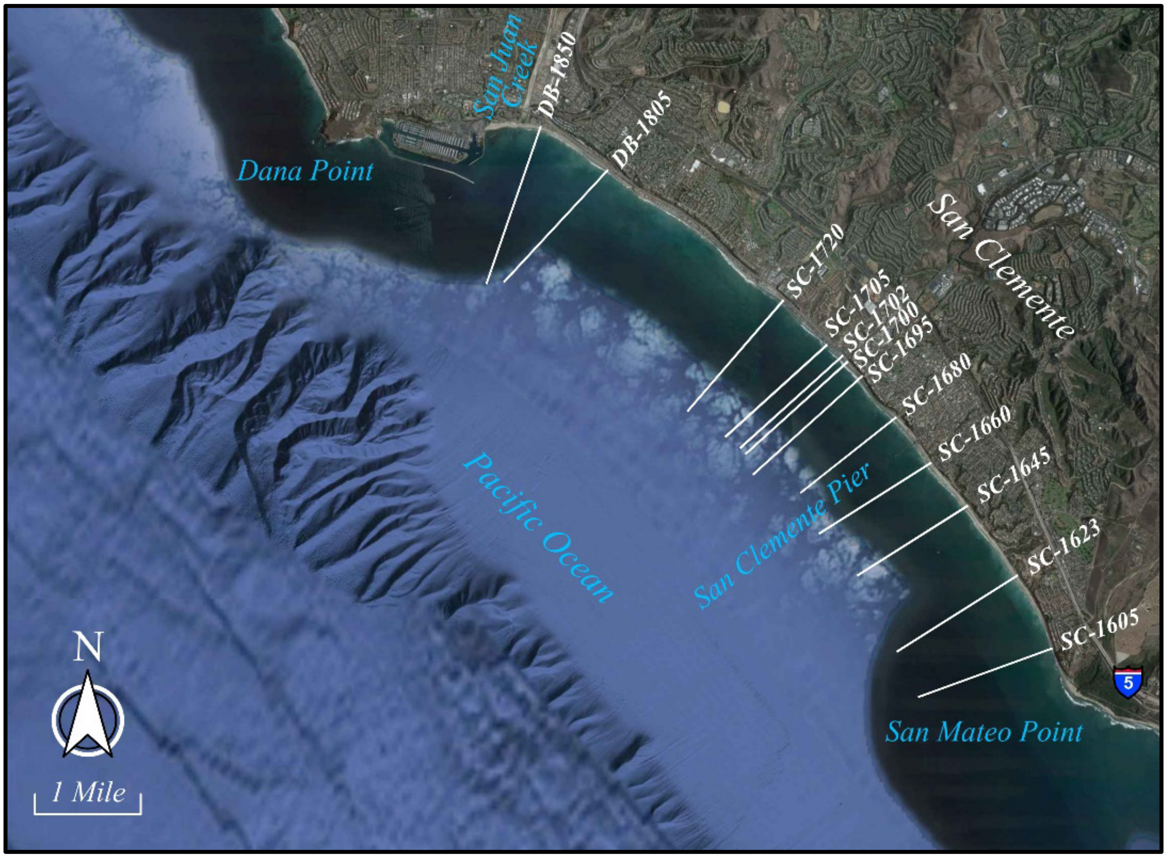


Figure 6-3. San Clemente Beach Monitoring Program, Beach Profile Transect Location Map

The current City of San Clemente Beach Monitoring Program incorporates publicly available light detection and ranging (LiDAR) data of the above-water beach to supplement the beach profile data and reduce temporal gaps in coverage between monitoring programs (CFC 2024a). LiDAR surveys from the years 1997, 1998, 2007, 2008, 2009, 2014, 2016, and 2018 are utilized. The data were acquired by various entities, including United States Geological Survey, the USACE's National Coastal Mapping Program, and Scripps Institution of Oceanography (National Ocean and Atmospheric Administration [NOAA] 2023). Full spatial coverage of the program's study area was not available from every LiDAR survey.

Table 6-1 summarizes the beach profile characteristics in the nine sub-reaches (i.e., distinct segment in a larger reach of coastline) in the monitoring program study area. The berm height was estimated from a representative transect in each sub-reach, while the depth of closure value corresponds to the deepest value among the transects in a given reach. Additional detail is provided in SANDAG's Annual Shoreline Monitoring Reports (CFC 2024b). The values derived for San Clemente were based on limited profile data acquired from 2001 to 2004 and should be regarded as approximate (CFC 2007).

The berm height and depth of closure values in Table 6-1 can be used to estimate the loss of beach due to sea-level rise using the equilibrium beach profile concept proposed by Dean (2002). Similarly, beach-width gains from artificial sand nourishment can be estimated using these values along with grain-size information. Both, the loss and gain of beach width in these sub-reaches were taken into account to estimate the proposed nourishment volumes required to achieve a desired beach width for southern Orange County beaches as part of RBSP III.

Table 6-1. Beach Profile Characteristics in Southern Orange County Sub-Reaches

Sub-Reach	Representative Transect	Berm Height (feet MLLW)	Depth of Closure (feet MLLW)
Doheny State Beach	DB-1850	13	-15
Shorecliffs	SC-1720	14	-15
Capistrano Shores	SC-1705	9	-14
North Beach	SC-1700	13	-16
San Clemente City Beaches	SC-1695	9	-13
Pier Bowl & T-Street	SC-1660	14	-16
Boca Del Canon Beach	SC-1645	14	-20
San Clemente State Beach	SC-1623	14	-14
Cyprus Shores	SC-1605	14	-17

Notes:
MLLW = Mean lower low water

6.1.3 Sediment Grain Size

Sediment grain-size data are essential for analyzing the compatibility of a sand source for beach nourishment and are a tool to predict the longevity of a beach fill, the dispersion rate of sand from a beach fill project, and morphologic changes over time. For example, based upon the outcomes of RBSP I and RBSP II, beach fills composed of coarser than native material tended to persist longer than those fills composed of finer-grained material.

Several studies have documented the grain-size distribution of Orange County beaches, showing sand characteristics in Orange County are largely similar to those characteristics seen in northern San Diego County. A Shoreline Feasibility Study prepared for the City of San Clemente (USACE 2012) investigated nearshore grain sizes along eight different beach sections in San Clemente, which indicated median grain sizes ranged from 0.31 millimeters (mm) to 0.12 mm, with coarser sand typically found in the southern reaches of San Clemente. Capistrano Beach currently has a Sand Compatibility and Use Guidelines (SCUG) (M&N 2020) document in place that characterizes the sand typically found on Capistrano Beach, which indicated median grain sizes range from 0.55 mm to 0.1 mm, with the average being 0.23 mm. Doheny State Beach has an average median grain size of 0.4 mm according to the most recent SandSnap data (USACE 2025b). During future project development for RBSP III, additional analysis of grain size may be performed to ensure optimal compatibility of offshore sources for each receiver site to maximize duration of beach fills.

6.1.4 Shoreline Position

As discussed previously, beach profile surveys have been conducted intermittently in southern Orange County since the early 1980s (Section 6.1.2 above, USACE 1991, CFC 2024a). Surveys typically are conducted in the spring and fall to capture seasonal, annual, and long-term changes. Beach widths are computed from the beach profile data as the distance between the landward edge of the beach sand and the point at which the beach profile intersects the plane of the Mean High Water (MHW) datum, which can include both wet and dry beach areas. More recently, the City of San Clemente Beach Monitoring Program augmented the beach-width database using LiDAR data. The results are tabulated in the monitoring program reports (CFC 2024a).

Beach width provides an indication of recreational area as well as the protection afforded to upland facilities. Comparing fall and spring beach widths indicates winter seasonal changes (typically erosion), while comparing spring and fall beach widths shows summer seasonal changes (typically accretion). Additionally, comparing consecutive fall beach widths show the nature of inter-annual and long-term changes.

Table 6-2 summarizes the beach-width changes and trends documented in nine sub-reaches in San Clemente and Dana Point between 2001 and 2023. No large-scale beach nourishment projects were conducted during this period; however, two small projects occurred at North Beach with 5,000 cy in 2005 and 12,000 cy in 2016.

Table 6-2. Beach Width Changes in Southern Orange County Sub-Reaches, 2001 to 2023

Sub-Reach	Fall 2023 Beach Width (feet) [1]	Beach-Width Change (feet) [1] *Fall 2001 to Fall 2023*	Beach-Width Trend (feet per year) [1,2] *Fall 2001 to Fall 2023*
Doheny State Beach	181	-72	-4.0
Shorecliffs	149	-23	-1.5
Capistrano Shores	2	-11	-0.6
North Beach	132	-16	-0.6
San Clemente City Beaches	0	-11	-0.4
Pier Bowl & T-Street	209	112	2.5
Boca Del Canon Beach	179	34	1.5
San Clemente State Beach	137	10	1.7
Cyprus Shores	12	-118	-6.2

Notes:
[1] Shoreline data derived from representative transect in the reach (Table 6-1)
[2] Trends derived by linear regression

At the time of the fall 2023 survey, beach widths among the nine sub-reaches ranged from 209 feet at the Pier Bowl & T-Street sub-reach to 0 feet at the San Clemente City Beaches sub-reach. Beach widths were less than 100 feet at three sub-reaches: Capistrano Shores, San Clemente City Beaches, and Cyprus Shores. Only one sub-reach, Pier Bowl & T-Street, had a beach width exceeding 200 feet. Over the 22-year period between fall 2001 and fall 2023, net beach gains were observed at three sub-reaches in the central portion of the region: Pier Bowl & T-Street, Boca Del Canon Beach, and San Clemente State Beach. In contrast, net beach-width losses occurred at the remaining six sub-reaches, each located at the northern or southern extremities of the region. This outcome reflected shoreline change rates ranging from accretion of 2.5 feet per year at Pier Bowl & T-Street to erosion of 6.2 feet per year at Cyprus Shores.

Figure 6-4 displays the fall 2023 beach widths in the monitoring program study area in context of the historical range documented at each site, which is composed of available beach profile and LiDAR data collected during the months of September through December between 1983 and 2022. Fall 2023 beach widths in the Pier Bowl & T-Street sub-reach (Transects SC-1680 and SC-1660) represented historical maximums. Further south at the Boca Del Canon Beach sub-reach (Transect SC-1645) and the San Clemente State Beach sub-reach (Transect SC-1623), beach widths fell near the middle or upper portion of the historical range. Throughout the remainder of the region, fall 2023 beach widths were relatively narrow by historical comparison. Beach widths were particularly narrow at the Capistrano Shores sub-reach (2 feet at Transect SC-1705), the San Clemente City Beaches sub-reach (0 feet at Transect SC-1695), and the Cyprus Shores sub-reach (12 feet at Transect SC-1605). Ultimately, the shoreline position data are used to evaluate the need for beach nourishment, likely performance of beach fills, and optimum renourishment intervals.

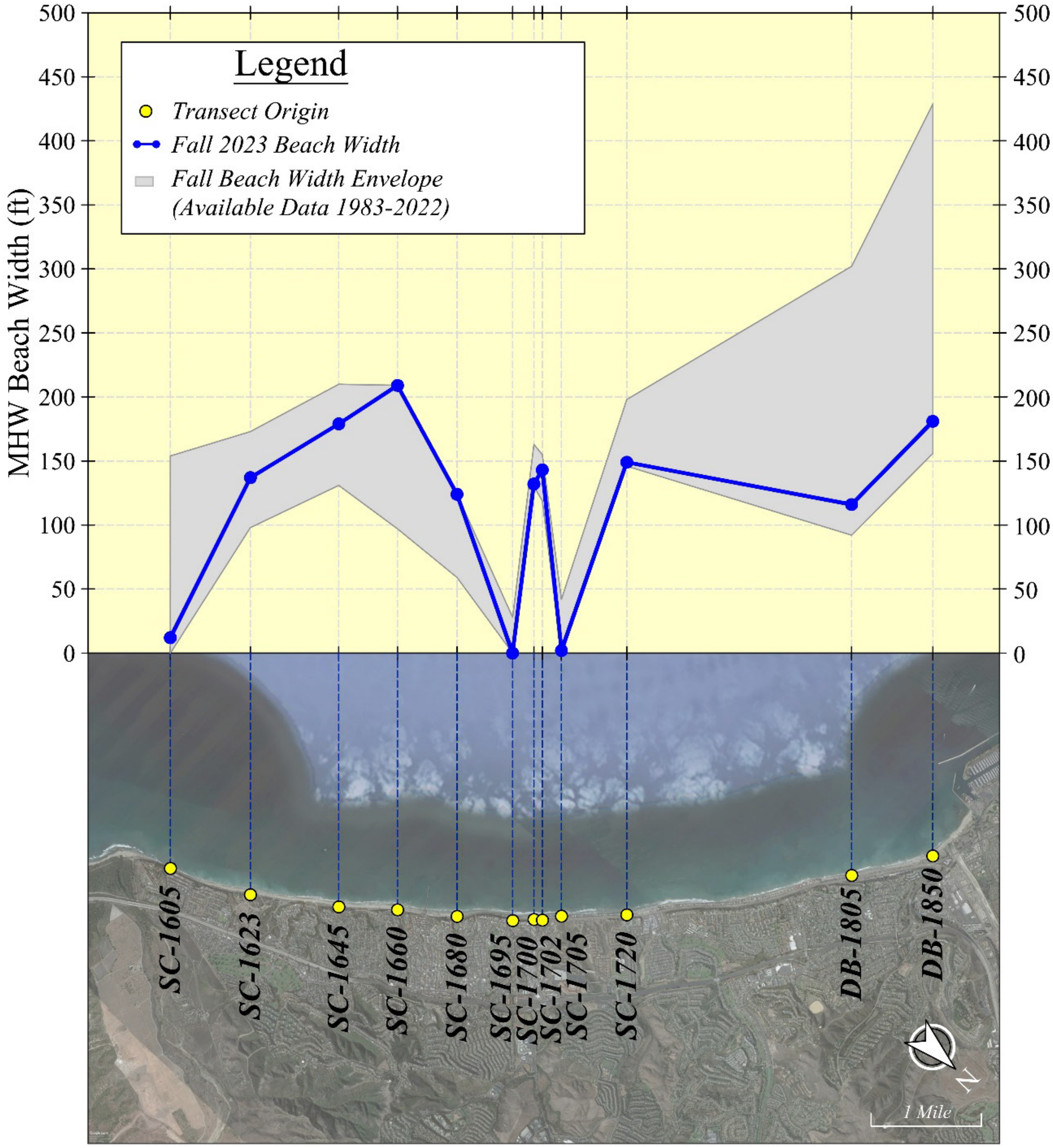


Figure 6-4. Fall 2023 Mean High Water Beach Widths Relative to 1983-2022 Historical Fall Beach Width Envelope

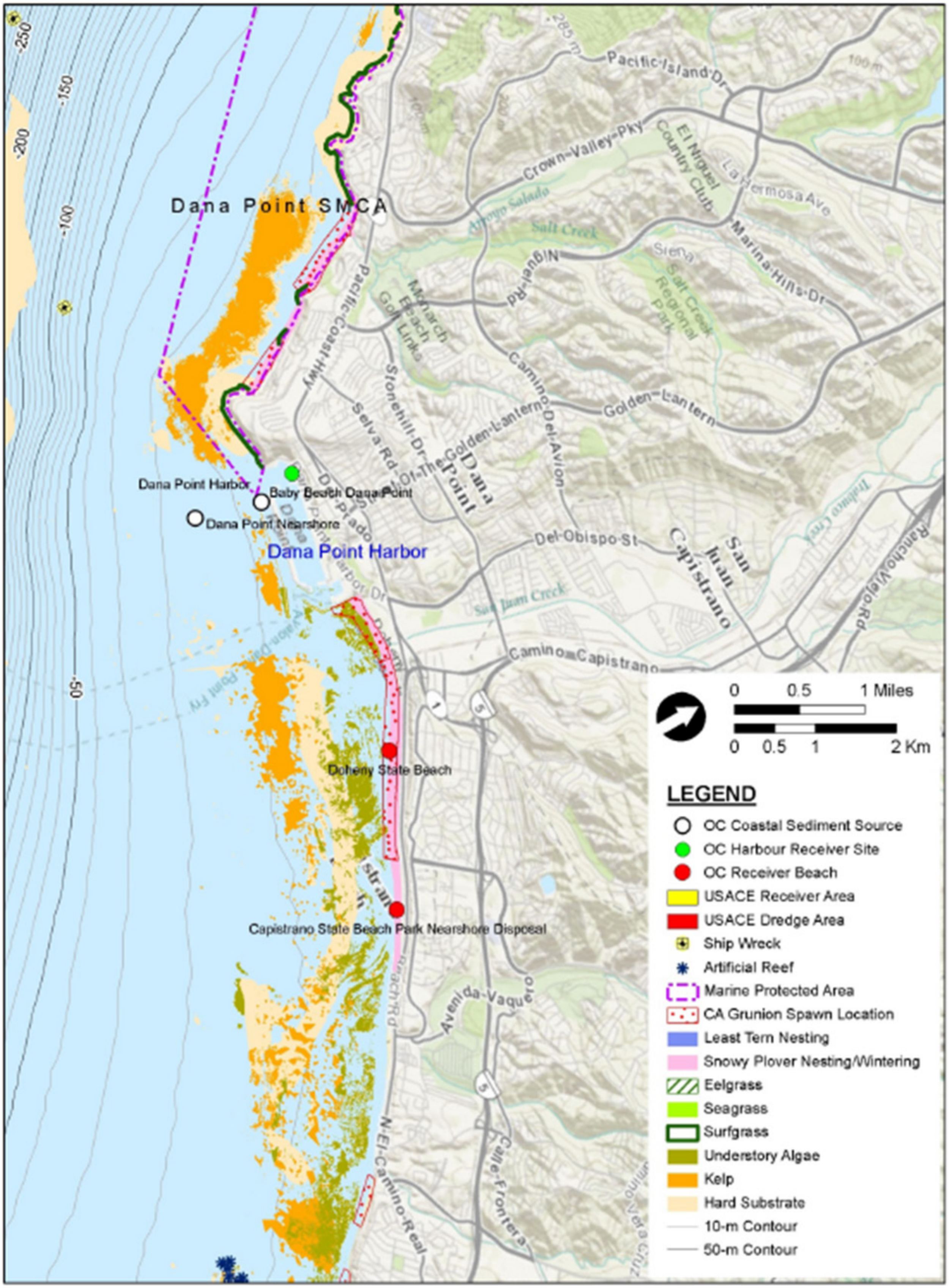
6.1.5 Nearshore Inventory

A wide variety of marine ecosystems and nearshore biological habitats occur in the proposed RBSP III area, and include sandy beaches, sandy offshore habitat, rocky reefs, kelp forests, and seagrass beds. Sandy beach habitat supports shorebirds, including the threatened western snowy plover and provides spawning habitat for the California grunion, a state-managed fish. Additionally, pismo clam beds occur in sandy substrate extending from intertidal to nearshore depths in some locations. Soft-bottom habitats also support eelgrass beds and diverse invertebrate populations, which provide a food source for various fishes that live on or near the bottom. Nearshore reefs and kelp beds support a diverse community composed of a variety of macroalgae, invertebrates, and fishes, while marine mammals forage on invertebrates and fish throughout the water column over hard or soft bottoms and in kelp beds. These marine biological resources support important commercial fisheries, are the target of recreational fishing and diving, and are the subject of educational research. In addition, federally designated habitat areas of particular concern include canopy kelp beds, seagrasses, and rocky reefs.

Sensitive marine biological habitat existing along San Clemente mainly occurs in the vicinity of Mariposa Point, which may pose a constraint to sand placement. Other areas of the City of San Clemente are less sensitive and, therefore, pose less of a constraint. Comprehensive reports have been prepared that summarize known resources in southern Orange County (Everest 2013); however, these studies are old, and digital spatial data are unavailable due to the inability to locate the original data files. Table 6-3 lists known potential data sources, the year of most recent surveys, and an assessment of whether those data are dated and/or available, while Figures 6-5 and 6-6 graphically present the nearshore marine biological resources from Dana Point to San Clemente. Up-to-date existing conditions information is required to evaluate and identify the potential for impacts to marine habitats from the proposed RBSP III.

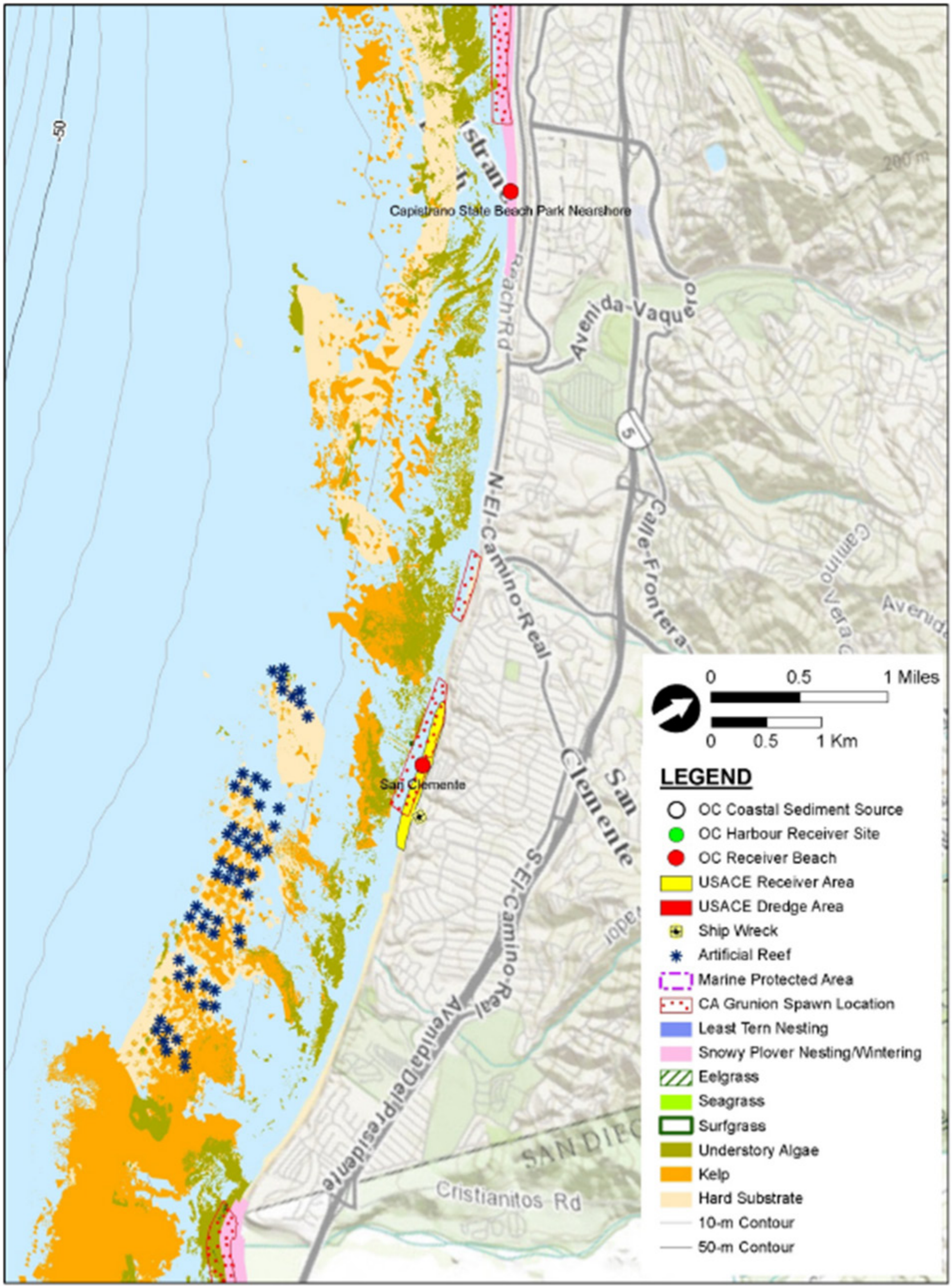
Table 6-3. Spatial Habitat Data in the Project Area

Receiver Beach	Existing Known Data Sources	Spatial Data Available?	Requires Updating Prior to Project Implementation
Dana Point	Everest 2013	No	Yes
San Clemente, North Beach	Everest 2013 M&N 2017	No Yes	Yes
San Clemente, Pier	Everest 2013 Marine Taxonomic Services 2023	No Yes	Yes



Source: Everest 2013

Figure 6-5. Sensitive Biological Resources, Dana Point to Capistrano Beach



Source: Everest 2013

Figure 6-6. Sensitive Biological Resources, Capistrano Beach to San Clemente

6.1.6 Other Related Projects (ongoing, planned, and potential)

Various sand management activities have been and/or are ongoing in the southern Orange County region. Beach replenishment efforts include large-scale beach restoration projects and opportunistic nourishment. Sand placed at specific locations conveys throughout the littoral system over time, eventually becoming too dispersed to be measurable in a single location. Specific projects and activities are discussed below.

The San Clemente Shoreline Protection Project, a 50-year federal beach nourishment initiative, commenced in December 2023. This project, administered by USACE with the City of San Clemente as the local sponsor, aims to provide sand to the region near the San Clemente Pier. The initial planned placement volume was 251,000 cy (USACE 2023), with subsequent renourishments cycles of the same sand quantity planned at intervals of 5 to 6 years. The project was suspended in January 2024 due to undesirable material and difficult dredging conditions at the borrow site near Oceanside Harbor, resulting in minimal material being delivered to the beaches at that time. The project resumed in April 2024 using an alternative borrow site near Surfside-Sunset, and about 114,000 cy was placed on the beach (City of San Clemente 2024a). The project resumed again in November 2024, with an additional 82,000 cy of sand placed on the beach. In total, 196,000 cy of the initial planned 251,000 cy was placed on the beach (City of San Clemente 2025).

Other small-scale nourishments have occurred throughout the southern Orange County area. Under an emergency permit, Orange County Parks placed 45,000 cy of sand sourced from the Santa Ana River at Doheny State Beach and Capistrano Beach between June and September of 2023 (Orange County Parks 2023), and 20,000 cy at Capistrano Beach between July and September of 2024 (Brodeur 2024). The City of San Clemente also conducted opportunistic nourishment at North Beach with sand sourced from the Santa Ana River on three occasions: 5,000 cy in 2005, 12,000 cy in 2016 and 37,000 cy in 2024 (City of San Clemente 2021 and 2024b).

Opportunistic sand nourishment is also expected to continue in the future on an as-available basis. Orange County Public Works is currently, as of early 2025, in the process to secure permits under a county-wide Sand Compatibility and Opportunistic Use Program (SCOUP). A SCOUP allows jurisdictions to implement individual nourishment projects, typically over a 5-year period restricted by the regulatory permits (M&N 2006). Additionally, Orange County Parks has an existing permit to nourish Capistrano Beach and to bury existing sandbags under their SCUG program, which is a similar concept to a SCOUP. Potential future sources for the SCOUP or SCUG may include inland construction projects, flood control projects, or harbor dredging (M&N 2020).

Orange County Transportation Authority (OCTA) is currently conducting the Orange County Coastal Rail Resiliency Study (OCTA 2025). The objective of the study is to evaluate strategies to protect the railroad corridor between Dana Point and San Mateo Point for up to 30 years. Although the study is still in process, it has identified sand nourishment as a potential protection strategy. An initial assessment identified several potential critical areas where future nourishment projects may be implemented.

The City of San Clemente is also conducting a Nature-Based Feasibility Study (NBFS) that includes significant volumes of beach nourishment, a sand retention pilot project, and living shorelines. The study is currently underway and will be completed in 2025. Subsequent planning, permitting, and engineering are expected to occur between 2026 and 2027, with a potential project implementation in 2028 or 2029, or possibly sooner. The NBFS is being developed with consideration of potential future nourishment in San Clemente by USACE, SANDAG, Orange County, and OCTA. It is intended to complement these efforts, supplement, and potentially replace them as needed over time.

The above events are not intended to be an exhaustive list of past and ongoing beach nourishment and related maintenance projects in the southern Orange County region. However, the above events include the efforts that were considered when determining the receiver site footprint locations and volumes proposed for RBSP III. The proposed project would complement or build upon these efforts. Analysis of potential cumulative impacts from RBSP III and other projects would be completed as part of the future environmental review process.

6.2 Recommendations for Efficiencies

Beach and littoral cell nourishment has become a recognized strategy to combat beach erosion and the damage that can occur along eroded shorelines to structures and facilities. Notably, SANDAG has proven experience with beach nourishment projects in the San Diego region through RBSP I and RBSP II. Various efforts by other entities have also been implemented in southern Orange County. The experience from past RBSPs and other projects can help inform the approach for RBSP III and identify strategies to enhance its efficiency and/or cost-effectiveness. Lessons learned and recommendations for efficiencies applicable to southern Orange County are presented below by project phase. It is important to note that a number of these potential streamlining opportunities build on previous projects and nourishment efforts. Streamlining strategies may not be possible, or as effective, for newly identified sites and/or nourishment volumes.

6.2.1 Design

SANDAG has gained valuable insight from RBSP I and RBSP II that could be applied to future project design. The design lessons presented in Section 3 could apply to southern Orange County too, with the exception of very site-specific items, such as access.

For southern Orange County, the USACE San Clemente Shoreline Protection Project provides valuable insight. A key lesson is the importance of confirming sand quality at the offshore borrow site prior to construction. That project initially placed poor-quality material on the beach in San Clemente due to inconclusive data of sand character at borrow site SM-1, north of Oceanside Harbor. The contractor reported a lack of sand at the site and, over 2 weeks, placed nearly 15,000 cy of cobble and some sand on the beach. This issue halted the project until the contractor could relocate to a different borrow site in northern Orange County. After the completion of the separate Surfside/Sunset Beach project, sand from a northern Orange County borrow site was successfully used to nourish San Clemente. However, the delays, public dissatisfaction, and increased costs caused by the initial poor-quality material were substantial. Therefore, future projects such as RBSP III should prioritize comprehensive pre-construction evaluations of offshore borrow sites to ensure appropriate sand quality.

6.2.2 Environmental Review

California Environmental Quality Act (CEQA) requires a “project” that may result in a change in the environment to evaluate its environmental impacts and develop measures to reduce these impacts. Under the National Environmental Policy Act (NEPA), if a federal agency has an approval decision or provides funding for an “action”, that action must be evaluated for environmental and related social and economic effects. Historically, beach nourishment in the San Diego region has been addressed at the individual project level, with the exception of jurisdiction-specific SCOUPs, which are programmatic and typically include limited placement amounts and extend for 5 years per regulatory limits. Both RBSP I and RBSP II addressed compliance with CEQA via an Environmental Impact Report (EIR) with SANDAG as the state lead agency. NEPA was satisfied via Environmental Assessment (EA)/Finding of No Significant Impact (FONSI) which is a lower-level document than an Environmental Impact Statement (EIS). Given funding sources for RBSP I, the federal lead agency was United States Navy (plus a separate EA via the USACE lead agency for permitting purposes). For RSBP II, with no United States Navy funding, the federal lead agency was USACE. The analysis was provided in a joint EIR/EA document that addressed a single placement event with multiple sites along the regional coastline.

One method to streamline efforts for CEQA/NEPA documentation of the two southern Orange County RBSP III sites is to utilize existing information from similar projects in the area. Useful information on existing conditions may be obtained from the USACE City of San Clemente Shoreline Protection Project EIR/EIS, and the City of San Clemente SCOUP Mitigated Negative Declaration (MND). Monitoring data from the USACE project could also inform the impact analysis for RBSP III, if receiver site footprints and volumes are similar/comparable.

In general, rebuilding previously used nourishment footprints or placing similar sand volumes as prior projects could streamline the analysis for RBSP III. This approach is applicable in San Diego because monitoring conducted after construction of RBSP I and RBSP II confirmed a lack of significant impacts to resources. However, in the potential RBSP III two-county scenario, the project would have a greater number of receiver sites, greater volumes to be placed, and more borrow sites than previously evaluated. This more-complex project could trigger a joint EIR/EIS. Ultimately the level of analysis and documentation required for compliance would depend on the potential for significant impacts associated with the proposed project.

It is currently unknown whether a single comprehensive CEQA/NEPA document would be prepared for RBSP III to address both southern Orange County and San Diego County project sites, or if environmental documentation would be prepared separately by county. Efficiencies could be realized via a single comprehensive document, but coordination between jurisdictions and identification of CEQA lead agency would be key to this effort. CEQA allows for a lead agency to prepare the document and denotes responsible agencies as public agencies which propose to carry out the project. SANDAG as the single lead agency in the San Diego region has precedent. In this case, SANDAG could prepare the environmental document that covers areas outside their jurisdiction and certify the document. Additionally, the Orange County Cities would have to be responsible agencies per CEQA and certify the environmental document for their implementation of the proposed project outside the San Diego region. Multiple CEQA co-lead agencies could also be explored (SANDAG and both cities of Dana Point and San Clemente), but would likely be the most complex approach. Ultimately, the determination of appropriate CEQA/NEPA documentation would be determined by the lead agency(ies) after confirmation of the proposed project.

6.2.3 Permitting

Future beach nourishment projects would require extensive permitting from various federal, state, and local jurisdictions. This involves coordination with permitting and regulatory agencies, including, at a minimum, USACE, Regional Water Quality Control Board (RQWCB), California Coastal Commission (CCC), California Department of Fish and Wildlife (CDFW), California State Lands Commission (CSLC), United States Environmental Protection Agency (USEPA), United States Fish and Wildlife Service (USFWS), and NOAA. Similar to the environmental process discussed in Section 6.2.2 above, it is currently unknown if a single permitting effort would take place for both southern Orange County and San Diego County project sites. While consolidating permit efforts between jurisdictions may streamline costs, applying for a single permit for a project spanning multiple jurisdictions and counties can be complex. Nuances of three key permitting agencies (USACE, RWQCB, and CCC) are discussed below. The efficiencies to be gained by a single project permit application (crossing both counties) are linked in part to the structure of the agency itself.

USACE issues Section 404 permits for the discharge of dredged or fill material into waters of the United States, including wetlands (USACE 2025c). Submitting one comprehensive permit application that covers the entire project site would streamline the permitting process and ensure consistency in the evaluation of the project's impacts. There are 38 USACE district offices across United States that exercise regulatory decisions. The City of San Clemente and City of Dana Point fall within the Los Angeles Regulatory District (USACE 2025d); therefore, one consolidated permit application is likely the most streamlined approach. Early coordination with the USACE district office in the planning process is key to navigate the permitting process spanning several jurisdictions.

The RWQCB 401 Water Quality Certification and Wetlands Program is responsible for regulating discharged and fill material to waters of the state. Similar to the USACE process, the RWQCB permitting process would be streamlined by submitting one comprehensive application that covers the entire project. There are nine RWQCB regions that exercise rulemaking and regulatory activities by basins. The City of San Clemente and City of Dana Point fall within Region 9 of the San Diego RWQCB (California State Water Resources Control Board 2025); therefore, one consolidated permit application is likely the most streamlined approach.

CCC requires coastal development permits (CDPs) for proposed developments in the coastal zone per compliance with the Coastal Act. CDPs are generally issued by CCC or local governments with certified local coastal programs for their respective jurisdiction (CCC 2025). Submitting one consolidated coastal development permit application to CCC that addresses the entire project across multiple jurisdictions and counties is feasible but is likely to be the most complex compared to other agencies. A consolidated permit application may simplify the coastal permit review process by eliminating the need to prepare and process permit applications through multiple jurisdictions but would still require approval from each jurisdiction involved. In the case of RBSP II, the cities agreed to a single consolidated CDP issued at the state level. Consulting with CCC and local jurisdictions early in the planning process to understand the specific requirements would be crucial to determine the best approach for the proposed project.

Coordination with other regulatory agencies, such as CDFW, CSLC, USEPA, USFWS, and NOAA fisheries would be similar, requiring early coordination in the planning process to determine the specific requirements for the proposed project. Additionally, depending on future biological mapping and modeling results, some sites may be more complex than others to permit. Determination of the most efficient permitting strategies may be confirmed after initial mapping and modeling is complete. Based on the lessons learned from RBSP I and RBSP II, early coordination efforts with applicable permitting and regulatory agencies are essential for the successful planning, implementation, and cost management of RBSP III.

6.2.4 Construction

The lessons learned for construction and implementation of projects from RBSP I and RBSP II presented in Section 3.5 Study would apply to southern Orange County as well, with the exception of very site-specific items such as site access.

6.2.5 Beach Fill Performance

Section 2 discussed decades of beach nourishment activities and associated monitoring in the San Diego region to provide input on sites and beach fill configurations, as well as re-nourishment cycles. Beach fill performance data would typically be used to inform RBSP III design; however, there is not enough available data to draw conclusions on how the potential beach fills would perform in the proposed southern Orange County beaches as compared to San Diego beaches. The nourishment data and status of profile monitoring in southern Orange County are summarized below, and also in Section 6.1.6 above, for full disclosure.

Accounts of opportunistic beach nourishment in the southern Orange County portion of the proposed RBSP III area date back to 1928. Reports indicate waste material from development of Doheny Palisades was placed on the beach near San Juan Creek (Shaw 1980). Additionally, according to Wiegel (1994) and Shaw (1980), more than 2 million cy of sand was placed on Doheny State Beach and Capistrano Beach from 1966 to 1970. This was primarily due to San Juan Creek flood control measures and hauling of sand from terrace deposits at Camp Pendleton. However, the beach fill performance outcome of these early beach nourishment efforts is largely unquantified due to lack of beach profile monitoring.

The City of San Clemente conducted opportunistic nourishment at North Beach with sand derived from the Santa Ana River, including 5,000 cy in 2005 and 12,000 cy in 2016 (City of San Clemente 2021). Although beach profile surveys were conducted as part of these 2005 and 2016 placements, the fill volumes are too small to provide meaningful information to predict performance of the larger beach fills contemplated for RBSP III.

More recently, Orange County Parks placed 45,000 cy of sand sourced from the Santa Ana River at Doheny State Beach and Capistrano Beach between June and September 2023 (Orange County Parks 2023), and an additional 20,000 cy at Capistrano Beach between July and September of 2024 (Brodeur 2024). These relatively modest quantities were placed in locations with widely spaced beach profile transects, making it difficult to document the performance of the fill material. Furthermore, the fate of this recently placed fill material will not be known for several years. The USACE San Clemente Shore Protection Project, which included placement of 196,000 cy of sand, was also completed in late 2024. The outcome of this beach fill is likely the best option to provide applicable information for evaluating the potential performance of the larger beach fills contemplated for RBSP III; however, profile monitoring is still ongoing so the results will not be known for several years.

6.2.6 USACE Contractor Building the Project

As discussed in Section 6.1.6 above, USACE is conducting the San Clemente Shoreline Protection Project, which includes renourishment at 5- to 6-year intervals for the next 50 years. One potential opportunity to lower costs for RBSP III is to coordinate with USACE to construct RBSP III as part of their own when they return to conduct renourishment in the region in the next 5 to 10 years. This approach could reduce contractor mobilization costs; however, it would require the SANDAG project be added to the USACE San Clemente Shoreline Protection Project. While this approach may be feasible, the time and costs required to modify the USACE project to include RBSP III beaches would be extensive (possibly decades), precluding work from occurring in the near future.

Alternatively, SANDAG could consider directly contracting with the same dredge contractor hired by USACE to construct RBSP III. This approach, known as "piggy-backing," could provide ready access to the contractor at the completion of the USACE project. SANDAG would need to coordinate with the contractor well in advance, as dredging companies schedule work years ahead. While there are uncertainties associated with this approach, it remains a viable option for cost savings.

6.3 Project Components

The proposed RBSP III would provide beach replenishment to as many as 15 receive sites in San Diego County and three in southern Orange County beaches. This section presents the scope of the proposed project specific to southern Orange County, including description of receiver sites, borrow sites, and potential programmatic renourishment cycles. Approximately 1.6 million cy of dredged sediment from offshore borrow sites would be placed on up to three receiver beaches. Table 6-4 details the proposed receiver sits and volumes, while Figures 6-7 through 6-10 show the potential receiver site envelopes. Figures 6-7 through 6-10 use base aerials from January 2024 and are not directly representative of the current beach-width condition at these sites. As described, beach-widths can vary seasonally. Also, a single photograph captures a point in time where the tide may be high (less visible sand) or low (more visible sand).

Table 6-4. RBSP III Proposed Receiver Sites and Volumes

Receiver Site	Quantity (cy)
Dana Point	500,000
San Clemente North Beach	250,000
San Clemente State Beach	800,000
Total	**1,550,000**

The general process for sand dredging from a borrow site, delivery, and spreading is similar among receiver sites. After sand is dredged from a borrow site, it is conveyed via the dredge to a nearshore pipe connection, then pumped through dredge discharge lines to the shore. Existing sand is used to build a dike between the ocean and receiver site, and the dredge material is placed behind the dike to help reduce turbidity. As the material deposits, it is spread along the shore via bulldozers to create a berm higher than the existing sand.

6.3.1 Proposed Receiver Sites

The proposed receiver site footprints and volumes in Table 6-4 are presented as maximum envelopes and maximum volume as modeling and detailed analysis has not been completed yet. The maximum approach provides conservative analysis to allow for flexibility for sea-level rise and programmatic nourishment events. These preliminary receiver site footprints and volumes were determined by incorporating strategies to streamline future efforts, and input from the City of San Clemente, the City of Dana Point, Orange County Parks, and applicable stakeholders. As further information, such as biological habitat mapping and detailed modeling, becomes available and/or is completed, additional refinements to the receiver site footprints and volumes may be identified.

Dana Point

The proposed receiver site at Dana Point would start just south of San Juan Creek and extend approximately 5,700 feet south to Capistrano Beach Park and would receive up to 500,000 cy, as shown on Figure 6-7.

San Clemente North Beach

The proposed receiver site at North Beach would extend from near the San Clemente Metrolink Station to approximately 1,700 feet south and would receive up to 250,000 cy, as shown on Figure 6-8.

San Clemente State Beach

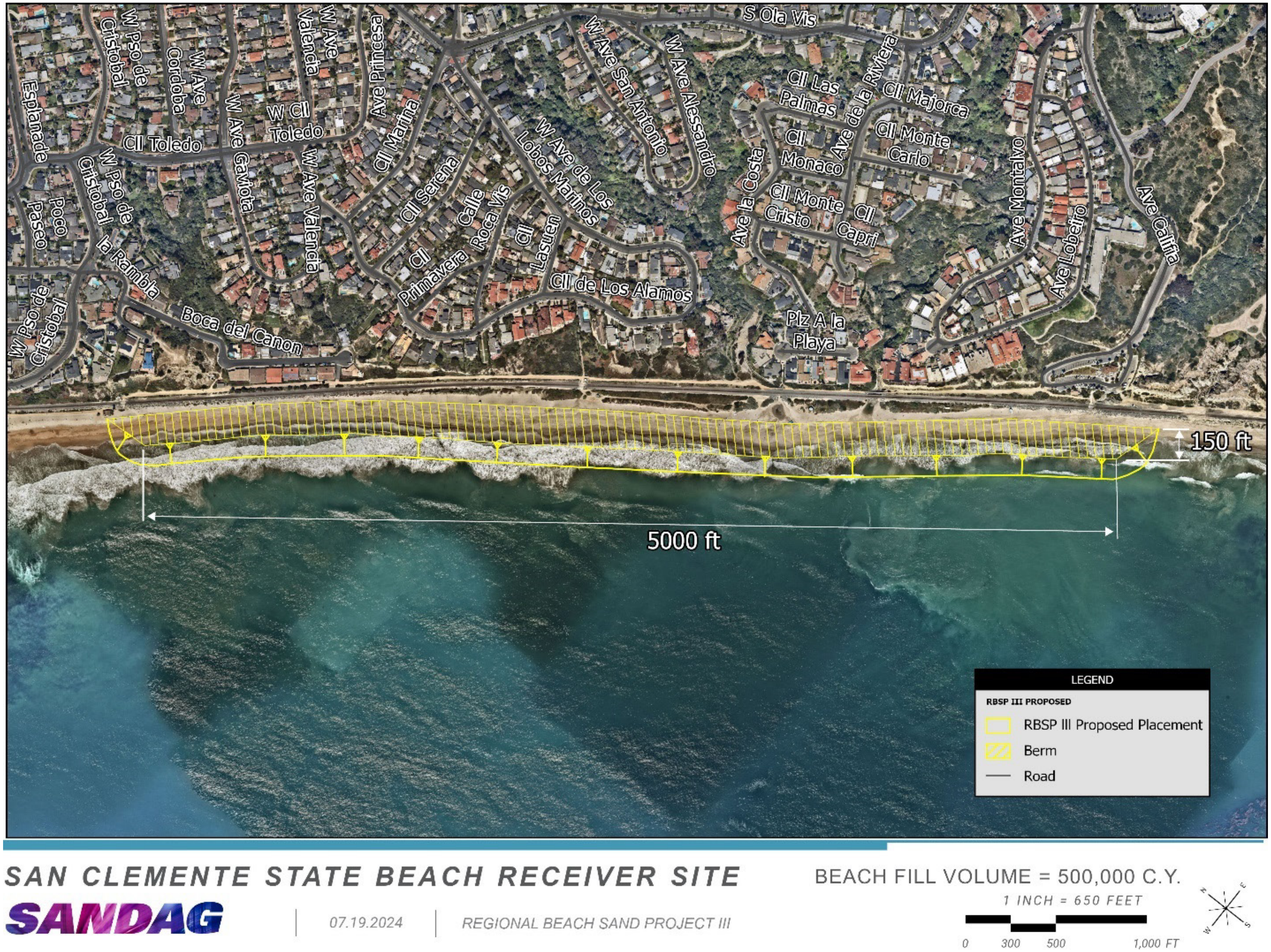
Two potential placement strategies are proposed for the San Clemente State Beach receiver site. As noted in Section 6.1.6 above, the USACE San Clemente Shore Protection project overlaps in this area. The placement strategy at this receiver site would depend on the USACE project, specifically if it moves forward with renourishment cycles as planned (Scenario 1), or does not stay on schedule for renourishment (Scenario 2). Under Scenario 1, the proposed receiver site would extend approximately 5,000 feet just north of Calafia State Park to avoid overlap with the USACE project, as shown on Figure 6-9. Up to 500,000 cy would be placed under this scenario. Under Scenario 2, the proposed receiver site would extend farther northwest totaling to an 8,000-foot stretch encompassing the San Clemente Pier, with a volume of up to 800,000 cy, as shown on Figure 6-10. This proposed placement strategy would provide more recreational benefit by covering the more populated area of the beach near the pier in the case that the USACE project does not take place. Additionally, the length of the receiver site proposed for nourishment at San Clemente State Beach is based on potential attendance numbers that are a reflection of the ease of public access.

Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 6-7. Dana Point Receiver Site

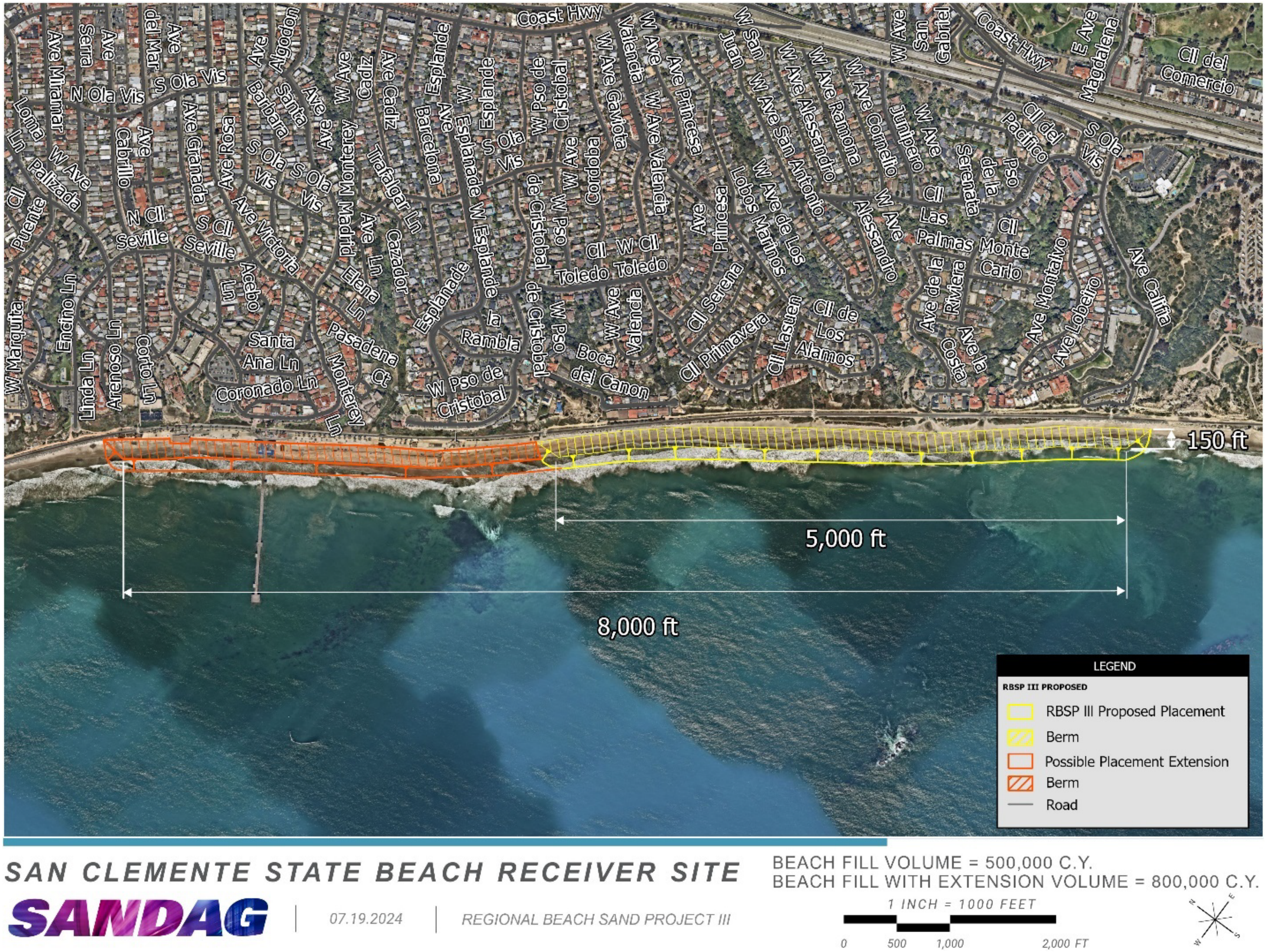
Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 6-8. San Clemente North Beach Receiver Site



Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 6-9. San Clemente State Beach Receiver Site (Scenario 1)



Notes: Base aerial is from January 2024 and does not directly represent the current beach-width condition.

Figure 6-10. Extended San Clemente State Beach Receiver Site (Scenario 2)

6.3.2 Proposed Borrow Sites

Several potential borrow sites located offshore along the coast from Huntington Beach to south of San Clemente are being considered for RBSP III that warrant further investigation. The term borrow site refers to a location that would be investigated in terms of sediment characteristics, marine resources, and ocean surface. In that larger area identified, a smaller dredge area would be identified in a later phase of the project where the actual material would be removed.

Locations for potential borrow sites include Surfside/Sunset, Huntington Beach, Newport Beach, San Mateo Point, and Camp Pendleton, as shown on Figure 6-2. Material at Surfside/Sunset has been repeatedly assessed and determined to be beach compatible; therefore, further investigations would not be necessary. Camp Pendleton is in San Diego County, but a potential borrow area in the mid-area of Camp Pendleton would be relatively close to southern Orange County beaches. Additional details regarding the exploration plans for proposed borrow sites are provided in Appendix C. Analysis of offshore borrow sites would be conducted in future phases to ensure the availability of compatible sandy material.

6.3.3 Programmatic Nourishment Regime

RBSP I and RBSP II were one-time efforts; however, a programmatic approach is being considered for RBSP III, with proposed periodic renourishment to address long-term losses and erosion. Proposed renourishment cycles for southern Orange County beaches are presented in Table 6-5. Renourishment quantities would be determined during the design phase of the project. These cycles are based on evaluation of shoreline change trends (as discussed in Section 6.1.4 above), even though the available information is limited. The proposed renourishment intervals may be refined in future phases of RBSP III based on the outcome of numerical modeling. A programmatic approach provides advantages to individual projects such as: 1) having a streamlined approach to environmental review and permitting to address the same actions repeated over defined time intervals, 2) programming funding to be available to enable project progress to nourish farther into the future, 3) sets a schedule and expectation to maintain beaches based on sand needs and past performance of fills, and 4) motivating dredge contractor to station and maintain large hopper dredges on the west coast, reducing costs.

Table 6-5. RBSP III Proposed Renourishment Cycles

Sub-Reach	Ideal Renourishment Interval
Dana Point	5 Years
San Clemente North Beach	5 Years
San Clemente State Beach	5 Years

While an interval is identified for San Clemente State Beach, RBSP III renourishment would ultimately be dependent on the USACE San Clemente Shoreline Protection Project. The USACE project renourishment schedule includes placement of 251,000 cy at 5- to 6-year intervals. If the USACE project continues with its planned renourishment cycles, then additional renourishment every cycle may not be necessary as part of RBSP III. Coordination with USACE would occur in future phases of the project to determine the appropriate approach for RBSP III.

6.4 Economic Considerations

6.4.1 Economic Benefit-Cost Analysis

A Benefit-Cost Analysis (BCA) was performed for RBSP III to quantify the potential economic benefits and its value to the public. The primary benefit accrued from the project consists of significantly increased recreational usage and associated revenue. Other benefits such as reducing physical damage to public facilities, emergency costs, and potential loss of roads and utilities were not considered as part of the economic analysis, though these benefits could be substantial at some sites. Additionally, some benefits, such as habitat preservation and public safety, are not easily quantifiable and, therefore, not included. Detailed economic analysis is provided in Appendix D. This section focuses on the incremental costs and benefits of included southern Orange County sites as part of RBSP III.

Project Costs

The total cost for the proposed RBSP III Phase 2 and Phase 3, including both San Diego County and southern Orange County, is presented in Table 6-6 and Table 6-7. Phase 2 includes the environmental permitting and design efforts, while Phase 3 includes the construction implementation and 5-year post-construction monitoring. The cost presented here is a conservative estimate for purposes of the feasibility determination. The cost of Phase 2 and Phase 3 totals to approximately $278 million with the majority of the costs occurring during construction implementation. This cost assumes southern Orange County sites move forward as part of a comprehensive RBSP III effort (e.g., one environmental document, consolidated permits). The incremental cost to incorporate southern Orange County beaches compared to the cost for San Diego sites only is approximately $98 million.

Table 6-6. SANDAG RBSP III Phase 2 Preliminary Cost Estimate (San Diego County and Orange County Sites)

Item Number	Item Description	Quantity	Unit	Unit Cost	Subtotal
Environmental, Permitting, and Design Phase					
1	Environmental (CEQA/NEPA) and Permitting	1	LS	$1,845,000	$1,845,000
2	Habitat Mapping	1	LS	$270,000	$270,000
3	Biological Technical Report	1	LS	$130,000	$130,000
4	Final Engineering (includes support on San Diego retention pilot project)	1	LS	$1,410,000	$1,410,000
5	Potential Habitat Burial Assessment	1	LS	$100,000	$100,000
6	Receiver Site Sampling (for new sites and updates to previous sites)	1	LS	$90,000	$90,000
7	Offshore Investigation	1	LS	$3,950,000	$3,950,000
8	Borrow Site and Dredge Pipeline Surveys for Final Engineering Plans	1	LS	$370,000	$370,000
1-8	**Total Phase 2 Costs**	-	-	-	**$8,165,000**

Notes:
LS = lump sum
Assumptions:
1. Phase 2 costs include support for one San Diego pilot retention project during the environmental, permitting, and design phase. There is no retention project proposed for Orange County.

Table 6-7. SANDAG RBSP III Phase 3 Preliminary Cost Estimate (San Diego County and Orange County Sites)

Item Number	Item Description	Borrow Site	Quantity	Unit	Unit Cost	Subtotal
Construction Hard Costs						
9	Mobilization & Demobilization	-	1	LS	$15,000,000	$15,000,000
10	Interim Mobilization	-	18	EA	$300,000	$5,400,000
San Diego County Sites						
10	Oceanside	SO5	1,500,000	CY	$26.22	$39,324,477
11	North Carlsbad	SO5	240,000	CY	$25.28	$6,068,194
12	South Carlsbad	SO5	300,000	CY	$23.03	$6,907,674
13	Batiquitos	SO5	118,000	CY	$21.31	$2,514,732
14	Leucadia	SO5	132,000	CY	$20.68	$2,729,207

Item Number	Item Description	Borrow Site	Quantity	Unit	Unit Cost	Subtotal
15	Moonlight	SO5	105,000	CY	$20.26	$2,127,614
16	Cardiff	SO5	300,000	CY	$19.01	$5,703,127
17	Solana Beach	SO5	300,000	CY	$17.61	$5,283,658
18	Del Mar	SO5	183,000	CY	$17.30	$3,165,626
19	Torrey Pines	SO5	245,000	CY	$18.80	$4,604,854
20	Tourmaline	MB1	300,000	CY	$18.19	$5,455,740
21	Mission Beach	MB1	450,000	CY	$18.21	$8,195,616
22	Coronado Shores	MB1	200,000	CY	$24.15	$4,830,972
23	Glorietta Bay	MB1	10,000	CY	$39.41	$394,053
24	Imperial Beach	MB1	420,000	CY	$27.35	$11,485,152
Orange County Sites						
25	Dana Point	Surfside/ Sunset	500,000	CY	$39.32	$19,658,775
26	San Clemente North Beach	Surfside/ Sunset	250,000	CY	$41.63	$10,408,610
27	San Clemente State Beach (Extended footprint including the USACE Project footprint)	Surfside/ Sunset	800,000	CY	$43.05	$34,436,834
Contingency						
28	Construction Contingency	-	1	LS	35% of construction	$67,793,220
Other Items						
29	Construction Management	-	1	LS	$250,000	$250,000
30	Construction Survey or Inspection	-	20	EA	$25,000	$500,000
28-30	**Total Construction, Contingency, Management, Inspection**	**-**	**-**	**-**	**-**	**$70,793,220**
9-30	**Total Hard Costs**	-	6,353,000	CY	$41.63	**$264,488,135**
Item Number	**Item Description**	**Borrow Site**	**Quantity**	**Unit**	**Unit Cost**	**Subtotal**
Construction Soft Costs						
28	Permit Compliance Reporting, Pre, During, and Post-Construction Biological Monitoring, and other Miscellaneous Monitoring	-	1	LS	$3,050,000	$3,050,000
29	Shoreline Monitoring (Beach Profiling After for 5 years added to base)	-	1	LS	$910,000	$910,000
30	Borrow Site Survey Support	-	1	LS	$480,000	$480,000
31	Borrow Post-Construction Monitoring	-	1	LS	$215,000	$215,000
32	Pre and Post-Construction Receiver Site Detailed Topography	-	1	LS	$770,000	$770,000
28-32	**Total Soft Costs**	-	-	-	-	**$5,425,000**
9-32	**Total Phase 3 Costs**	-	-	-	-	**$269,913,135**

Notes:
LS = lump sum
EA = each site
Assumptions:
1. Dredging and pumping includes land-based equipment for building the beach fill template.

2. Mobilization and demobilization cost is taken from inflating bids from RBSP II to 2025 prices. The total cost would be $15 million excluding interim mobilizations regardless of dredge volumes and county participation. This estimate splits the total $15 million to each county based on their dredge volumes.
3. Maximum volumes for receiver sites are the basis of this estimate.
4. Unit costs for Glorietta Bay are calculated based on pumping to the Coronado Shores receiver site ($24.15 per cy) and trucking material to the Glorietta Bay receiver site ($15.26 per cy).
5. Sand for northern San Diego County sites comes from borrow site SO-5 off of Del Mar, sand for southern San Diego County sites comes from borrow site MB-1 off of Mission Beach, and sand for Orange County sites comes from Surfside/Sunset. Material quality from SO-5 and MB-1 borrow sites is similar to previous projects and excellent. Material quality from the Surfside/Sunset borrow site is similar to previous projects and excellent.
6. Unit costs for dredging and nourishment are based on production rates of a 4,850 cy hopper dredge.
7. Material is dredged and pumped to the beach receiver sites by a hopper dredge.
8. Construction contingency is 35%. The value is based on considering the USACE estimate of 38% and SANDAG guidance of 25-40% at a 10-15% design level. Other items such as Construction Management and Construction Survey or Inspection are required services expressed as a percentage of the cost.
8. While Phase 2 costs include support for one San Diego pilot retention project during the environmental, permitting, and design phase, the Phase 3 estimate does not include costs for implementation due to the uncertainty of which concept would move forward. There is no support for an Orange County retention project included.
9. This is the total cost including both San Diego County sites and southern Orange County sites for SANDAG RBSP III efforts. This cost does not apply if Orange County sites move forward as a standalone project (i.e., separate environmental document, separate permitting).
10. Unit costs are not projected out to a specific year, and are representative of 2025 costs. However, the contingency percentage of 35% sufficiently covers potential cost increases, therefore this total cost accurately reflects possible conditions between now and the year 2030, and is sufficient for planning purposes.

Costs have increased substantially since RBSP II was constructed in 2012 due to various factors. The most influential factor on the incremental cost specific to southern Orange County is the distance from the borrow site to the receiver sites, as transportation costs increase with distance. The current cost estimate in Table 6-7 assumes all sand for southern Orange County sites comes from Surfside/Sunset borrow site off of north Orange County, which is the site with most information available confirming suitable material but is also one of the farthest in distance, thus increasing costs. The best solution to decrease costs of distance is to identify suitable sand borrow sites closer to Dana Point and San Clemente. If alternative borrow sites identified for investigation in Appendix C are determined to be suitable for use, then costs could be lower.

Additionally, the overall proposed strategy for RBSP III is substantially different than RBSP I and RBSP II, including entirely new receiver sites in southern Orange County. Adding entirely new receiver sites and increased sand quantities requires more biological and physical monitoring, and numerical modeling of the sand fate, which adds significantly to the project cost. Other major factors contributing to high costs, including construction mobilization and inflation, are discussed in detail in Section 5. Finally, certain items (e.g., contingency) in the estimate are calculated as a percentage of the construction cost, so if the cost is high then those items would also be higher than in a lower estimate. The total cost presented in this section is a preliminary estimate and is likely to change as the project refines in future phases.

Benefit-Cost Ratio Results

A BCA is a systematic approach for evaluating the economic value of different policy or project options by comparing their expected costs and benefits. For hazard mitigation projects, the BCA determines the future risk-reduction benefits of a project and weighs those benefits against project costs (Federal Emergency Management Agency 2024). A BCA results in a Benefit-Cost Ratio (BCR), which is a direct comparison of expected benefits against projected costs. A BCR over 1.0 is generally considered cost-effective.

Economic benefits were estimated using a model that Dr. Phillip King developed combining aspects of various federal agencies' methodologies with empirical research and established practice to California to provide the most accurate estimate of the value of beach replenishment under RBSP III. The methodology relies on day-use value, carrying capacity, and estimating lost value. The detailed methodology approach and detailed southern Orange County benefits are included in Appendix B and Appendix D, respectively.

The methods used for RBSP III are consistent with the core assumptions underlying federal methods and the general principles for BCA largely agreed upon in the economics profession. Crucially, the analysis used for RBSP III leverages more recent and site-specific empirical studies to generate more specific estimates for the proposed beaches. In doing so, the BCA for RBSP III employs the most current methods and studies of beaches in southern California.

The results of the analysis indicate significant economic benefits from the proposed sand replenishment. Three beaches in southern Orange County were evaluated, highlighting that replenishment would yield hundreds of millions of dollars in avoided losses in recreational value. North Beach is identified as having the highest potential benefits. The methodology also includes a sensitivity analysis to test the robustness of the results against variations in key assumptions, such as visitor crowding tolerance, and erosion rates. The findings suggest that, even with conservative assumptions, the economic benefits of replenishment remain substantial. Detailed economic benefits for each receiver site are included in Appendix D.

Based on the estimates of recreational benefits, the BCR for the proposed RBSP III efforts, including both San Diego and southern Orange County beaches, is 5.5. Adding in southern Orange County beaches slightly lowers the BCR compared to the BCR of 7.7 for San Diego County only. This is due to the high cost of sand for southern Orange County sites. As noted above, if additional borrow sites are determined suitable, then costs would be lowered, thus improving the BCR. However, even with current costs, the results still show the RBSP III project is economically justified, with benefits far outweighing the costs shown in Table 6-8. Overall, when considering solely the non-market recreation value of a beach day to patrons, most of the proposed RBSP III beaches show a compelling case for replenishment. Continued erosion and the concomitant loss of recreation value to beachgoers as the beach shrinks, presents a threat to the efforts of the CCC in its work to preserve the beaches for future public access. Additionally, a failure to maintain the San Diego County and Orange County beaches would inhibit economic activity and recreational value, and place public and private infrastructure at risk. Beach replenishment offers a powerful way to maintain beaches for successive generations and should be a top priority for the region.

Table 6-8. Benefit-Cost Analysis for RBSP III Orange County Beaches

Site	Total Cost	Total Benefit	BCR
San Diego County and Orange County Beaches	$278,078,135	$1,537,357,844	5.5

It should be noted that this study does not include the value of the identified RBSP III beaches as buffers against storm damage. Given the high value of property in San Diego and Orange counties, and the fact that coastal property is among the most highly valued property, an analysis of these additional storm damage benefits would undoubtedly yield an even higher BCR.

6.4.2 Regional Funding Options

The BCA results outlined in Table 6-8 provide the information needed to pursue grant funding opportunities to implement RBSP III. This study serves as a basis for funding decisions in the future. Incorporating southern Orange County into RBSP III allows the region to collaborate and streamline efforts to obtain regional funding. Federal, state, local, and special tax district funding opportunities are discussed in the Section 5.2.

7. Conclusions and Decisions to be Made

The San Diego and southern Orange County region is experiencing a net loss of sand along its coastline and requires periodic addition of sediment into the littoral system to build beaches that provide for human recreation, habitat for numerous sensitive species, protection of public infrastructure, and indirectly contributes to the economic well-being of the region. SANDAG last constructed a regional beach nourishment project in 2012 (i.e., RBSP II), following the initial RBSP I in 2001. This Feasibility Study addresses a possible configuration of RBSP III in the San Diego region. The proposed configuration builds upon the two prior projects and recent beach nourishment efforts undertaken by USACE and other jurisdictions, to benefit from lessons learned and identify possible efficiencies for cost-effective implementation. The initial concept for RBSP III consists of potential offshore borrow sites and up to 14 ocean-facing receiver sites from Oceanside to Imperial Beach, plus one site along San Diego Bay. This Feasibility Study identifies maximum envelopes for those sites totaling up to 4.8 million cy of sand. Section 6 of this Feasibility Study focuses on southern Orange County beaches, proposing up to 1.6 million cy of sand on up to three receiver sites. The proposed project also identifies reoccurring nourishment on 5- to 10-year intervals over a span of 50 years depending on the site. Additionally, opportunities for one pilot retention project in San Diego County are identified to help keep sand on the beach.

As indicated by the economic analysis, the results for San Diego sites only show an overwhelming benefit for the proposed project with a BCR of 7.7, well over the BCR recommended threshold of 1. This is based on comparing the preliminary anticipated cost estimate of $180 million to implement RBSP III, to the estimated nearly $1.4 billion in recreational benefits across the region. When including both San Diego sites and southern Orange County sites, the economic results show a BCR of 5.5. This is based on comparing the combined preliminary cost estimate of $278 million to implement a comprehensive RBSP III, to the estimated nearly $1.5 billion in recreational benefits across both the southern Orange County and San Diego regions. While the BCR is slightly lower, the results still show an overwhelming benefit and score well above the threshold of 1. The proposed RBSP III is also technically feasible to accomplish, as it would follow the same successful approach used for RBSPs I and RBSP II. While the Feasibility Study focuses on the San Diego region, Section 6.0 describes an expanded RBSP III with three more receiver sites in southern Orange County and seven more potential borrow sites up to Huntington Beach.

Based on the information presented in this Feasibility Study, there are a number of items to be discussed by SANDAG and the SPWG, so that SANDAG staff and the supporting consulting team (where applicable) can take steps to further advance the proposed project. Below is a list of decisions to be made and/or next steps, in no particular order.

- Determine region’s desire to pursue a programmatic approach for regional beach nourishment or continue to one-off nourishment projects.
- Revaluate and define the strategy for sand nourishment in the region. Determine what the region is trying to accomplish and what is the best approach to achieving this goal.
- Determine preferred approach regarding coordination with USACE to construct RBSP III or potential to contract with same dredge contractor.
- Determine if the proposed feeder beach concept is of interest. If moved forward, determine if other receiver sites to the south would be eliminated.
- Determine if the region would like to pursue a pilot sand retention project and reach an agreement on its location.
- Confirm the inclusion of new receiver sites in San Diego County not included as part of RBSP I and RBSP II.
- Confirm inclusion of proposed receiver sites in southern Orange County as part of RBSP III for the next phases of the proposed project (Phase 2 – environmental and engineering; Phase 3 – construction).

- Complete environmental impact analysis and identify mitigation and monitoring needs as appropriate.
- Determine if CEQA/NEPA document would address a one-time event or programmatic approach.
- Confirm lead agency and approach to CEQA/NEPA (e.g., one document or two, lead agency and responsible agencies, co-lead agencies).
- Confirm permitting approach with regulatory agencies (i.e., consolidated permit applications or separate).
- Complete proposed borrow site investigations at MB-1, SO-5, SO-4, SO-6, SO-7, and SM-1 to confirm sand suitability and availability.
- Complete proposed borrow site investigations at Huntington Beach, Newport Beach, San Clemente, and Camp Pendleton to confirm sand suitability and availability specific to southern Orange County.
- Determine preferred approach regarding dredge ownership or long-term lease options. Complete a BCA for potential long-term lease of a dredge in a later phase of RBSP III.
- Seek funding to evaluate options for local jurisdictions to develop long-term funding to provide for the required matching funds for construction.
- Continue collaboration with the other Southern California regions as part of the newly formed Southern California Sand Collaborative to leverage funding opportunities for California.

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Appendix A

San Diego County Offshore Borrow Site Investigation

Appendix A

San Diego Association of Governments Regional Beach Sand Project III Offshore Borrow Site Investigation – Exploration Plan and Scope of Work San Diego County

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1. Introduction and Background

San Diego Association of Governments (SANDAG) previously completed two Regional Beach Sand Projects (RBSP) in 2001 and 2012 (RBSP I and RBSP II, respectively), adding approximately 3.6 million cubic yards (CY) of sand to the San Diego region's local beaches. These projects were initial pilot projects, representing the first major steps in addressing the severe sand deficit on the region's beaches and identifying a long-term approach to managing the region's shoreline. Because of the continued deficit within the littoral system, repeated and consistent replenishment is necessary to maintain regional beaches and the recreational, economic, habitat, and protective services they provide.

This Appendix provides a plan and preliminary scope of work for offshore explorations at potential offshore borrow sites to support a third RBSP (RBSP III) in San Diego County, as well as potential opportunities for future placements. Implementation of RBSP III would involve dredging beach-quality sand from offshore borrow sites and placing it on highly eroded beaches in the San Diego region similar to past projects. Potential borrow areas under consideration include: 1) expansions of the previous RBSP borrow areas off of Mission Beach and Del Mar, and 2) re-exploration of known North County San Diego borrow areas. This preliminary assessment considered information available from published literature, previous offshore explorations, and experience with the RBSP borrow sites. This plan and scope of work may need to be updated if additional explorations are performed or new information becomes available[1].

The available information includes a wide-ranging study by Osborne et al. (1983) for California Department of Boating and Waterways on potential offshore sand and gravel resources in southern California from Santa Monica Bay south to Imperial Beach, San Diego. Osborne's 1983 studies provided substantial baseline information and framework for further confirmation investigations over many years. Several sites identified by Osborne have been suitable for past RBSPs (with adjustments), although several areas have also been found unsuitable. Previous studies and local knowledge gained since then have helped focus further investigations at the proposed borrow sites outlined in this Exploration Plan.

These previous studies include RBSP I explorations performed in the Silver Strand Littoral Cell at locations bordering the Tijuana River, namely SS-1 and SS-2 (Sea Surveyor 1999; see **Figure A-1**). The Tijuana River has deposited a vast cobble delta offshore, i.e., a broad submerged system of gravel and cobbles. Previous marine surveys[2] have shown the offshore area west and north of the river mouth is mostly gravelly with little to no sand and is likely not suitable for dredging. USACE (1998, 2002) explored a potential borrow area south of the delta (an area now encompassing the South Bay Ocean Outfall) deemed "Borrow Area B", however the area was not used as other replenishment sources were available at that time. For RBSP I, dredging was attempted at a smaller subarea (SS1-B) based on additional exploration (Noble Consultants 2000). However, the dredge contractor encountered cobbles and dredging was terminated. The broader SS-1 area reportedly has large volumes of borrow materials available (URS 2009). However, the sediment appears to have variable compositions including possible cobble layers and silt layers which would not be suitable for beach replenishment. Sediment contamination testing was not performed. Additional testing and close monitoring of the sediments being dredged would be required in this area.

Zuniga Shoal was another area investigated in the Silver Strand Littoral Cell; an area where the Zuniga Jetty has formed a broad shoal of sediment at the entrance to San Diego Harbor. Vibracore sampling at ZS-1 (**Figure A-1**) collected silty fine sand and silt that was probably too fine for beach replenishment (URS,

[1] To the Teams' knowledge, the available information pertaining to borrow investigations is current and up to date.
[2] San Diego Nearshore Seafloor Substrate survey performed for California State Coastal Conservancy

2009). It might be possible to re-explore potential borrow areas off Imperial Beach, but the current available information suggests the likelihood of locating adequate quantities of high-quality sand is low.

Thereby, increased boundaries are being considered for RBSP III at two of the offshore borrow sites used for RBSP II, namely MB-1 and SO-5, located off of Mission Beach and Del Mar, respectively. These borrow sites were located during previous RBSP offshore investigations[3] and have yielded large quantities of high-quality sand that could provide additional resources for RBSP III. It is also proposed to re-explore several RBSP II borrow sites previously investigated in northern San Diego County. Two of these sites (Cardiff SO-6 and Encinitas SO-7) were used for RBSP II and I, respectively, and may still have suitable material remaining.

Figure A-1 shows locations of previous RBSP and other offshore borrow areas, including: 1) borrow sites investigated (but not used for replenishment), 2) areas proposed for additional explorations (at borrow sites previously sourced for beach replenishment), and 3) proposed new borrow areas evaluated per this assessment.

[3] from RBSP I and II and, in 2024, for the Encinitas-Solana Beach Storm Damage Reduction Project.

2. Borrow Area Expansions

Previous dredge areas for MB-1 and SO-5 are shown on **Figures A-2 and A-3**, respectively**.** The dredge area as-builts include post-survey bathymetric surveys prepared by Coastal Frontiers (2009) for MB-1 and Coastal Frontiers (2012) and United States Army Corps of Engineers (USACE; 2024) for SO-5. The SO-5 borrow site was dredged in 2024 for the Encinitas-Solana Beach Project. The borrow site at Mission Beach has not been dredged since RBSP II. Earlier offshore explorations (for RBSP II reported in URS 2009) indicated substantial volumes of sand at the MB-1 and SO-5 borrow sites, summarized below in **Table A-1**.

Table A-1. Previous Dredge Amounts

Borrow Location	RBSP II Investigation Area Volume (CY)[1]	RBSP I and RBSP II Dredged Volume (CY)[2]	Encinitas-Solana Beach Dredged Volume (CY)	Estimated Remaining Borrow Site Volume (CY)
MB-1	3,257,407	717,921	Not used	2,539,486
SO-5	3,851,852	1,499,986	1,200,000[3]	1,151,866

[1] URS 2009
[2] Moffatt and Nichol 2012
[3] personal communication, Caleb Lodge, USACE email June 16, 2024

Previous volume estimates at MB-1 and SO-5 assumed dredging could extend to depths up to about 20 feet (ft) below the seafloor, as this depth was the maximum explored at the time and is considered the practical depth limit of dredging. At SO-5, the maximum dredge depths to date are estimated to be up to about 10 ft in the deepest areas dredged for Encinitas-Solana Beach (USACE 2024).

Potentially expanded borrow area footprints at MB-1 and SO-5 considered local geologic setting, bathymetry, previous vibracores, and avoidance of known constraints such as bedrock outcrops, shipwrecks, or other known bottom features. Previous investigations include vibracore[4] explorations by Sea Surveyor (1999), Noble Consultants (2000), URS (2009), and Diaz Yourman - GeoPentech - Kinnetic Laboratories Joint Venture (2022). The depth of closure[5] was about -30 ft Mean Lower Low Water (MLLW). The practical water depth limits for dredging were considered at that time to range up to -80 ft MLLW, although dredge areas to date have been mostly in water depths shallower than -80 ft MLLW[6].

2.1 Mission Beach

The proposed expanded MB-1 area at Mission Beach is shown on **Figure A-2**. The previous RBSP I and RBSP II borrow areas were selected to be in the offshore paleo channel of the San Diego River based on geophysical surveys (conducted during RBSP I and again for RBSP II). The paleo channel appears to be a broad feature offshore and appears to be substantially deeper and wider than the previous dredge areas (Hildebrand and York 2021). The borrow area yielded late Pleistocene and Holocene littoral deposits containing medium to coarse sand with shells. The dredge sites provided good quality sand which was

[4] Vibracores are commonly used to explore marine sediment in nearshore coastal settings. The vibracore is a submersible coring tube vibrated in the sediment at the seafloor, typically operated from a support vessel with a winch or crane onboard. Vibracores can typically collect samples up to 20 feet deep in sand.
[5] defined as the limit of sediment movement in the beach profile
[6] Currently dredge depths of 60 feet are more typically considered, with the maximum vertical dredge cut at 70 feet.

placed at Mission Beach and at Imperial Beach as part of RBSP I and at Oceanside and Imperial Beach as part of RBSP II. Hard bottom conditions were not encountered.

Following RBSP I, the RBSP II field explorations were performed over a broader area including a potential expansion of the former RBSP I borrow area to the east and south. The previous dredge areas are obvious bottom features in the multibeam bathymetry. Potential geologic constraints include shallow bedrock indicated along the margins of the borrow area. Based on surveys, previous vibracores were located to avoid encountering shallow bedrock. Several shipwrecks and other cultural features are known to exist in the general area.

A rectangular area south of the former dredge areas at the potential expanded borrow area at MB-1 is considered ("Expanded Southern Borrow") and is estimated to encompass approximately 75 to 80 acres including the vibracores shown on **Table A-2**. Seafloor elevations range between -60 and -75 ft MLLW. The sediment recovered typically included poorly graded ("clean") medium to coarse SP-type sand[7]. The D_{50} of the samples ranged between 0.47 and 0.62 millimeters (mm). Fines content (percentage of silt and clay) was very low, between 0 and 1%, and is summarized below.

Table A-2. Average Grain Size Distributions for MB-1 Expanded Southern Borrow

Vibracore	Soil Classification Composite[1]	% No. 200[2]	D_{50}[3]	Seafloor Level (ft MLLW)	Dredge Level (ft MLLW)	Assumed Dredge Depth (ft)
MB-201	SP	1	0.62	-60.3	-80.3	20
MB-205	SP	1	0.48	-74.2	-94.2	20
SDG-95	SP	0	0.60	-74	-94	20
SDG-96	SP	0	0.47	-66	-86	20
SDG-97	SP	NA	0.74	-60	-80	20
SDG-98	SP	NA	0.45	-75	-95	20
SDG-99	SW	NA	0.48	-63	-83	20
Estimate for Entire Area		**1**	**0.55**			**20**

[1] Per Unified Soil Classification System, SP = poorly graded sand, SW = well sorted sand
[2] Percent passing No. 200 standard sieve, No. 200" sieve is equivalent to a sieve size of 0.075 mm, typically used to determine percent silt and clay.
[3] The D_{50} of sand grain size is the median or average size of the sand grains in a sample. It's a common way to describe the size of sediment and compare different samples.

The expanded southern area volume is in a portion of RBSP II not previously dredged and was included in the total volume estimated for the entire RBSP II borrow site (**Table A-1**). Dredge depths to 20 ft in the western part of the site could require dredging in water depths up to about 95 ft, which is beyond the limits of conventional technology. Dredge depths up to 20 ft were assumed; however, more likely, dredge depths would be limited to 10 ft or less over the western part of the proposed borrow area (**Table A-2**).

A northern area expansion at MB-1 also appears feasible based on available geophysical information, as shown on **Figure 1** below, although relatively few vibracores cover the area. Previous vibracores include MB-203 and MB-204. Both vibracores recovered medium-grained, SP-type sand with D_{50} between 0.5 and

[7] "Clean" is used generally to describe sand particle size with low fines content. Poorly sorted SP-type sand is typically a clean sand. The D_{50} particle size (particle size where 50 percent [%] of the grains are smaller) is commonly used to compare sand particle size gradations.

0.6 mm and less than 2% of fines. The northern expansion could encompass 120 acres or more, although shallow bedrock below the sand could be a limiting factor.

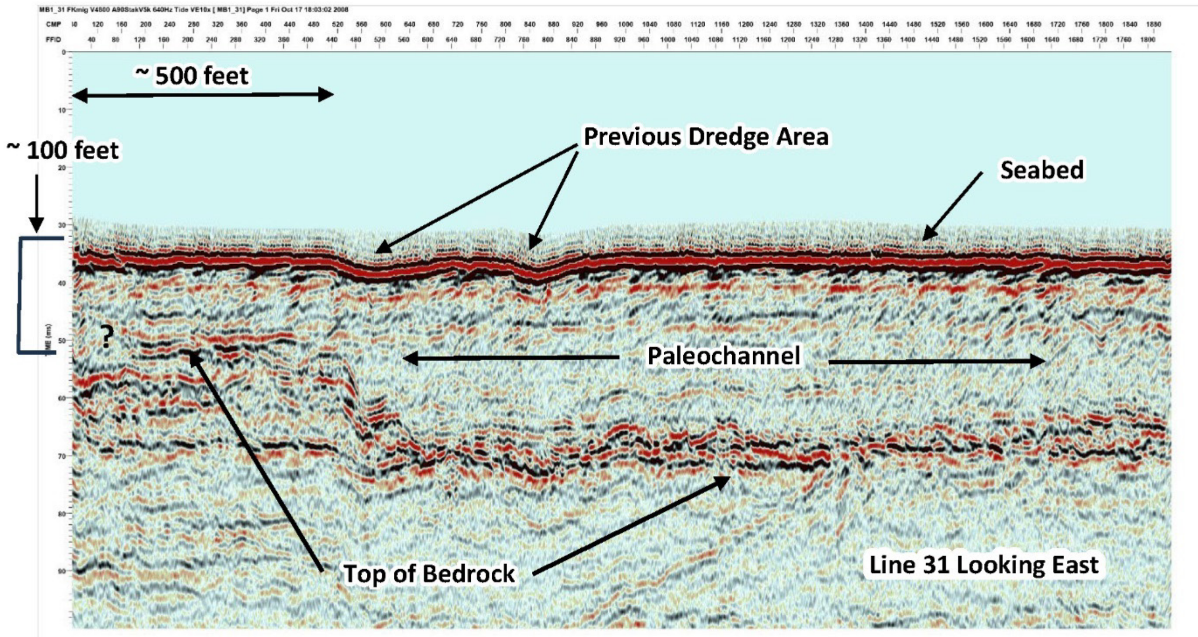

Figure 1 - **Previous Marine Survey off Mission Beach**. This figure shows the multi-channel seismic reflection profile performed by Fugro (URS 2009). The potential north expansion of MB-1 would be to the left on the profile. The geophysical information is estimated to extend several hundred ft below the seabed at the location shown on Figure A-2. The previous RBSP I dredge area is indicated by low areas at the seabed. At depths below the dredge area, the profile shows the top of bedrock in the ancient San Diego River paleochannel. Sediment thickness in the paleochannel is estimated to be greater than potential dredge depths. A northern expansion of MB-1 appears feasible, although the sediment thickness appears to be thinning to the north, which could limit the extent of an expanded borrow.

Previous explorations at MB-1 are shown on **Figure A-2**. Based on available geophysics, the ancient littoral deposit at MB-1 appears to have some northerly lateral extent, and the expanded borrow area could potentially be shifted north with more explorations. Moreover, the previous RBSP I and RBSP II borrow areas likely include substantial thicknesses of suitable sand remaining in place. Preliminary estimated dredge volumes are shown in **Table A-3**.

Table A-3. Anticipated Dredge Volumes for Expanded MB-1

Borrow Location	Potential Constraint	Range of Water Depths (ft)	Approximate Potential Dredge Area (acres)	Assumed Dredge Depth (ft below seabed)	Estimated Expanded Borrow Area Volume (MCY)	Other Considerations
MB-1 Southern Expansion	Unknown bottom feature(s). Setback from shipwreck/dive site (Ruby E).	-60 to -80	75 to 80	20	2.5	marine archaeology assessment update may be required
MB-1 Northern Expansion	Shallow bedrock at paleochannel margin. Setback from dive site (Yukon).	-60 to -80	125 to 130	20	Up to 4.1 (depending on borrow geometry)	20-ft dredge depth to be confirmed

Notes:
MCY = million cubic yards

The MB-1 borrow site is near an area of many offshore artifacts known locally as “shipwreck alley”. GeoArch (2000) identified unverified side-scan sonar targets in the general area of the expanded dredge area described in this Appendix. A possible bottom feature was estimated to be about 50 ft long with a strong magnetic signature based on the magnetometer survey (Coastal Frontiers 2009).

Table A-4 provides preliminary recommendations for additional investigations. Explorations would be primarily using vibracores, with additional focused marine surveys. The selected dredge area should be further evaluated for possible bottom features. The exploration layout would be planned to cover the proposed expansions as needed for beach replenishment.

Table A-4. Recommended Offshore Investigations at MB-1

Borrow Location	Exploration Objective(s)	Bathymetric Survey	Marine Geophysical Surveys	Vibracore Explorations (number of vibracores)	Other Explorations
MB-1 Southern Expansion	Confirm thickness/extent of suitable sand	Update multibeam bathymetry covering previous and proposed dredge areas	Side-scan sonar, and marine magnetometer	10 (including RBSP II footprint)	Submersible remote-operated vehicle camera survey
MB-1 Northern Expansion	Investigate northerly limits of suitable sand and confirm dredge depths		Side-scan sonar and extend previous sub-bottom survey lines north	20	New bathymetry could be deferred to design investigations

2.2 Del Mar

The proposed expanded SO-5 area at Del Mar is shown on **Figure A-3**. The previous borrow area for RBSP I, located in deeper water, yielded some fine-grained material that was placed at Fletcher Cove in Solana Beach and at North Carlsbad, Del Mar, and Torrey Pines Beach. It is suspected that some of the relatively fine materials encountered may have been initially dredged from the surficial silt cover and that coarser materials may have been encountered at depth. Some of the previous vibracores (Sea Surveyor 1999) penetrated only about 6 ft in the previous borrow area. It may be possible to recover suitable sand in areas where some of the silt cover had been removed for RBSP I.

For RBSP II, the area was shifted closer to shore to be closer to the closure depth and to the north to intersect the paleochannel of the San Diequito River. The marine surveys indicated the paleochannel appears to be in the northern portion of the survey area. The sediment was interpreted to represent Holocene and late Pleistocene littoral deposits. The sea floor texture in the area is mostly sandy.

The RBSP II dredge area “footprint” is shown on **Figure A-3**. Dredging completed for the Encinitas-Solana Beach Storm Damage Reduction Project in 2024 essentially re-occupied the previous RBSP II footprint. The available dredge as-built bathymetry (USACE 2024) suggests dredge depths up to about 10 ft over a broad portion of the SO-5 footprint. The post-dredge survey map of borrow site SO-5 prepared by USACE (2024) is included as **Attachment A**.

A potential expanded northern area extended as a trapezoidal area immediately north of the RBSP II and USACE footprint (**Figure A-3**). It is anticipated the expanded borrow area would still be within the offshore paleochannel of the San Diequito River and in a similar relict beach setting as the existing borrow area. The potential northern limits are based on bedrock and kelp mapped in the area, as shown on **Figure 2**.

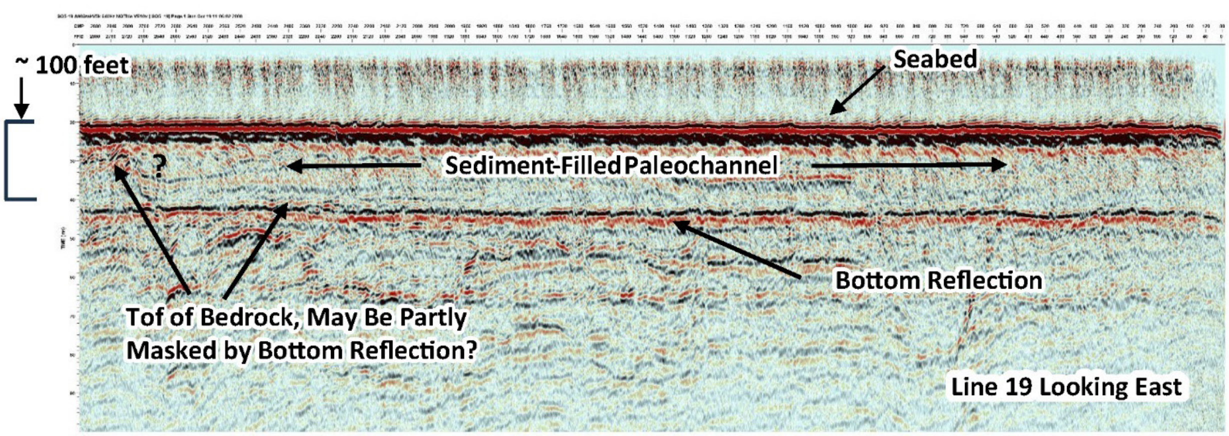

Figure 2 - **Previous Marine Survey off Del Mar.** This figure is a multi-channel seismic reflection profile performed by Fugro (URS 2009). **Figure A-3** shows line location. Former dredge areas are not apparent because RBSP II had not been dredged at the time. The profile shows the ancient San Dieguito River paleochannel margin shallowing to the north. The northern expanded borrow area at SO-5 was located to avoid bedrock. Sediment thickness in the paleochannel is estimated to be greater than potential dredge depths, although the sediment thickness appears partly obscured by a bottom refection, i.e., a mirrored or multiple image of the seabed. Even with the multiple, there is no clear expression of shallow bedrock in the southern expanded area shown on **Figure A-3**.

Four RBSP vibracores were taken [previously within the proposed expanded SO-5 area **(Figure A-3**). Two vibracores for USACE (KLI 2022) were located on the northern limits of previous dredging, and the findings are summarized in **Table A-5**. The sediment generally included poorly graded medium to coarse sand. The D_{50} of the composite samples ranged between 0.15 and 0.71 mm, with fines content (% passing) ranging between 1 and 9%, Based on these findings, there appears to be little to no silt cover. Thin layers of shell and gravel were also recovered in some of the samples.

Table A-5. Average Grain Size Distributions for SO-5 Expanded Northern Borrow

Vibracore (note 1)	Soil classification composite	% No. 200	D_{50} (mm)	Seafloor Level (ft MLLW)	Dredge Level (ft MLLW)	Assumed Dredge Depth (ft)
SO-5-203	SP	1	0.71	-35.9	-55.9	20
SO-5-204	SP	2	0.67	-45	-65	20
SO-5-205	SP	1	0.67	-47.3	-67.3	20
SO-5-208	SP-SM	9	0.15	-63.5	-83.5	20
SO-5VC-22-01[1]	SP	1	NR	-48.5	-68.5	20
SO-5VC-22-02[1]	SP	1	NR	-45.5	-68.5	20
Estimate for Entire Area		**3.3**	**0.55**			**20**

Note 1. KLI 2022
NR = not reported

It may also be possible to further increase the existing RBSP II borrow area to the west and south. The west boundary could cover the east portion of the former RBSP I borrow area. Some of the deeper dredge cuts had been made along the shoreward edge of the former borrow area and may have removed the fine sand/silt cover. Sand remaining may be relatively fine-grained, considering vibracores SDG-72, SDG-74, and SDG-76 (Sea Surveyor 1999). The southerly limits were based on bedrock mapped at the seabed. Vibracores SDG-79 and SO5-211 recovered medium to coarse sand (to 20 ft deep) beyond the existing RBSP II footprint. Preliminary estimated dredge volumes are shown in **Table A-6**.

Table A-6. Anticipated Dredge Volumes for Expanded SO-5

Borrow Location	Potential Constraint	Range of Water Depths (ft)	Approximate Potential Dredge Area to be Investigated (acres)	Assumed Dredge Depth (ft below seabed)	Estimated Expanded Borrow Area Volume (MCY)	Other Considerations
Northern Expansion	Shallow bedrock, kelp	-36 to -70	70 to 80	20	2.5	Set back from closure depth
Western and Southern Expansion	Silt cover, shallow bedrock, kelp	--36 to -7	150 to 160	20	5	Recover material from RBSP I dredge area

Previous explorations at the SO-5 area are shown on **Figure A-3**. The most recent vibracores were performed by KEI (2022) for USACE. Explorations would be primarily using vibracores, with limited marine surveys of the former RBSP I borrow area. **Table A-7** provides preliminary recommendations for additional investigations. The exploration layout would be planned to cover the proposed expansions as needed for beach replenishment.

Table A-7. Recommended Offshore Investigations at SO-5

Borrow Location	Exploration Objective(s)	Bathymetric Survey	Marine Geophysical Surveys	Vibracore Explorations	Other Explorations
Northern Expansion	Confirm thickness/ extent of suitable sand	Update multibeam bathymetry covering previous and proposed dredge areas	Side-scan sonar and extend previous sub-bottom survey lines north	10	Confirm bathymetry at closure depth
Western and South Expansion	Confirm material in the area between SO-5 and at former RBSP I dredge area		Side-scan sonar	20 (including RBSP I footprint)	Collect bottom (seabed) samples of former dredge area

2.3 North San Diego County

Potential additional North County offshore borrow areas were evaluated between Torrey Pines and Oceanside (**Figure A-1**). Almost all of the potential borrow sites have been identified in the literature (e.g., Osbourne et al. 1983), and several have been investigated in a limited way with widely spaced vibracores and/or grab samples collected at the seabed. Bedrock and kelp have been mapped offshore fairly continuously along the North County coastline. The "known" borrow sites from RBSP I and II have been located in ancient offshore paleochannels (i.e., eroded bedrock "gaps" at the major rivers) now backfilled with sediment. It may be possible to locate borrow areas beyond the bedrock shelves, but water depths of 80 ft or more would be prohibitive. The shoreward limit is the depth of closure, generally at -30 ft MLLW.

Considering natural and man-made constraints and previous dredging, it is proposed to re-explore several RBSP II borrow sites that may still have beach suitable material in the general area of the former borrow areas at San Elijo and Cardiff. Potential borrow areas at Torrey Pines and Oceanside would also be re-explored as potential new borrow areas, having not been previously sourced.

2.4 Torrey Pines

The former SO-4 borrow site was located offshore of Los Peñasquitos Lagoon in 40 to 80 ft of water (Sea Surveyor 1999). The potential borrow area identified at SO-4 would have encompassed 230 acres; however, only a 50-acre area along the nearshore boundary was considered suitable based on two vibracores that penetrated to only about 7 ft below the seafloor. The suitable material was described as very fine sand with shells. The two shoreward vibracores, SDG-84 and SDG-88, contained fine sand with a D_{50} of about 0.1 mm with fines less than 7%. The sand was classified as "SP" due to low fines content. The recovered fine-grained sediment may be consistent with clean sandy estuarine deposits. Closer to the shore, it might be possible to locate fine to medium sand.

The seismic reflection data (Sea Surveyor 1999) indicated a westward, thickening sediment prism approximately 10 ft thick along the eastern (nearshore) boundary. The sediment thickness in the nearshore appears reasonably consistent with Holocene sediment thickness mapped using compressed, high-energy, radar-pulse (CHIRP) sonar north of Scripps Canyon along the Rose Canyon fault (Hograth et al. 2007).

The available geophysics suggests bedrock may be deeper than about 10 ft below the seabed. For preliminary purposes, dredge depths would be assumed limited to about 10 ft.

As shown on **Figure 3** below, Inman (1984) reconstructed paleo-shorelines at La Jolla; this mapping shows the 120,000-year-old marine terrace (an ancient wave-cut surface) offshore of Los Peñasquitos Lagoon in water depths inshore of 18 meters (about 60 ft). The marine terrace represents an ancient wave-cut surface that may be covered by sand in a paleo-littoral cell. The geologic objective of a new borrow area at Torrey Pines is to target a relict beach in a similar setting as SO-5 by shifting the former SO-4 area to be closer to the coast, but still beyond closure depth. Previous explorations off Torrey Pines to the south and northwest yielded mostly fine sand. If successful, the approximate limits of the new borrow area would encompass 70 to 80 acres offshore of Peñasquitos Lagoon; the proposed exploration area is shown on **Figure A-4**.

2.5 San Elijo and Encinitas

North County borrow sites were heavily utilized for RBSP I and RBSP II, namely SO-6, San Elijo (Cardiff) and SO-7, Encinitas (Batiquitos Lagoon). The previous dredge areas have a pronounced appearance in the local bathymetry, and as-built bathymetry surveys are available covering the former borrow areas (Coastal Frontiers 2009). These borrow areas supplied large quantities of suitable sand, wherein dredging eventually encountered bedrock; therefore, dredging was limited or even terminated. Approximate limits of previous dredge areas are shown on **Figure A-5** and **Figure A-6** for San Elijo and Encinitas, respectively.

The SO-7 area was not utilized for RBSP II; however, a number of vibracore samples suggest additional suitable sand may be present along the western margins of the previous dredge area, and possibly within nearby areas not previously targeted for dredging (Noble Consultants 2000), as shown on **Figure 4** below. The offshore paleochannel may not have been completely dredged at both areas, although the eastern margin is limited due to the presence of artificial reefs. Additional vibracores are proposed to re-explore these areas. The areas proposed for re-exploration are shown on **Figures A-5 and A-6**.

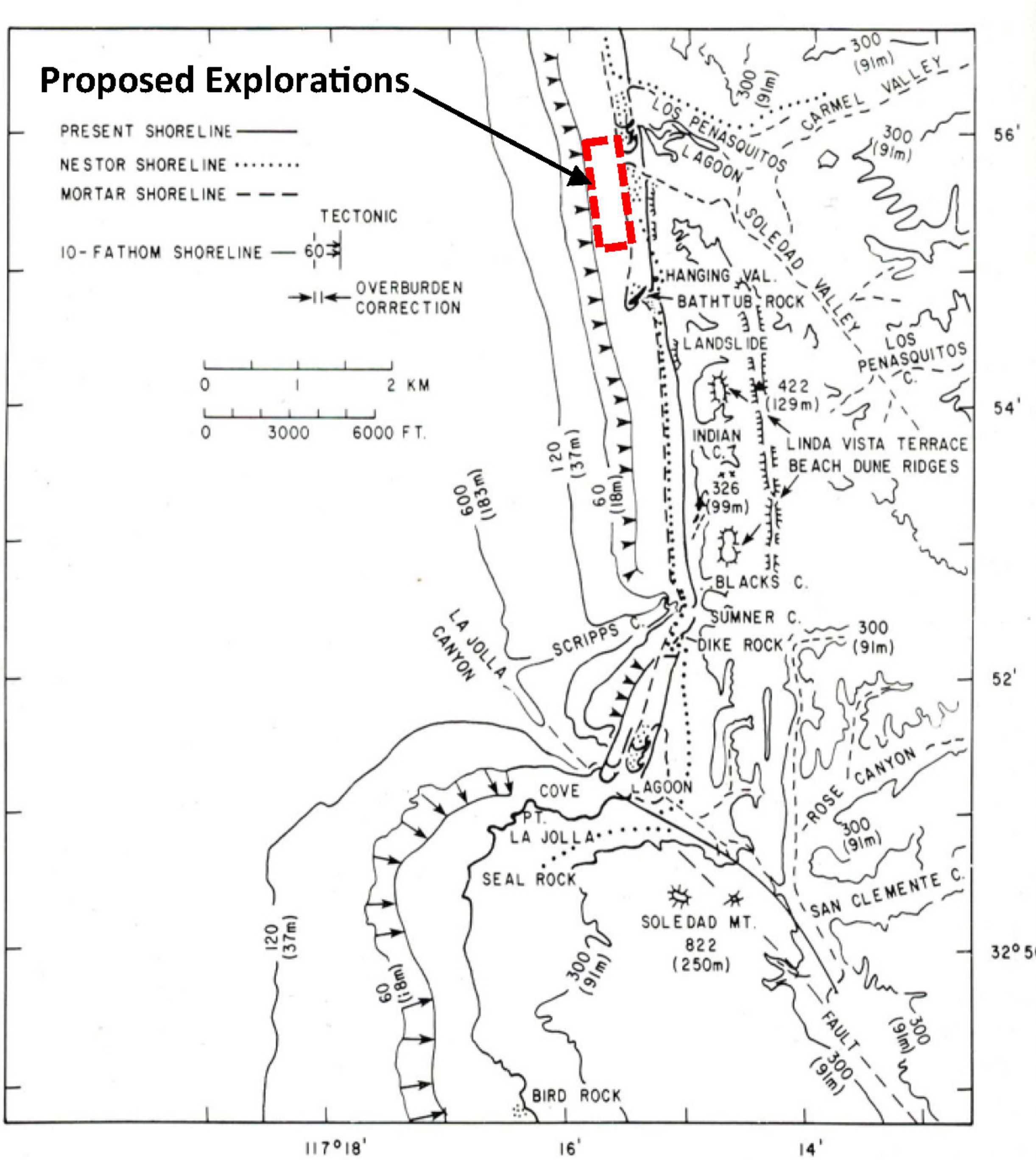

Figure 3 - Potential Favorable Locations at Torrey Pines. This figure is from Inman (1984) showing paleo-shorelines (ancient beaches) offshore at La Jolla. The proposed exploration area at Torrey Pines would target the outer, seaward limits of the late Pleistocene terrace, outlined above in red and shown on **Figure A-4**.

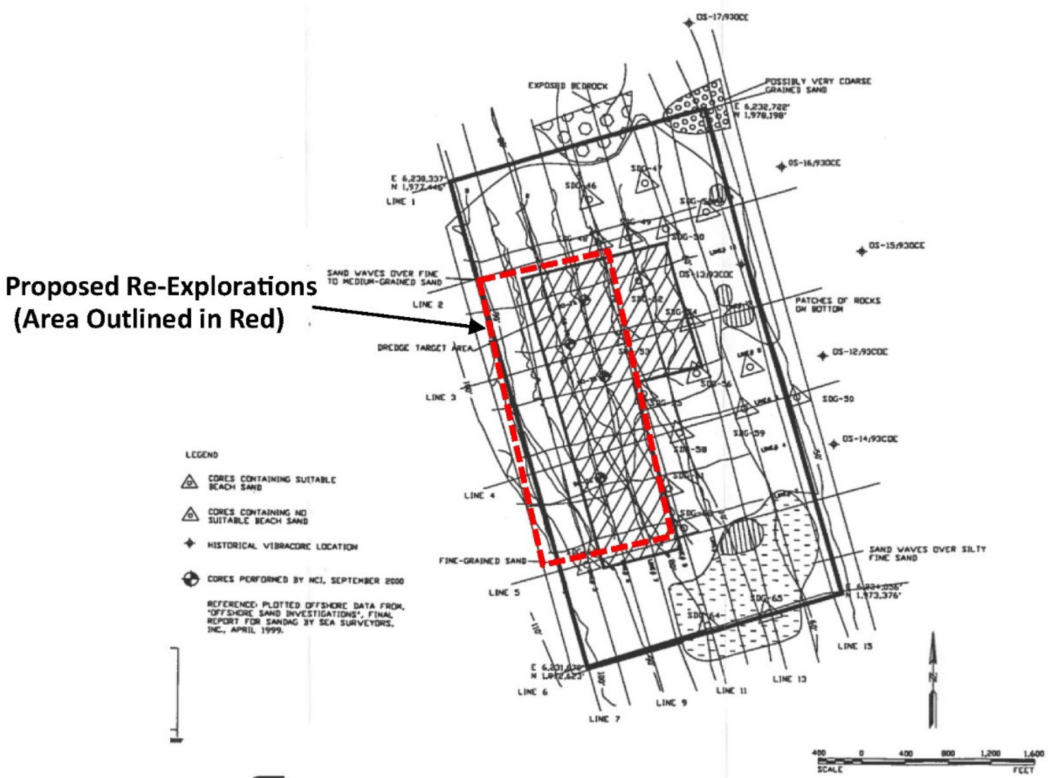

Figure 4 – Map of Proposed Re-Explorations at Encinitas. This figure shows a map from Noble Consultants (2000) of SO-7 Encinitas (offshore Batiquitos Lagoon) showing potential borrow area west of the area used for RBSP I. Four vibracores 7A, 7B, 7C, and 7D recovered fine to medium SM-SP-type sand. Proposed additional explorations would target this area, shown on **Figure A-6**.

2.6 Oceanside

North of Oceanside Harbor, RBSP II investigations identified a potential borrow area SM-1 ("Oceanside"), encompassing the width of the modern floodplain and channel of the Santa Margarita River, as shown on **Figure A-7**. The entire borrow area was estimated to include about 7.7 million cubic yards (MCY) if dredged to 20 ft (URS 2009). This proposed borrow area apparently has never been dredged and is located northwesterly and shoreward of Borrow Site 2A (USACE 2011) located northwest of Oceanside Harbor. Dredging in 2024 for San Clemente beach replenishment encountered sand with gravel at Borrow Site 2A. Gravel posed problems for the hopper dredge, and the gravelly sand material was considered not dredgeable. The SM-1 candidate borrow area is even farther north of a borrow site south of the Oceanside Pier currently proposed for the Oceanside ReBeach project, as shown on **Figure 5** below (GHD 2024).

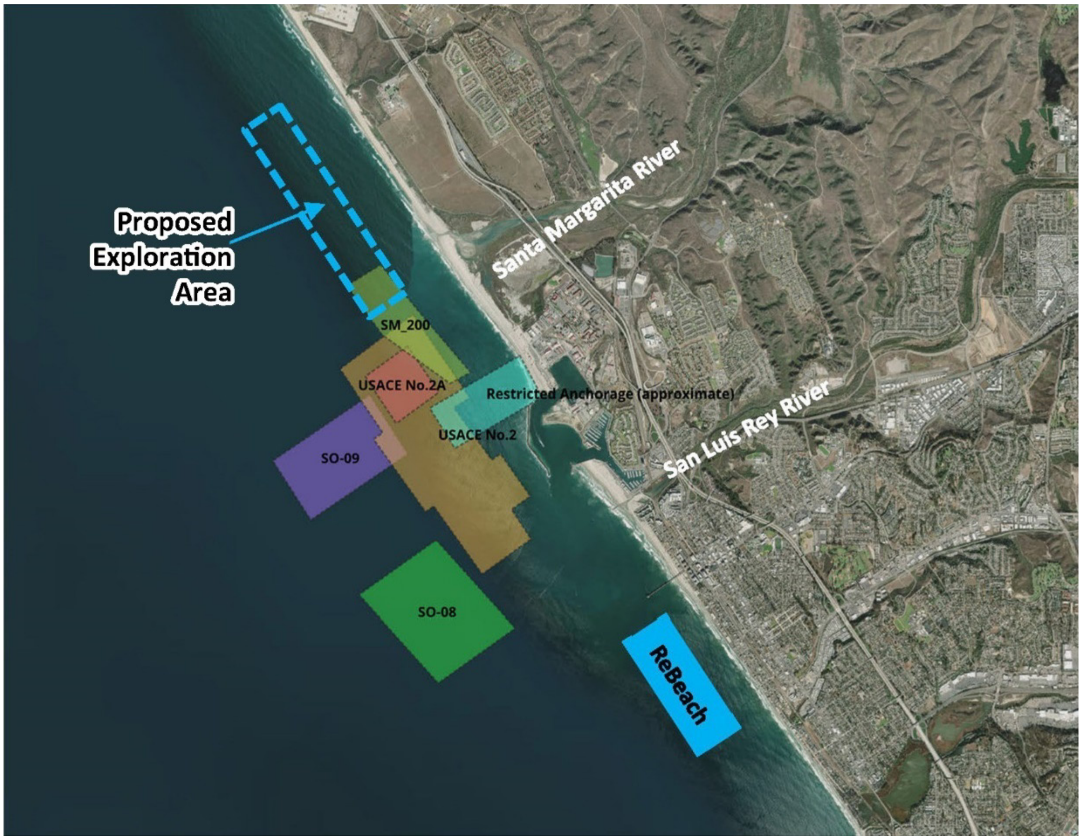

Figure 5 - **Map of Offshore Borrow Areas at Oceanside**. This figure shows previous and proposed borrow areas at Oceanside Harbor and the Santa Margarita River. Borrow area SM-1 (light green) was explored but not used for RBSP II. Borrow areas SO-9 and SO-8 were used for RBSP I in a limited way because the sand was mostly too fine and not suitable. USACE Borrow 2A (orange) was dredged initially for San Clemente but discontinued due to gravel content. The approximate proposed borrow footprint for the Oceanside Sand Nourishment and Retention Pilot Project (ReBEACH) located south of Oceanside Pier is shown in blue (GHD 2024).

Borrow areas off of Oceanside Harbor have mostly been in the ancient offshore paleochannels of the Santa Margarita and San Luis Rey rivers (Osbourne et al. 1983). The offshore sediment within dredge depths may have been mixed littoral (beach), fluvial (river), and/or estuarine deposits in an interfering system of deltaic deposits with gravel channels. These sediments would also tend to be relatively fine-grained due to watershed geology.

Previous borrow areas off of Oceanside Harbor have been in similar river-dominated geologic settings and in relatively deep water (**Figure 5**). The ReBeach exploration area was located over an area interpreted to occur within wave-cut terraces cut or eroded into Pleistocene sediment (AECOM 2024; Darigo 1984). The area targeted for vibracores was moved south of the San Luis Rey River to avoid its paleochannel. Based on this geologic model, the offshore environment at the proposed borrow area (to be located south of Oceanside Pier) is mostly in ancient littoral deposits (sometimes described as “relict beaches”) locally with a thin, silty-sand cover. According to AECOM (2024), the proposed dredge material was described as follows:

- Fines content ranged between about 3% and 25%; the average fines content is about 11%.

- The D_{50} particle size ranged between about 0.1 mm and 0.35 mm. The average D_{50} particle size is about 0.25 mm (fine sand).
- The surficial silty sand "cover" thickness ranged between about 2 ft and 5 ft.
- Some gravel was encountered.
- The dominant sand colors were gray and pale brown.

According to GHD (2024), the dredged material is proposed for both direct "dry" beach placement and for nearshore placement at ReBeach. The area proposed for dredging is about 109 acres, between -48 and -58 ft MLLW, i.e., up to about 10 ft deep and is estimated to include 1.7 MCY. The shallow materials would be used for nearshore placement.

The concern at SM-1 is the material may be relatively fine and gravelly under the influence of the ancient Santa Margarita River. The sediment recovered in the RBSP II vibracores at SM-1 was mostly dark gray, silty, fine sand, with some thin silt cover. Vibracores SM-207 and SM-210 recovered sand with D_{50} about 0.2 mm, 10% of fines, and less than 1% of gravel. Relatively few gravels were encountered in the previous vibracores at SM-1, and none of the vibracores met refusal on gravel. A small area of cobbles was identified at the seabed in the southerly part of the previously proposed borrow. Therefore, the proposed exploration area at SM-1 would be shifted further north away from the cobbles/gravels as shown on **Figure A-7**.

Although the SM-1 materials may be relatively fine-grained, and potentially not optimal for direct (dry) beach placement but suitable for nearshore placement, a substantial volume of relatively fine sand likely exists in this area. A northerly area at the mouth of the Santa Margarita River (north of the gravel area) would be targeted for additional investigations, approximately shown on **Figure A-7**. By shifting SM-1 more northerly, the borrow could be located in a nearshore setting more dominated by "drowned" wave-cut terraces with Pleistocene sediment like the borrow proposed downcoast at ReBeach, as shown on **Figure 6**.

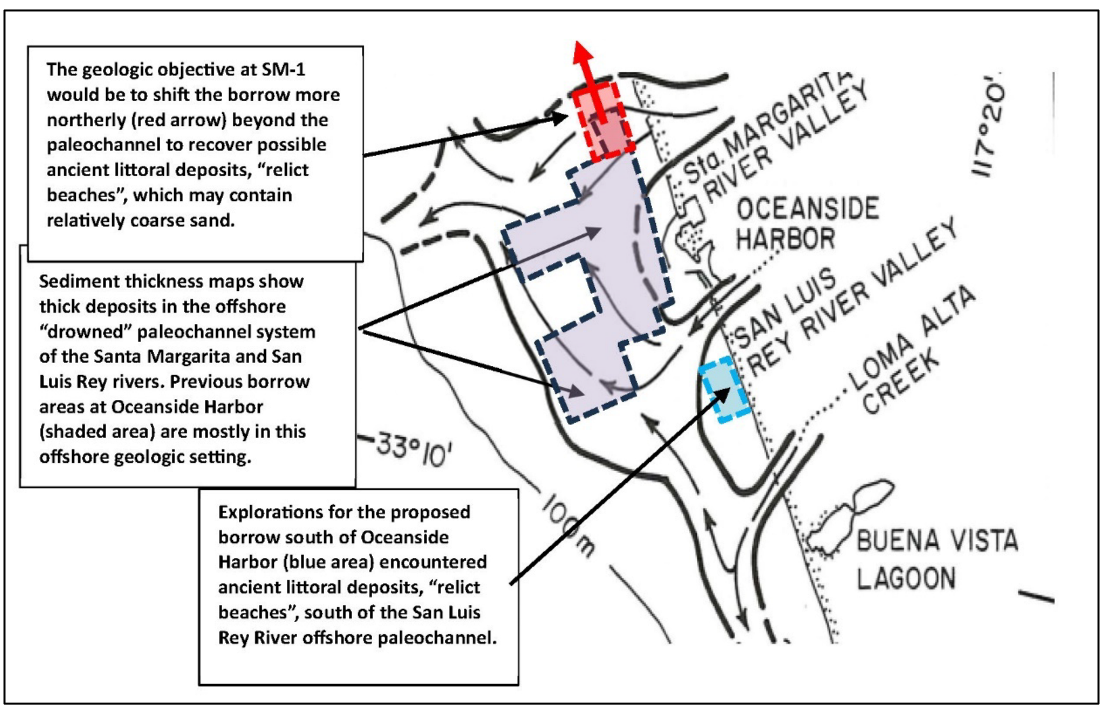

Figure 6 – Map of Interpreted Geology Offshore Oceanside. This figure shows the generalized extents of the ancient river paleochannels offshore of Oceanside Harbor interpreted by Darigo (1984). The

thickest sediment deposits offshore are mostly in the paleochannels, although the deposits tend to be variable compositions of silt, sand, and gravel, making it difficult to predict suitable sand. Explorations for the proposed ReBeach borrow south of the San Luis Rey River (blue area) encountered ancient littoral deposits, “relict beaches”, with a thin, silty sand cover. Previous explorations for RBSP II suggest SM-1 could be enlarged or shifted to target a similar geologic setting north of the Santa Margarita River.

If an extended SM-1 area proves suitable, an additional stretch of southernmost Camp Pendleton (continuing more northerly of the river) may have similar sand suitability. Some of the vibracores proposed at SM-1 could be planned to cover a longer swath of coastline at Camp Pendleton.

3. Additional Investigations

Recommendations for investigations at MB-1 and SO-5 are provided above in **Tables A-4** and **A-7**, respectively. Potential borrow areas considered for re-exploration are summarized below in **Table A-8**. Some of these borrow areas may have comparatively small yields (if dredging is limited to 10 ft or less) but could contribute to future North County beach placement. A preliminary geotechnical exploration plan follows below in **Table A-9**.

Table A-8. Anticipated Dredge Volumes for Potential RBSP III Borrow Areas

Borrow Location	Potential Constraints	Range of Water Depths (ft)	Approximate Area to be Investigated (acres)	Assumed Dredge Depth (ft below seabed)	Estimated Borrow Area Volume (MCY)	Other Considerations
MB-1 Southern Expansion	Unknown bottom feature(s) and setback from shipwreck/dive site (Ruby E)	60 to 80	75 to 80	20	2.5	marine archaeology assessment update may be required
MB-1 Northern Expansion	Shallow bedrock at paleochannel margin and setback from dive site (Yukon)	60 to 80	125 to 130	20	Up to 4.1 depending on borrow geometry	20-ft dredge depth to be confirmed
MB-1 Southern Expansion	Unknown bottom feature(s) and setback from shipwreck/dive site (Ruby E)	60 to 80	75 to 80	20	2.5	marine archaeology assessment update may be required
MB-1 Northern Expansion	Shallow bedrock at paleochannel margin and setback from dive site (Yukon)	60 to -80	125 to 130	20	Up to 4.1 depending on borrow geometry	20-ft dredge depth to be confirmed
SO-4	Shallow setting	36 to 46	70 to 80	10	1.2	Material may be mostly fine sand with gravel
SO-6	Seaward continuation of paleochannel	69 to 82	80 to 90	10	1.3	Joint Powers Authority outfall setback
SO-7	Seaward continuation of paleochannel	79 to 89	40 to 50	10	0.7	Confirm artificial habitat inshore
SM-1	Shallow setting and material quality, gravel content	33 to 39	240 to 250	10	3.9	If found suitable, confirm dredging would not conflict with Camp Pendleton operations and/or future planning

Table A-9. Recommended Offshore Investigations for MB-1, SO-5, and North County Borrow Areas

Borrow Location	Exploration Objective(s)	Bathymetric Survey	Marine Geophysical Surveys	Vibracore Explorations	Other Explorations
MB-1 Southern Expansion	Confirm thickness/extent of suitable sand	Update multibeam bathymetry covering previous and proposed dredge areas	Side-scan sonar and marine magnetometer	10 (including RBSP II footprint)	Submersible remote-operated vehicle camera survey
MB-1 Northern Expansion	Investigate northerly limits of suitable sand and confirm dredge depths		Side-scan sonar and extend previous sub-bottom survey lines north	20	New bathymetry could be deferred to design investigations
S0-5 North Expansion	Confirm thickness/extent of suitable sand	Update multibeam bathymetry covering previous and proposed dredge areas	Side-scan sonar and extend previous sub-bottom survey lines north	10	Confirm bathymetry at closure depth
SO-5 Western and South Expansion	Confirm material in the area between SO-5 and at the former RBSP I dredge area		Side-scan sonar	20 (including RBSP I footprint)	Collect bottom (seabed) samples of former dredge area
SO-4	Confirm material quality	Compile available bathymetry	Side-scan sonar	7 to 10	Confirm bathymetry at closure depth
SO-6	Determine offshore paleochannel extent	Expand as-built survey from RBSP II	Review available sub-bottom profiles	7 to 10	Update kelp surveys
SO-7	Determine offshore paleochannel extent	Expand as-built survey from RBSP I	Review available sub-bottom profiles	7 to 10	Update kelp surveys
SM-1	Confirm material quality and explore expanded potential borrow area	Compile available bathymetry	Side-scan sonar, magnetometer, and extend sub-bottom geophysical profiles north	20	Confirm bathymetry at closure depth

The exploration layout would be planned to cover the proposed expansions and nearby areas, if needed. Next steps would include additional research, team and stakeholder (e.g., Camp Pendleton) coordination, and preparing more detailed work plans as needed to obtain proposals and permits and for field investigations.

The investigations outlined above could be phased and may need to be updated depending on site conditions, project requirements, and permitting. Key components for additional investigations are outlined below.

3.1 Work Plan Development

This section provides preliminary recommendations for work activities and exploration methodology. The additional investigations described below are to support geotechnical assessments of the proposed borrow areas. Additional investigations might be warranted to support project design, environmental permitting, and/or construction.

3.1.1 Planning and Coordination

Planning activities should include compiling updated base maps using an appropriate geographic coordinate scheme covering the expanded borrow areas, outlined below:

- Obtain California State Lands Commission (CSLC) Geological and Geophysical Survey Permits (several contractors, including the subconsultants on this AECOM team, maintain these permits).
- Prepare detailed Exploration Plan, including locations for vibracores and planned geophysical survey lines. The following tasks should be completed in support of the Exploration Plan:
  - Research pre-survey and post-survey reports as available to update mapping of artificial structures, subsea telecommunications cable routes, and proposed future cable routes. The possible presence of offshore utilities should be checked to avoid damage or disruption. Expansion areas at MB-1 should be checked for possible telecom cables that may have been installed in the vicinity since RBSP II.
  - Compile updated and/or new information for the nearshore habitat areas at the proposed borrow areas, updates of San Diego Nearshore Habitat Mapping, if available, including multibeam bathymetry, maps of the seafloor, seafloor substrate, kelp persistence, and other bottom features.
  - Specify the optimal period to conduct offshore explorations in order to reduce unanticipated delays due to weather and other contingencies. The month of August typically has optimum sea conditions for local offshore geotechnical work. Weather standby provisions should be identified in advance of field operations.
- Prepare Sampling and Analysis Plan and obtain agency approval of the plan.
- Coordinate planned activities with local authorities, e.g., Camp Pendleton. Notify United States Coast Guard, harbormasters, and others as required by the CSLC permits.

Additional details on the key components of the offshore borrow investigations are summarized below:

3.1.2 Bathymetric Surveys

Updated base maps, at minimum including compiling various bathymetric data sets, would increase site area understanding and would be useful for dredge area planning. Limited new bathymetric surveys may be warranted, if needed to update seafloor conditions, confirm post-dredging limits, and identify depth of closure. Typical survey methods have included multibeam echosounder and side-scan sonar. The marine magnetometer should be used to support marine cultural surveys, as needed. These surveys are often conducted after borrow site exploration and the material at the borrow sited is determined to be acceptable for beach nourishment (same as the approach used for RBSP II).

3.1.3 Marine Geophysical Surveys

Marine survey track lines should be planned in advance to cover the expanded borrow areas and any new areas. Sub-bottom profilers used in the past to obtain seismic data (Fugro Pelagos 2008) have included a

CHIRP sonar system and relatively low-frequency Geopulse-type systems. The data were collected in digital Society of Exploration Geophysicists (SEG-Y) format to allow limited post-survey processing and enhancement of the data.

The seismic field data should be processed to facilitate geologic interpretations (URS 2009). Processing parameters should be selected to accentuate the shallow portion of the seismic records within potential dredge depths (assumed to be up to approximately 20 ft below the seafloor). Vibracore locations should be selected based on the processed seismic records and other evaluations.

3.1.4 Vibracore Explorations

Vibracore locations need to be identified in advance of offshore operations in an appropriate GIS mapping system. Previous vibracores have been generally planned to provide a grid of sampling points on spacings ranging between about 1,000 and 1,500 ft. Exploration locations should be based on any additional information obtained, including bathymetry and/or geophysical surveys performed prior to vibracore operations. Location changes may be warranted during vibracoring based on field assessment of the cores.

Vibracoring requires a support vessel equipped with a crane or winch for maneuvering and hoisting the vibracore with adequate deck area for recovery. The vibracore support vessel should be fully equipped with all necessary navigation, safety, and lifesaving devices per United States Coast Guard requirements. Navigation and vessel positioning should be recorded via shipboard global positioning system, reported in latitude and longitude. Water depths at the vibracore should be monitored with the ship echosounder then recorded with a plumb line and corrected for tide stage. The vessel should be capable of operating in water depths between -20 ft and -100 ft MLLW.

The vibracore used should be a nominal 4 inches in diameter, equipped with sediment retainers, and able penetrate up to 20 ft below the seabed without meeting refusal in dense sand. The vibracore can be driven pneumatically using compressed air or electric-powered. Adequate materials should be onboard, including plastic liners, caps, replacement core barrels, and other materials needed for limited repairs.

A staging area should be considered at Mission Bay and/or Oceanside Harbor for the support vessel, including a work area to be able to sample, photograph, and store the vibracores. The support vessel could be mobilized at the staging area and would be able to dock intermittently, as needed.

A geotechnical specialist(s) should participate in the offshore investigation to provide preliminary geotechnical assessment of samples while underway. If possible, whole cores can be processed on the deck. Each core should be photographed, measured, assigned a soil color using a Munsell Chart, and then lithologically logged in accordance with the Unified Soil Classification System as outlined in ASTM International (ASTM) methods D2488 and D248.

As needed, a more detailed geotechnical log should need to be prepared for all sampling locations once the vibracore samples have been transported to the onshore staging area or other work area. The geotechnical assessment of the sediment should include at a minimum: grain size, color, maximum particle size, estimation of density (sand) or consistency (silts and clays), odor (if present), and description of amount and types of organics, shells, and other material present.

3.1.5 Geotechnical Laboratory Testing

Geotechnical gradation testing should be performed to evaluate beach replenishment suitability. Sediment samples should be transported to the geotechnical laboratory for more specific testing. Geotechnical testing should include grain-size laboratory analyses (sieve tests) following ASTM Method D6913 which yields the distribution of particle sizes (gradation) larger than the No. 200 sieve, which has nominal 75-micron openings.

It is generally assumed at least two samples may be selected for analysis over varying intervals of each core, based on geotechnical assessment of the core samples. A composite sample of the entire core may be appropriate. Additional tests should be performed if needed, e.g., for composite “cluster” samples, to cover material variability or other purposes.

Some additional core sampling and/or core assessment might be needed for project support. The remaining cores (portions not sampled), test samples, and/or representative portions of the cores should be archived at an appropriate storage area to be identified in advance of vibracore collection.

3.1.6 Geotechnical Data Evaluation and Reporting

The results of the field investigation and laboratory test results should be summarized in an Offshore Geotechnical Data Report (GDR) and a Sampling and Analysis Plan Report, as required by permitting agencies. The GDR should include photographs and logs of the vibracore samples, using an appropriate geotechnical data presentation system, descriptions of field operations, geotechnical laboratory data, and other evaluations as needed to support geotechnical assessment of borrow suitability by qualified geotechnical engineers and geologists. These reports should provide GIS-based maps and other graphics as appropriate to document the field investigation. A draft report should be provided for review by the project team, and permitting/regulatory agencies, as appropriate, followed by a final report (deliverable).

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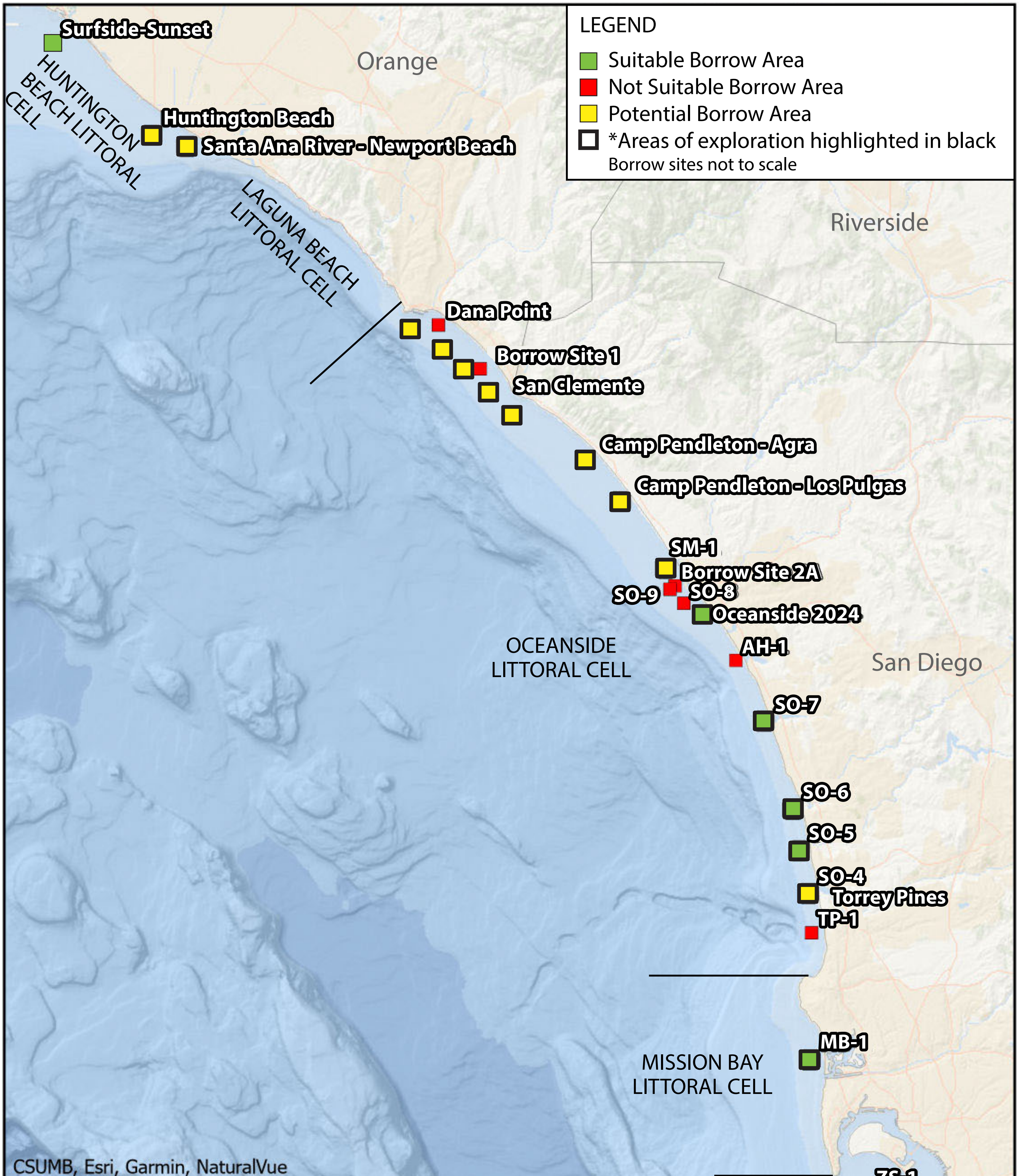
Figures



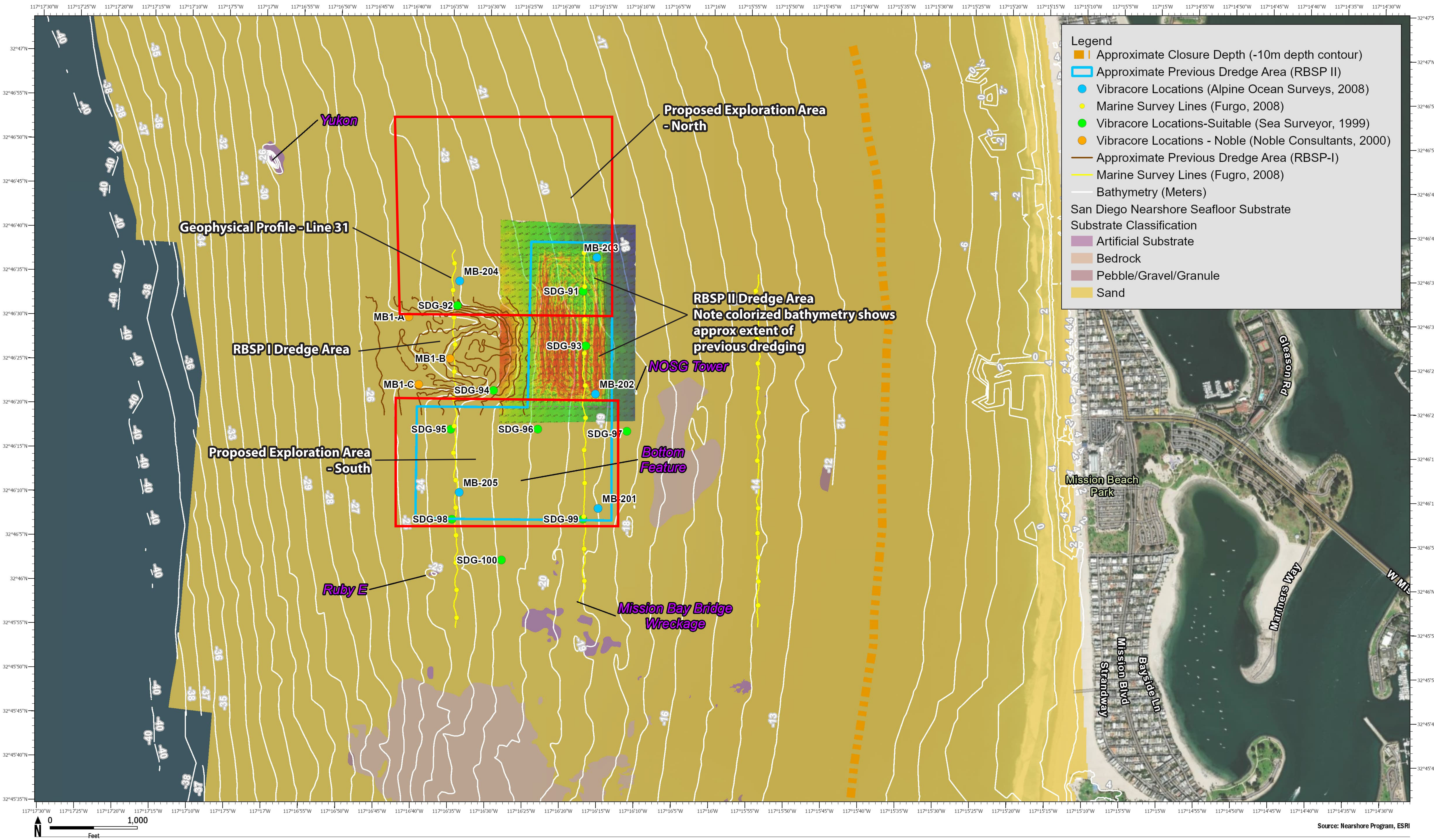
AECOM

POTENTIAL BORROW AREAS

3 0 3 6 Miles

SCALE: 1" = 10.2 Miles (1:648,000)

CREATED BY: EJV	DATE: 08/15/2024	FIG. NO:
PM: DS	PROJ. NO: 60720408	A-1



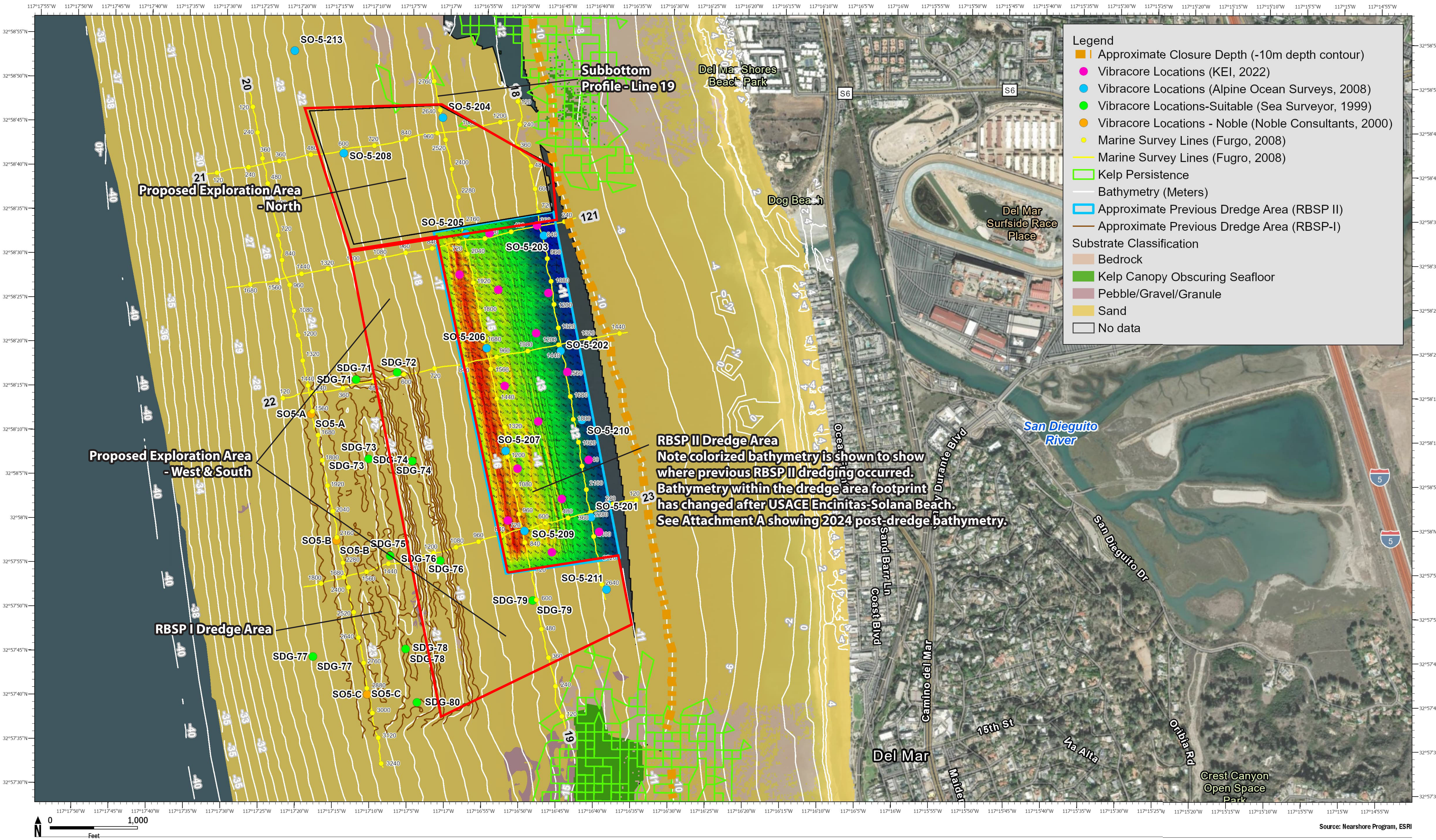
Source: Nearshore Program, ESRI

SANDAG RBSP-III

Offshore Investigation Review

Mission Beach MB-1

Figure A-2



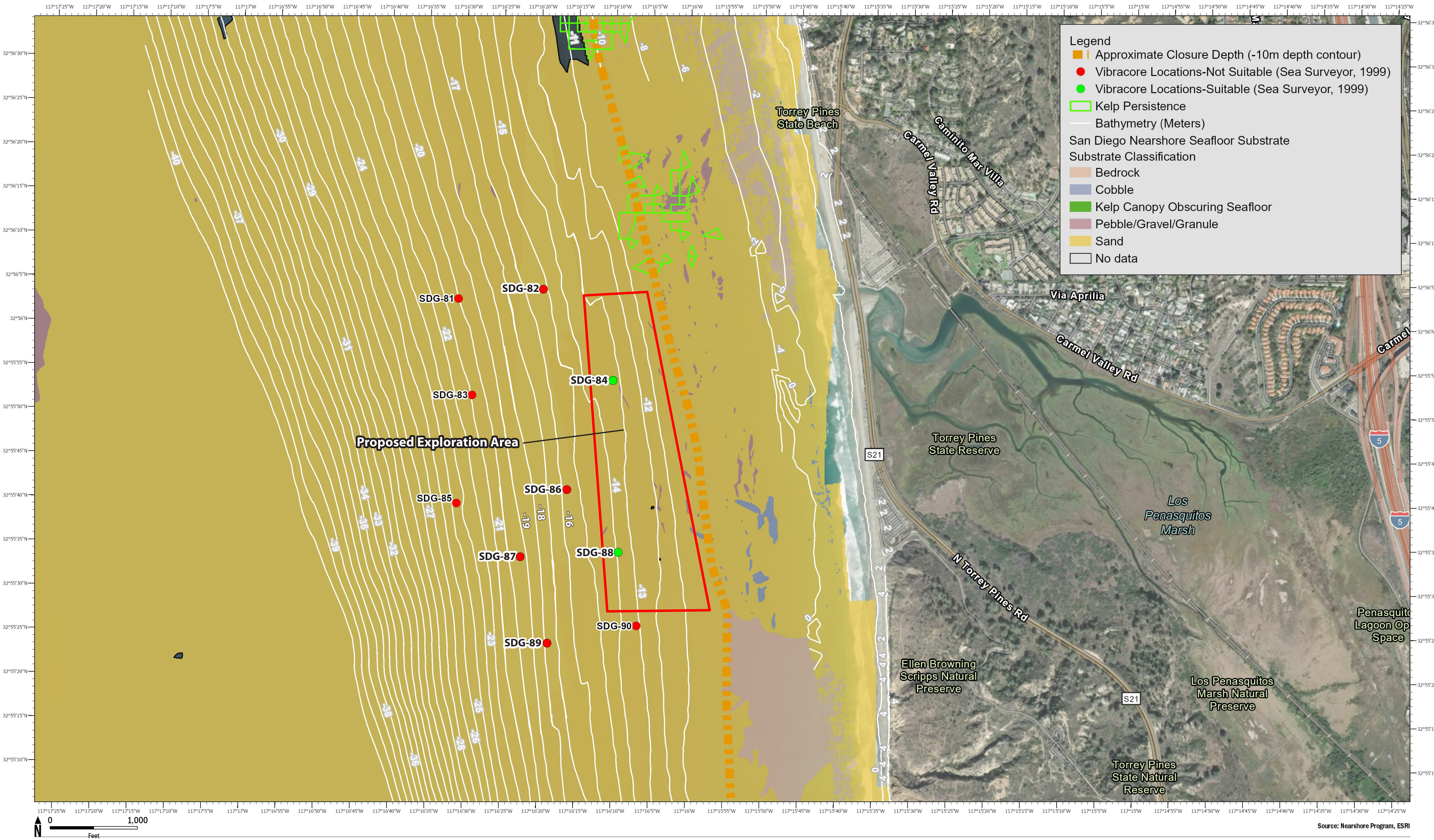
AECOM

SANDAG RBSP-III

Offshore Investigation Review

Del Mar SO-5

Figure A-3



AECOM

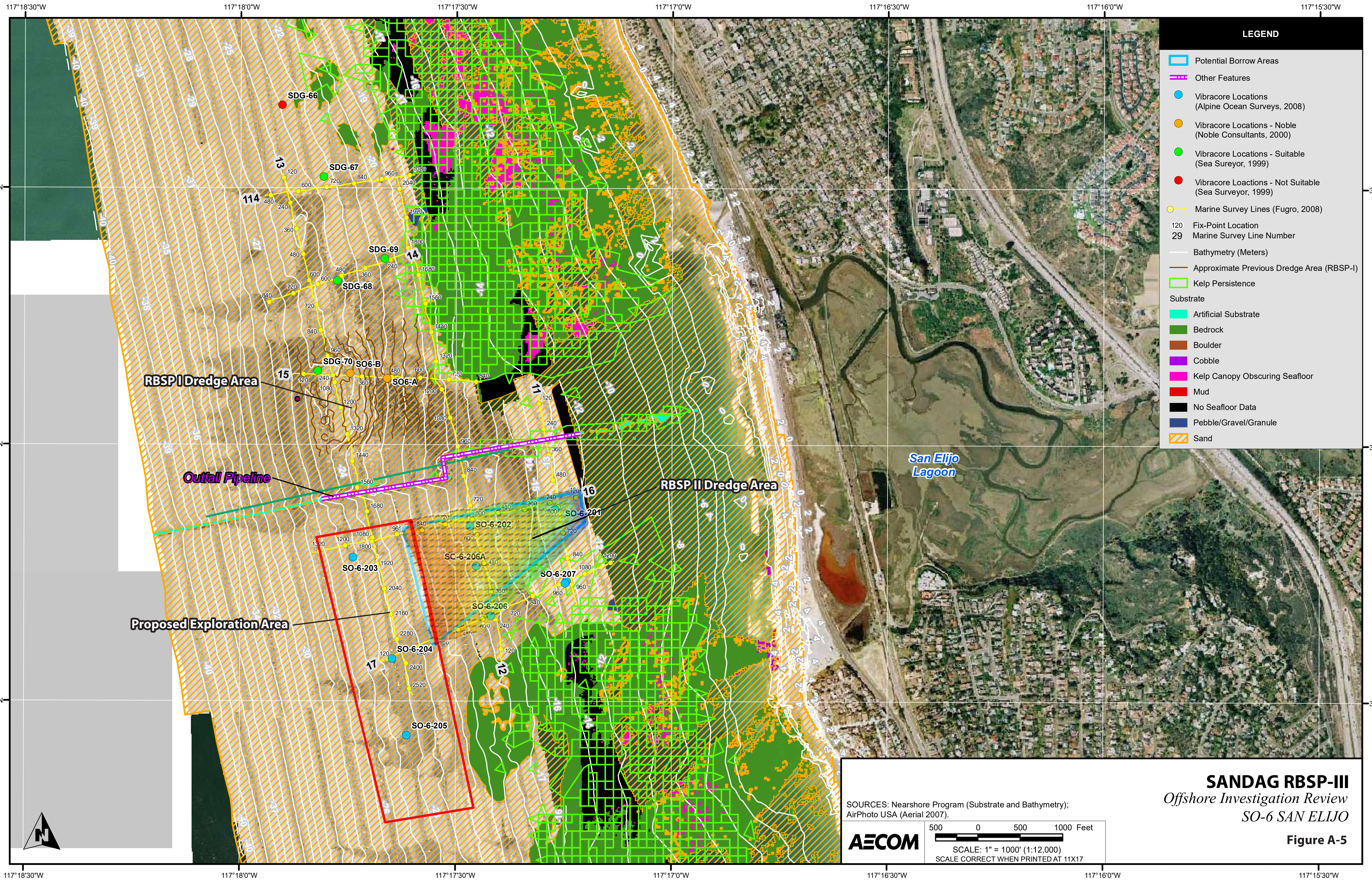
Source: Nearshore Program, ESRI

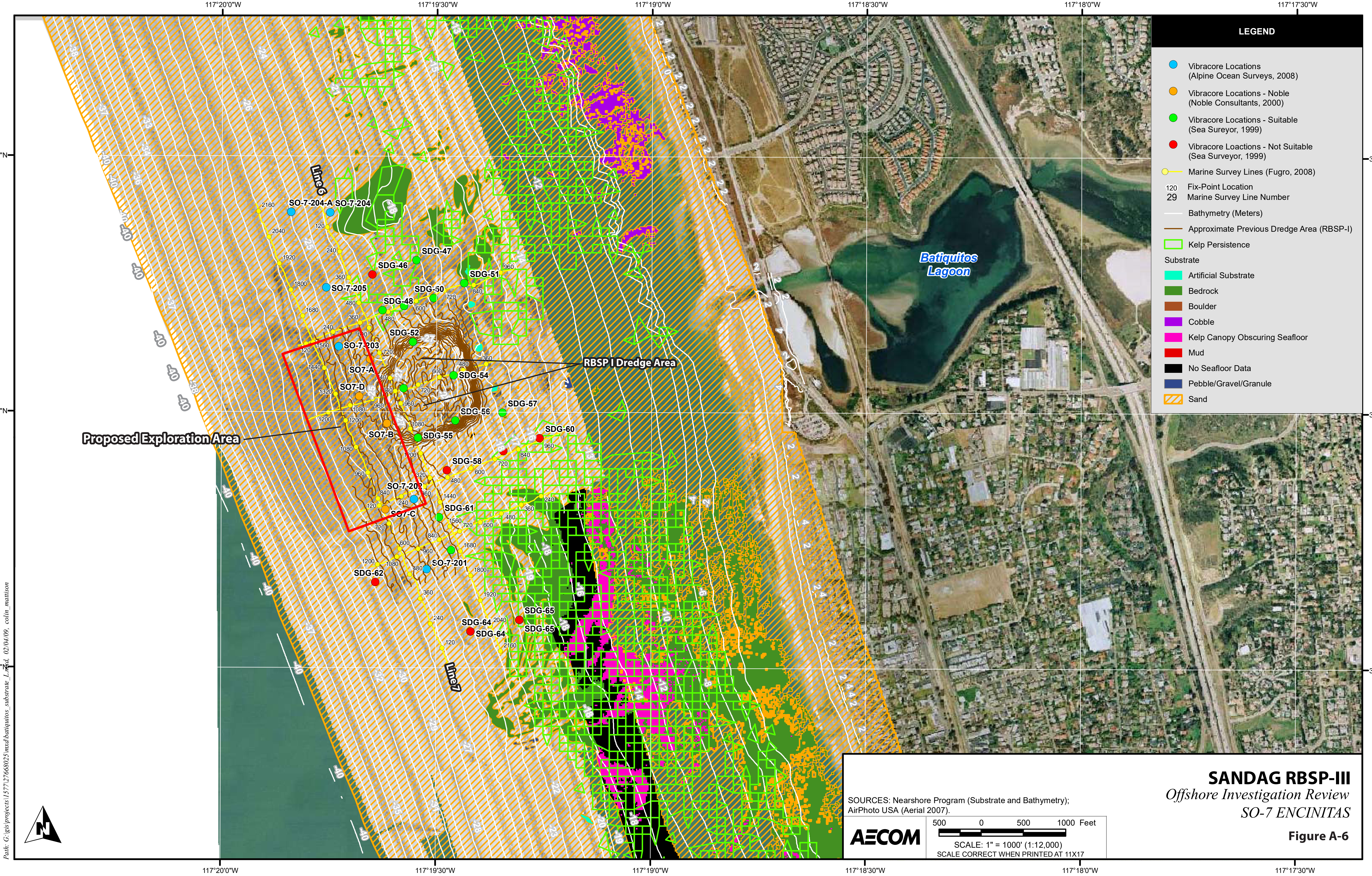
SANDAG RBSP-III

Offshore Investigation Review

Torrey Pines

Figure A-4


LEGEND
Potential Borrow Areas
Other Features
Vibracore Locations
(Alpine Ocean Surveys, 2008)
Vibracore Locations - Noble
(Noble Consultants, 2000)
Vibracore Locations - Suitable
(Sea Sureyor, 1999)
Vibracore Loactions - Not Suitable
(Sea Surveyor, 1999)
Marine Survey Lines (Fugro, 2008)
120 Fix-Point Location
29 Marine Survey Line Number
Bathymetry (Meters)
Approximate Previous Dredge Area (RBSP-I)
Kelp Persistence
Substrate
Artificial Substrate
Bedrock
Boulder
Cobble
Kelp Canopy Obscuring Seafloor
Mud
No Seafloor Data
Pebble/Gravel/Granule
Sand
RBSP I Dredge Area
Outfall Pipeline
RBSP II Dredge Area
Proposed Exploration Area
San Elijo Lagoon
SDG-66
SDG-67
SDG-68
SDG-69
SDG-70
SO6-B
SO6-A
SO-6-201
SO-6-202
SO-6-203
SO-6-204
SO-6-205
SC-6-206A
SO-6-206
SO-6-207
117°18'30"W
117°18'0"W
117°17'30"W
117°17'0"W
117°16'30"W
117°16'0"W
117°15'30"W
33°1'0"N
33°0'30"N
33°0'0"N
SOURCES: Nearshore Program (Substrate and Bathymetry);
AirPhoto USA (Aerial 2007).
AECOM
500 0 500 1000 Feet
SCALE: 1" = 1000' (1:12,000)
SCALE CORRECT WHEN PRINTED AT 11X17
SANDAG RBSP-III
Offshore Investigation Review
SO-6 SAN ELIJO
Figure A-5



SANDAG RBSP-III

Offshore Investigation Review

SO-7 ENCINITAS

Figure A-6

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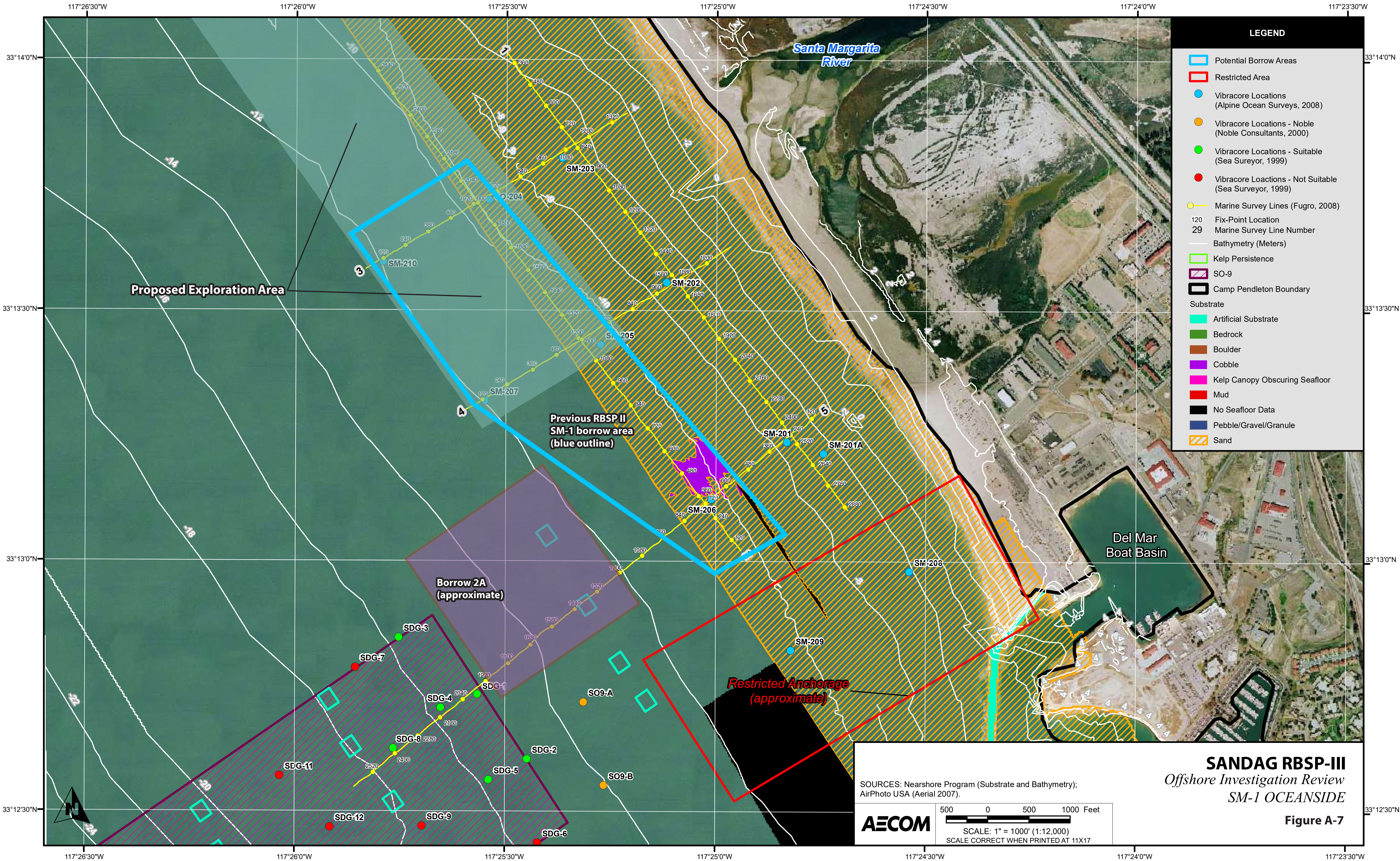


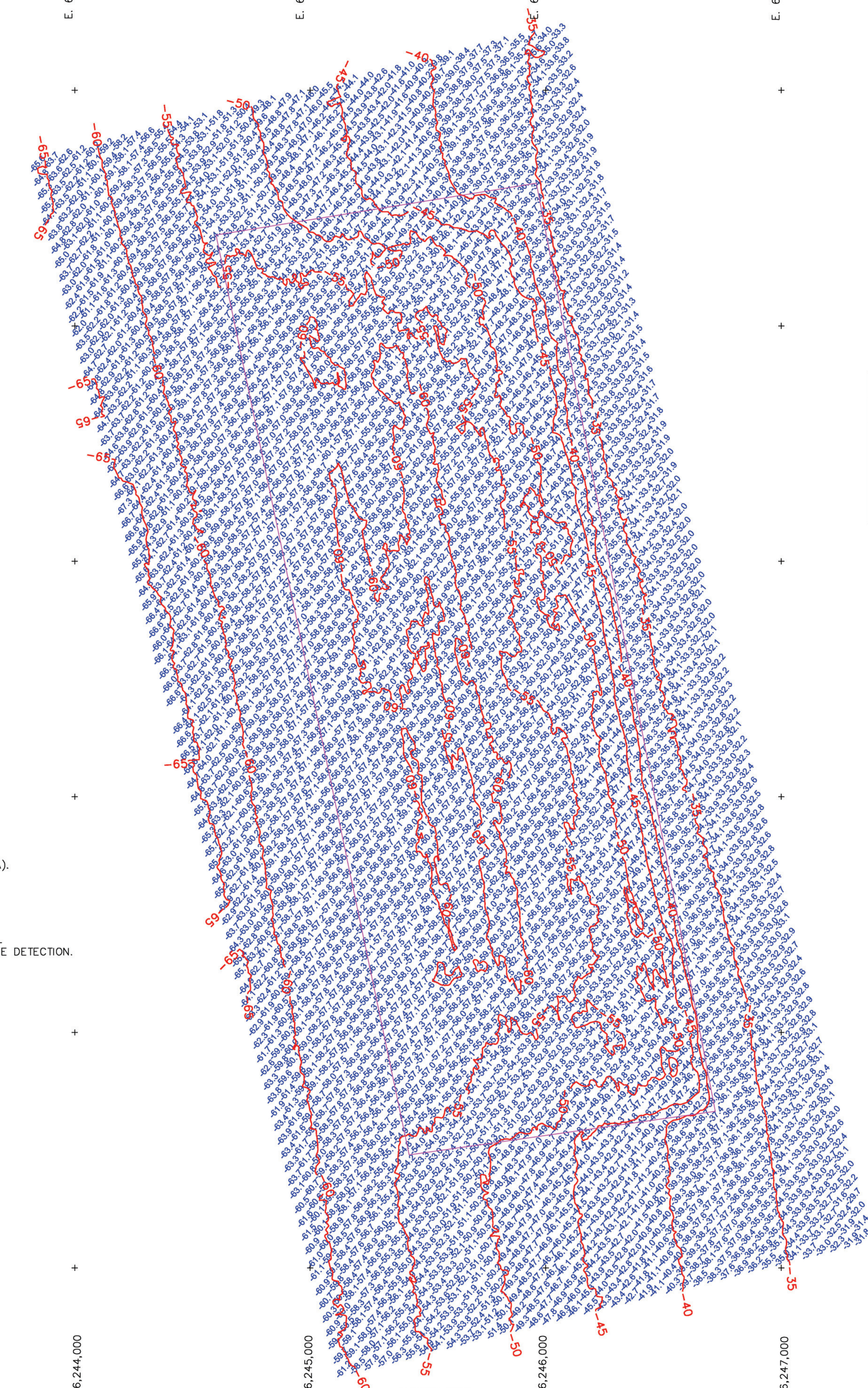
SANDAG RBSP-III

Offshore Investigation Review

SM-1 OCEANSIDE

Figure A-7

VALUE ENGINEERING PAYS



This drawing was produced in

U.S. SURVEY FEET

GRAPHIC SCALE: 1 In. = 300 Ft.

600 450 300 150 0 300 600

DEPTHS ARE MEAN LOWER LOW WATER

NOTES:

1. SOUNDINGS AND ELEVATIONS, INDICATE THE GENERAL CONDITIONS EXISTING ONLY AT THE TIME OF SURVEY – MAY 7, 2024.
2. COORDINATES ARE CALIFORNIA LAMBERT ZONE VI, (NAD 1983).
3. MLLW TIDAL CORRECTIONS ESTABLISHED FROM LA JOLLA NOAA TIDE GAUGE STATION ID 9410230.
4. MEAN LOWER LOW WATER (MLLW) IS BASED ON MONUMENT 9410230 TIDAL 7 (PID DC0986), WITH ELEVATION OF 10.97 US FEET, MLLW, EPOCH 1983 – 2001.
5. CONTOURS SHOWN ARE BASED ON SOUNDINGS FROM A 15 FOOT GRID. THE PLOTTED DEPTHS SHOWN ARE BASED ON SOUNDINGS FROM A 60 FOOT GRID. A POINTS FILE BASED ON A 3 FOOT GRID WAS PRODUCED FOR ENGINEERING PURPOSES.
6. SOUNDINGS AND TOPOGRAPHIC ELEVATIONS ARE SHOWN TO THE NEAREST 0.1 FT.
7. SOUNDINGS LOCATED BY REAL-TIME KINEMATIC GPS (LEICA SMARTNET NORTH AMERICA). DEPTHS MEASURED BY A MULTI-BEAM ECHO SOUNDER PROVIDING NEAR FULL BOTTOM COVERAGE.
8. SURVEY WAS PERFORMED USING THE 26' SURVEY VESSEL "EPOCH".
9. SURVEY WAS CONDUCTED AND PROCESSED USING METHODS FOR DETERMINING GENERAL CHANNEL CONDITIONS AND/OR COMPUTING VOLMUES. DATA NOT INTENDED FOR STRIKE DETECTION.

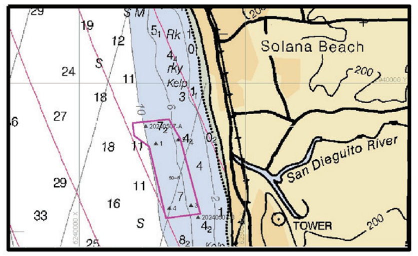
CONTROL OUTSIDE DRAWING FRAME

POINT ID	NORTHING	EASTING	ELEV (sFT)
7 1958	VERTICAL ONLY		10.97
6 1952	VERTICAL ONLY		4.66
NO 9 1971	VERTICAL ONLY		9.67

SO-5 BORROW AREA COORDS

POINT ID	NORTHING	EASTING
A	1,936,385.0	6,244,600.0
B	1,936,605.0	6,245,960.0
C	1,932,665.0	6,246,720.0
D	1,932,480.0	6,245,420.0

VICINITY MAP



SAFETY PAYS

Figure A-8

Attachment A

U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT

SUBMITTED BY: RONALD N. SPENCER, P.L.S. CHIEF, SURVEY & MAPPING SECTION

CHECKED BY: TYLER OVERMIRE

DRAWN BY: CRISTINA YU

MARK	DESCRIPTION	DATE	APPR.	MARK	DESCRIPTION	DATE	APPR.

PLOT DATE: MAY 20, 2024
DISTRICT FILE NO. C-204
PLOT SCALE: 1" = 300 FEET

SURVEYED BY: TYLER OVERMIRE, CRISTINA YU

DISTICT FILE NAME: ES2024_05_SO-5_post.dgn

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
SURVEY & MAPPING SECTION

SHORELINE REPLENISHMENT
SAN DIEGO COUNTY, CALIFORNIA
HYDROGRAPHIC SURVEY

ENCINITAS-SOLANA BORROW SITE SO-5

POST-DREDGE SURVEY

MAY 2024

Sheet Reference Number: 1

SHEET 1 OF 1

Appendix B

San Diego County Economic Methodology and Results

Appendix B

Economics Methodology and Results for the San Diego Association of Governments Regional Beach Sand Project III San Diego County Beaches

Prepared by:

Dr. Phil King

July 2025

Table of Contents

Figures

Tables

1. Introduction

The San Diego region's beaches have been steadily eroding for several decades. San Diego County's beaches are enormous drivers of economic activity in the region, and their preservation is critical to maintaining the health and well-being of its residents and visitors. San Diego Association of Governments (SANDAG) previously completed two regional beach sand projects (RBSPs) in 2001 and 2012 (RBSP I and RBSP II, respectively), adding approximately 3.6 million cubic yards of sand to the San Diego region's local beaches. These projects were initial pilot projects, representing the first major steps in addressing the severe sand deficit on the region's beaches and identifying a long-term approach to managing the region's shoreline. Because of the continued deficit in the littoral system, repeated and consistent replenishment may be necessary to maintain the regional beaches and the recreational, economic, and protective services they provide. The purpose of this study is to quantify the potential economic benefits and their value to the public if SANDAG were to conduct a third RSBP (RBSP III).

Implementation of RBSP III would involve dredging beach-quality sand from offshore borrow sites and placing it on highly eroded beaches in the San Diego region, similar to past projects. RBSP III also expands nourishment to encompass the entire Oceanside Littoral Cell and extends to include the evaluation of nourishing south Orange County beaches in the cities of Dana Point and San Clemente. This is the first time beaches outside of San Diego County would be included as part of a RBSP and reflects a more system-wide approach based on littoral cell rather than jurisdictional boundaries. However, this study focuses specifically on San Diego County beaches. Economic results specific to the Orange County region are presented in **Appendix D**.

2. What is a Benefit Cost Analysis?

Benefit-Cost Analysis (BCA) is a systematic approach for evaluating the economic value of different policy or project options by comparing their expected costs and benefits. For hazard mitigation projects, the BCA determines the future risk-reduction benefits of a project and weighs those benefits against project costs (Federal Emergency Management Administration [FEMA] 2024). A BCA results in a Benefit-Cost Ratio (BCR), a direct comparison of expected benefits against projected costs. A BCR over 1.0 is generally considered cost-effective.

The application of BCA in a recreation or hazard mitigation analysis often involves valuing non-market goods, such as clean air, water quality, a day at the beach, and biodiversity, which are typically not traded in markets but provide substantial benefits to society. Methods such as contingent valuation, hedonic pricing, and travel cost models (discussed in more detail below) are frequently used to estimate these values (Freeman 2003). By integrating these valuations, BCA helps to ensure that the environmental and social benefits of a project are appropriately weighed against the expected costs and losses to market goods (such as property). This balanced approach is essential for achieving sustainable resource management and ensuring that the benefits derived from natural resources are maximized while minimizing negative externalities (Pearce, Atkinson, and Mourato 2006).

Climate adaptation or hazard mitigation projects rely heavily on BCAs to prioritize actions that enhance resilience to climate change impacts. This involves evaluating the costs of adaptation measures, such as constructing flood defenses or implementing water conservation practices, against the benefits of avoided damages and increased resilience. For instance, investing in coastal defenses can be justified if the benefits (in terms of avoided property damage, loss of life, and adverse impacts to natural resources due to sea-level rise and storm surges) significantly outweigh the costs (Economics of Climate Adaptation Working Group [ECA] 2009).

2.1 Non-Market Values

Non-market valuation in natural resource economics refers to the process of assigning monetary values to goods and services that are not traded in traditional markets, such as clean air, water quality, biodiversity, and recreational opportunities. These resources provide significant benefits to individuals and to society; however, because they do not have explicit market prices, their value is often overlooked. Non-market valuation methods are essential for capturing the true economic value of these resources, which is crucial for informed policymaking and resource management.

There are various methods for non-market valuation, broadly categorized into revealed preference and stated preference approaches. Revealed preference methods infer values based on actual behavior and market transactions related to the non-market good. For example, the travel cost method estimates the value of recreational sites by observing how much people are willing to spend, in time and money, on travel to visit them, while the hedonic pricing method assesses the impact of environmental attributes on property values. Stated preference methods, on the other hand, rely on surveys to ask individuals about their willingness to pay for specific environmental improvements or their willingness to accept compensation for environmental losses. Contingent valuation and choice modeling are common stated preference techniques (Freeman 2003; Johnston et al. 2017; Barbier et. al. 2011).

The monetary value of the ecosystem to the public depends on the benefit people derive from its services. Ecosystem services can be categorized in several different ways. There are use values and non-use values. Typically, use values involve some human ''interaction'' with the environment, whereas non-use values do not, as they represent an individual valuing the pure ''existence'' of a natural habitat or ecosystem (Barbier et al. 2011; Barbier 2007; Barbier et al. 1997; Mehvar 2018). Direct-use values refer to both consumptive and non-consumptive uses that involve some form of direct physical interaction with environmental goods and services, such as recreational activities, resource harvesting, drinking clean water, and breathing unpolluted air (Barbier et al. 2011). Non-use values are based on the existence of the ecosystem, irrespective of human consumption (Mehvar 2018; Raheem et al. 2012). Non-use values, also known as passive use values, refer to the value people place on the mere existence of a resource, even if they never use it directly. This includes the value of knowing that a species or ecosystem exists and will be preserved for future generations (Pearce and Turner 1990; Champ, Boyle, and Brown 2017).

Understanding and quantifying these values are vital for comprehensive cost-benefit analyses and sustainable resource management. By incorporating non-market values (or NMVs), policymakers can make more informed decisions that reflect the full range of benefits provided by natural resources, leading to better outcomes for both the environment and society.

2.2 Avoided Costs

Avoided costs refer to the expenses that are prevented because of implementing adaptation measures to mitigate the impacts of climate change. These costs represent the savings from avoiding the negative consequences of climate-related events, such as floods, storms, heatwaves, and sea-level rise. Avoided costs can also be thought of as “risk reduction benefits” resulting from project implementation (FEMA 2024). By quantifying avoided costs, policymakers can better understand the economic efficiency and justification for investing in adaptation strategies.

Avoided costs encompass a wide range of direct and indirect expenses. Direct avoided costs include tangible savings such as reduced damage to infrastructure, buildings, and agricultural lands, which would otherwise require costly repairs, reconstruction, or replacement. Indirect avoided costs include less visible savings such as reduced healthcare expenses due to fewer heat-related illnesses, lower insurance premiums due to decreased risk, and less disruption to economic activities and supply chains (Hallegatte et al. 2017). Avoided costs can also capture the preservation of ecosystem services and environmental benefits that would otherwise be degraded or lost due to climate impacts. (Barbier 2014). For beach replenishment, avoided costs include both the preservation of recreation and environmental benefits that would be lost if the beach eroded and the avoided damage to properties that would be flooded if the beach continues to erode.

2.3 Discounting

The economic analysis in this study projects the impacts of erosion over the next decade. However, the understanding of future economic conditions and market prices/replacement costs is limited. The economic analysis for this study estimates prices and replacement costs in (real) 2024 United States dollars ($).

Often economic benefit/cost analysis *discounts* future costs and benefits, based on the theory that future benefits/costs are worth less than the same benefit/cost today. The discount rate is applied in various economic analyses, which enables policymakers to compare and evaluate the net present value (NPV) of different projects or investments. The NPV is calculated by discounting future costs back to their present value and subtracting the initial investment. A positive NPV indicates that the project is expected to generate more value than its cost, making it a worthwhile endeavor (Boardman et al. 2018).

The choice of discount rate is *critical* in a benefit/cost analysis. Currently there is no consensus among economists as to the proper discount rate or even if a discount rate should be used. Even a relatively low discount rate can imply that benefits and costs for future generations are valued far less than current benefits; many economists have argued that the social discount rate should be lower than the market cost of capital. For example, when projecting out to the year 2100, even a relatively low discount rate, such as 3 percent (%), implies that a $100 benefit is worth less than one-tenth of today’s valuation ($8.86). A 5% discount rate implies that by 2100 the benefit or cost is worth less than one-fiftieth of today’s value ($1.86). The impact of discount rates on future value is especially significant when it comes to environmental damages, which are often expensive or impossible to fix after the damage has occurred.

Agencies like FEMA, United States Army Corps of Engineers (USACE), National Oceanic and Atmospheric Association (NOAA), and National Fish and Wildlife Foundation (NFWF) provide specific guidelines for selecting appropriate discount rates. These guidelines, shown in Table 1, ensure that discount rates align with the specific context and objectives of each project, emphasizing both economic efficiency and sustainability.

Table 1: Federal Discount Rate Guidelines by Agency

Agency	Discount Rate
FEMA	7% Office of Management and Budget (OMB) Circular A-94 recommendation. FEMA also allows sensitivity analysis using lower rates, such as 3%, to account for different time preferences and uncertainties in long-term benefits (FEMA 2011).
USACE	2.5% Federal Water Resources Development Act recommendation. This lower rate is suitable for the long-term nature of water resource projects and emphasizes intergenerational equity (USACE 2023).
NOAA	3% to 7% OMB Circular A-94 recommendation. 3% used for projects with long-term benefits and intergenerational impacts to better capture the value of sustained ecosystem services (NOAA 2017).
NFWF	NFWF aligns its discount rate practices with NOAA and USACE. For conservation and restoration projects, NFWF may use lower discount rates, around 3%, reflecting the long-term ecological benefits and the importance of preserving natural resources for future generations (NFWF 2018).

This study used two different discount rates for the analysis: 0% and 3%. Associated graphs and charts present the results undiscounted (0% discount rate).

3. Federal Benefit-Cost Analysis Guidelines

Federal agencies require BCAs for project feasibility determinations and to secure funding. Typically, a project must show cost-effectiveness via a BCR greater than 1. However, not all federal agencies consider benefits beyond protection, avoided damages, and emergency repair and response. The analysis in this study focuses on benefits to beach recreation and draws on the methodologies of those agencies which allow beach recreation to be considered in the BCA and BCR calculation.

3.1 United States Forest Service

United States Forest Service (USFS) was an early innovator in the application of NMVs, particularly in the application of travel cost models to outdoor recreation. One of the earliest instances can be traced back to the 1960s and 1970s when USFS began to explicitly account for the NMVs of recreation in its management and planning processes (Clawson 1966). In the 1970s, USFS developed the Recreation Opportunity Spectrum (ROS) to classify and manage recreational settings, acknowledging the diverse needs of visitors (USFS 1979). In 2000, USFS modernized the ROS with the National Visitor Use Monitoring (NVUM) program to systematically collect data on visitor use and satisfaction, building on earlier efforts (Bowker et al 2009). The NVUM program's extensive data collection efforts are assumed to provide a representative sample of visitor use and preferences, ensuring that the valuation reflects true recreational values (Bowker et al 2009).

The analysis in this study incorporates key assumptions from the USFS methodology:

1. **Rational Behavior:** Non-market valuation assumes that visitors behave rationally, meaning they make consistent choices that maximize their utility. This is fundamental to the travel cost method, which presumes that the costs incurred by visitors reflect their valuation of the recreational experience.

2. **Willingness to Pay:** The contingent valuation method assumes that respondents accurately report their willingness to pay for recreational experiences or improvements. This requires that respondents understand and consider their budget constraints and personal preferences when answering survey questions.

3. **Substitution Effect:** Both valuation methods assume that recreational sites are substitutable to some extent. For instance, if one site becomes less desirable due to changes in quality or access, visitors will shift to alternative sites. This helps in understanding how changes in one site affect overall recreational value (Clawson and Knetsch 1966).

4. **Data Reliability:** Accurate non-market valuation depends on reliable, current data. The best benefit transfer analyses: (1) apply economic studies of similar resources/demographics, (2) apply an average or median of a number of studies for a more robust analysis, and (3) avoid using old data (Rosenberger and Loomis 2001).

3.2 United States Army Corps of Engineers

USACE has conducted many BCAs of beaches and other recreational sites throughout the United States, often in conjunction with beach replenishment projects. Most USACE analysis focuses on the "storm damage prevention" benefits that beaches provide. This involves estimating the value of a property at risk (e.g., a private residence) and the expected cost of flood damages as a percentage of property value, typically using FEMA's depth damage curves and hazard probability. Often these studies contain a Monte Carlo analysis which examines multiple scenarios or a sensitivity analysis which examines how changing assumptions change the model's results.

USACE incorporates recreational benefits into its BCA to ensure comprehensive evaluation of project impacts. Previously, USACE's consideration of recreational benefits was capped at 50% (USACE 1989). More recent guidance removed this limitation; the proportion of recreational benefits in the BCR depends on the nature and primary objectives of the project. For projects explicitly designed to enhance recreational opportunities, such as the development of parks, trails, or water-based recreation facilities, recreational benefits can constitute a substantial part of the BCR. According to the USACE Planning Guidance Notebook, recreational benefits are considered valid and significant contributors to the overall BCR (USACE 2000). The Economic Guidance Memorandum (EGM) on Unit Day Values (UDVs) provides a framework for calculating recreational benefits, emphasizing the importance of these benefits in justifying projects that serve multiple purposes, including recreation (USACE 2013).

The USACE methodology builds on the assumptions of the USFS methods discussed above (USACE 2013). The analysis in this study incorporates additional aspects from the USACE methodology:

1. **UDV:** The UDV method assigns a monetary value to a standard day of recreation based on factors like the quality of the experience and the availability of facilities (USACE 2013). This provides a standard for the value of the recreational experience per day.

   While this analysis utilizes the UDV approach, the USACE UDVs are quite low when compared to estimates obtained from more recent studies. The UDVs rely on decades-old surveys and data on visitor use, preferences, and expenditures. Although USACE updates its UDVs for inflation in the form of an EGM, it has not otherwise updated its UDVs to keep current with the scientific literature.

   In addition, the USACE criteria for assigning higher UDVs depend on criteria which may not matter to the visitor. For example, the USACE criteria assign a higher UDV to sites with multiple types of recreation and better facilities. However, people typically choose a site for one specific type of recreation, not multiple types. For example, Trestles beach is a world-class surfing spot where surfers are willing to travel long distances to surf. Trestles has few amenities other than world-class waves. The USACE criterion would assign a value of a few dollars per day to Trestles, given its unidimensional recreational amenity, its lack of facilities, and the fact that surfers must walk quite a distance from the parking lot. A detailed socioeconomic analysis (Nelsen et. al. 2007) indicated that Trestles has a value per day much higher than many other sites nearby with more facilities and easier access.

   Economic theory suggests that visitors will choose the site most suitable to their needs in terms of amenities and travel cost. In an area such as North San Diego County, where many beaches are available in a small area, it is reasonable to assume visitors choose a beach which maximizes these preferences; in other words, visitors may choose a beach with one amenity which they prefer or another with many. The value of the beach experience does not necessarily depend upon the number of amenities, though some amenities are highly valued by most visitors (e.g., lifeguards, parking, and restrooms).

   As a result of these limitations, the RBSP III estimates use updated information specific to California, as discussed in Section 4 below.

2. **Carrying Capacity:** Recreation values depend on an analysis of "carrying capacity," typically expressed as the number of people a facility can hold before crowding and safety become an issue. When the carrying capacity is exceeded, recreational value is diminished.

   Carrying capacity is another concept that a number of federal agencies use when evaluating a recreational site. Carrying capacity estimates the maximum number of people that a site or facility can hold. For most recreational beaches, the critical capacity constraint is the amount of "dry beach" area, which is the area of the beach above the mean high-tide line. In addition, at some beaches where the sand abuts parking, visitors typically create their own buffer between the parking lot and the beach (this can be mitigated with dunes). Parking is often a critical capacity constraint at some beaches as well. USACE has applied the concept of carrying capacity (USACE 1986) to numerous sites following a consistent methodology:

   "The capacity method involves the estimation of annual recreation use based on instantaneous facility capacities and expected daily, weekly, or seasonal use patterns. Since the estimates are based on instantaneous capacities …seasonal use patterns will probably account for the greatest variation is use estimates between projects." (USACE 1986)

This document goes on to state that:

"The total economic value estimated to result from projected demand cannot be considered a real benefit unless sufficient capacity will exist at the proposed site to accommodate it." (USACE 1986)

The analysis applied here employs the USACE's carrying capacity guidance. The methodology is also consistent with previous approaches approved by California Coastal Commission at Manhattan and Hermosa beaches (e.g., Sheehan et. al. 2022), with a turnover factor based on empirical studies (King and McGregor 2012). Although our data indicate that visitors will "cram in" more densely than this, especially at peak times, (such as a holiday weekend), this study assumes the recreational benefits are diminished once the beach reaches maximum capacity. This approach was created before the Covid-19 pandemic but seems even more relevant post-Covid-19.

3.3 Federal Emergency Management Agency

In addition to aligning with USFS and USACE methodologies, the analysis in this study aligns with the central assumptions of FEMA's approach. FEMA's BCA is designed to quantify the benefits of a mitigation project in terms of avoided damages and losses. These benefits are then compared to the costs of implementing the project. A project is considered cost-effective if the BCR is 1.0 or greater, indicating that the benefits equal or exceed the costs.

The analysis in this study employs several methods similar to FEMA's BCA approach:

1. Consideration of hazard risk likelihood,
2. Use of benefit transfer, and
3. Assumption that recreation is the key public benefit provided by beach replenishment.

FEMA's BCR ratio is similar to the methods used herein, taking into account the hazard risk/likelihood and economic factors such as discount rate. For coastal flooding mitigation projects, the BCR focuses on reducing flood risk and damage to properties, infrastructure, and natural resources. The benefits are typically measured in terms of avoided damages, including direct physical damage, economic losses, and disruption to critical services. FEMA provides detailed guidance on using coastal flood hazard analysis and mapping to support the BCA, ensuring accurate assessment of the potential benefits of mitigation measures. For beach replenishment projects specifically, FEMA considers the technical feasibility of the project and placement, environmental impact, cost, and maintenance. These considerations are factored into the RBSP III analysis; however, feasibility and environmental impact are not included in the BCR calculation.

The BCR calculated for RBSP III focuses on beach recreational benefits, which were previously excluded from the FEMA BCR methodology unless the project had a BCR greater than 0.75 without their inclusion. In 2020, FEMA changed the policy to allow ecosystem goods and services to be considered in analyses provided the project reduces risk to people, structures, and infrastructure. FEMA considers ecosystem good and service benefits, for the purposes of the BCA, through an increase in the health or functionality of an ecosystem after mitigation. This includes restoration, enhancement, creation, or protection of the ecosystem.

FEMA offers a comprehensive toolkit that includes software, detailed instructions, and supporting documents to help applicants perform a BCA according to their methodology. The disadvantage of FEMA's software is that one must accept whatever assumptions have been made in their modeling, which may be inappropriate for a specific site.

FEMA determines the ecosystem services provided by a given land cover, such as forest, wetland, or beach, via meta-analysis and benefit transfer. According to FEMA, beaches provide mostly aesthetic value (75% of the value) which they determine via two hedonic models from Georgia and North Carolina. Beaches also provide recreational value (25% of total value). The recreational value estimates are based on several studies across five states including California, many of which are used to determine the estimates used in this analysis for RBSP III. The key difference between FEMA’s methodology and the methodology used herein for RBSP III is that FEMA uses a standardized per-acre value for ecosystem services based on land cover type. While the method in this study uses a value based on attendance, FEMA uses Geographical Information System (GIS) to regularize the estimates of NMV based on beach acreage. Based on aesthetic value and recreational value, irrespective of attendance, FEMA recommends a standard rate of $300,649 per acre (2020 $).

Crucially, this standardized rate does not account for variations in attendance, which drives recreational value. According to FEMA’s methodology, a larger beach has greater value, even if that beach is remote and provides limited access. This is not the case in California, where *access* to coastal recreation drives much of beach value. In addition, the emphasis (75%) placed on aesthetic value derived from the impact of beach views on property values (hedonic modeling) diminishes the importance of the public in comparison to homeowners and private property.

4. Methods

The analysis in this study combines aspects of the various federal agencies' methodologies with empirical research and established practice specific to California to provide the most accurate estimate of the value of beach replenishment under the RBSP III. It relies on the following key assumptions.

4.1 Day-Use Value

Beachgoing, which encompasses a visit to the beach that includes sunbathing, swimming, skim-boarding, and picnics is the most popular recreational activity in California. Statewide, this type of beach recreation generates a huge NMV and drives many local economies. To estimate the impact of erosion on recreational value, the value of beach visitation must first be estimated. As with most ecosystem functions, goods, and services (EFGS), beach access is generally free; therefore, beachgoing has a NMV.

A comprehensive model of beachgoing NMV is beyond the scope of this project and would require an elaborate and extensive survey of southern California beachgoers. However, past research leverages both revealed and stated preference studies to determine the value of a day at a southern California beach, and the values found in these studies can be applied to the RBSP III sites via benefit transfer (discussed above). There are two methods of benefit transfer calculation. *Function transfer* assumes "there is uniform function between two sites" and applies estimates based on the value of that function (Liu 2010). Alternatively, *point transfer* requires separating ecosystems into spatial units and assumes that "the economic value for an ecosystem service at the study site is the same as that of the policy site," essentially that the two *locations* are similar enough to apply the value from the primary data (Liu 2010).

The recreational value of beaches in California has been studied extensively, typically in terms of Willingness to Pay (WTP) for a trip to the beach. Economists can measure WTP by estimating the travel cost to and from the site (revealed preference) or by asking visitors how much they would be willing to pay (stated choice). Most of the studies cited in Table 2 are travel cost models (Parsons 2003). This WTP is typically expressed as a "day-use value" which is essentially the same as USACE's UDV.

The table below, modified from Pendleton et al (2006), presents estimates of the day-use value of beaches, mostly in southern California, based on travel cost and contingent choice studies. These estimates of day-use value vary by study and by beach with valuations ranging from $20 to $145 per day (2024 $). As indicated in Table 2, the average is $62 per day (2024 $), and the median is $52.

This method is also consistent with a recent California Coastal Commission decision in Solana Beach (Michael Baker International 2016). Several local coastal programs employed this method in determining the NMV of beaches including: the City of Pacifica, the City of Oceanside, and Ventura County. A study funded by NOAA for the California Coastal Commission (Engel et al. 2015) also recommended this approach.

4.2 Carrying Capacity

With coastal erosion, beaches will lose area; this loss in area will lead to a loss in attendance as the beach becomes more crowded and some visitors choose not to attend. The relationship between lost area and lost attendance can be modeled using the carrying capacity of a given beach. Carrying capacity is the number of visitors that can visit a beach at one time—essentially the maximum occupancy of a beach. When a beach becomes too crowded and people choose to go elsewhere or not to visit the beach, the carrying capacity has been exceeded. Studies indicate that beachgoers generally require about 100 square feet (sq ft) of space per person or "towel space" (e.g., Sheehan et. al. 2022). However, most beachgoers do not spend an entire day at the beach. While the turnover rate may vary site to site, past estimates use a rate of 1.5 to 2 (King and McGregor 2012). The carrying capacity, therefore, is determined by dividing the area by required towel space and multiplying the result by the turnover rate.

Table 2: Estimates of Day-Use Value for California Beaches[1]

Region	Counties	Usage Level	Studies	Consumer Surplus Values (2024 $)
Southern	San Diego Orange Los Angeles Ventura Santa Barbara	High	12	$19.45
				$28.11
				$31.54
				$36.10
				$39.52
				$43.78
				$45.37
				$49.54
				$58.80
				$123.81
				$136.65
				$144.96
		Low	0	-
Central	San Luis Obispo Monterey Santa Cruz San Mateo San Francisco	High	1	$62.48
		Low	0	-
Northern	Marin Sonoma Mendocino Humbolt Del Norte	High	0	-
		Low	0	-
California Average		N/A*		$62.27
Midpoint (Pendleton et al 2006)		N/A		$52.02

*Not applicable.

Daily attendance is rarely equivalent to carrying capacity, except during the busiest days in high season. Therefore, the modeling of erosion impacts needs to adjust for the average utilization rate at a given beach, or how close daily visitation is to the maximum occupancy (carrying capacity) of the beach.

Many beaches are highly seasonal, with more than half of visits taking place in the summer high season. At some of these seasonal beaches, the beach may be nearly at capacity for much of the summer (high utilization), and nearly empty in the winter (low utilization). Thus, a loss of area would impact the summer attendance far more than low season attendance. Models of erosion's impact need to also take seasonality into account.

Recreational value depends on attendance, not on area, at least up to the point that the loss in area impacts attendance. To estimate the loss in NMV is to estimate the loss in *attendance* due to beach erosion, the methodology in this study follows the USACE guidance (Warren and Rea 1989; CDM Smith Federal Programs 2017; Reclamation Bureau 2010) and assumes a "carrying capacity" of 100 sq ft per person per day. Because attendance is not uniform, the carrying capacity constraint will limit attendance first on the busiest days (e.g., weekends in July and August and the 4th of July); as the beach shrinks, more days will

[1] The consumer surplus values, in order, are from the following sources: Leeworthy and Wiley (1993), King (2002) – midpoint between two methods, Chapman and Hanemann (2001) – corrected for inflation using the Consumer Price Index, Lew and Larson (2005), Larson (2002), Leeworthy (1995), Sheehan et al (2022), Pendleton et al (2006), Nelsen (2012).

be impacted by limited carrying capacity. In estimating carrying capacity, this study for RBSP III also factored in a conservative turnover rate of 2.5, allowing for more visits per day of shorter length.

Carrying capacity is a daily measure; therefore, the analysis in this study compared changes in carrying capacity to site's daily attendance. Attendance estimates at each beach were calculated using daily data whenever possible, however some beaches lacked precise daily attendance estimates or data was not made available to the project team. Therefore, to model daily attendance, the RBSP III analysis used daily data from four separate beaches where accurate daily attendance counts were available to create a model: Coronado Shores, Moonlight, Mission Beach, and Imperial Beach. Each of these beaches had either a digital counter to count each day's attendance or daily lifeguard estimates. Each day's attendance was represented as a percentage of that beach's total annual attendance; these attendance percentages were then averaged to create percentages of the year's total attendance for each and every day of the year.[2] This results in a "Representative Beach Profile," which could then be easily applied to beaches for which there were only annual counts, such as Oceanside and Del Mar, to give attendance per day estimates. A similar process was applied for those beaches which had only monthly counts, such as Carlsbad, Torrey Pines, Tourmaline, and Mission Beach, where each day's attendance was instead converted into a percentage of that month's attendance and then applied to each month. For our single weekly beach, Glorietta Bay, the process was analogous. Additionally, a comparable model was made for those beaches that include a higher percentage of surfers. This model used daily data from Doheny and Batiquitos (Ponto Beach) beaches to create a "combination" beach profile, representing a clientele composed of both surfers and non-surfers.

Importantly, considering the crucial nature of weekends as a driver of beach visitors, data were aligned by day of the week despite the different years, ensuring that the weekend peaks were maintained. The importance of this can be seen clearly in Figure 1. Without the alignment of the days of the week, many of the highest attendance days could have been averaged out, and many of the peaks would have been lost. The peaks are essential as they represent the busiest days, which are the first to be constrained by a beach's falling carrying capacity.

[2] All beach attendance data were averaged across at least 2 years; for Coronado Shores, for example, daily counts averaged between 2019 and 2023 were used before calculating the percentage of attendance. Additionally, no beach data from 2020 or 2021 were used for any beach, as those years are not representative.

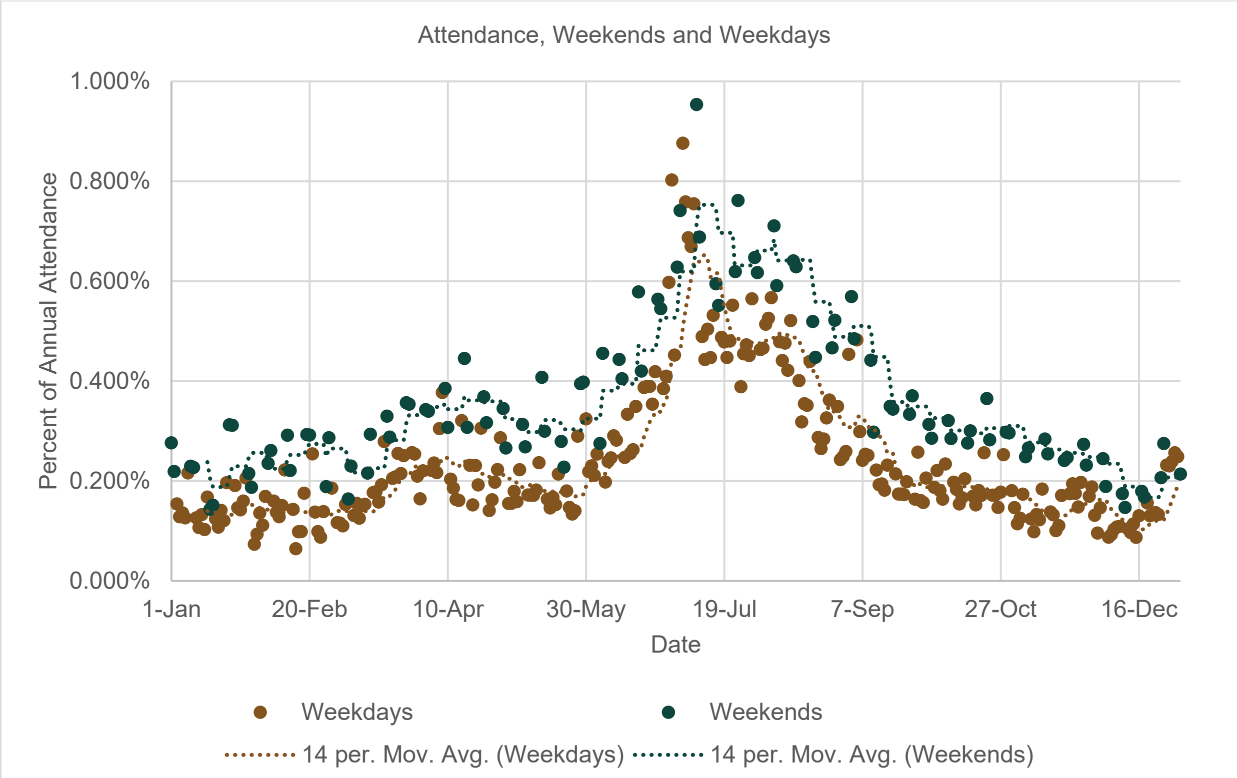


Figure 1: Annual Weekend Attendance vs Weekday Attendance

The above graph shows the difference between weekend attendance and weekday attendance over the course of the year in the representative beach profile, composed of Coronado Shores, Moonlight, Mission Beach, and Imperial Beach. The difference between the two trendlines indicates the importance of weekends as peak attendance days for beachgoers.

4.3 Estimating Lost Value

To estimate lost value, attendance estimates are compared to the beach's total capacity. The carrying capacity of the beach is estimated by looking at the rate of erosion in the past and predicting average erosion in future years to see how the beach area diminishes. Beach area was calculated using past transect data from Coastal Frontiers Corporation (2024) and in consultation with its team. Additionally, the length estimates include approximately 50 feet of margin on either side of the beach length to account for predicted sand dispersion. Then the beach area is divided by a standard value for necessary space (100 sq ft of space per visitor) and then multiplied by the daily turnover rate (typically 2.5) to give the number of people who can visit the beach and fit comfortably in the beach's area.

$$(Initial\ Beach\ Width - \ Erosion\ Rate * Time) * Beach\ Length = Beach\ Area$$

$$\frac{Beach\ Area}{Towel\ Space} * Turnover\ rate = Beach\ Capacity$$

Then, for each beach, each day's attendance (as predicted by the model or taken from the daily counts) is compared to the calculated carrying capacity of the beach. The sum of visitors expected to exceed carrying capacity throughout the year results in the number of people who couldn't visit the beach each year because of the limited capacity. To determine the NMV of this lost visitation, the visits are multiplied by value of a visit ($62 per day). Even when carrying capacity is exceeded, the model does not assume that visitors will not go to the beach at all (though they may not) but assumes a loss in value due to crowding for all visitors.

For C representing capacity at each beach, D representing each day's attendance over the course of the year, and V representing the value of a visit per person ($62):

$$Lost\ NMV\ from\ overcapacity = V * \sum_{i=1}^{365} \begin{cases} D_i - C, & D_i > C \\ 0, & D_i \leq C \end{cases}$$

4.4 Storm Damage

Protective services are considered "indirect-use" values in the typology of EFGS/Ecosystem Services. Indirect use values include "coastal protection, erosion control, water catchment and purification, maintenance of beneficial species, and carbon sequestration," of which coastal protection and erosion control are protective services (Barbier et al. 2011). In the context of coastal California, beaches, bluffs, and other geological features of the coastline largely protect *built* assets such as roads, rail, and developed property.

Evaluating the protective benefit of the coastline, therefore, requires understanding the value of the property and infrastructure the coastline protects, and what the adverse impacts to that property would be if the coastline were to no longer serve this purpose.

In the past, the USACE methods typically required that storm damage prevention constitute a fixed percentage of the total benefits, generally 50% (USACE 1989). The most direct method to determine the protective benefits is to model the impacts that the ocean, storms, and wave action would have on currently protected land. This is typically performed using GIS mapping. This method is based on the notions of replacement and repair cost. The protective value of a beach, for example, is the value of the damage to the homes it prevents from being inundated by winter storms. If that beach were not there, those homes would be inundated and/or destroyed. Thus, the protective value is the value of those homes. This can be approximated using the number of properties (parcels) and the average value per property (obtained through either assessor's data or real estate sites like Zillow.com). It is important that the source of values be consistent.

Finally, the protective value is *not* equivalent to the value of damaged property in a sea level rise scenario. Rather, it is the value of damage property in a hypothetical scenario where the beach has eroded away. Coastal engineers may also need to be consulted, especially where the protective benefit is bluff erosion control.

An analysis of storm damage is not within the scope of this project. However, given the high value of property on the coast, it is likely that storm damage benefits would be very significant and possibly even greater than the recreational benefits.

4.5 Final Methodology

The methods used for RBSP III are consistent with the core assumptions underlying federal methods and the general principles for benefit cost analysis largely agreed upon in the economics profession. Crucially, the analysis in this study leverages more recent and site-specific empirical studies to generate more specific estimates for the beaches in the RBSP III. In doing so, the BCA for RBSP III employs the most current methods and studies of beaches in southern California.

5. Results

This section summarizes the results for beaches included in the RBSP III. A detailed analysis of each beach in San Diego County follows. A similar analysis of three Orange County beaches is included as Appendix D.

The economic analysis applies the methods described in Section 3 above to examine 15 different beaches in San Diego County.

Table 3: Summary of lost NMV from beachgoing (recreational value) as San Diego County beaches erode

Beach	Undiscounted Replenishment Benefit	3% Discounted Replenishment Benefit
Torrey Pines NR	$603,313,513	$504,911,084
Moonlight	$461,463,272	$395,978,836
Oceanside	$179,171,960	$147,212,180
Imperial	$171,607,568	$141,268,885
Cardiff	$100,005,619	$81,516,695
Del Mar	$59,487,084	$51,538,543
South Carlsbad	$35,172,550	$29,578,351
Leucadia	$16,353,275	$13,539,025
Glorietta Bay	$8,760,726	$7,532,803
Coronado Shores	$5,622,811	$4,754,400
Solana	$4,532,454	$3,525,439
North Carlsbad	$2,937,003	$2,373,149
Tourmaline	$0	$0
Batiquitos	$0	$0
Mission	$0	$0
Total	**$1,648,427,835**	**$1,383,729,390**

Results show significant lost NMV across many of the different beaches along the southern California coast, suggesting a strong need for replenishment based on recreational value. The analysis of the impact of beach replenishment on recreational value indicates which beaches should be prioritized. As shown in Table 3, implementing replenishment projects at many beaches in the region would yield hundreds of millions or tens of millions in benefits from avoided losses in recreational value. Torrey Pines and Moonlight have particularly large losses in value with projected erosion. Torrey Pines has a combination of high attendance and high erosion rates, meaning that many people will start being turned away in very high numbers in the next few years. Moonlight, on the other hand, has lower erosion rates, but it is already operating above capacity, and erosion will make this preexisting problem much worse. Moonlight is still over capacity even after replenishment, with NMV losses by the end of the decade in the low hundreds of millions, simply because of the number of visitors.[3] In addition, Oceanside, Imperial Beach, Cardiff, Del Mar, South Carlsbad,[4] Leucadia, Coronado Shores, and Glorietta Bay receive over $5 million in NMV benefits from replenishment.

At Moonlight and Imperial Beach, the proposed replenishment project will not alleviate all capacity constraints on beach attendance--the beach will still experience significant overcrowding even after

[3] Importantly, Moonlight uses some slightly different analysis techniques than some of the other beaches to account for the additional complexity there. Not only does Moonlight have a back-sand area with additional space for families to set down their towels, but it also has a playground, which could bring families for relatively brief periods of time to visit the beach. Given this, Moonlight includes some extra area to account for the space behind, and it uses a turnover rate of 3 to represent the greater proportion of brief family visits to the playground.

[4] South Carlsbad results must be taken as considerably more uncertain than other beaches in this model because of the uncertainty surrounding the receiver site's access, as described in more detail later in this appendix.

replenishment. Further sand placement and widening at these beaches could potentially result in greater recreational value by reducing overcrowding. Imperial Beach, for example, sees high NMV losses even after replenishment, driven by high seasonal peaks on the 4th of July weekend and in summer weekends more generally. Widening the beach further, even 20 or 30 feet, would help with crowding on these days. Similarly, the recreational benefits of additional sand placement at Moonlight would most likely outweigh the costs. Additionally, Del Mar could also benefit from a small amount of additional replenishment, though the benefits there are much lower. Additional sand placement at these beaches in this cycle could provide further space for beachgoers at low additional cost.

While still significant, the benefits of replenishment at Solana Beach and North Carlsbad (Carlsbad State Beach) are comparatively lower than elsewhere in the county, at $4.5 and $2.9 million, respectively (undiscounted). In Solana Beach, Fletcher Cove acts as a significant sand reserve; while the sand outside of the cove is likely to be eroded away within the next decade, the cove provides a reserve of beach space, reducing losses.[5] For North Carlsbad, the low rate of erosion and the high starting beach width limits the number of days in the year that significant exceed capacity. These two beaches, therefore, require closer examination before deciding whether to replenish them in this cycle and, in terms of recreational value, are lower priority than those listed above.

5.1 San Diego County Beaches

5.1.1 Torrey Pines

Replenishment of the Torrey Pines Nature Reserve yields the greatest benefits in terms of avoided lost recreational value. Daily data is not collected for Torrey Pines, and therefore monthly estimates converted to daily estimates using the All-Use Beach Profiles. Torrey Pines is analyzed as a large, general use beach. While it has some surfers, they are not a high enough percentage to impact general attendance.

The high losses in recreation value result from the very high average erosion rate (10.8 feet per year [ft/year]) and narrow remaining width of the beach in 2023 (79 feet). Without replenishment, Torrey Pines will likely disappear completely by around 2031, leaving more than a million visitors a year unable to attend and resulting in more than $600 million in losses.

[5] Solana Beach attendance estimates are based on the number of 156,400 from 2015, incorporating an annual growth rate of 2% to place it at about 186,912 in 2024. The 2015 estimate is from Michael Baker International “City of Solana Beach Public Recreation Fee Report”, pg 1-2. The annual growth rate is per an email with Leslea Meyerhoff.

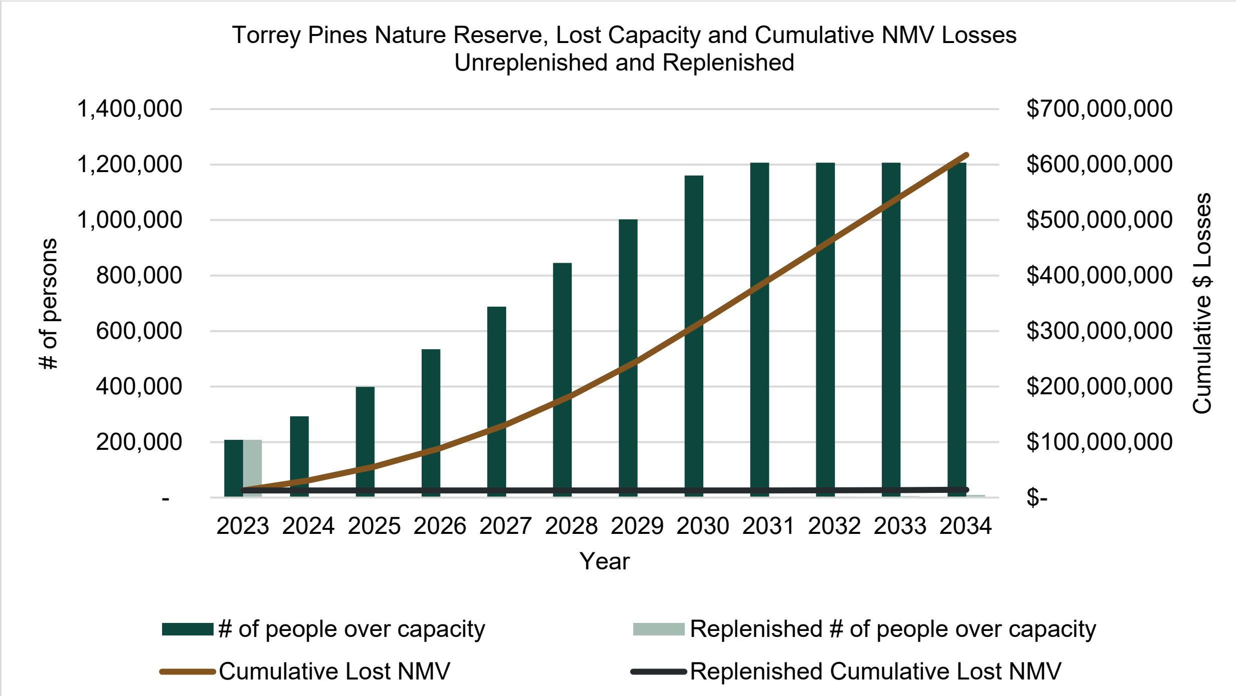


Figure 2: Expected NMV loss due to coastal erosion with and without replenishment at Torrey Pines

While the high rate of erosion does lead to a small amount of crowding again from 2030 on, Torrey Pines overall sees a huge NMV benefit from replenishment. The value of replenishment is $603 million undiscounted ($504 million with a 3% discount rate).

5.1.2 Moonlight

Replenishment of Moonlight Beach would preserve hundreds of millions in recreational value. Moonlight Beach already experiences NVM losses due to erosion and overcrowding. The model of the impacts of erosion and replenishment for Moonlight uses an erosion rate of 3.2 ft/year. Daily attendance data were available for Moonlight; therefore, no beach profile was used. Importantly, two aspects required unique assumptions in this analysis. First, Moonlight was modeled with a higher turnover rate of 3 because of the playground amenities and the number of families who come for relatively short playground visits. Second, Moonlight has additional amenities such as volleyball courts, a playground, a snack bar, and additional recreational area behind the beach, allowing for a higher visitor capacity.

The high losses in recreational value result from high attendance, narrow initial width (100 feet).[6] Even considering the park area behind the beach, Moonlight's expected capacity was exceeded by more than 700,000 in 2023. This number only grows to more than a million people over capacity in 2034. Therefore, while erosion is relatively low, the preexisting problem of crowding means that it still ranks as one of the greatest NMV losses of the beaches; without replenishment, the total NMV losses are around $662 million.

[6] These calculations for Moonlight Beach were done under the assumption that the full length of the beach, about 1,500 feet from A street to D street, is getting replenished, rather than the much shorter 900-foot stretch as marked in the original image. Such a site would lead to even higher NMV numbers at the cost of accuracy, because beachgoers do go beyond the 900-foot stretch. Given this, the study's authors recommend expanding the receiver site to better serve beachgoers and gain further benefits from replenishment.

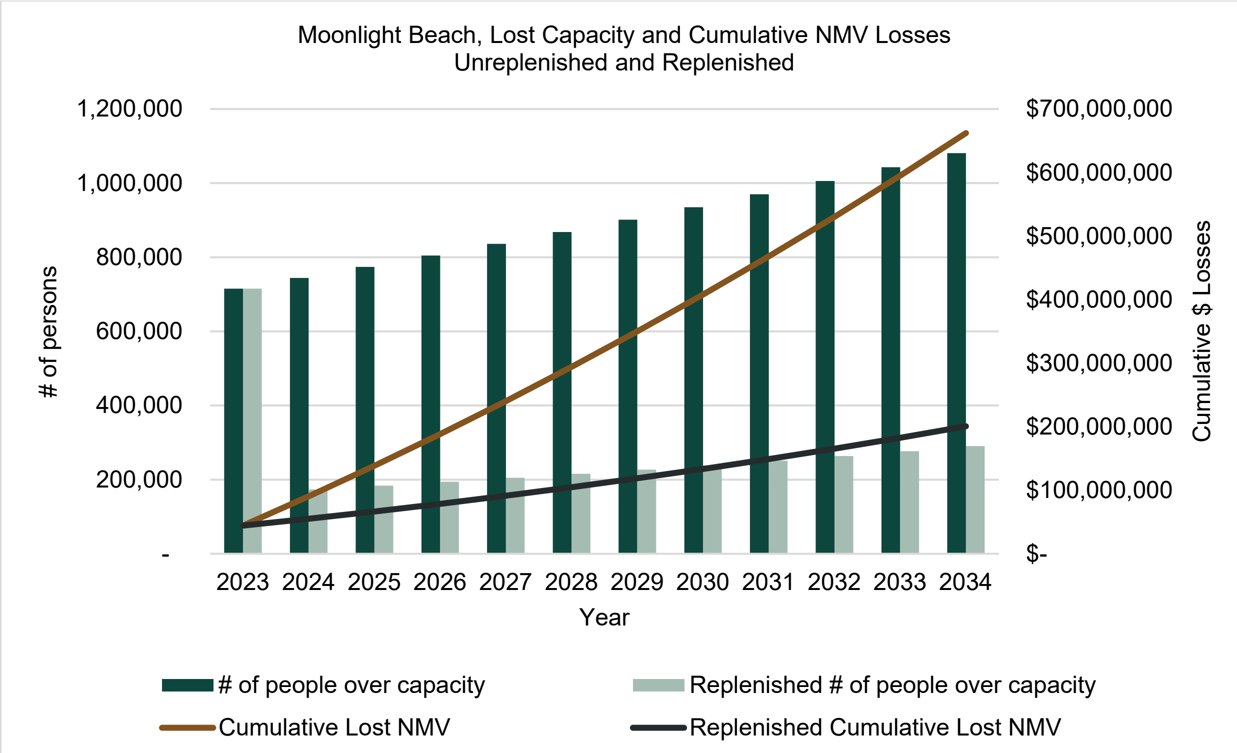


Figure 3: Expected NMV loss due to coastal erosion with and without replenishment at Moonlight

While there is still significant crowding after replenishment (enough to make a strong argument for a larger extension of the beach), the cumulative NMV by the end of the decade is only about $201 million. Therefore, the Moonlight replenishment, over the next decade, would have a cumulative NMV benefit (avoided loss in recreational value) of about $461 million, or $396 million with a 3% discount rate, as seen in Table 3.

5.1.3 Oceanside

Due to the popularity of Oceanside Beach, replenishment has significant recreational benefits. RBSP III focuses on the southern end of the beach, where the sand has all but disappeared completely. The model uses a projected erosion rate of 5.9 ft/year. Daily data are not collected for Oceanside Beach; therefore, annual estimates were converted to daily estimates using the All-Use Beach Profiles. Importantly, as RBSP III proposes to nourish a sub-section of the beach, only 10% of the total Oceanside Beach annual attendance was used to represent visitation to this portion of the beach. Oceanside Beach is analyzed here as a large general use beach. While it has some surfers, they are not a high enough percentage to impact attendance patterns.

The high replenishment value results from narrow initial width. Unlike most beaches in this study, this stretch of Oceanside starts with a very narrow beach, one where in some spots and times, there is only a “wet” low-tide beach. This study (generously) estimates about 30 feet of sand on average for this stretch of Oceanside’s beach. With a very narrow initial width and predicted erosion of 5.9 ft/year, the beach disappears entirely by 2029, leaving *all* visitors along this stretch unable to attend and NMV losses for the decade totaling almost $180 million.

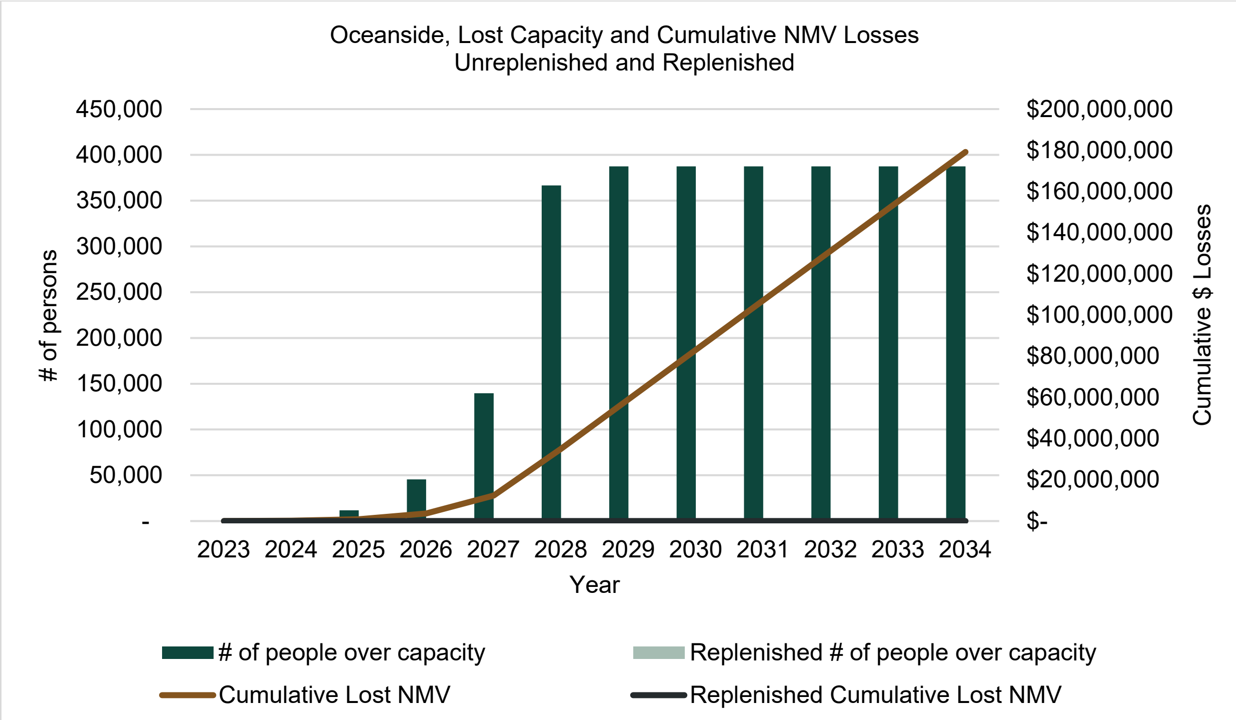


Figure 4: Expected NMV loss due to coastal erosion with and without replenishment at Oceanside

With replenishment, overcrowding is alleviated, and no NMV is lost. The replenished will still be 241 feet wide in 2034; in fact, replenishment results in excess capacity for the receiver site. However, it is likely that the excess capacity at this portion of Oceanside could allow visitors to move south along the coast from other, more crowded sections, which may yield further NMV benefits. At current attendance, the benefit over the next decade to replenishing Oceanside is $179 million without discounting, and $147 million with a 3% discount rate, as shown in Table 3.

5.1.4 Imperial Beach

Similar to Moonlight, replenishment at Imperial Beach has a high benefit due to high attendance and significant annual erosion. The model uses an estimated erosion rate of 10.1 ft/year and daily attendance data from Imperial Beach. In 2023, the beach was already over capacity; without replenishment, Imperial Beach will be overcrowded by more than 850,000 people in 2034. Total NMV losses by the end of the decade will be about $295 million without replenishment.

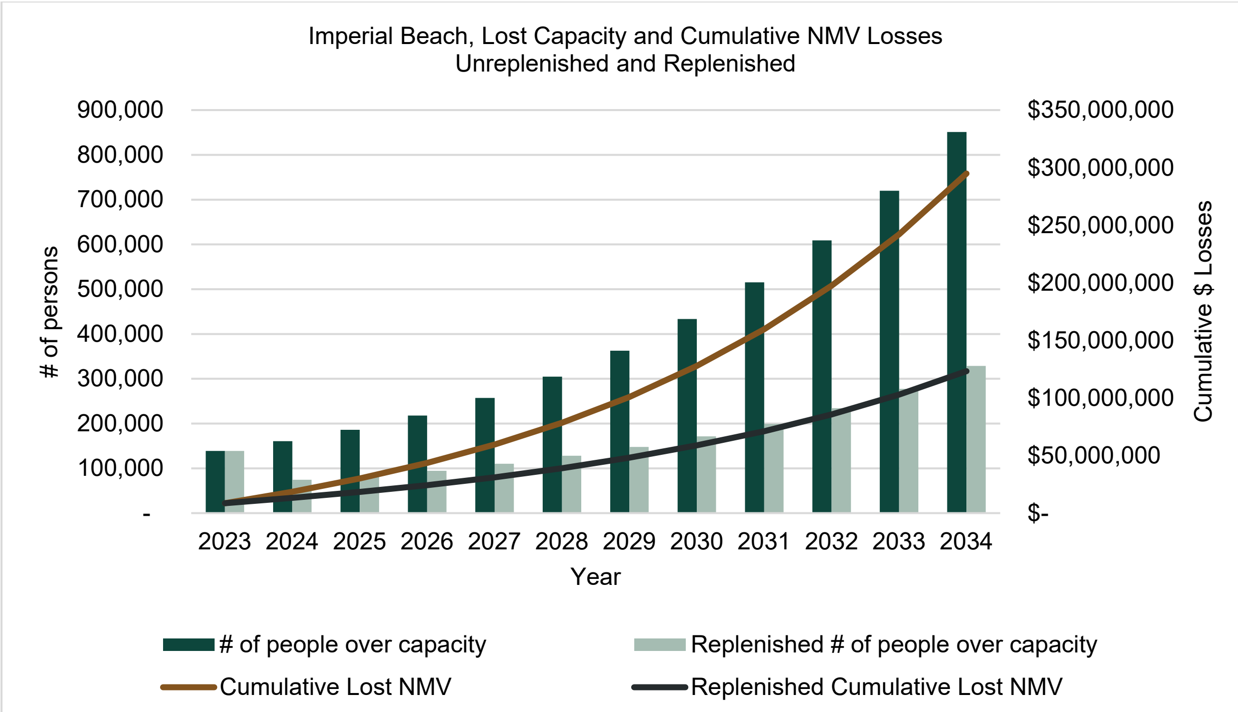


Figure 5: Expected NMV loss due to coastal erosion with and without replenishment at Imperial Beach

Replenishment improves the results significantly, though there is still lost NMV with the proposed replenishment. Replenishment reduces NMV losses through 2034 to $123 million, a significant reduction in losses (55%), though the remaining losses suggest the addition of further sand could pay off. As proposed, the NMV benefit to replenishment for Imperial Beach is about $171 million without discounting, and $141 million with a 3% discount rate.

5.1.5 Cardiff

Cardiff is another major beach in the SANDAG region, catering to a broad range of beachgoers. Once again, this is a general use beach; surfers do not make up a significant portion of the beach's attendance patterns. The model uses monthly data converted to daily estimates using the All-Use Beach Profile. Cardiff's erosion rate of 6.97 feet and the preexisting overcapacity issues in 2023 indicate that there will be significant NMV losses, and projections indicate this problem worsens without replenishment. By 2034, attendance will be almost 350,000 people over capacity annually. In total over the next decade, NMV losses in Cardiff will be about $102 million without replenishment.

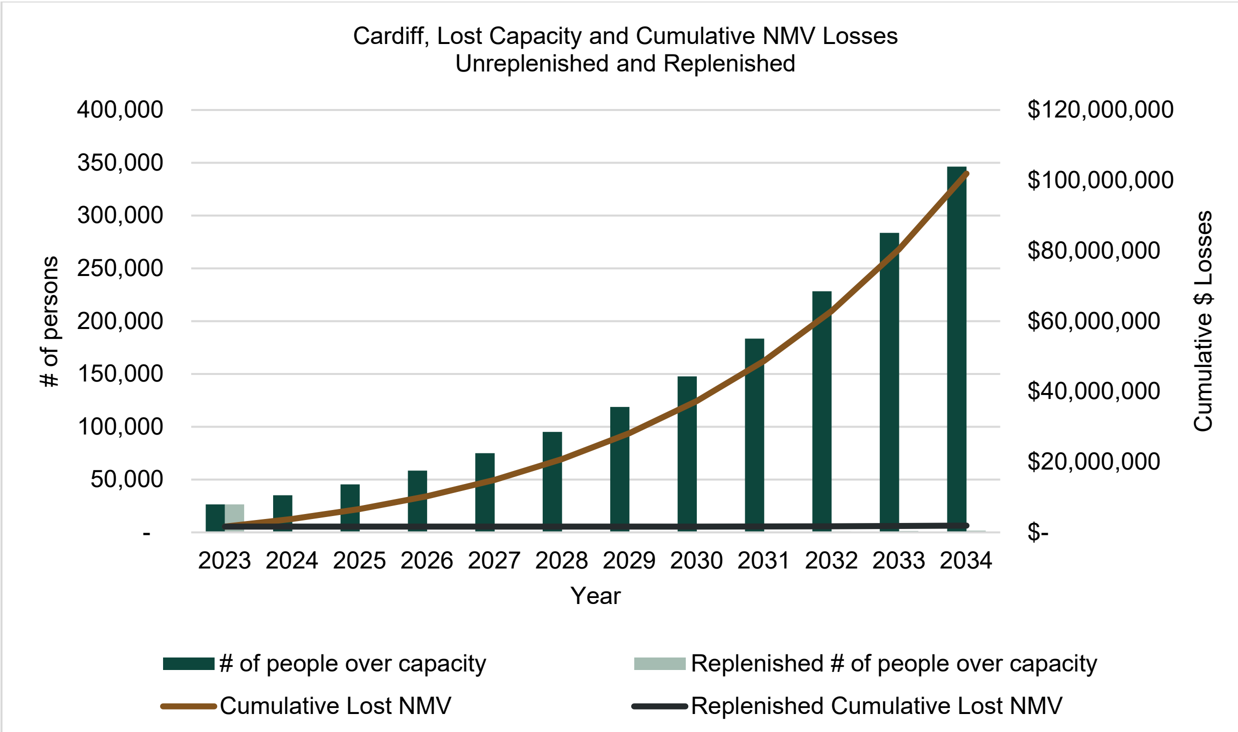


Figure 6: Expected NMV loss due to coastal erosion with and without replenishment at Cardiff

Replenishment alleviates this problem almost entirely, with NMV losses by 2034 totaling less than $2 million. The cumulative NMV benefits to replenishment for Cardiff in total through 2034 are, therefore, about $100 million without discounting and $81.5 million with a 3% discount rate.

5.1.6 Del Mar

Del Mar is a beach with general uses and relatively few surfers. The model used available annual data converted to daily estimates using the All-Use Beach Profile. Del Mar is a popular beach with a low erosion rate. However, Del Mar's popularity implies that it is over capacity by about 91,000 people a year. This remains constant in the model, resulting in total lost NMV of about $68 million by 2034.

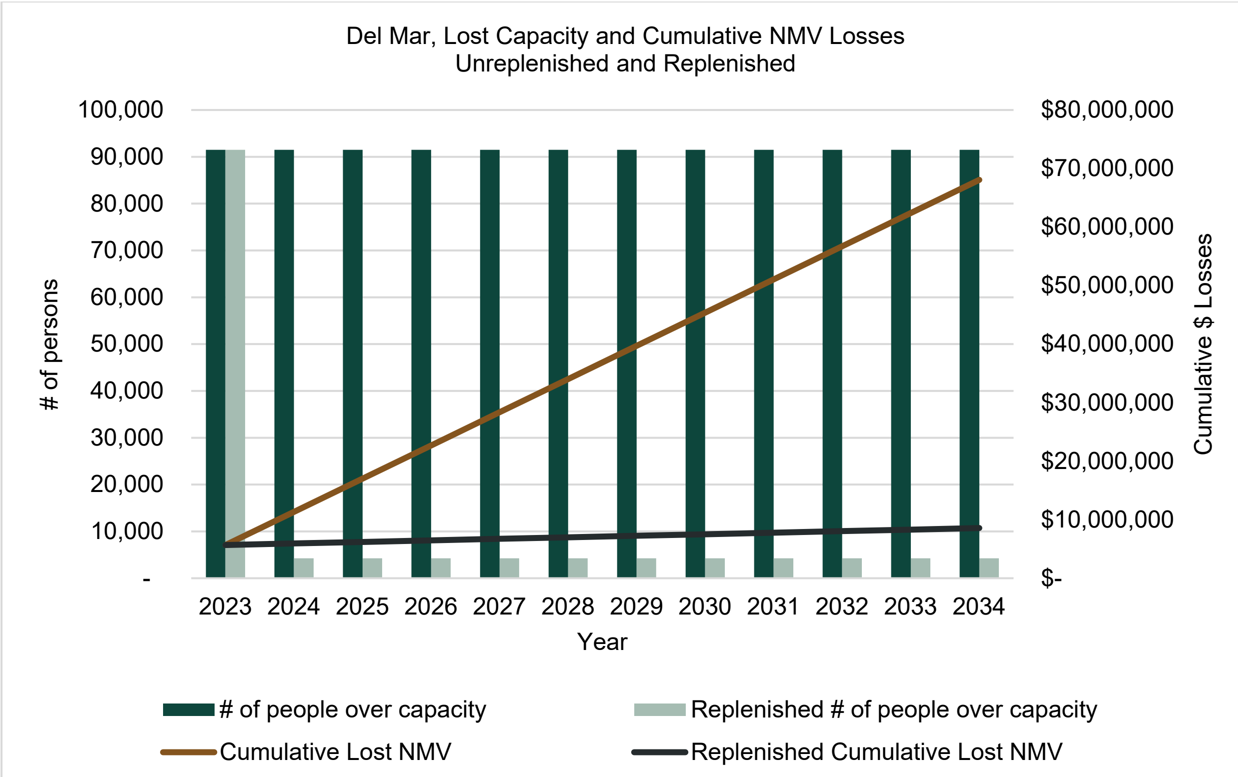


Figure 7: Expected NMV loss due to coastal erosion with and without replenishment at Del Mar

Replenishment does significantly improve overcrowding, although it does not alleviate the issue entirely. At the proposed replenishment width, the beach will still be over capacity by more than 4,000 people a year. Nevertheless, the replenishment as proposed would reduce the lost NMV over the next decade to about $8.5 million, resulting in cumulative NMV benefits of about $59.5 million without discounting, and $51.5 million with a discount rate of 3%.

5.1.7 South Carlsbad

Recreational impacts at South Carlsbad were modeled using an expected erosion rate of 1.5 ft/year and monthly attendance data converted to daily estimates using the All-Use Beach Profile. Crucially, the replenishment site at South Carlsbad has significant access issues that could adversely impact attendance, and as a result, attendance estimates for this beach should be considered more uncertain than the other beaches in this study.

South Carlsbad's lost NMV without replenishment is comparatively much lower, in part because of a low erosion rate of 1.5 ft/year. Without replenishment, in 2034, South Carlsbad will lack the capacity for 80,000 visitors, resulting in $36.7 million in lost NMV, as seen in Table 3.

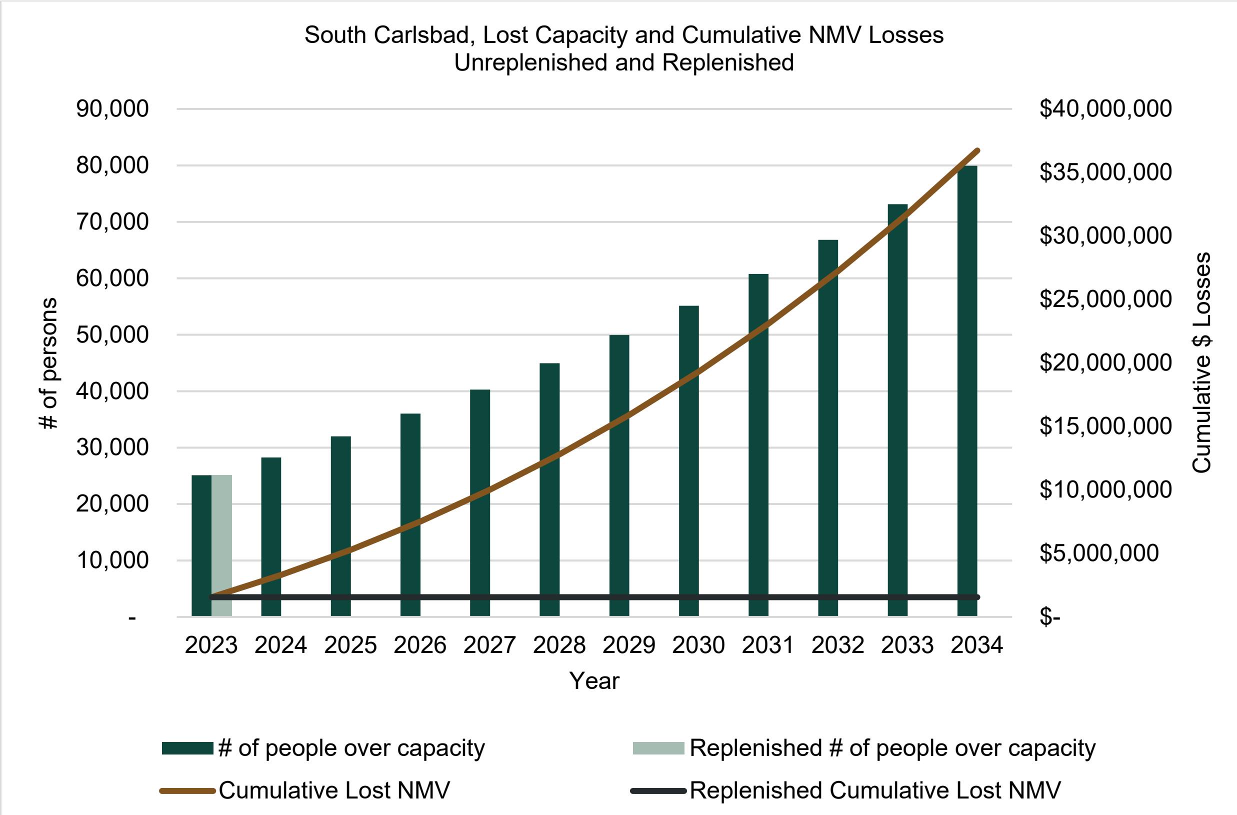


Figure 8: Expected NMV loss due to coastal erosion with and without replenishment at South Carlsbad

With replenishment, however, there is no longer crowding along South Carlsbad over the next decade, resulting in about $35 million in avoided losses without discounting, and $29.6 million with a 3% discount rate.

5.1.8 Leucadia

Leucadia, sometimes known as Beacon's Beach, has a high number of surfers, unlike most of the other beaches proposed as part of RBSP III. Due to the prevalence of surfing, attendance patterns are different, with highs and lows spread out throughout the year based on the waves on each day.[7] Fortunately, Leucadia has detailed daily attendance data, so no estimations were needed. Importantly, considering the predominance of surfing, the model uses a lower space estimate of about 50 sq ft of beach per person. Studies suggest that surfers don't spend as much time on the sand, and therefore need less space. One estimate by Dwight et al (2007) suggests that surfers spend up to 54% of their beach visit in the water (Dwight et al. 2007; Nelsen et al. 2013). Leucadia is a beach with preexisting crowding problems, seeing about 7,000 people above capacity already in 2023. With expected erosion of 3.2 ft/year, without replenishment annual capacity will be exceeded by nearly 47,000 in 2034, resulting in NMV loss of $16.7 million.

[7] Attendance patterns for surfers vary from most beachgoers both throughout the day and throughout the year (Nelsen et. al. 2007).

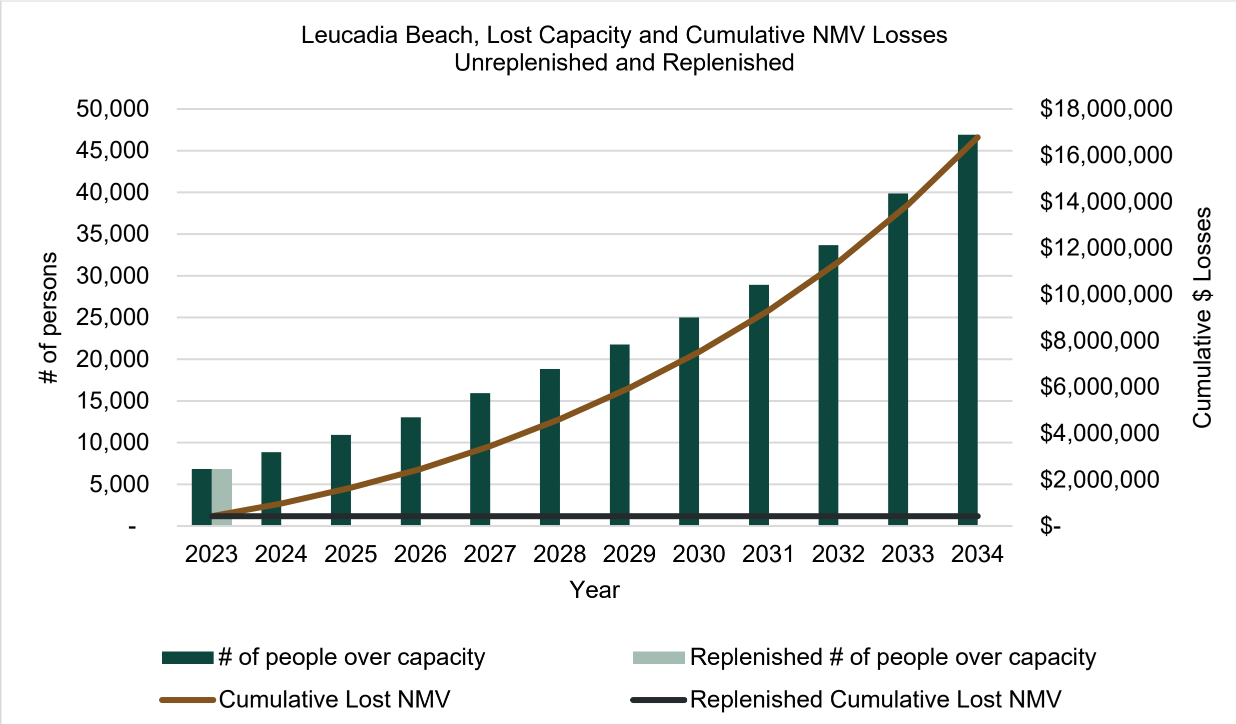


Figure 9: Expected NMV loss due to coastal erosion with and without replenishment at Leucadia Beach

Replenishment mitigates these losses completely. With replenishment, the cumulative NMV benefit over the next decade is about $16.4 million without discounting, and $13.5 million with a 3% discount rate.

5.1.9 Glorietta Bay

Glorietta Bay is a small, protected beach inside of San Diego Bay. There are correspondingly very few surfers because of the lack of waves. Therefore, the All-Use Beach Profile was used to convert weekly attendance data to estimated daily attendance. Erosion rates at Glorietta Bay are estimated at only 0.5 ft/year, due to its protected location. However, Glorietta Bay is a short beach with not much excess sand to lose, and attendance already exceeds capacity by 13,000 in 2023. Without replenishment, by 2034, annual attendance will exceed capacity by more than 17,000 people, driven by peaks in attendance in the summer season. Without replenishment, the cumulative NMV losses over the next decade will be about $11.1 million.

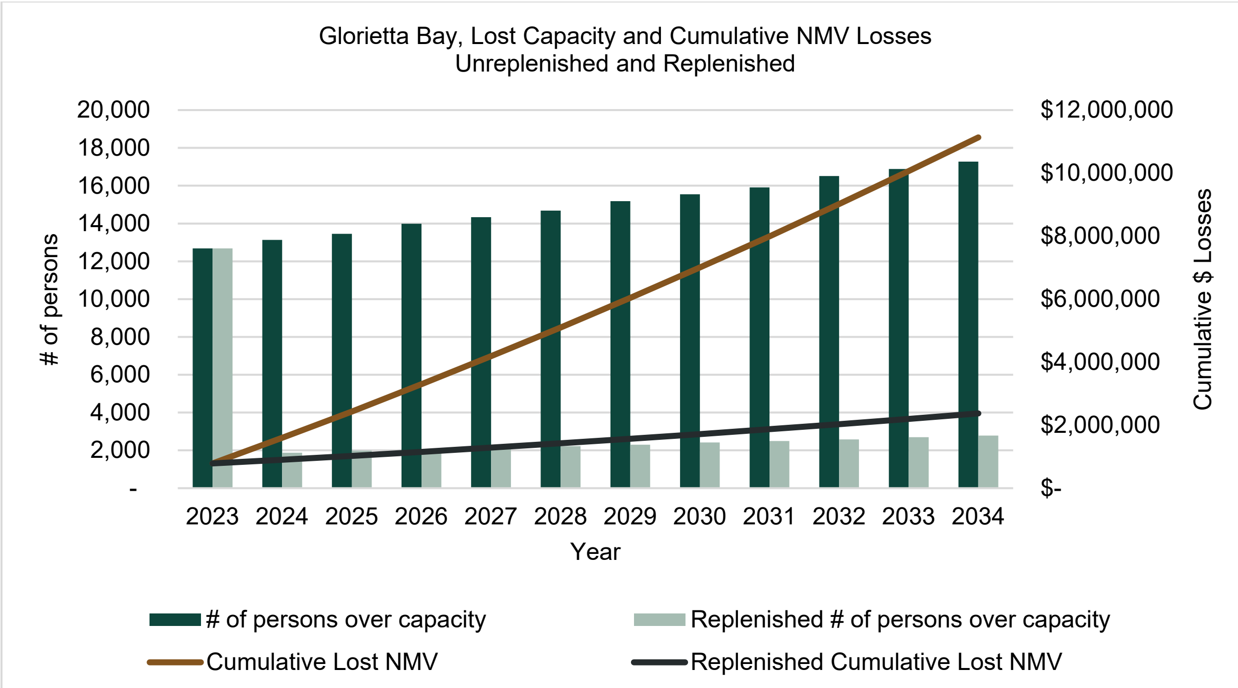


Figure 10: Expected NMV loss due to coastal erosion with and without replenishment at Glorietta Bay

With replenishment, the situation improves significantly. Post-replenishment Glorietta Bay will be less than 3,000 people per year above capacity through 2034, bringing the total NMV losses over the next decade down to $2.4 million. Replenishment, therefore, results in cumulative avoided losses over the next decade of $8.8 million without discounting and $7.5 million with a 3% discount rate, as shown in Table 3.

5.1.10 Coronado Shores

Annual attendance at Coronado Shores totals about 320,000 people. The beach at Coronado Shores caters almost exclusively to non-surfers, as the lack of waves makes it unappealing for surfing. Daily attendance data was available for Coronado Shores. The model assumes an erosion rate of 1 ft/year. However, while the erosion rate is low, attendance at Coronado Shores already exceeds capacity by about 5,000 people in 2023. As erosion impacts the beach, annual attendance will exceed capacity by about 12,000 people in 2034. Cumulative NMV losses through 2034 will be about $6 million without replenishment.

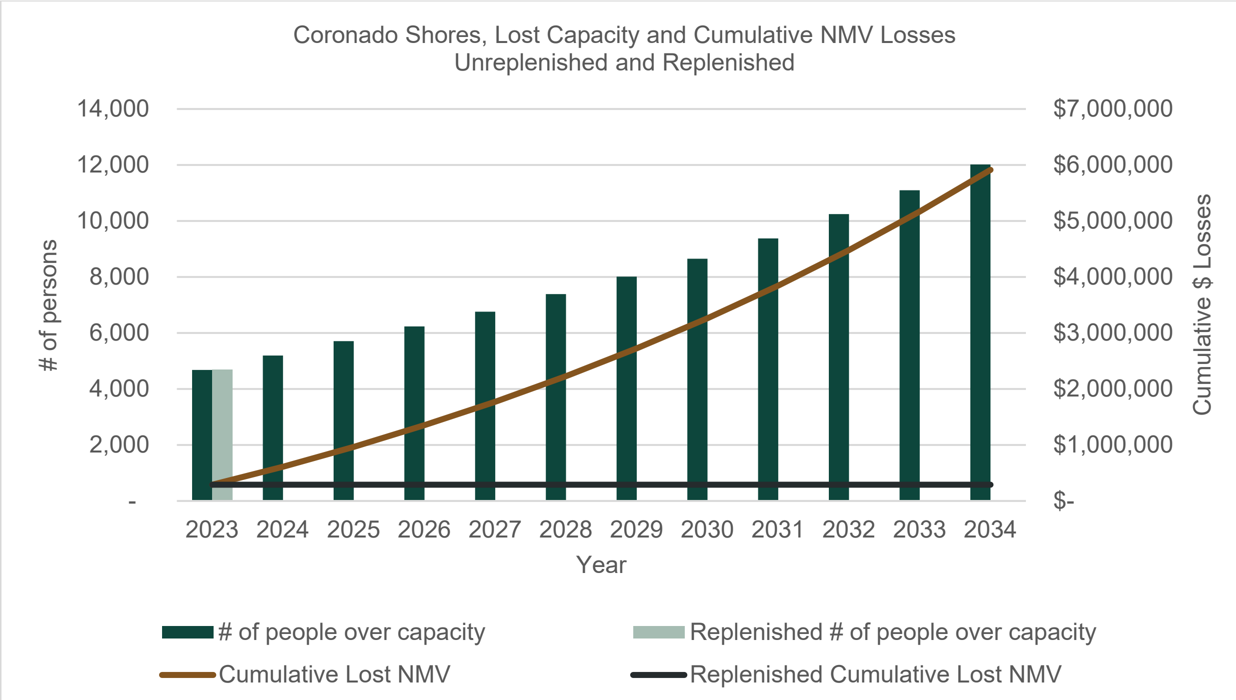


Figure 11: Expected NMV loss due to coastal erosion with and without replenishment at Coronado Shores

With replenishment, NMV losses at Coronado Shores are reduced significantly, down to only $300,000 in cumulative losses by 2034. Replenishment, therefore, results in cumulative avoided losses over the next decade of about $5.6 million without discounting or $4.7 million with a 3% discount rate.

5.1.11 Solana

Solana beach sees significant numbers of surfers as well as general-use beachgoers. Only annual attendance estimates were available for Solana, so the Combination Beach Profile was used to estimate daily attendance to account for the varied beach use. The model uses an estimated erosion rate of 5.6 ft/year, resulting in the total loss of beach area by 2032. Overall, the erosion of the rest of the beach results in about 18,000 people over capacity per each year from 2032 on, resulting in total NMV losses by 2034 of about $4.5 million.

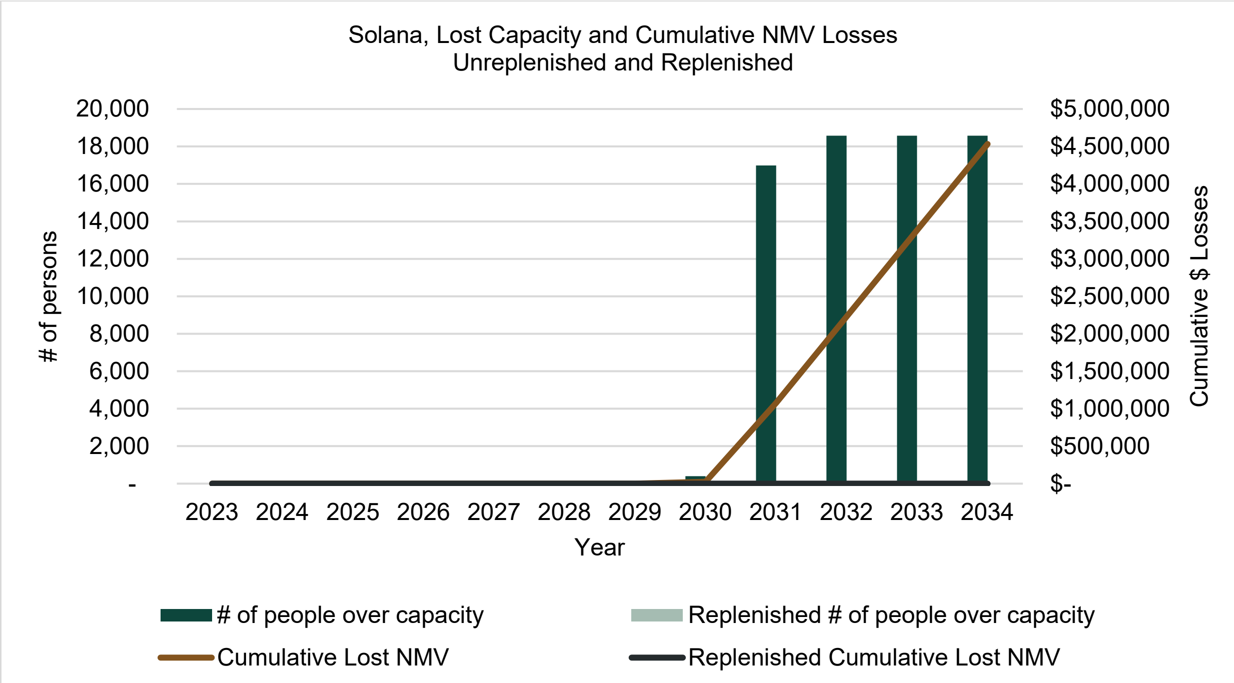


Figure 12: Expected NMV loss due to coastal erosion with and without replenishment at Solana

With replenishment, NMV losses at Solana are avoided. Therefore, the cumulative NMV benefit of replenishment at Solana Beach over the next 10 years is also about $4.5 million without discounting or $3.5 million with a 3% discount rate.

5.1.12 North Carlsbad

North Carlsbad (Carlsbad State Beach) is primarily used by non-surfers. The model uses estimated erosion of 2.6 ft/year and available monthly attendance data converted to daily estimates using the All-Use Beach Profile. While North Carlsbad is already slightly overcapacity, with moderate erosion and 132 feet of preexisting width, Carlsbad sees relatively low cumulative NMV losses of about $3.2 million by 2034.

Proposed replenishment to 150 feet of width reduces expected losses and ongoing overcrowding. With replenishment, Carlsbad does not hit overcapacity again until 2030, and the total NMV losses by the end of the decade are about $260,000. Therefore, the expected NMV benefits from replenishment are about $2.94 million without discounting and $2.4 million with a discount rate of 3%.

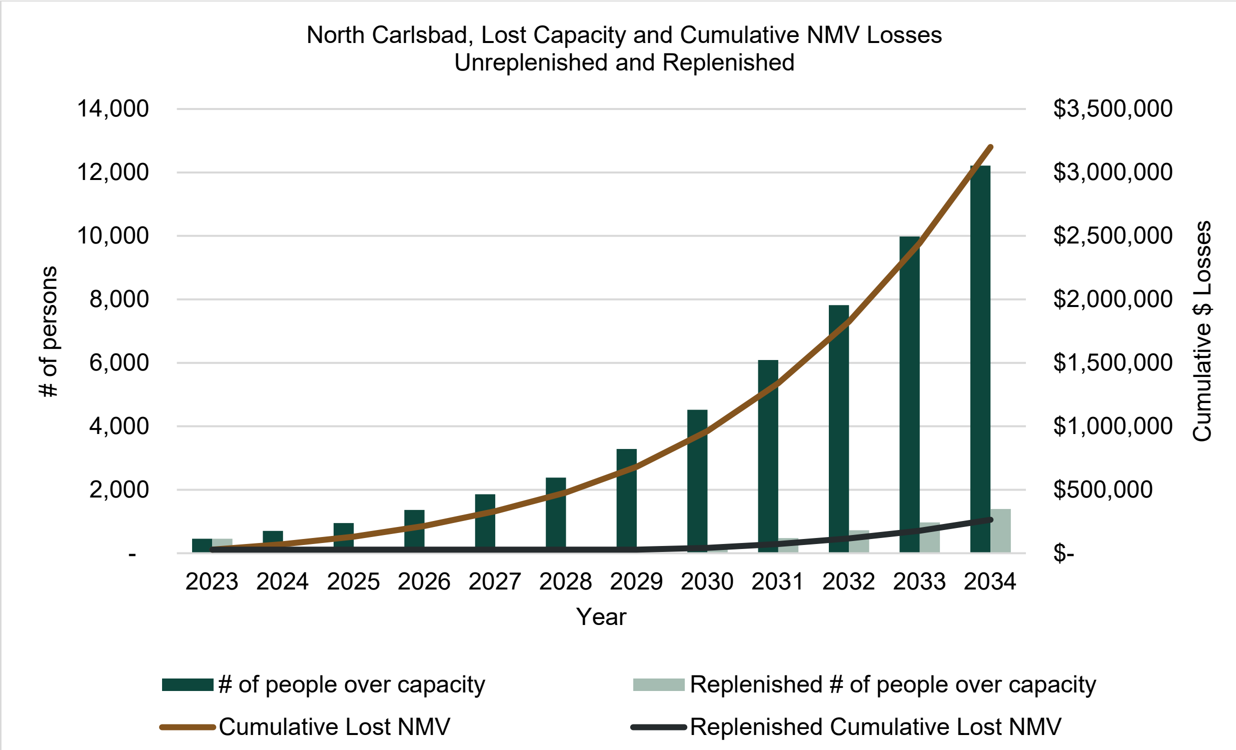


Figure 13: Expected NMV loss due to coastal erosion with and without replenishment at North Carlsbad

5.1.13 Tourmaline

Tourmaline Beach is located north of Mission Beach in the SANDAG region. This beach is an All-Use Beach, used by both surfers and non-surfers alike, with the total number of visitors reaching about 200,000 each year. Daily attendance was estimated using the All-Use Beach Profile from available annual attendance estimates. The model suggests that Tourmaline does not need replenishment to support existing recreation despite a low preexisting sandy beach width. The beach length and low erosion rate of 0.3 ft/year mean that Tourmaline is not overcrowded by 2034, and there is no NMV loss.

5.1.14 Batiquitos

Batiquitos, also known as Ponto Beach, is located right next to the Batiquitos Lagoon in San Diego County. This beach is used by both surfers and general beachgoers. Based on available daily attendance and expected erosion of 3.2 ft/year, the model suggests that Batiquitos does not need replenishment due to its beach width of over 100 feet. Without replenishment, the beach will not be overcrowded by 2034, and there is no NMV loss. While replenishing the beach down the coast could serve to protect valuable beachfront property, there is no expected gain or avoided loss in recreational value.

5.1.15 Mission Beach

Mission Beach is a popular All-Use Beach in San Diego County. Based on available daily attendance data (totaling about 3 million visitors each year) and expected *accretion* of 1.5 ft/year, the model suggests Mission Beach has significant excess (and increasing) capacity and does not need replenishment. Crucially, Mission Beach is wide and becoming wider, with an accretion rate of 1.5 ft/year. This is driven by sand coming down along the coast from other beaches; thus, while Mission does not benefit directly from replenishment, replenished sand from sites upcoast will drift to Mission.

6. Sensitivity Analysis

To ensure that this project was not too reliant on particular assumptions about towel space, erosion rates, or other assumptions in the model, the authors of this study ran a variety of sensitivity analyses to ensure that the overall results were robust to differing (but possible) assumptions.

6.1 Visitor Crowding Tolerance

The first robustness assessment in this study examines the towel space estimate, estimating what the results would be with a reduction of the space estimate from 100 sq ft of space per person to about 66 sq ft per person, or two-thirds of this study's original estimate.[8] This represents what would happen if people were less sensitive to crowding and required less personal space. As it is possible that, over time and as beaches narrow, beach patrons will become less bothered by higher rates of crowding, this model helps illustrate what would happen if tastes shift correspondingly. Moreover, this one-third reduction in necessary space per person impacts the model in the same way as an increase in the turnover rate; the change is equivalent to an increase in the turnover rate from 2.5 to 3.75.[9] The results below, therefore, provide a useful estimate of what the results would be for changes in the turnover rate or the towel space estimate.

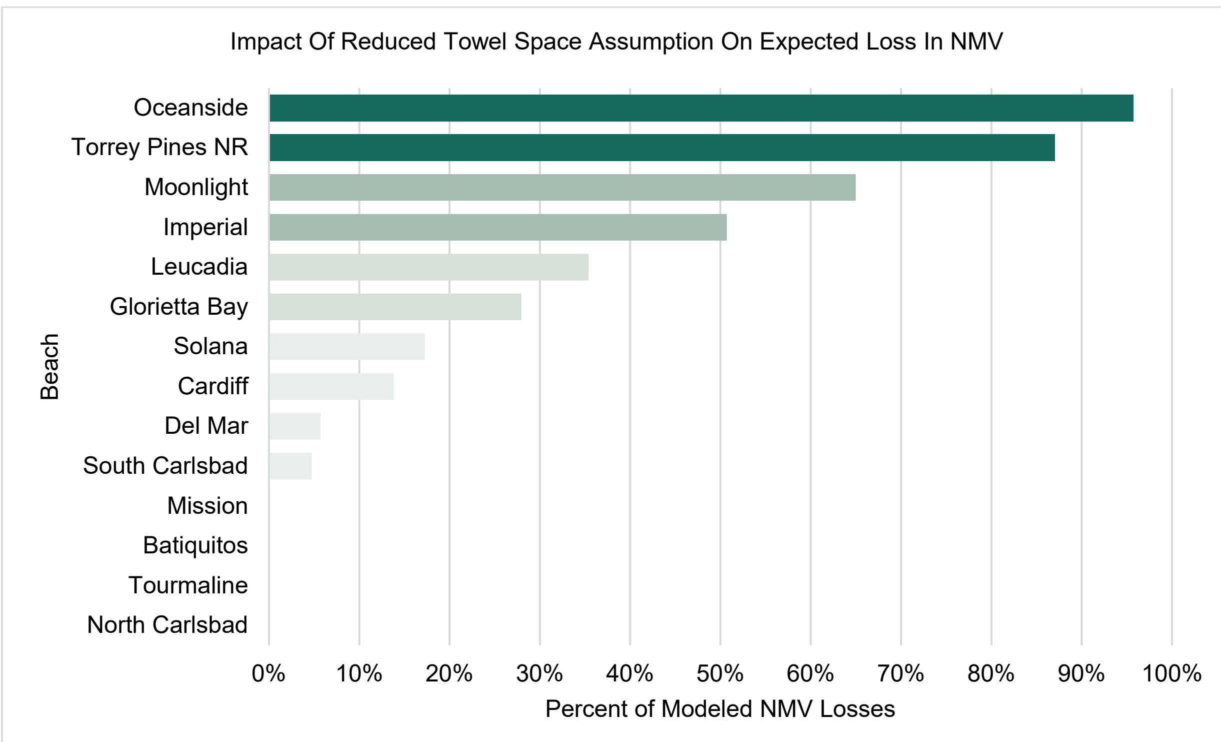


Figure 14: Impact of reducing the carrying capacity assumption from 100 sq ft per person to 66 sq ft per person on NMV loss, shown as a percentage of modeled NMV loss.

[8] Importantly, for Leucadia which already uses a reduced towel space estimate, the towel space estimate was also reduced by 33%. For Leucadia, therefore, the towel space estimate of 50 sq ft per person was adjusted down to only 33 sq ft of space per person for the purposes of this robustness check.
[9] Or from 3 to 4.5, in the case of Moonlight, which as previously mentioned was originally modeled with a higher turnover.

As shown in Figure 14 above, a reduction in towel space required for each person, from 100 sq ft per person to 66 sq ft per person, significantly reduces the NMV value of replenishing these sites. Some beaches see changes in NMV of less than 5%, and other beaches see changes in NMV losses of 100%. However, the total NMV of replenishment remains over a billion dollars, and most of the beaches in this study remain worth replenishing in this alternative model.

Increasing visitors' tolerance for crowding does eliminate NMV gains for a small subset of San Diego County beaches. As shown in Table 4 below, North Carlsbad no longer sees benefits or avoided losses from replenishment. Solana, Coronado Shores, South Carlsbad, Del Mar, and Glorietta Bay see very significant drops, resulting in cumulative benefits to replenishment of under $5 million.

Table 4: Lost NMV in Model with Reduced Towel Space, Model Results

Beach	Undiscounted Replenishment Benefit	3% Discounted Replenishment Benefit
Torrey Pines	$524,905,480	$431,318,529
Moonlight	$299,902,897	$255,206,734
Oceanside	$171,472,759	$140,075,579
Imperial	$87,014,437	$69,848,439
Cardiff	$13,834,606	$10,863,060
Del Mar	$3,413,127	$2,957,072
South Carlsbad	$1,669,599	$1,343,724
Leucadia	$5,787,840	$4,579,067
Glorietta Bay	$2,449,494	$2,093,379
Solana	$782,766	$607,720
Coronado Shores	$639,158	$513,979
North Carlsbad	$0	$0
Tourmaline	$0	$0
Batiquitos	$0	$0
Mission	$0	$0
Total	**$1,111,872,163**	**$919,407,284**

While the NMV reductions from increased turnover or reduced space preferences are significant, the results shown above should not be used to represent the conclusions of this study as a whole. Overall, the turnover rate of 2.5 and the space per person estimate of 100 sq ft remain the most plausible estimates, and the results provided in this appendix are what should be considered for the BCA. Nevertheless, this shows that, even if the model's parameters vary from their expected values, the results remain robust.

While this study generally uses standard turnover and towel space estimates, beaches will of course have different turnover rates as people stay longer or shorter periods of the day. In the aggregate, however, these numbers are representative of beachgoing patterns (King and McGregor 2012). For those beaches, such as Moonlight and Leucadia, where beach use was markedly different from the rest of the study sites, turnover and space per person estimates were adjusted to represent that difference. At Moonlight, for example, the turnover rate was increased to represent the number of families who came briefly to visit the playground. At Leucadia, due to the high percentage of surfers, the space per person estimate was halved, as surfers spend less time on the beach itself and, therefore, need less space.

6.2 Erosion Rates

Additionally, despite having some confidence that the erosion rates used are a good model of future erosion (as they are based on historical erosion patterns), this sensitivity analysis modeled the resulting NVM benefits if those estimates are too high and erosion was actually much less than predicted. Because higher erosion rates yield higher lost NMV estimates, the reduction in erosion rates reduces the benefits of replenishing these beaches. When each beach's erosion rate was halved from the estimates in the initial model, creating a "low-erosion" scenario, many beaches saw significantly reduced NMV benefits to replenishment. Graphed below in Figure 15 are the results for San Diego County, comparing the low-erosion model to the "standard erosion" model, which show how some beaches were impacted more than others by the change in erosion rate.

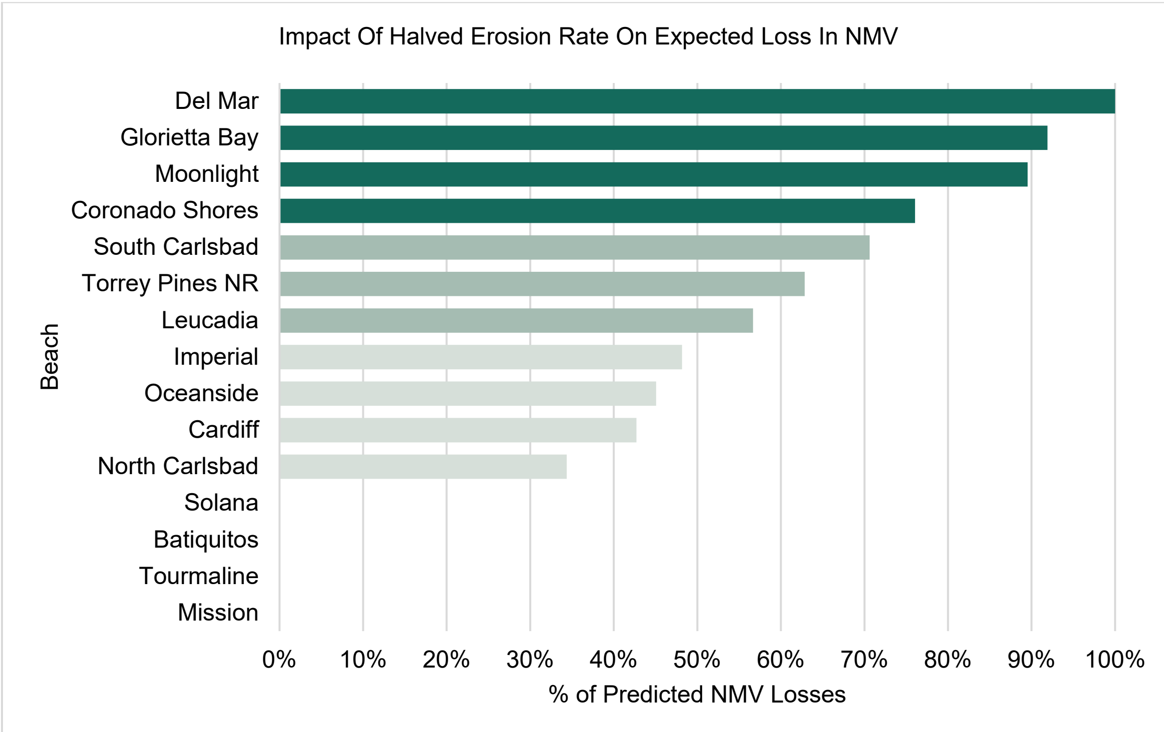


Figure 15: Impact of halving erosion on NMV loss, shown as a percentage of modeled NMV loss

Despite the fall in the net NMV benefit of replenishment, the overall results held, with more than a billion dollars in net benefits to replenishment. This suggests that in total, the beaches in this study are clearly in need of replenishment even if the erosion assumption is adjusted. The low-erosion scenario results are shown in Table 5 below.

Table 5: Lost NMV in Model with Halved Erosion Rate, Model Results

Beach	Undiscounted Replenishment Benefit	3% Discounted Replenishment Benefit
Torrey Pines NR	$379,126,110	$316,487,839
Moonlight	$413,202,410	$356,217,907
Oceanside	$80,746,894	$63,098,966
Imperial	$82,651,497	$69,755,762
Cardiff	$42,721,953	$35,711,693
Del Mar	$59,487,084	$51,538,543
South Carlsbad	$24,837,817	$21,157,459
Leucadia	$9,266,489	$7,811,369
Glorietta Bay	$8,051,570	$6,949,604
Coronado Shores	$4,276,481	$3,657,479
Solana	$0	$0
North Carlsbad	$1,009,463	$836,975
Tourmaline	$0	$0
Batiquitos	$0	$0
Mission	$0	$0
Total	$1,105,377,769	$933,223,596

A few beaches no longer need replenishment or see very low net benefits to replenishment under this new model, including Solana, Coronado Shores, and North Carlsbad. However, as this study's authors believe that the standard erosion scenario is more likely considering past rates of erosion, those results should be evaluated during benefit-cost calculations rather than the ones produced by this low-erosion model. The standard erosion model located in the main body of the analysis will provide more accurate estimates of the NMV benefit of replenishing each specific beach, but this alternative, low-erosion model illustrates the robustness of our findings. Even in this model with significantly reduced erosion, most of the beaches are at or above $5 million in net NMV replenishment benefits, with only Solana and North Carlsbad falling below.

6.3 Receiver Sites and Site Access

Another important consideration is if the area of the receiver site is an accurate representation of the beach overall. This is crucial because if attendance counts are not based on the same area of the beach as the replenishment site, this can lead to serious errors. Ideally, people who spend their beach visit within the bounds of the receiver site are counted in attendance calculations and those who do not aren't counted; outliers could lead to inaccurate estimates of how much towel space is needed for the beach's visitors.

This concern also impacts those beaches where access is lacking in the receiver site area. Fortunately, this was a major concern for only one beach in this study: South Carlsbad. The replenishment site is not in a location with good access, meaning that attendance counts might not accurately estimate the number of people at that particular location, instead counting people elsewhere along that stretch of coastline. Therefore, estimates produced by this model should be taken with additional uncertainty in the case of South Carlsbad.

As many beaches have few access points, it is also worth considering how receiver sites should be chosen relative to ease of access. If people are not willing to walk far from the access point to their chosen spot on the beach, and there are few entrance points, the area near the entrance points can quickly become crowded disproportionate to the total beach. If this problem is severe enough, people could be dissuaded from visiting the beach even though there are areas of the beach with plenty of available space.[10] In this scenario, the best way to provide more area for beach patrons may be to shrink the receiver site's length and increase the width (adding more sand to a smaller part of the coastline)—focusing the sand placement nearest the access point(s). Condensing the placement improved the recreational value by concentrating sand placement on the usable space. However, at Moonlight, despite expectations that visitors would concentrate around the single access point, examination of beachgoer behavior revealed that visitors were willing to walk further than expected and the access site estimate used in the study was 1500 ft.

[10] Surfers are the exception to this. Surfers are typically willing to drive and walk significantly further than non-surfers in order to find the best waves. For surfer beaches, therefore, said walking distance estimates have to be evaluated differently (Nelsen 2012; Nelsen et al. 2007).

7. Conclusion

Overall, when considering solely the non-market recreation value of a beach day to these patrons, most of these beaches show a compelling case for replenishment. Every beach except for Tourmaline, Mission Beach, and Batiquitos sees NMV benefits to beachgoers from replenishment, and most see benefits (avoided losses) in the tens or hundreds of millions. The benefits of nourishing these beaches total about $1.6 billion over the next 10 years. These results indicate that preserving the San Diego region's beaches generates benefits at least 20 times the nourishment cost over the life of RBSP III, which is indicative of the acute need to maintain San Diego's beaches to sustain its economy. Based exclusively on the avoided losses in recreational value, Torrey Pines, Moonlight, and Oceanside see the highest benefits. Additionally, additional replenishment beyond the proposed replenishment dimensions would benefit Moonlight, Imperial Beach, and Del Mar. Moreover, these results are robust, with compelling results even when the model's underlying assumptions are adjusted. These conclusions suggest a compelling argument for the addition of sand to many sites along the southern California coast, ensuring beachgoers can continue to get the recreation value that they have come to expect from their visit.

Continued erosion and the concomitant loss of recreation value to beachgoers as the beach shrinks presents a threat to the efforts of the California Coastal Commission in its work to preserve the beaches for future public access. Additionally, a failure to maintain San Diego's beaches would inhibit economic activity and recreational value, and place public and private infrastructure at risk. Beach replenishment offers a powerful way to maintain these beaches for successive generations and should be a top priority for the region.

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Appendix C

Orange County Offshore Borrow Site Investigation

Appendix C

San Diego Association of Governments
Regional Beach Sand Project III
Offshore Borrow Site Investigation – Exploration Plan
Orange County

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July 2025

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1. Introduction and Background

San Diego Association of Governments (SANDAG) previously completed two regional beach sand projects (RBSPs) in 2001 and 2012 (RBSP I and RBSP II, respectively), adding approximately 3.6 million cubic yards of sand to the San Diego region's local beaches. These projects were initial pilot projects, representing the first major steps in addressing the severe sand deficit on the region’s beaches and identifying a long-term approach to managing the region’s shoreline. Because of the continued deficit in the littoral system, repeated and consistent replenishment is necessary to maintain regional beaches and the recreational, economic, and protective services they provide. SANDAG is currently evaluating the feasibility to conduct a third RBSP (RBSP III). The proposed RBSP III expands nourishment to encompass the entire Oceanside Littoral Cell and extends to include the evaluation of nourishing southern Orange County beaches in the cities of Dana Point and San Clemente. This is the first time beaches outside of San Diego County would be included as part of a RBSP but reflects a more system-wide approach based on littoral-cell rather than jurisdictional boundaries.

This Appendix provides a preliminary plan for offshore explorations at potential borrow sites that could support beach replenishment along the southern Orange County shoreline as part of RBSP III. Implementation of beach replenishment projects would involve dredging beach-quality sand from offshore borrow sites and placing it on highly eroded beaches as needed. This preliminary assessment considered information available from published literature, previous offshore explorations, and experience with known borrow sites.

Concurrently, the City of San Clemente is actively developing a coastal resiliency strategy using beach sand replenishment as the primary means of restoring sandy beaches. In support, the City of San Clemente’s ’s Offshore Sand Source Investigation is currently in progress, i.e., a phased study wherein the initial primary objectives are to evaluate existing information to identify potential borrow sites and to guide subsequent field data collection efforts. The offshore explorations at candidate borrow sites for the City of San Clemente’s effort are expected to begin in the summer or fall of 2025 (Coastal Frontiers 2025). The research efforts to support the assessment for RBSP III, described in this Appendix, and the sand source investigation for the City of San Clemente have been a collaborative effort; proposed offshore sand source investigations have similar objectives. While the research presented in this appendix focuses on San Clemente, it is assumed information would also apply to Dana Point.

Several potential borrow areas warrant further investigation including locations at Huntington Beach, Newport Beach, and Camp Pendleton (**Figure C-1**). Camp Pendleton is in San Diego County, but a potential borrow area in the mid-area of Camp Pendleton would be relatively close to southern Orange County beaches. Preliminary review identified candidate borrow areas shown in more detail on **Figures C-2 through C-4**. Borrow area layouts were considered based on depth of closure (generally taken as -30 feet [ft] Mean Lower Low Water (MLLW) and potential dredge depths limited to about -60 ft MLLW. The available information included published bathymetry maps, Nearshore Habitat Inventory Mapping, and maps compiled previously for the Regional Beach Sand Project (RBSP) II. Recommendations for additional surveys and vibracore explorations follow below.

The existing United States Army Corps of Engineers (USACE) borrow area at Surfside-Sunset has been a long-term sand source used to restore 17 miles of coastline from the mouth of the San Gabriel River downcoast to the Newport Bay Harbor entrance. Surfside Sunset recently (in 2024) supplied about 196,000 cubic yards to supplement the San Clemente Shoreline Sand Replenishment Project. The imported sand placed south of the San Clemente Pier was pale brown, fine to coarse sand with gravel and shells. The initial sand nourishment operation began on December 21, 2023, using a borrow site near the Santa Margarita River (Borrow Site 2A). The material was deemed unacceptable and composed mostly of cobble, gravel, and shell fragments with some sand. Operations were halted on January 9, 2024, while possible options were reviewed. The project resumed in April 2024 using the Surfside-Sunset borrow site, and about half of the planned nourishment volume (114,000 cubic yards [cy]) was placed on the beach. The contractor returned in November 2024, placing 82,000 cy of material (also from the Surfside-Sunset borrow site) between November 8 and 30, 2024. A total of 196,000 cy of the planned 251,000 cy was placed on the beach.

Recognizing the dredge travel distance (over 30 miles) required at Surfside Sunset, the primary objective for this preliminary study was to identify potential offshore borrow areas at locations closer to San Clemente and Dana Point. However, a large portion of the area offshore of San Clemente and Dana Point has previously been explored by USACE (2011) with geophysics and vibracores; the sand recovered was found to be mostly relatively silty and fine-grained and was considered unsuitable. Recognizing southern Orange County's current replenishment needs, it could benefit the region to re-investigate selected areas offshore of San Clemente to be able to cover a broad range of physical settings, as discussed below.

2. Previous Studies

A wide-ranging study by Osborne et al. (1983) for California Department of Boating and Waterways reported on potential offshore sand and gravel resources in southern California from Santa Monica Bay south to Imperial Beach, San Diego. The investigation was based on side-scan-sonar and high-resolution seismic reflection (sub-bottom) geophysical surveys and 49 widely spaced vibracores. Osborne's 1983 studies provided substantial baseline information and framework for further confirmation investigations. Many potential borrow areas were identified over the entire study area; these areas were thought to include substantial sand volumes, typically with a wide range of material characteristics.

Several sites identified by Osborne have been suitable for the RBSP (with adjustments), although several areas have also been found unsuitable. Experience from the RBSP has shown the Osborne (1983) study results tend to overestimate sediment quantities, because the estimates are for sediment thicknesses deeper than typical dredge depths and encompass very large areas. Without additional explorations, material characteristics at the Osborne borrow sites are not known sufficiently well enough to refine or update previous quantity estimates. USACE and others have re-explored Osborne's potential borrow areas more recently, as summarized below.

3. Potential Borrow Sites

The following paragraphs provide: 1) a preliminary assessment of potential offshore borrow areas and 2) an exploration plan for borrow site investigations. Additional explorations at Surfside Sunset are not a consideration for this assessment because the borrow has been well characterized and is a proven borrow area. Rather, the general setting at Surfside Sunset helps to provide a framework for additional explorations in similar settings downcoast and general knowledge that ample suitable beach materials are available, if needed.

3.1 Surfside-Sunset

The regional studies noted above (Osborne et al. 1983) identified several large potential borrow areas including the area known as Surfside-Sunset (**Figure C-1**). The existing Surfside Sunset borrow area is a very large offshore area located southwest of Anaheim Bay. USACE periodically dredges beach-compatible materials to replenish the Surfside Beach, Sunset Beach, and the Santa Ana River mouth. The beaches at Surfside and Sunset then act as a feeder beach for nourishing the downcoast beaches. The borrow area includes several contingent subareas; the largest portion is known as Borrow Area B, with a northerly expansion area at Borrow Area BB. In 2018, it was estimated Area B is at least 45,000,000 cubic yards. Materials investigated have been repeatedly assessed and determined to be beach-compatible. Surfside Sunset Subarea BB (a sub-area) was recently sourced for beach replenishment at San Clemente by USACE, see **Figure 1**, below.

3.2 Huntington Beach and Newport Beach

Osborne (1983) identified two potential borrow locations off Huntington Beach and Newport Beach (**Figure 1**). Two of the subareas identified may be feasible for beach replenishment; these areas had been deemed "Borrow Areas A-I and A-IV" off of Huntington Beach and Newport Beach, respectively.

The A-IV borrow area off of Huntington Beach was approximately between the 30-foot and 80-foot-depth contours. The offshore materials were described as Pleistocene and Holocene-age sediment. Of the four vibracores in the area, only one (V-29S) was considered suitable (sand size between 0.18 millimeters [mm] and 0.71 mm). The single suitable vibracore penetrated only about 4.3 ft and may have met refusal on gravel. The other three vibracores were marginally fine. The minimum sediment thickness was estimated at about 10 ft, although there was not enough seismic sub-bottom coverage to isopach the area (i.e., to be able to prepare sediment thickness maps). The area volume was estimated to be 14.8 million CY (MCY) (Osborne 1983).

The A-I area off of Newport Beach is much larger, although it straddles the Newport Submarine Canyon which would limit the extent as a borrow area due to bottom steepness and depth. The vibracore information (four were completed; two were suitable, and two were moderately fine) is sparse for such a large area. It is inferred that the borrow area includes a thin cover of Holocene sediment overlying Pleistocene sediment. The area volume in Holocene sediment was estimated up to 24 ft thick containing 80 MCY (Osborne 1983).

Exploration would be targeted to be approximately centered on the "suitable" vibracores. (in subareas Osborne interpreted to be underlain by sediment greater than 10 ft thick, and in water depths shallower than about -60 ft relative to mean sea level [MSL]). The more southerly of the two borrow areas (A-I) would have reduced travel distance and would be preferred for additional exploration. Potential constraints include the Orange County Sanitation District ocean outfall passing through area A-IV, which will require a setback distance between the outfall and the borrow to avoid outfall impacts (if the borrow area is confirmed suitable). The available National Oceanic and Atmospheric Administration (NOAA) navigation charts show areas of artificial fishing reefs (construction debris piled offshore), shipwrecks, and other features offshore that will require confirmation if the area looks promising as new a borrow site.

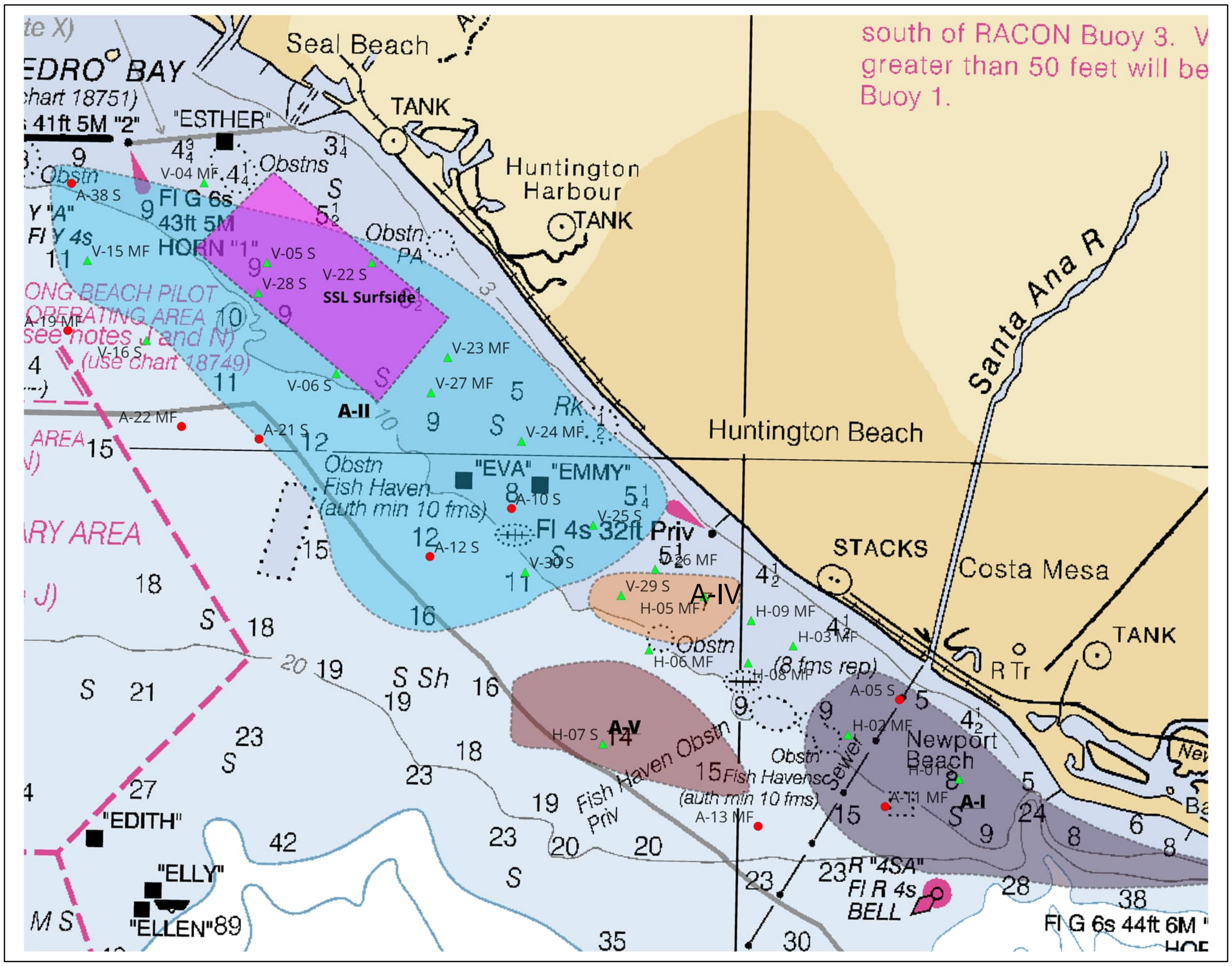

Figure 1 - **Potential Borrow Areas off Huntington Beach and Newport Beach (after Osborne 1983).** The map shows the existing borrow at Surfside-Sunset (area of purple rectangle). Subarea BB (not shown) was recommended as an ideal borrow area to continue to replenish the beach at Surfside-Sunset (AECOM 2018). Surfside-Sunset is within Osbourne's Area A-II (shown in light blue)

3.3 Newport Beach to Dana Point

Continuing south of Newport Beach, the inner shelf becomes narrower, mostly with a thin cover of sand over bedrock in the Laguna Beach Cell. The abundance of sand in this coastal area may be influenced by the Newport Submarine Canyon (by capturing sand from moving south) and by changing wave direction.

Historically, many recreational dive sites are shown along Laguna Beach on NOAA navigation charts and various boating maps, suggesting rocky outcrops and reefs offshore. Reef areas usually have thin sand, and extensive kelp suggests hard substrate. Limited vibracores were performed at Newport Harbor, Corona del Mar, and Laguna Main Beach; the sand was mostly unsuitable (USACE 1993). The available information suggests sand explorations would have limited success over the reach of coast south of Newport Beach continuing to Dana Point. Osborne's 1983 study did not identify potential borrow sites along Laguna Beach. Moreover, the reach of coast from Corona del Mar south to Dana Point is in a marine protected area; dredging would not likely be allowed.

However, Osborne investigated a potential borrow area at Dana Point and south of San Juan Creek, as shown on **Figure 2** below. The area Osborne deemed “Area III” was considered marginally to unsuitably fine based on 10 vibracores[1].

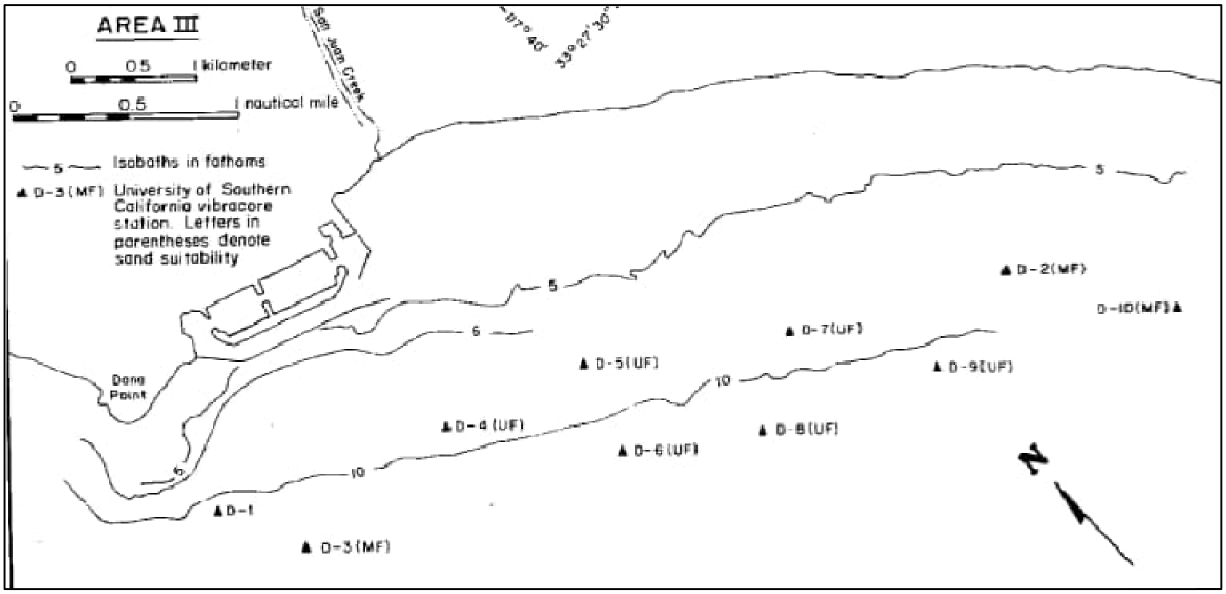

Figure 2 – Previous Vibracore Explorations at Dana Point (from Osborne, 1983). The early vibracore explorations at Dana Point were widely spaced (10 vibracores spaced about 1 mile apart downcoast from Dana Point). The vibracores mostly penetrated a thin cover of silty, very fine to fine sand found to overlie bedrock.

3.4 San Clemente to San Mateo Point

The reach of coast offshore of San Clemente has historically been a challenging area to find beach-suitable sand. Osborne (1983) considered the shelf sediment between Dana Point and San Mateo Point would not likely yield sediment deposits suitable for beach restoration and nourishment, as the natural geology may pose a constraint.

The natural geology offshore of San Clemente has been mapped as broad bedrock shelf in the nearshore. Except for San Juan Creek, there are no major tributaries that would have down cut a deep paleochannel in the bedrock, i.e., a cut through the bedrock that could be backfilled with sediment. As shown on **Figure 3** (below), the Capistrano Formation is the dominant coastal bluff forming a geologic unit along San Clemente, and the same formation likely extends offshore as a submerged bedrock shelf (**Figure 4**). The Capistrano Formation, however, is mostly fine-grained mudstone and claystone (i.e., contains sparse sandy sediment) and would not be a significant sand source when eroded by waves (e.g., past wave action during sea level rise). In this setting, coarse sand deposits are less likely offshore. Further downcoast, the coastal bluffs are dominantly sandstone, albeit mostly fine-grained sandstone (San Mateo and Monterey formations). These shoreline reaches with sandstone may have eroded materials with more sand content offshore.

[1] Vibracores were performed by University of Southern California (USC) in 1979 according to Osborne (1983). Vibracore logs were not available for this study.

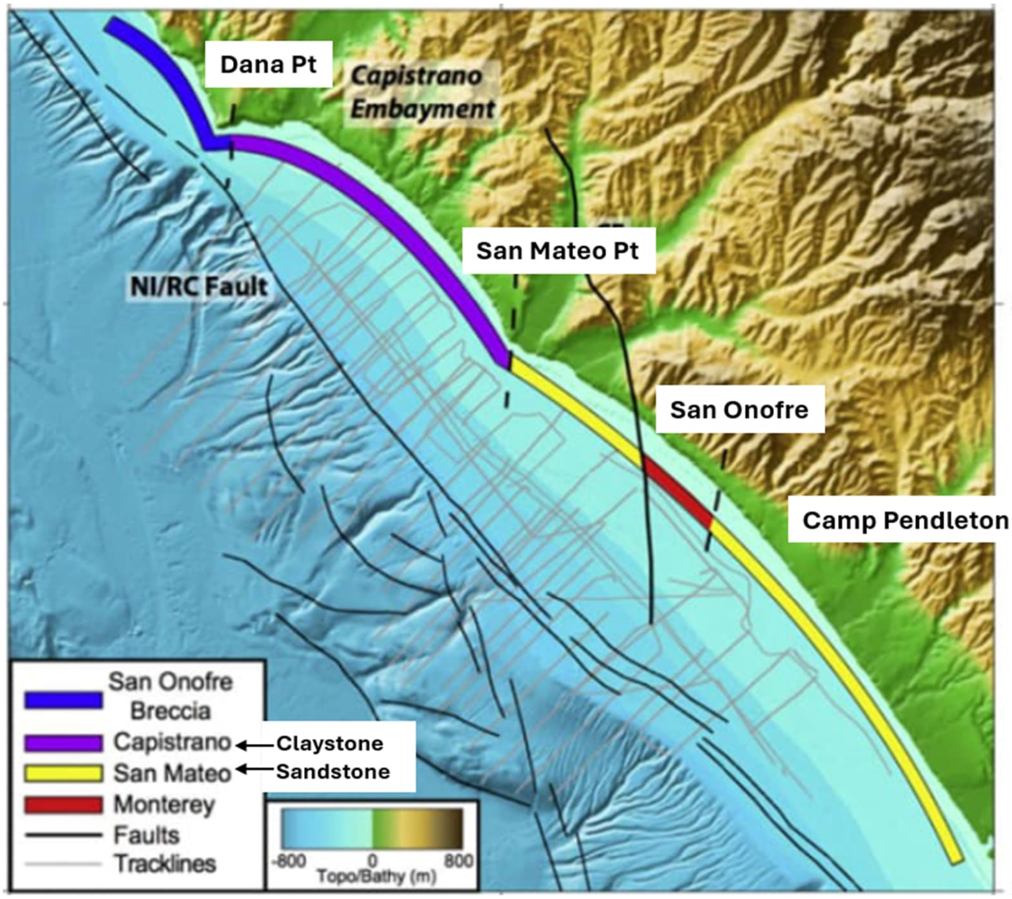

Figure 3 - **Generalized Coastal Geology along San Clemente and Camp Pendleton.** The color bands shown along the shoreline represent the cliff-forming geologic units inferred to extend offshore as a submerged shelf. The Newport Inglewood Rose Canyon Fault (NI/RC Fault) is further offshore (figure modified from Klotsko et al. 2015).

Figure C-3 shows offshore seabed conditions with locations of previous vibracores. USACE (2011) compiled previous investigations to characterize the sediments offshore of San Clemente. As described by USACE, proposed Borrow Area 1 was planned for the area extending from just upcoast of San Clemente Pier south to just offshore of San Mateo Point, approximately 6.2 miles.

The previously proposed Borrow Area #1 and adjoining areas had been investigated using geophysical surveys (including sub-bottom profiling, side-scan sonar, and a multibeam bathymetric survey) beginning off of the coast at Capistrano Beach and downcoast to San Mateo Point, approximately 8.7 miles (Fugro West 2002). The marine surveys began at the surf zone and extended out to water depths of about 58 ft. The area surveyed consisted of bedrock outcropping at the surface of the ocean floor closer to shore, and unconsolidated sediment thickening up to about 50 ft oceanward[2]. **Figure 4** (below) is an example of the interpreted sediment thickness west of San Clemente Pier.

[2] Fugro West's maps provided bedrock extent and interpreted sediment thickness and are included in USACE 2011.

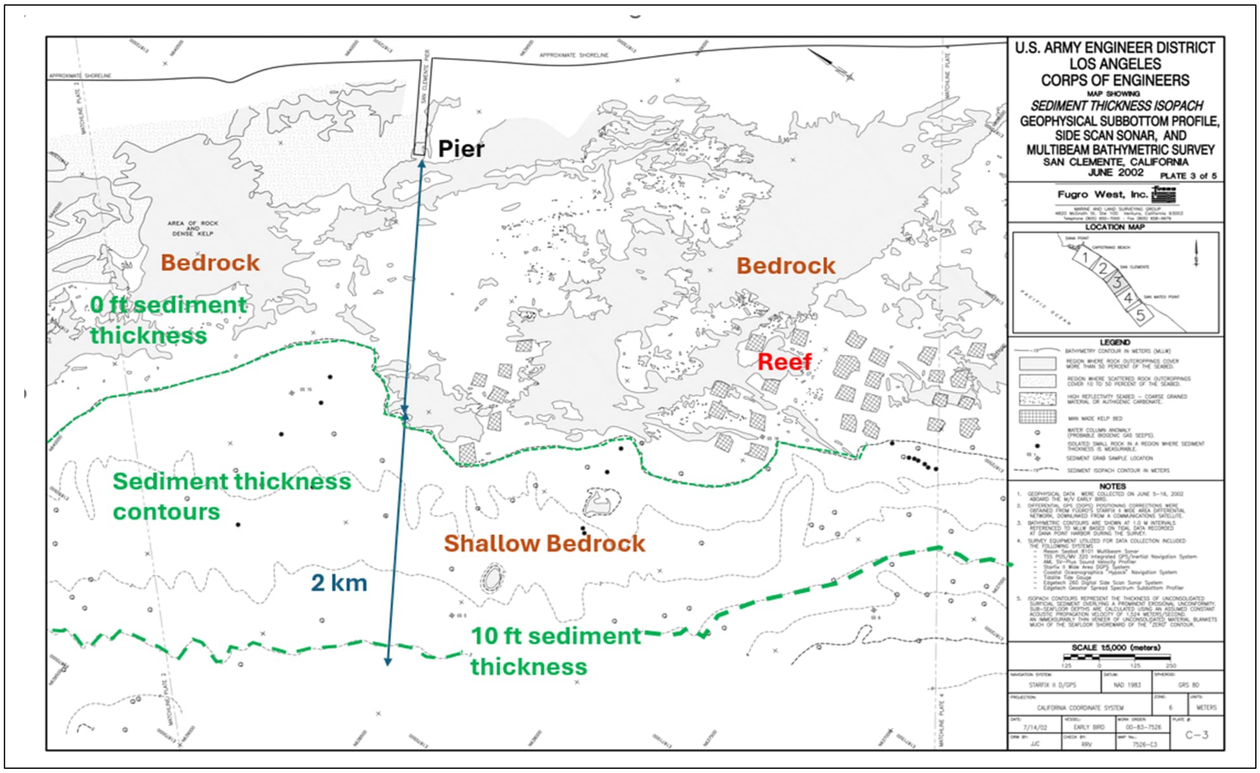

Figure 4 - Example of Sediment Thickness/bedrock Maps at San Clemente (maps prepared for USACE by Fugro West, 2002). Several sediment thickness contours are highlighted in green to help visualize mostly thin sediment (less than 10 ft thick) and shallow bedrock outcrops at the seabed out to about 1 mile (2 km) west of San Clemente Pier.

USACE re-investigated the area with additional vibracores located at least 1 mile offshore to avoid the shallow bedrock indicated by the Fugro West seismic survey. Locations are shown on **Figure C-3**. The elevations of the seabed at the vibracores varied from -54 ft MLLW to -62.2 ft MLLW, considered to be the limit of practical dredging operations. The vibracores penetrated between 2 and 13.5 ft of sediment; bedrock was encountered in three of the vibracores. The vibracores encountered silty, very fine sands and sandy silts overlying bedrock.

There were some indications of suitable sand in one of the vibracores off of San Mateo Point, but sediment gradation (grain size) tests were not supportive. USACE judged the materials to be too fine-grained for beach-nourishment purposes, verifying the earlier exploration results (by USC, reported in Osborne 1983). USACE (2011) opted to use a borrow site at Oceanside: “Borrow 2A” located 21 miles downcoast of San Clemente (**Figure C-1**).

Judging from the geology and previous vibracores, coarse sand has a low likelihood over the Capistrano Embayment. Areas near San Clemente that could be considered for additional explorations might include re-investigations and data-gap filling of areas including relatively widespread vibracore coverage. Several potential areas for exploratory vibracoring are shown on **Figure C-3** at locations interpreted greater than 10-ft sediment thickness and with water depths less than about -60 ft MSL

The area offshore and southwest from San Mateo Point apparently has not been previously explored with vibracores. The geomorphic form of the sediment contours (below the seabed) suggests possible ancient sub-bottom features in the area offshore of San Mateo Point. There were some suggestions of suitable sand offshore of San Mateo Point according to USACE (2011), although vibracore SC-1 penetrated fine sand and silt, meeting refusal at about 12 ft below the seabed (SC-1 vibracore location is shown on **Figure**

C-3). Based on available information (shown on **Figure 5** below), a potential exploration area would cover about 1 square mile downcoast of SC-1 as shown on **Figure C-3**.

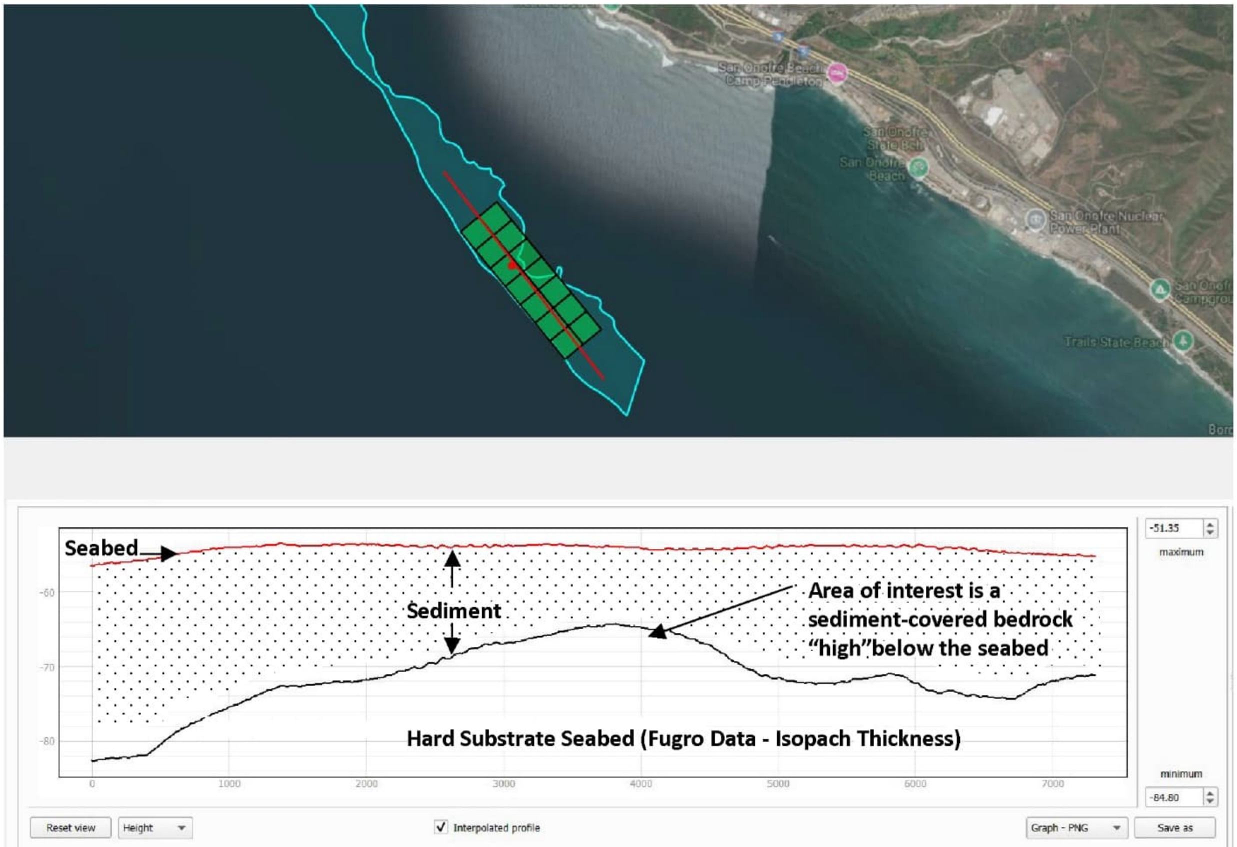

Figure 5 – Preliminary Interpreted Sub-Bottom Profile Off San Mateo Point. This north-south profile is based on Fugro 2002 seismic reflection data in GIS (preliminary figure provided by Coastal Frontiers). Fugro West sediment thickness mapping suggests at least 10-ft-thick sediment covers the area in water depths less than -60 ft MSL (area outlined in blue). Vibracores would target a sediment-covered bedrock high; the feature appears to be several thousand ft across (north/south) and could be interpreted as a seaward projection of San Mateo Point, an ancient promontory preserved below the seabed, covered by sediment. The vibracore objective would be to locate relatively coarse sand deposited in a high wave action setting during sea level rise. The green grid shows a possible vibracore layout over a 10-acre grid.

3.5 Camp Pendleton to Oceanside

The available information covering Camp Pendleton includes a substantial compilation of geophysical and sediment sampling data for the Oceanside Littoral Cell by United States Geological Survey (USGS) (Warrick et al. 2022). However, the marine surveys were mostly restricted to deeper water offshore[3]. Therefore, these available USGS data are limited to relatively deep coastal waters beyond typical dredge depths, but the mapping helps confirm sediment thickness trends along Camp Pendleton. The Nearshore Habitat Inventory Mapping covers all of Camp Pendleton and shows areas of offshore bedrock, kelp, and sand. This information, namely the absence of kelp and generally favorable appearing offshore geologic setting, helped identify a possible borrow area at "Agra" along Camp Pendleton, as shown on **Figure C-4**.

[3] Marine surveys were kept in deep water likely to accommodate wide survey vessel turns, required when profiling shoreward, and towing long lines of geophones.

Marine geophysical surveys were performed along San Onofre to map sediment thickness in the shallow nearshore using CHIRP[4] sonar (Klotsko et al. 2015). This high-resolution marine survey method can extend into shallow water depth with sufficient resolution to map unconsolidated sediment units. The marine survey data near "Agra" had been interpreted as a thin cover of young marine sediment overlying older sediment "reworked" by waves during sea level rise, as shown on **Figure 6** sourced from Klotsko et al. (2015). It is possible the older sediment may have been derived from Pleistocene terrace deposits and/or sandstone formations that form the modern coastal bluffs.

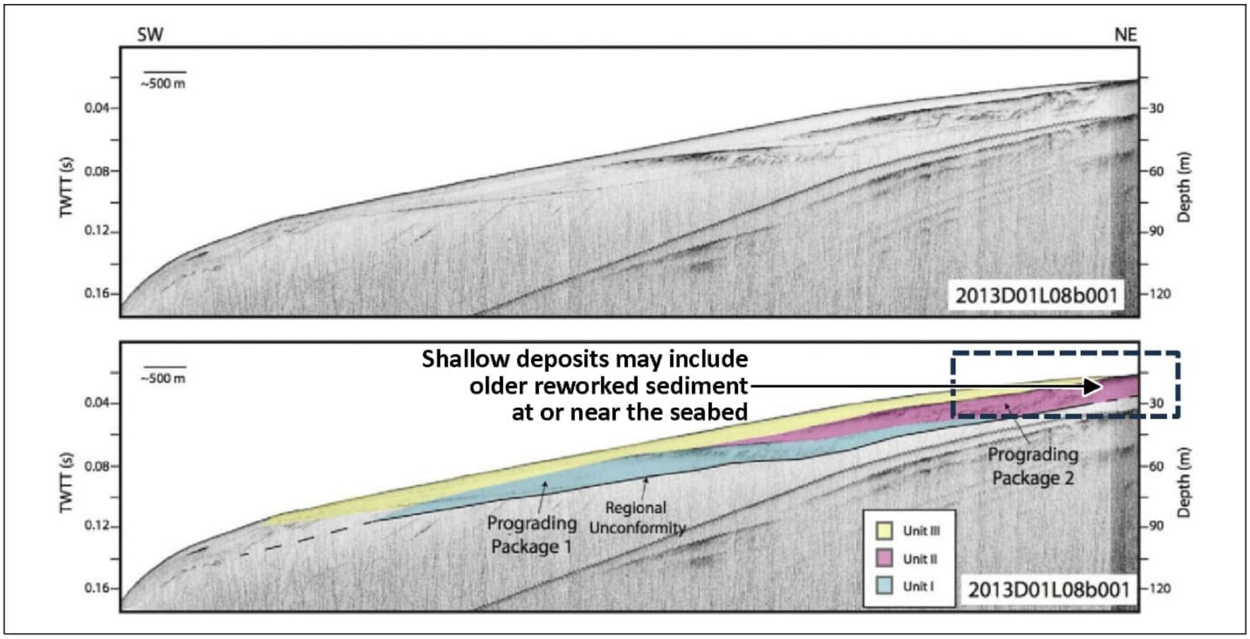

Figure 6 - Seismic Reflection Profile Offshore Camp Pendleton. Figure after Klotsko et al. 2015 shows the uninterpreted (upper illustration) and interpreted (lower illustration) CHIRP profile looking north at the location shown on **Figure C-4**. On the upper right side of the lower illustration (outlined), there appears to be a cover of young marine sediment (Unit III, yellow) that thins shoreward. Young marine sediment tends to be fine-grained. The older sediment (Unit II, pink) may have been eroded from a shoreline platform and/or bluff and then redeposited during sea level rise (Klotsko et al. 2015). Ancient beach deposits tend to be "clean" and well-sorted and may have shifted shoreward (prograded) during sea level rise. The profile extends into shallow water depths of about 15 meters (about 45 ft). If the sand is suitable, a borrow area could be considered at this depth and shoreward. Vibracores would determine sediment type, thickness, and character.

If the candidate borrow area at "Agra", shown on **Figure C-4**, proves suitable, a stretch of southern-most Camp Pendleton, near Las Pulgas Creek, is in a similar geologic setting offshore and may have similar sand suitability. **Figure 7** below shows a more southerly candidate borrow area near Las Pulgas Creek at southern Camp Pendleton.

North of Oceanside Harbor, RBSP II investigations identified a potential borrow area deemed SM-1, ("Oceanside") encompassing the width of the modern floodplain and channel of the Santa Margarita River, as shown on **Figure 8** below. The entire borrow area was estimated to be about 7.7 MCY if dredged to 20 ft (URS 2009). The concern at SM-1 is the material may be relatively fine and gravelly. The sediment recovered in the RBSP II vibracores at SM-1 was mostly dark-gray, silty, fine sand, with some thin silt cover. Vibracores SM-207 and SM-210 recovered sand with D_{50} about 0.2 mm, 10-percent (%) of fines, and less

[4] CHIRP stands for compressed, high-intensity, reflected pulse, used like sonar for sub-bottom profiling. High-resolution seismic data can often resolve sediment unit thickness but not necessarily sediment character/type.

than 1% of gravel. Relatively few gravels were encountered in the previous vibracores, and none of the vibracores met refusal on gravel.

It may be feasible to re-explore the previous SM-1 proposed borrow, including potentially expanding the footprint beyond the Santa Margarita River to the north. The upcoast travel distance required to nourish Orange County beaches could be prohibitive. As described in **Appendix A, Plan and Scope of Work - San Diego County**, additional explorations for RSBP III may be proposed at SM-1 to confirm the borrow suitability and potential expansion.

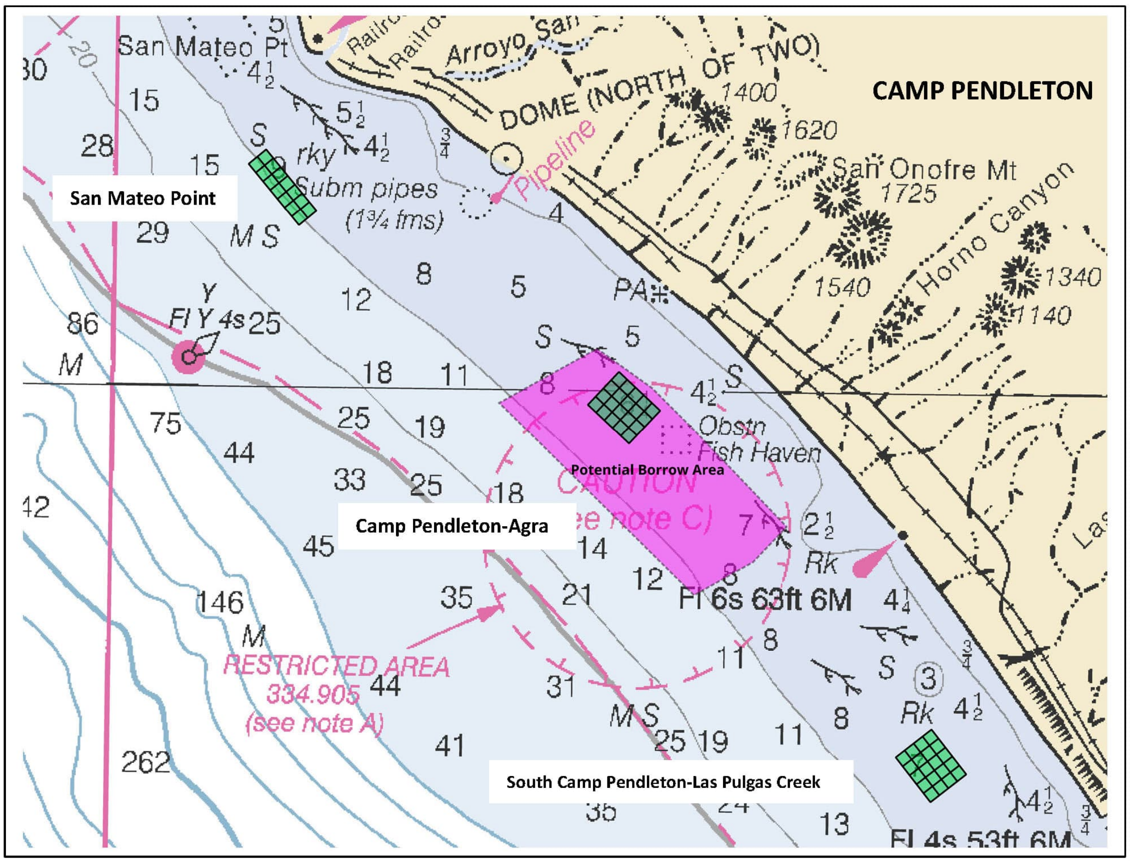

Figure 7 - **Potential Exploration Areas at Camp Pendleton and San Mateo Point.** Available marine geophysical data (Klotsko et al. 2015) suggest the sand thickness could support a borrow area off of Las Pulgas Creek if the sand is suitable grain size and meets other conditions, as required. The green grids show potential vibracore layouts over a 10-acre grid that could be considered for borrow development according to Coastal Frontiers. The Restricted Area shown on the historical base map may be outdated and should be confirmed for vibracoring.

Figure 8 - **Previous and Proposed Borrow Areas at Oceanside Harbor and the Santa Margarita River**. Borrow area SM-1 (light green) was explored but not used for RBSP II. USACE Borrow 2A (orange) was dredged initially for San Clemente but discontinued due to gravel content. The proposed borrow footprint for the Oceanside Sand Nourishment and Retention Pilot Project (“ReBeach”) is shown in blue (GHD 2024).

4. Additional Investigations

The plan for explorations outlined below (**Table C-1**) should be considered preliminary because the potential borrow areas encompass large areas and are currently under evaluation for the City of San Clemente's Offshore Sand Source Investigation (Coastal Frontiers, 2025). Following those investigations, it may be possible to refine the areas with additional explorations and/or marine surveys.

The offshore explorations for RBSP II were conducted in two phases: 1) marine geophysical surveys (seismic reflection profiling) followed by 2) sediment sampling with a heavy duty vibracore sampler (URS, 2009). Sub-bottom (geophysical) surveys, as done in the past are a potential supplemental exploration approach, although these surveys are typically planned to cover broad areas. However, limited marine surveys could supplement vibracoring and still be cost effective.

A preliminary offshore exploration plan is in the following **Table C-1** that would include between 30 and 50 vibracores. As noted above, the exploration program for the City of San Clemente's Offshore Sand Source Investigation may cover some of these areas and/or other candidate areas based on ongoing study, schedule, and budget. All the candidate areas shown on **Table C-1** are considered feasible as potential borrow areas. Next steps are anticipated to include additional research and area refinement based on stakeholder input. More detailed work plans will be prepared to obtain permits and other approvals for field investigations.

Table C-1. Offshore Investigations for Potential Borrow Areas

General Location of Potential Borrow	Approximate Exploration Area ($mile^2$)	Bathymetric Surveys	Potential Future Survey Needs	Vibracore Explorations (number of vibracores)	Potential Constraints
Huntington Beach	~1 $mile^2$	Update bathymetry maps with available, information and perform multibeam surveys as needed for design	Side-scan sonar and reconnaissance sub-bottom profiles	5 to 10	Offshore fishing reefs, shipwrecks, setback from OCSD outfall
Newport Beach	~1 $mile^2$			5 to 10	
San Clemente	Fill in data gaps with exploratory vibracores		Probably not needed	5 to 10	Habitat, extensive shallow bedrock, setback from Aliso Creek outfall
	~1 $mile^2$ at San Mateo Point				
Camp Pendleton Agra	~5 $mile^2$		Side-scan sonar, marine magnetometer and Remote Operated Vehicle surveys if metallic anomalies are detected	7 to 10	Offshore fishing reefs; Camp Pendleton operations
Camp Pendleton South-Las Pulgas				7 to 10	

Notes:
m^2 = square miles
~ = approximately

The exploration layout would be planned to cover the proposed expansions and nearby areas, if needed. Vibracores would be planned to cover a grid, with locations staggered at about 10 acres if possible. Actual dredge area footprints and dredge volume estimates would be determined based on the suitable vibracores and other considerations.

Appendix A (see section titled **Work Plan Development**) provides preliminary recommendations for work activities and exploration methodology to support geotechnical assessments of the proposed borrow areas. The investigations could be phased and may need to be updated depending on site conditions, project requirements, and permitting. Additional offshore information may be required when specific borrow areas, discharge line corridors, and receiver beaches are selected.

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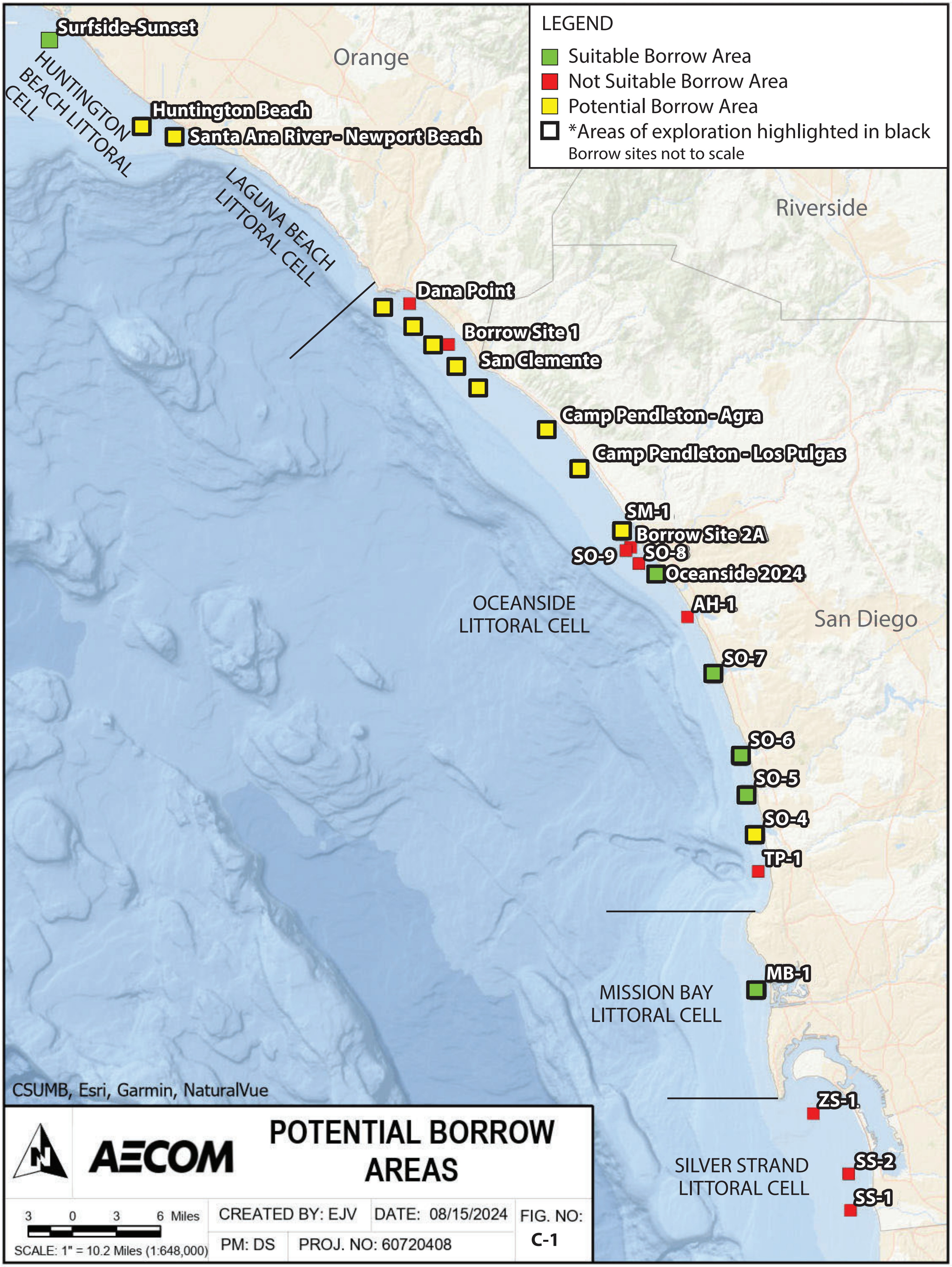
Figures



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POTENTIAL BORROW AREAS

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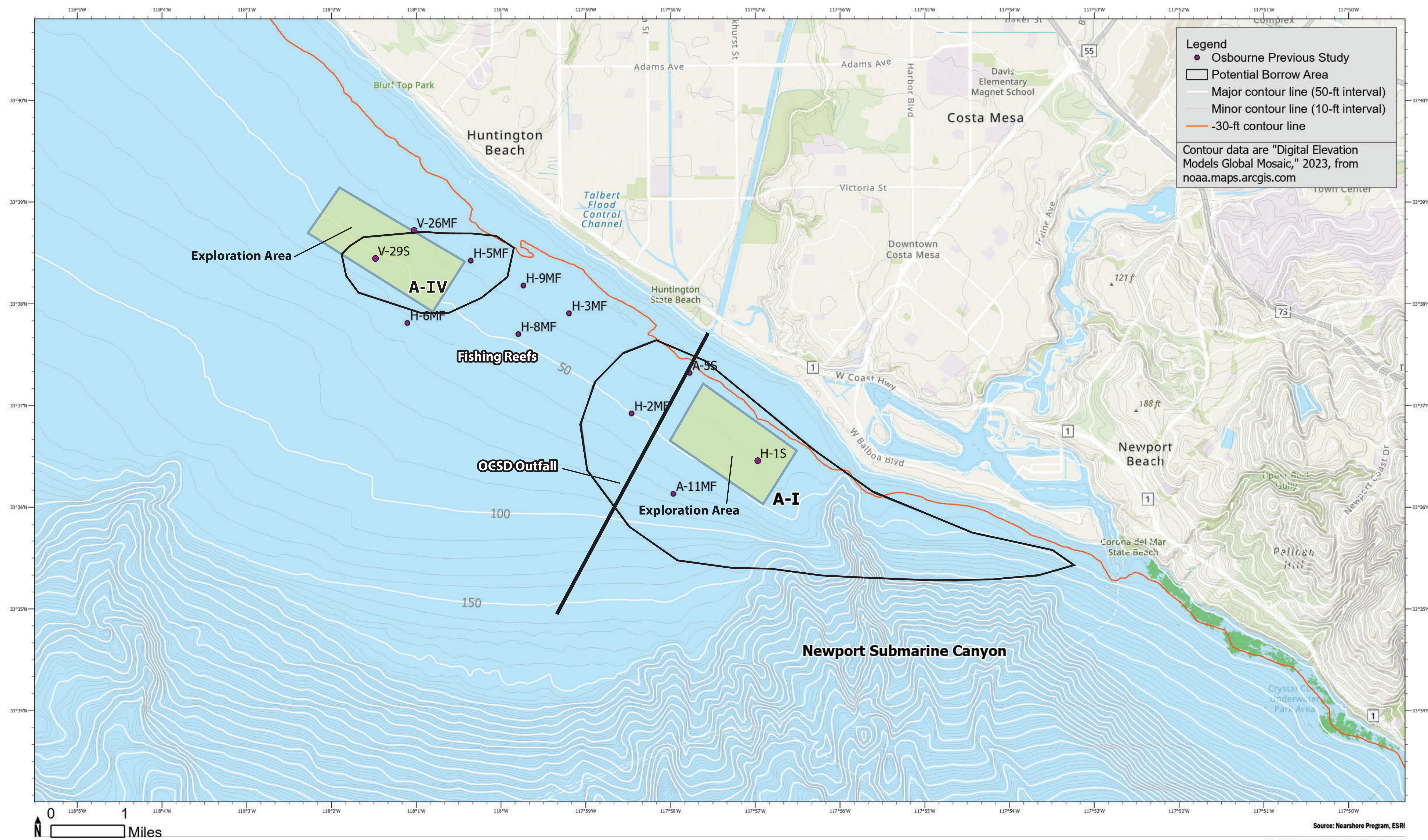

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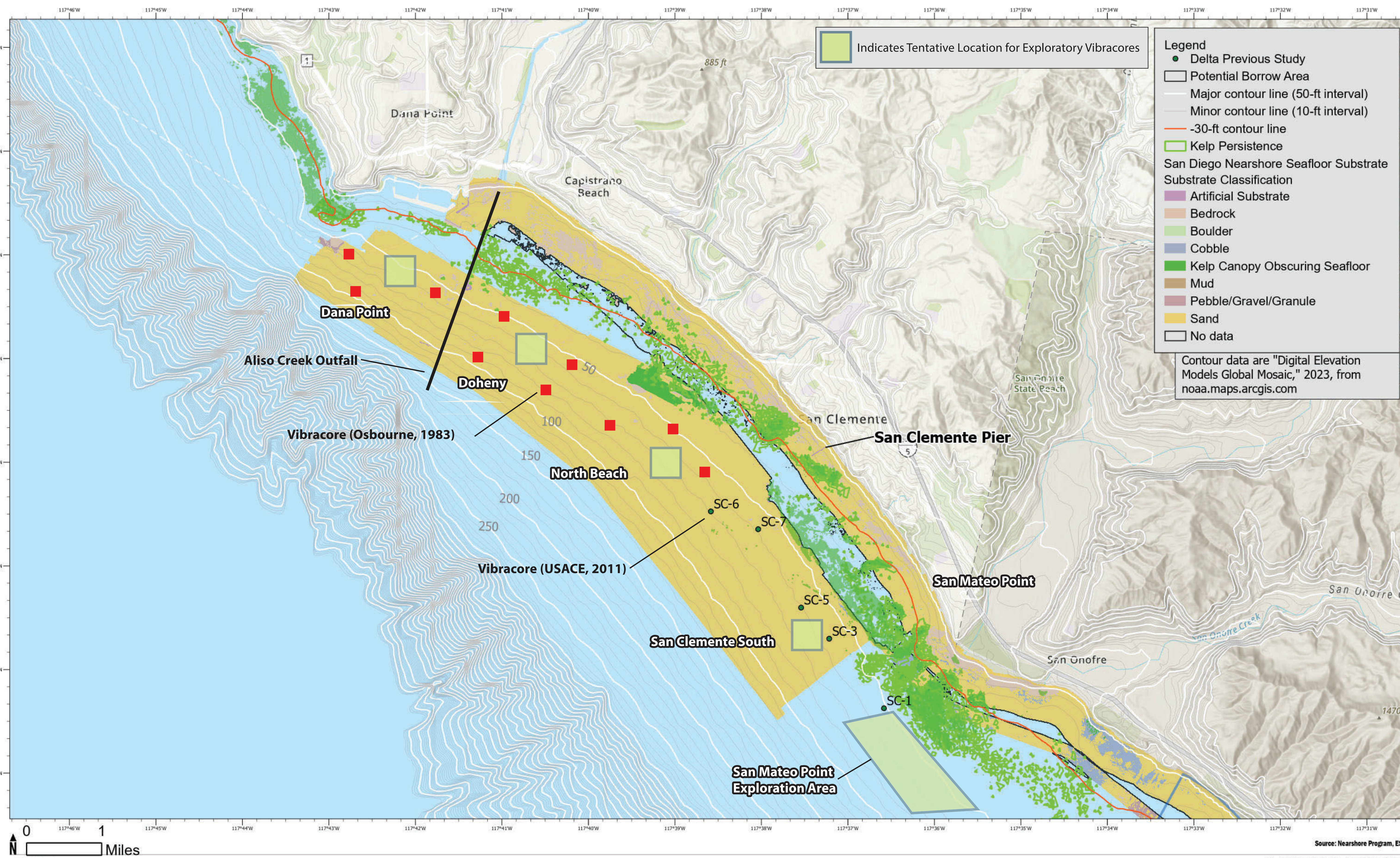
SANDAG RBSP-III
Offshore Investigation Area Review
Santa Ana River - Newport Beach

SANDAG RBSP-III

Offshore Investigation Review

Santa Ana River - Newport Beach

Figure C-2 Offshore Investigation Review Santa Ana River - Newport Beach



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SANDAG RBSP-III

Offshore Investigation Area Review

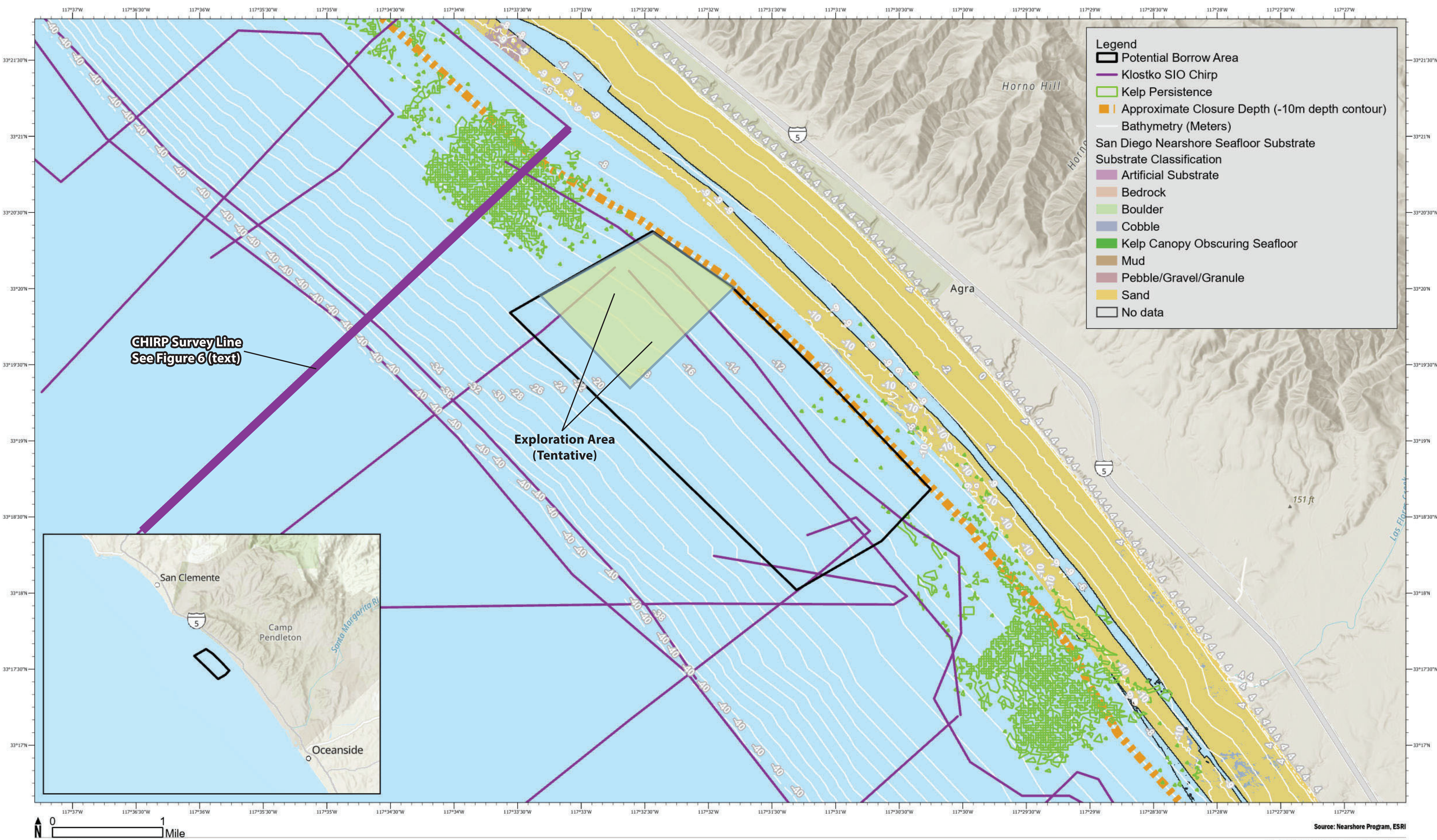
San Clemente State Beach

SANDAG RBSP-III

Offshore Investigation Review

San Clemente

Figure C-3 Offshore Investigation Review San Clemente



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SANDAG RBSP-II
Offshore Investigation Area Review
Camp Pendleton South

SANDAG RBSP-III

Offshore Investigation Review

Camp Pendleton – Agra

Figure C-4 Offshore Investigation Review Camp Pendleton Agra

Appendix D

Orange County Economic Methodology and Results

Appendix D

Economics Methodology and Results for San Diego Association of Governments Regional Beach Sand Project III

Orange County Beaches

Prepared by:

Dr. Phil King

July 2025

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Tables

1. Introduction

San Diego Association of Governments (SANDAG) previously completed two regional beach sand projects (RBSPs) in 2001 and 2012 (RBSP I and RBSP II, respectively), adding approximately 3.6 million cubic yards of sand to the San Diego region's local beaches. These projects were initial pilot projects, representing the first major steps in addressing the severe sand deficit on the region’s beaches and identifying a long-term approach to managing the region’s shoreline. Because of the continued deficit in the littoral system, repeated and consistent replenishment is necessary to maintain regional beaches and the recreational, economic, and protective services they provide. SANDAG is currently evaluating the feasibility to conduct a third RBSP (RBSP III). The proposed RBSP III expands nourishment to encompass the entire Oceanside Littoral Cell and extends to include the evaluation of nourishing Orange County beaches in the cities of Dana Point and San Clemente. This is the first time beaches outside of San Diego County would be included as part of a RBSP but reflects a more system-wide approach based on littoral-cell rather than jurisdictional boundaries. This is also supported by the Orange County Coastal Regional Sediment Management Plan and the South Orange County Regional Coastal Resilience Strategic Plan, both of which suggest several nourishment projects to support beaches along the coast (Everest International Consultants et al 2013; Anchor QEA et al 2024).

The purpose of this appendix is to quantify the potential economic benefits of implementing RBSP III and its value to the public. Implementation of RBSP III would involve dredging beach-quality sand from offshore borrow sites and placing it on highly eroded beaches in both the San Diego County and Orange County regions, similar to past projects. This study focuses specifically on Orange County beaches.

Attendance estimates at each beach were calculated using daily data whenever possible, which was available for Dana Point and San Clemente State Beach. This data was reported on their monthly visitation sheet, which tracked the number of vehicles and pedestrians entering the park each day. Precise estimates for North Beach attendance were not made available to the authors within the project’s timeline, so attendance was estimated using interviews with various experts in Orange County.

2. Orange County

RBSP III considers three Orange County beaches in addition to the beaches located in the San Diego region. These three beaches are Dana Point, North Beach, and San Clemente State Beach. This section expands on the specifics of each Orange County beach and clarifies the benefits of replenishing each of the sites. It is best understood in conjunction with the economics methodology and results in **Appendix B**, as detailed discussion on the Benefit-Cost Analysis guidelines and methodology used for this RBSP III study are further explained in **Appendix B**.

Table 1: Summary of lost non-market value from beachgoing (recreational value) as Orange County Beaches erode

Beach	Undiscounted Replenishment Benefit ($)	3% Discounted Replenishment Benefit
North Beach	$65,927,845	$55,699,430
Dana Point	$62,750,386	$48,951,448
San Clemente State Beach	$56,531,150	$48,977,576
Total	**$185,209,382**	**$153,628,454**

Notes:
$ = United States dollars
% = percent

As shown above, North Beach, Dana Point, and San Clemente State Beach[1] each receive over $50 million in undiscounted non-market value (NMV) benefits from replenishment.

2.1 Dana Point

Dana Point is a general-use beach located in Orange County. The Dana Point replenishment site straddles both Doheny and Capistrano beaches; therefore, both were used to create a complete estimate for Dana Point attendance, which reaches approximately 940,000 visitors annually.[2] Fortunately, because daily data were available for both, very accurate estimates of attendance can be made for each day of the year. Dana Point has much less usable space than the width would suggest due to a significant amount of surface gravel; therefore, the model uses a reduced beach width of 60 feet (ft) to represent the reduced quantity of sand. While there is no preexisting overcrowding, the erosion rate of 4.3 ft per year means that overcrowding very quickly becomes a problem; more than 350,000 visitors will not fit comfortably on the beach by 2034, resulting in total lost NMV of almost $63 million without replenishment.

[1] For San Clemente, the entire replenishment site was not used; instead, a portion of the replenishment site of around 2,500 feet near the pier and lifeguard stands was the focus for the analysis because the benefits are concentrated near the pier.
[2] Only half of Doheny Beach's attendance was used in the total for the Dana Point replenishment site because a significant portion of Doheny Beach is located outside of the replenishment area and should not be counted towards the replenishment site's attendance. The campground area is in the replenishment site. Past the jetty north along the coast, where the park area is located, is not within the nourishment envelope.

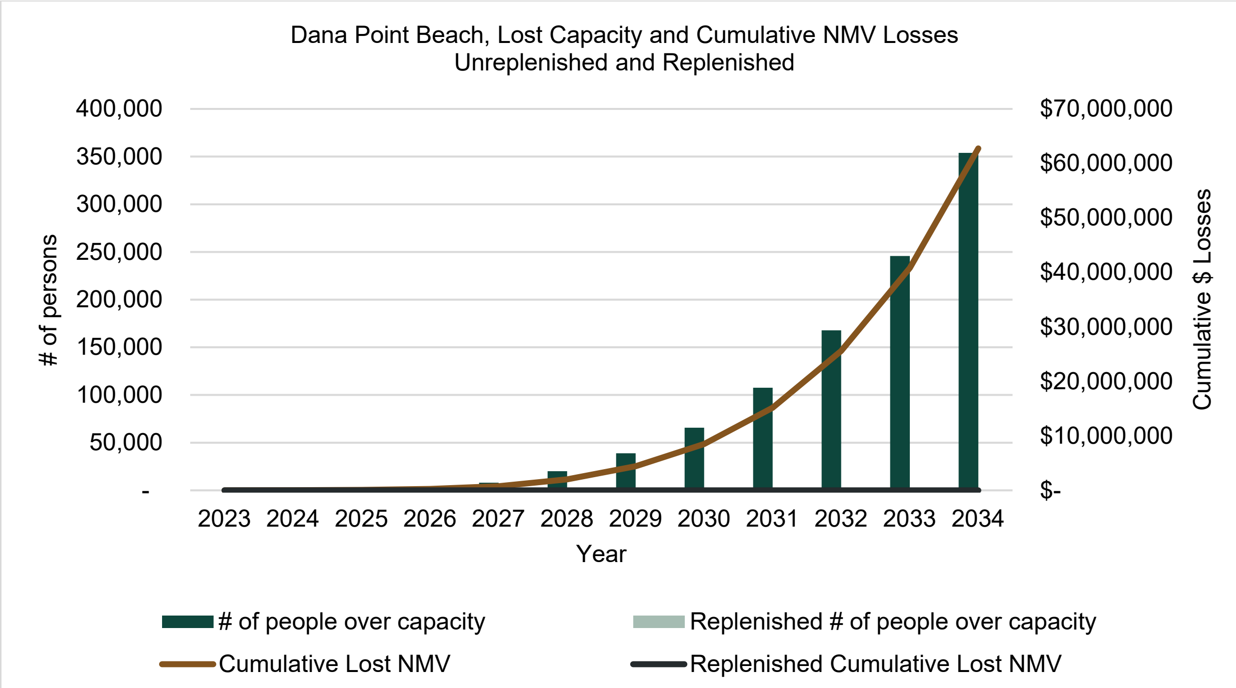

Figure 1: Expected NMV loss due to coastal erosion with and without replenishment at Dana Point

Replenishment would mitigate NMV losses through 2034, resulting in avoided losses of $63 million without discounting and $49 million with a 3% discount rate.

2.2 North Beach (San Clemente)

North Beach, located in San Clemente, Orange County, is another general-use beach; while there is surfing, it is not significant enough to shift overall attendance patterns. The model uses available annual attendance estimates (about 200,000 visitors annually) converted to daily estimates using the Representative Beach Profile (City of Encinitas Attendance Data 2024; Coronado Shores Attendance Data 2024; Mission Beach Lifeguard Counts 2024; Imperial Beach Lifeguard Counts 2024).[3] Similar to Dana Point and San Clemente State Beach, North Beach has a large quantity of gravel covering the beach, which reduces usable beach width. For North Beach, the usable beach width is estimated at 10 ft, resulting in approximately 50,000 people over capacity in 2023. By 2034, with a low erosion rate of 0.6 ft per year, North Beach is more than 140,000 people above capacity for each year, with cumulative lost NMV of almost $70 million.

[3] See Appendix B. Daily attendance was estimated using daily reference data from Coronado Shores, Moonlight, Mission Beach, and Imperial Beach because these beaches had daily attendance available.

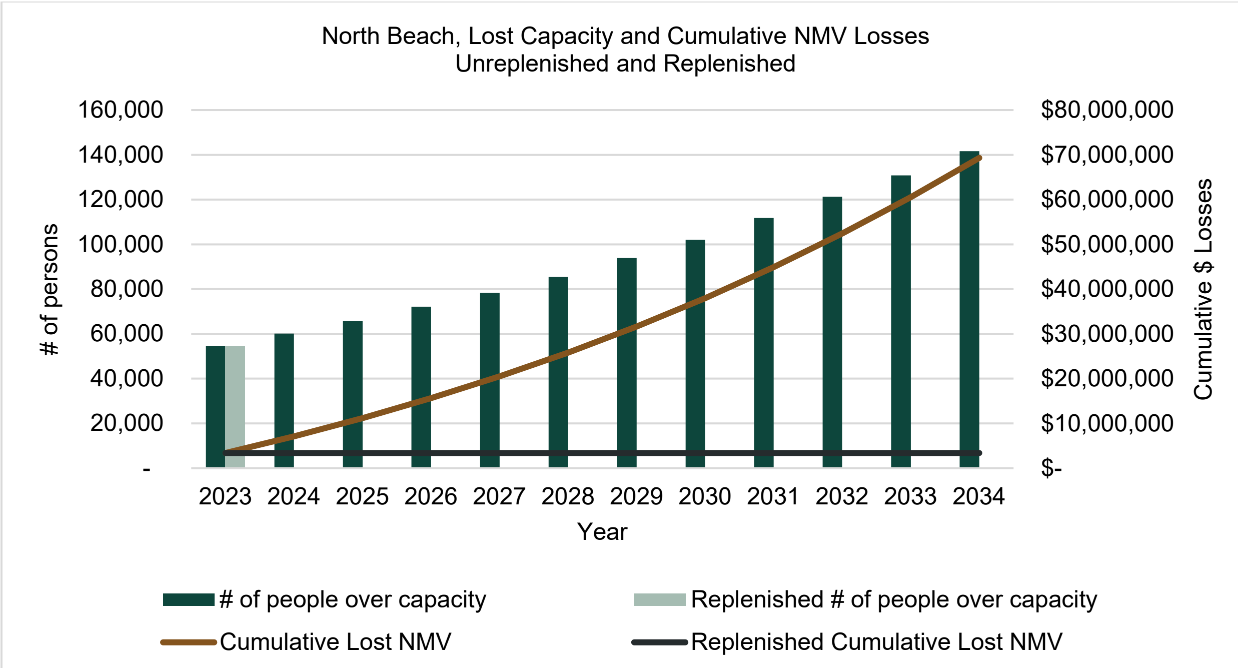

Figure 2: Expected NMV loss due to coastal erosion with and without replenishment at North Beach

With replenishment, the beach would no longer experience any crowding, especially as much of the gravel would be covered with new sand. Therefore, after replenishment, North Beach has no NMV losses. By 2034, replenishment results in cumulative NMV benefits of approximately $66 million undiscounted and $56 million with a 3% discount rate, as shown in **Table 1**.

2.3 San Clemente State Beach

San Clemente State Beach sees consistent overcapacity every year, particularly along the stretch near the pier.[4] Annual visitation totals about 490,000. Without replenishing the already narrow beach, the total lost NMV is almost $62 million.

[4] Sand added in the 2500 ft stretch near the pier will add to the recreational value, so that is what this section focuses on.

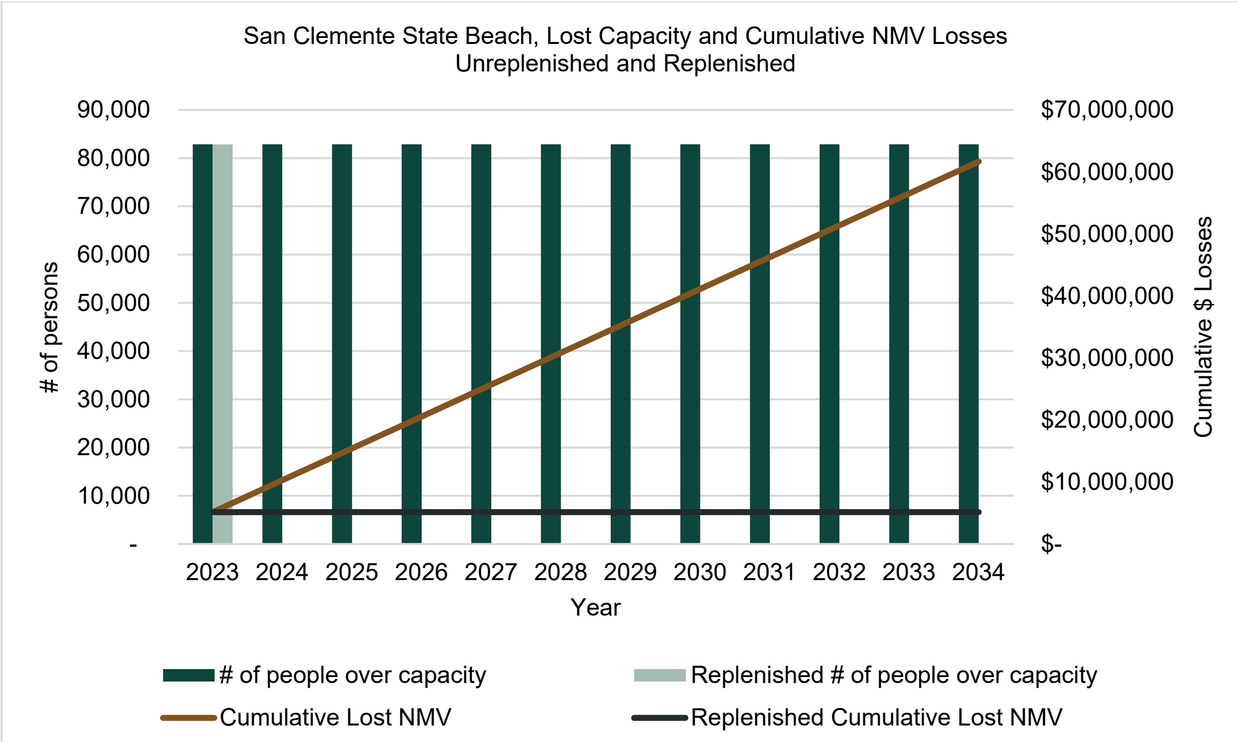

Figure 3: Expected NMV loss due to coastal erosion with and without replenishment at San Clemente State Beach

Replenishment mitigates lost NMV at San Clemente State Beach completely over the next decade, resulting in cumulative avoided losses of approximately $57 million without discounting and $49 million with a discount rate of 3%.

3. Sensitivity Analysis

To ensure that RBSP III was not too reliant on particular assumptions about carrying capacity, erosion rates, or other assumptions in the model, the authors of this appendix ran a sensitivity analysis.

3.1 Visitor Crowding Tolerance

The first sensitivity analysis examines the carrying capacity assumption, calculating the results with a reduction of the carrying capacity estimate from 100 square ft per person to 66 square ft, or two-thirds of this study's original estimate. Moreover, this change in assumption impacts the model in the same way as an increase in the turnover rate; the change in towel space is equivalent to an increase in the turnover rate from 2.5 to 3.75. The results below, therefore, provide a useful estimate of what the results would be for changes in the turnover rate as well.

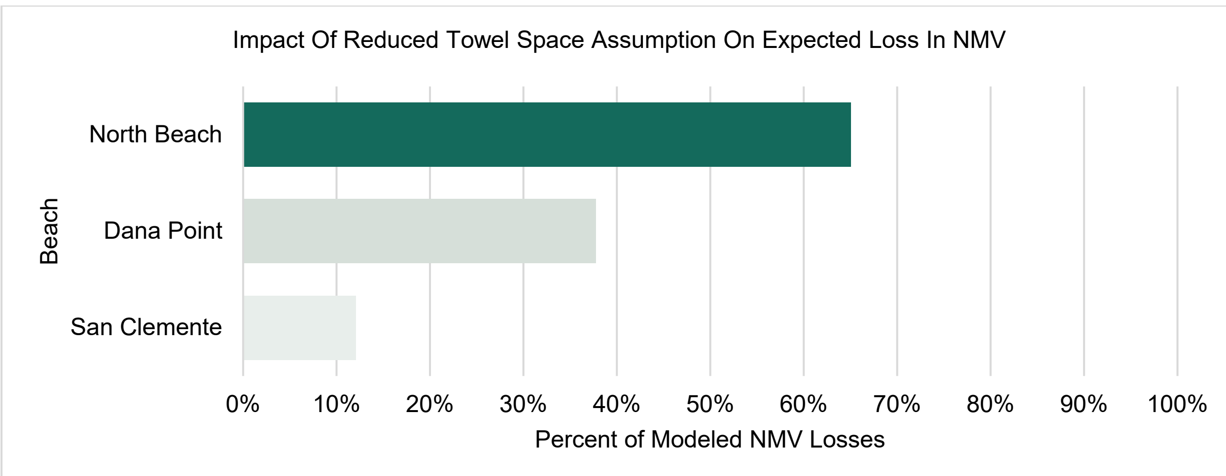

Figure 4: Impact of increasing carrying capacity on NMV losses, shown as a percentage of modeled NMV loss

As shown in **Figure 4** above, a reduction in carrying-capacity required for each person, from 100 sq ft per person to 66 sq ft per person, significantly reduces the NMV value of replenishing these sites. Nevertheless, all Orange County beaches in this study remain worth replenishing.

Table 2: Lost NMV in Model with Increased Carrying Capacity, Model Results

Beach	Undiscounted, Net Replenishment Benefit	3% Discounted, Net Replenishment Benefit
North Beach	$42,876,762	$35,734,371
Dana Point	$23,678,084	$18,018,319
San Clemente	$6,813,760	$5,903,319
Total	**$73,368,605**	**$59,656,010**

Increasing visitors' tolerance for crowding reduces NMV gains at San Clemente State Beach. As shown in **Table 2** above, San Clemente State Beach sees a new net replenishment benefit of only about $7 million, undiscounted.

While this study generally uses standard turnover and space per person estimates, beaches will of course have different turnover rates as people stay longer or shorter periods of the day. In the aggregate, however, these numbers are representative of beachgoing patterns.[5]

3.2 Erosion Rates

Given the uncertainty about future erosion rates, we conducted a sensitivity analysis with each beach's erosion rate halved from the estimates in the initial model, creating a "low-erosion" scenario. **Figure 5** presents the results of this analysis, comparing the low-erosion model to the "standard erosion" model, which shows how some beaches were impacted more than others by the change in erosion rate.

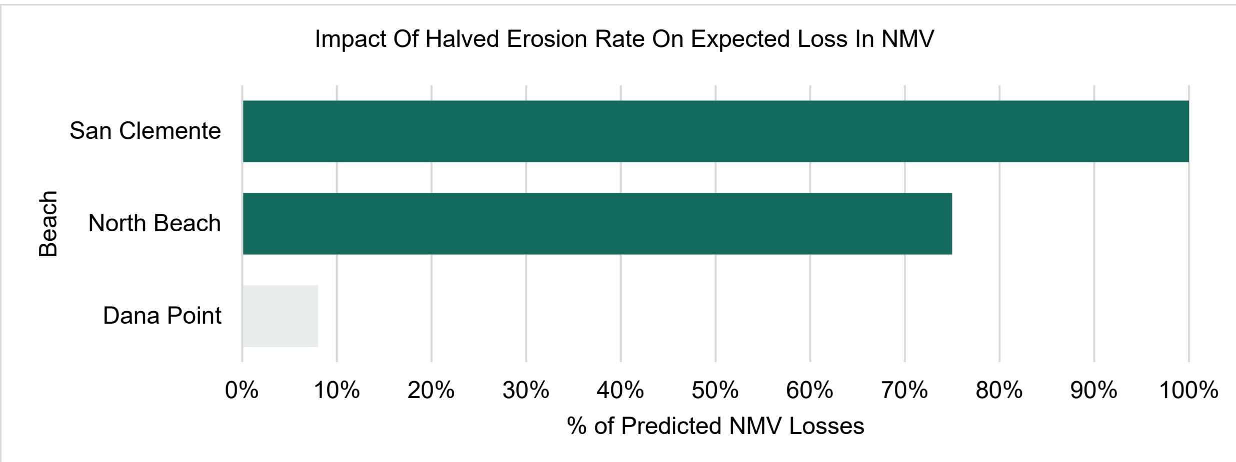

Figure 5: Impact of halving erosion on NMV loss, shown as a percentage of modeled NMV loss

Despite the fall in the net NMV benefit of replenishment, the overall results held, suggesting that the beaches in this study are clearly in need of replenishment even if the erosion assumption is adjusted. The low-erosion scenario results are shown in **Table 3.**

Table 3: Lost NMV in Model with Halved Erosion Rate, Model Results

Beach	Undiscounted, Net Replenishment Benefit	3% Discounted, Net Replenishment Benefit
North Beach	$49,448,555	$42,286,119
Dana Point	$5,041,759	$3,939,552
San Clemente State Beach	$56,531,150	$48,977,576
Total	**$111,021,464**	**$95,203,246**

Although Dana Point sees lower net replenishment benefits than the standard erosion model, at about $5 million, the benefits are still significant and Dana Point would benefit from reducing erosion.[6] The standard erosion model located in the main body of the analysis will provide more accurate estimates of the NMV

[5] Philip King and Aaron McGregor (2012), "Who's counting: an analysis of beach attendance estimates and methodologies in southern California." In the aggregate, visitors often stay an average of 3-4 hours.

[6] These results suggest that future work on coastal preservation in the Dana Point region may wish to consider options for reducing erosion, e.g., groins, reefs, etc., rather than merely replacing lost sand. Reduced erosion may provide a more long-term solution for this section of the beach.

benefit of replenishing each specific beach, but this alternative, low-erosion model illustrates the robustness of the findings. Even in this model with significantly reduced erosion, all the Orange County beaches are at or above $5 million in net NMV replenishment benefits.

3.3 Receiver Sites and Site Access

Access to each beach, as well as the amenities provided, also influence attendance. As many beaches have single or few access points, receiver sites should be chosen relative to ease of access. If people are not willing to walk far from the access point to their chosen spot on the beach, and there are few entrance points, the area near the entrance points can quickly become crowded.

4. Summary

The results shown herein indicate that the total NMV benefit for the beaches selected in Orange County are $185 million undiscounted and $154 million with a discount rate of 3%. These results present a compelling case for replenishment at all three of the Orange County beaches in this study. The economics methodology and results in **Appendix B** presents further analysis.

5. References

Anchor QEA and Summit Environmental Group. 2024. “South Orange County Regional Coastal Resilience Strategic Plan.” Orange County Parks.

Everest International Consultants, Science Applications International Corporation, and King, Phillip. 2013. “Orange County Coastal Regional Sediment Management Plan.” US Army Corps of Engineers and Orange County.

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