CALIFORNIA COASTAL COMMISSION
South Coast District Office
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5-19-0345 (OC Parks) - Status Report

August 13, 2021

Exhibits

Exhibit 1 – Project Location & Site Plan

Exhibit 2 – CDP No. 5-19-0345 Special Permit Conditions

Exhibit 3 – Benchmark Timeline

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Exhibit 1 – Project Location & Site Plan

Capistrano Beach County Park

Preferred Interim Plan

OC parks
13042 OLD MYFORD ROAD I IRVINE , CA 92602
PLANNING AND DESIGN DIVISION
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Exhibit 2 – CDP No. 5-19-0345 Special Conditions

SPECIAL CONDITIONS:

1. **Limited Authorization of the Shoreline Protection Elements.**
   A. This coastal development permit authorizes the approved shoreline protection (sandcubes and armor rock) only for a period of one (1) year (i.e. until December 9, 2021). After such time, the authorization for the continuation and/or retention of the armor rock and sandcubes shall cease. This time period may be extended as described in Part D of this condition.

   B. No later than June 9, 2021 [six (6) months from the Commission's approval of CDP No. 5-19-0345], the permittee (OC Parks) shall provide a report on the status of the nature-based adaptation pilot project feasibility study and the Capistrano Beach Park Master Plan to the Executive Director. The report shall include recommended benchmarks for completion of these two documents and submittal of the appropriate applications—CDP amendment application, CDP application, and/or Public Works Plan request—to the Coastal Commission's South Coast District office. The Executive Director shall schedule public review and comment on that report at the next available Commission hearing.

   C. No later than six (6) months prior to the end of the term of the authorization identified in Part A of this special condition, the permittee shall apply for a new coastal development permit or amendment to this permit to remove the shoreline protection or modify the term of its authorization, including with respect to any necessary mitigation.

   D. The coastal development permit application submitted by the permittee pursuant to Part C of this special condition shall include, at a minimum, the nature-based adaptation pilot project feasibility study (Special Condition 6) and the results of the public access surveys (Special Condition 2.D). Provided the new permit application is received and filed as complete before the end of the authorization period listed in Part A of this special condition (i.e. by December 9, 2021), the termination date for that authorization shall be automatically extended until the time the Commission acts on the new application and to allow sufficient time to implement any new or amended project improvements. The application shall also identify and address changed circumstances and/or unanticipated impacts associated with the presence of the rock revetment and sandcubes, including but not limited to excessive scour and impacts to shoreline processes and beach width, or other impacts from coastal hazards and sea level rise.

   E. Failure to obtain a new coastal development permit for an amendment to this permit authorizing removal of and/or an additional term to retain the shoreline protection shall cause this development to be in violation of the terms and conditions of this coastal development permit.

2. **Revised Final Plans.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the applicant shall submit for review and written approval of the Executive Director, two hard copies and one electronic copy of revised final plans in substantial conformance with the plans submitted September 3, 2020 except where required to be modified as follows:

   A. The applicant shall maintain and reuse the armor rock and sandcubes that currently exist onsite to the maximum extent feasible. No new armor rock shall be placed onsite without an amendment to this permit. New sandcubes may be placed as needed to replace damaged or removed sand cubes and a minimal amount of new sandcubes may be added if necessary. Demolition or repair and maintenance (but not demolition and reconstruction) of existing park facilities threatened by further erosion or failure may be conducted as necessary throughout the term of this permit. Prior to undertaking any demolition or repair and maintenance, the applicant shall consult with the Executive Director of the Commission to determine whether separate authorization is required. The footprint of the shoreline protection shall not extend seaward of existing protection, or the linear projection of existing protection, as authorized pursuant to the respective emergency coastal development permit.

   B. Pedestrian access shall be extended from the coastal bike trail through the project site in a condition that maximizes accessibility for all people to the extent feasible.

   C. A Revised Revetment Monitoring and Maintenance Plan, submitted for review and approval of the Executive Director in substantial conformance with the Sandcubes Monitoring and Maintenance Plan (**Exhibit 5**) submitted September 28, 2020 shall be modified to also require:

      (1) Periodic inspections (as outlined in the Sandcubes Monitoring and Maintenance Plan) of the sandcubes and surrounding beach area for debris associated with the sandcubes.

      (2) Immediate removal and disposal of any debris associated with the sandcubes.

      (3) Replacement or repair of any damaged sandcubes. Replaced or repaired sandcubes shall be located within the as-built footprint of the revetment. No coastal development permit or amendment to this permit shall be required for replacement or repair of any damaged sandcubes within the authorized footprint during the authorized term of this permit.

      (4) Periodic inspections (weekly during summer months [May through September] and monthly during the rest of the year) of the armor rock and surrounding beach area for any errant or displaced rock. If any rock has been displaced from the as-built footprint, it shall be recovered from the beach and either repositioned into the revetment or removed from the site within thirty (30) days of the inspection.

      (5) Periodic inspections (weekly during summer months [May through September] and monthly during the rest of the year) of the beach

conditions seaward and up and down coast of the revetment for indications of scour, presence or absence of a low-tide or high-tide beach fronting the structure, approximation of available recreational beach width fronting the parking area, as well as for the beach width up and down coast and the presence or absence of rip channels, edge waves for other such conditions.

(6) Import and placement of sand shall be conducted in conformance with the Capistrano Beach County Park Sand Compatibility and Use Guidelines prepared for OC Parks by Moffatt & Nichol dated September 2020.

(7) Sand placement events shall avoid placement of material on wet sand or in marine waters to the maximum extent feasible.

(8) Annual reporting from the inspections, noting any maintenance or replacement of sandcubes (location and number), any errant rock that was placed back onto the structure or removed (location and number), need to import or place sand (number of events, volume of sand and placement location), beach width estimates and the location and timing of any observed scour areas, edge waves, rip channels, etc. Reports shall be submitted to the Executive Director after the first year of monitoring and with any application for a new or amended coastal development permit.

(9) The applicant shall undertake monitoring and maintenance of the revetment in accordance with the approved final Revetment Monitoring and Maintenance Plan. Any proposed changes to the revised Revetment Monitoring and Maintenance Plan or Sand Compatibility and Use Guidelines shall be reported to the Executive Director. No changes to these approved plans shall occur without a Coastal Commission approved amendment to this coastal development permit unless the Executive Director determines that no amendment is legally required.

D. The applicant shall prepare a Public Access Survey Plan that, at a minimum, includes:

(1) A beach intercept survey that asks visitors:

   a. To rank the value of Capistrano Beach County Park's public access and recreation amenities including, but not limited to, natural beach area, terraced (elevated) sandy beach, beach parking, bike and pedestrian paths, viewing areas, and picnic tables.

   b. How often they visit the Capistrano Beach County Park.

   c. The mode(s) of transportation they use to get to Capistrano Beach (i.e. public transit, trolley, personal car, carpool, bicycle, etc.).

   d. Baseline demographic and socioeconomic information to understand who is visiting the beach and inform equitable adaptation planning of public access amenities.

(2) A signage plan that encourages public participation in the survey in English and Spanish. The dimensions, material(s), text, font, and location of each sign and/or stencil shall be submitted.

(3) A plan for equitable distribution of the survey throughout the term of permit. The surveys shall be made available in English and Spanish, at a minimum. If electronic survey methods that require access to a smart phone are proposed, paper surveys shall also be provided onsite for the entire duration of the permit term and collected and tabulated along with the electronic data regularly.

3. **Public Access Program.** By acceptance of this permit, the applicant agrees to, and shall ensure, the following:

   A. Safe public access to or around areas where construction and maintenance activities will occur shall be maintained during all project operations.

   B. Use of public parking areas for storage of construction and/or maintenance materials shall be avoided and where avoidance is not possible, shall be minimized to the greatest extent feasible.

   C. The permittee shall post the site with a notice, in English and Spanish, indicating expected dates of construction and maintenance activities and/or beach closures.

   D. Following construction and for the duration of this permit, the permittee shall maintain the existing informal access path to the beach on the northernmost portion of the parking lot in a condition that maximizes accessibility for all people to the extent feasible whenever beach area is present.

   E. The permittee shall continue to provide free public access and free vehicle parking during the entire term of this coastal development permit.

   F. The permittee shall implement the Public Access Survey Plan for the entire term of permit.

4. **Habitat and Sensitive Species Protection Measures during Project Activities.**

   A. Nesting Bird Surveys. For any construction or maintenance activities involving heavy machinery, the permittee shall retain the services of a qualified biologist to conduct nesting bird species surveys in order to determine the presence of bird species including, but not limited to, California least terns, western snowy plovers, great blue herons, and snowy egrets. All project construction activities shall be carried out consistent with the following:

   (1) The applicant shall ensure that the biologist shall conduct the surveys thirty (30) calendar days prior to construction or maintenance activities to detect any active bird nests or breeding behavior in all trees within a 500-foot radius of the project site. A follow-up survey must be conducted three (3) calendar days prior to the initiation of construction and nest surveys must continue on a monthly basis throughout the nesting season or until the project is completed, whichever comes first. These surveys shall be submitted to the Executive Director within five days of completion.

   (2) If an active nest of any shore or wading bird is found within 300 feet of the project, or an active nest for any raptor species is found within 500 feet of the project, the applicant's biologist shall monitor bird behavior and construction

noise levels. The nest shall not be removed or disturbed. The biological monitor shall be present during all significant construction activities (those with potential noise impacts) to ensure that nesting birds are not disturbed by construction related noise. Project-related activities may occur only if noise levels are at or below a peak of 65 dB at the nest site(s). If project-related noise exceeds a peak level of 65 dB at the nest site(s), sound mitigation measures such as sound shields, blankets around smaller equipment, mixing concrete batches off-site, use of mufflers, and minimizing the use of back-up alarms shall be employed. If these sound mitigation measures do not reduce noise levels, construction shall cease and shall not recommence until either new sound mitigation can be employed.

B. An appropriately trained biologist shall monitor all project activities for disturbance to sensitive species or habitat area. Based on field observations, the biologist shall advise the applicants regarding methods to minimize or avoid significant impacts, which could occur upon sensitive species or habitat areas. The biological monitor shall have the authority to stop work if any adverse impacts to sensitive species at the project site and/or within the project vicinity could result from continuation of the proposed development. The applicants shall not undertake any activity that would disturb sensitive species or habitat area unless specifically authorized and mitigated under this coastal development permit or unless an amendment to this coastal development permit for such disturbance has been obtained from the Coastal Commission.

C. Grunion Monitoring and Avoidance Plan. By acceptance of this permit, the applicant agrees that if feasible, permitted maintenance operations shall avoid seasonally predicted grunion runs, and that if it is infeasible for permitted maintenance operations to avoid seasonally predicted grunion runs, it will abide by the following Grunion Monitoring and Avoidance Plan.

(1) The applicant shall obtain the seasonally-predicted grunion run schedule from the California Department of Fish and Wildlife website and schedule maintenance to avoid grunion spawning seasons.

(2) The applicant shall obtain California Department of Fish and Wildlife and Coastal Commission Executive Director approval, as defined in the Coastal Development Permit conditions.

(3) Assessment by trained personnel (i.e., qualified biological monitor) of the potential of the beach to support grunion spawning at each outlet where work will occur. Grunion monitoring will be required only at sites that have been identified as those supporting grunion spawning.

(4) A monitoring schedule. If maintenance needs to be performed during the grunion spawning season in the project area that may support spawning, the predicted grunion run prior to the maintenance work will be monitored. The predicted grunion run will be monitored for three nights: the night after the full or new moon phase and the two following nights. The monitoring would occur from the time of the high tide for two hours following the tide or until the grunion stop running if they are still running two hours after the high tide.

(5) Results of grunion locations. If grunion are observed to run in the vicinity of the project area, the area where they ran will be marked physically and/or by Global Positioning System (GPS) locations. The density of the grunion throughout the area will be noted.

(6) The applicant will ensure that maintenance workers will avoid the spawning area during all work activities.

(7) If spawning occurred within portions of a maintenance area, work in those areas will be avoided or rescheduled until after the grunion eggs have hatched. This occurs during the two weeks between grunion runs, i.e., the two or three days before every full or new moon or when it has been otherwise determined that the eggs from the run have washed out to hatch.

5. **Protection of Water Quality during Construction.** To protect coastal water quality during construction and demolition activities, the applicant shall comply with the following requirements:

A. General BMPs and Procedures

(1) Best Management Practices (BMPs) designed to minimize adverse impacts resulting from construction and demolition activities shall be implemented prior to the onset of such activity, including BMPs to minimize erosion and sedimentation, minimize the discharge of pollutants and non-stormwater runoff, and minimize land disturbance, as applicable. The description and location of all water quality BMPs to be implemented during construction and demolition shall be specified.

(2) All BMPs shall be maintained in a functional condition throughout the duration of the construction and demolition activities and shall be promptly removed when no longer required.

(3) The use of temporary erosion and sediment control products (such as fiber rolls, erosion control blankets, mulch control netting, and silt fences) that incorporate plastic netting shall be prohibited, to minimize wildlife entanglement and plastic debris pollution. Only products with 100% biodegradable (not photodegradable) natural fiber netting shall be allowed.

(4) All construction methods and equipment to be used shall be specified.

B. BMPs for Construction Activities Adjacent to Coastal Waters

(1) Construction work and equipment operations below the mean high water line shall be minimized to the extent feasible, and, where possible, shall be limited to times when tidal waters have receded from the authorized work areas.

(2) All work shall be performed during favorable tidal, ocean, wind, and weather conditions that will enhance the ability to contain and remove, to the maximum extent feasible, construction and demolition debris.

(3) Equipment or construction materials not essential for construction work shall not be allo ed at any time in the intertidal one.

(4) The footprint of areas within which demolition and construction activities are to take place (including staging and storage of equipment, materials, and debris; and equipment fueling and maintenance) shall be minimized to the extent feasible, to minimize impacts on the marine environment. Construction activities shall be prohibited outside of designated construction, staging, storage, and maintenance areas.

(5) Vegetable-oil-based hydraulic fluids shall be used in heavy equipment used in construction lasting one week or longer overwater or adjacent to coastal waters, if feasible.

(6) Biodiesel fuel shall be used in heavy equipment used in construction lasting one week or longer overwater or adjacent to coastal waters, if feasible.

C. BMPs for Stockpile and Debris Management

(1) All demolition and construction materials, equipment, debris, and waste shall be properly stored and contained, and shall not be placed or stored where it may be subject to wave, wind, rain, or tidal dispersion, to prevent pollutants from entering coastal waters, sensitive habitats, and the storm drain system.

(2) All stockpiles, construction materials, and demolition debris shall be enclosed on all sides, covered during rain events, and not stored in contact with the soil, and shall be located a minimum of 50 feet from coastal waters, sensitive habitat, and storm drain inlets.

(3) Sediment control BMPs shall be installed at the perimeter of staging and storage areas, to prevent sediment in runoff from construction-related activities from entering coastal waters.

(4) Demolition or construction debris and sediment shall be removed from work areas each day that demolition or construction occurs, to prevent the accumulation of debris, sediment, and other pollutants that may potentially be discharged into coastal aters.

(5) All trash and debris shall be disposed of in the proper trash and recycling receptacles at the end of e ery construction day.

(6) The applicant shall provide adequate disposal facilities for solid waste, including excess concrete, produced during demolition or construction.

(7) All debris resulting from demolition or construction activities, and any remaining construction materials, shall be removed from the project site within 24 hours of completion of the project.

(8) Debris shall be disposed of at a legal disposal site or recycled at a recycling facility. If the disposal site is located in the coastal zone, a coastal development permit or an amendment to this permit shall be required before disposal can take place unless the Executive Director determines that no amendment or ne permit is legally re uired.

D. BMPs for Spill Prevention and Equipment Maintenance

(1) Spill prevention and control measures shall be implemented to ensure the proper handling and storage of construction products or materials that may have adverse environmental impacts. The discharge of any construction products or materials into coastal waters shall be prohibited.

(2) Leaks or spills of fuel, oil, grease, lubricants, hydraulic fluid, chemicals, preservatives, paints, or other construction products or materials shall be immediately contained on-site and disposed of in an environmentally-safe manner as soon as feasible.

(3) Construction vehicles operating at the project site shall be inspected daily to ensure there are no leaking fluids and shall be serviced immediately if a leak is found.

(4) Fueling and maintenance of construction equipment and vehicles shall be conducted off-site, if feasible. Any fueling and maintenance of mobile equipment conducted on site shall take place at a designated area located at least 50 feet from coastal waters, sensitive habitat, and storm drain inlets (unless these inlets are blocked to protect against fuel spills). The fueling and maintenance area shall be designed to fully contain any spills of fuel, oil, or other contaminants. Equipment that cannot be feasibly relocated to a designated fueling and maintenance area (such as cranes) may be fueled and maintained in other areas of the site, provided that procedures are implemented to fully contain any potential spills.

(5) Equipment, machinery, and vehicles shall be washed only in designated areas specifically designed to contain runoff and prevent discharges into coastal waters. Thinners, oils, and solvents shall not be discharged into the sanitary sewer or storm drain systems.

6. Permit Compliance.

A. The permittee shall undertake and maintain the development in conformance with the special conditions of the permit and the final plans, including but not limited to the reconstruction and construction of shoreline protective devices. Any proposed changes to the approved plans shall be reported to the Executive Director in order to determine if the proposed change shall require a permit amendment pursuant to the requirements of the Coastal Act and the California Code of Regulations. No changes to the approved plans shall occur without a Commission-approved permit amendment unless the Executive Director determines that no permit amendment is required.

B. The permittee shall submit a nature-based adaptation pilot project feasibility study that, at a minimum, analyzes the feasibility of implementation of a nature-based adaptation strategy, in place of some or all of the revetment (armor rock and sandcubes) authorized by this permit, and that can be included as part of a mid-term or long-term management plan. A pilot project, such as the construction of a living shoreline or cobble berm, shall be submitted to the Executive Director no later than six (6) months prior to this permit's expiration unless the authorization termination deadline is extended by the Executive Director as outlined in Special Condition 1.D of this permit. If the study indicates that a nature-based strategy is feasible, the permittee shall submit a new coastal development permit application or an application to amend this permit to implement the pilot project. If the pilot project is feasible at the southeastern-most portion of the site, the applicant shall submit an alternatives analysis that includes removal of the southern parking area and restoration of the full beach system to the inland extent of the property.

C. Upon completion of the Capistrano Beach Park Master Plan, the permittee shall submit an application for an amendment to this coastal development permit, a new coastal development permit, or Public Works Plan to the Commission for review and approval for the portions of the plan that constitute development.

7. **Assumption of Risk, Waiver of Liability and Indemnity.** By acceptance of this permit, the applicant acknowledges and agrees (i) that the site may be subject to hazards, including but not limited to waves, storms, flooding, erosion, and earth movement, many of which will worsen with future sea level rise; (ii) to assume the risks to the permittee and the property that is the subject of this permit of injury and damage from such hazards in connection with this permitted development; (iii) to unconditionally waive any claim of damage or liability against the Commission, its officers, agents, and employees for injury or damage from such hazards; and (iv) to indemnify and hold harmless the Commission, its officers, agents, and employees with respect to the Commission's approval of the project against any and all liability, claims, demands, damages, costs (including costs and fees incurred in defense of such claims), expenses, and amounts paid in settlement arising from any injury or damage due to such hazards.

8. **As-Built Plans.** WITHIN 90 DAYS OR PROJECT COMPLETION, the permittee shall submit as-built plans for the approved revetment, which include volume of existing rock, volume and number of sandcubes, revetment footprint, revetment toe and crest elevations, locations of public access paths or ramps, locations of drain pipes or outlets, and locations of the fixed or permanent benchmarks from which the elevation and seaward limit of the revetment can be referenced for required monitoring and necessary maintenance.

Exhibit 3 – Benchmark Timeline

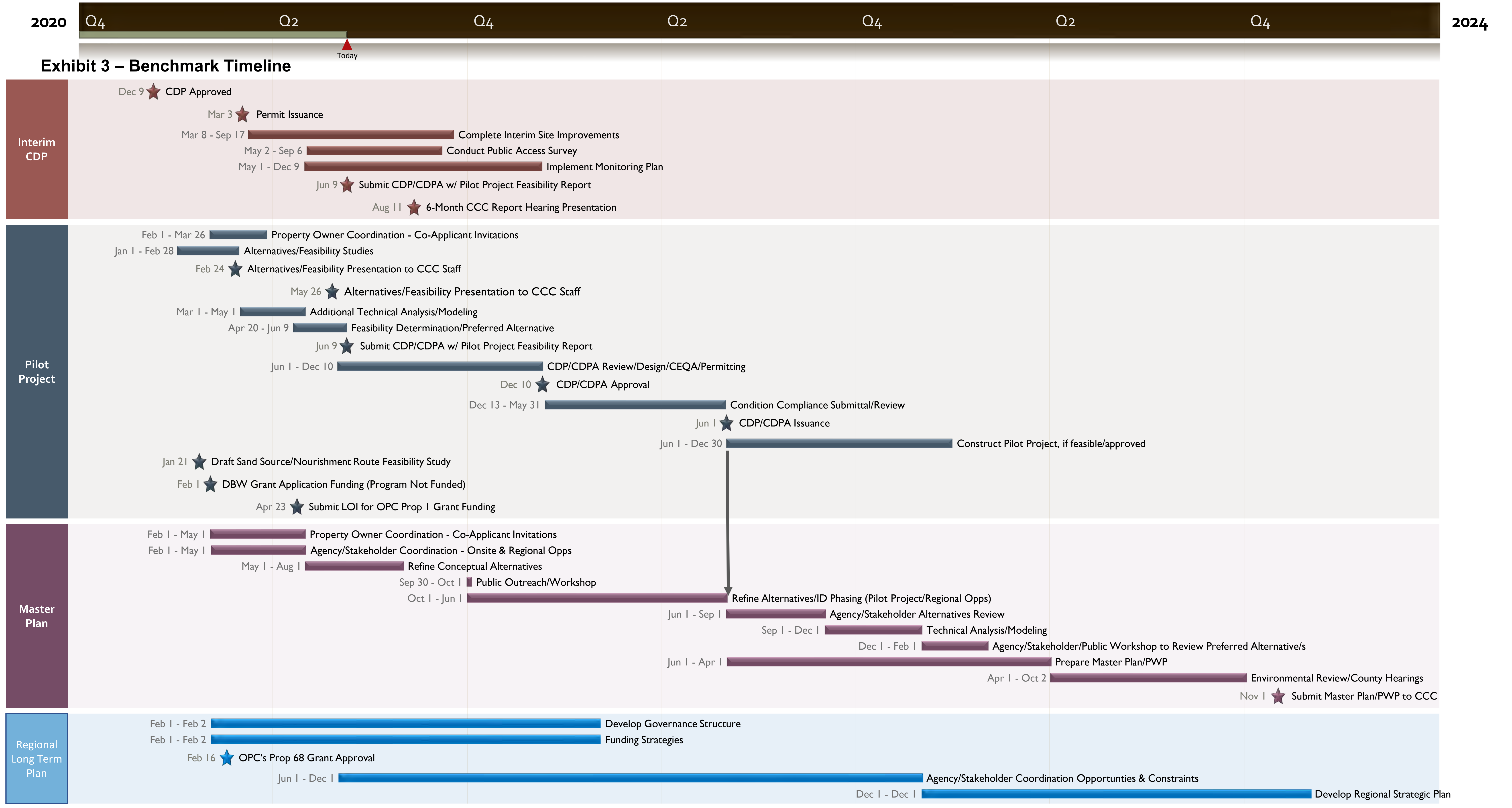

Exhibit 4 – Feasibility Study

CAPISTRANO BEACH COUNTY PARK

NATURE-BASED PILOT PROJECT FEASIBILITY STUDY REPORT

June 2021

Prepared for:

County of Orange, OC Parks

OCparks

13042 Old Myford Road
Irvine, CA 92620

Prepared by:

moffatt & nichol

4225 E. Conant St.
Long Beach, CA 90806

M&N Job No. 8189-04 and 10186-09

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1 INTRODUCTION

Capistrano Beach County Park is a recreational coastal beach with facilities that opened to the general public in 1980. Located in the City of Dana Point in Orange County, CA, the park is operated and maintained by the County of Orange, OC Parks. It has a shoreline length of approximately 1,500 feet (ft) and is bounded by Doheny State Beach to the west, private homes to the east, Pacific Coast Highway and a major railway to the north, and the Pacific Ocean to the south. Capistrano Beach is a south-facing, historically narrow beach even considering that it has benefitted from past large-scale sediment deposits, both artificial and natural.

Capistrano Beach County Park ("Capo Beach") has been subjected to ongoing shoreline erosion. The erosion has caused the loss of park facilities and continues to threaten the remaining facilities and amenities (M&N, 2019). This document is prepared as one aspect of the OC Parks' response to the vulnerability of the County Park.

The purpose of this study is to evaluate feasibility and prepare concept plans for a "nature-based" Pilot Project to adapt to coastal erosion and sea level rise (SLR). The Pilot Project was initiated in response to Capo Beach Coastal Development Permit (CDP) 5-19-0345 condition 6.B. The intent of the Pilot Project is to replace some of the sandcubes and/or rock that currently exist along the Capo Beach shoreline. The Pilot Project would serve to inform the mid-term and/or long-term management plan for the park. The CDP condition identifies a potential pilot project as a living shoreline or cobble berm. Both components are evaluated in this feasibility study, with a cobble berm being a foundational component of all proposed concepts.

Two locations are evaluated for potential implementation of the Pilot Project (Figure 1-1):

- North Reach – The boundary extends from the rock revetment at the County Park entrance, north to and including a segment of Doheny State Beach—a length of up to approximately 1,150 linear feet (lf). The reach encompasses the northern bike path, City of Dana Point stormwater treatment facility, Doheny State Beach Day Use parking lot and turnaround, and beach area where damage has recently occurred.

- South Reach – The boundary extends from the County Park stormwater outfall, south to the border of the park and the private residential neighborhood—a length of approximately 325 lf. The reach encompasses the County parking lot and beach where damage has recently occurred. Within the South Reach location, two alternative shoreline positions were evaluated, one of which is more landward than the other.

This report summarizes the project components, provides supporting information from key references and technical studies, provides context for the preliminary design, and evaluates pros and cons of each of the potential implementation locations. The Pilot Project is developed with the consideration of "green-grey" engineering practices, focusing on the potential crossroads of using natural materials, habitat enhancement, and managed retreat to rethink the look, function, and management of the coast.

Although the project would only be implemented on a small scale (limited area of Park shoreline), a key objective is to test the effectiveness of cobble as an alternative solution for shoreline protection and for understanding potential long-term park and coastal impacts. The Pilot Project is planned for inclusion in the interim period California Coastal Commission (CCC) CDP application process and will inform the development of the County's Master Plan.

FIGURE 1-1. POTENTIAL PILOT PROJECT LOCATIONS

2 SITE CONDITIONS

This section summarizes key site conditions which have triggered the development of the Pilot Project. For a detailed description of existing and projected site conditions, including site description, oceanographic conditions (present and projected conditions), geologic conditions, and biological conditions, refer to the Capistrano Beach County Park Coastal Resilience Study (M&N, 2019).

The Project area shoreline has fluctuated over the years due to natural processes (San Juan Creek sediment flood flows) along with anthropogenic effects (e.g., construction of Dana Point Harbor; land development; and beneficial reuse of dredge material). Beach widths have varied over time, from 0 ft (west end) at its narrowest to 100 ft at its widest (east end). Historically, the Capistrano Beach shoreline benefitted from large introductions of sediment disposal projects, but nourishment events in recent decades has been minimal. Additionally, due to droughts, urbanization, and sediment retention features, the fluvial input from San Juan Creek has decreased over the years. Over the last three decades, the beach has been characterized by acute erosion (discussed further in section 5.1 herein) and a narrow sandy beach generally during all times of the year.

Capistrano Beach County Park amenities (past and present) include public parking, restrooms, picnic tables, basketball court, walkways, and a section of the coastal trail/bicycle path. In addition to public recreational and access opportunities, the sandy beach has the potential to provide habitat for marine species, including grunion and snowy plover. Capistrano Beach County Park facilities have incurred significant damage due to storm waves and high tides, resulting in multiple events with the immediate need for emergency response shoreline protection methods. Recent erosive and damaging events occurred on November 19 and December 15, 2015; October 25, November 30, and December 26, 2018; and June 7 and July 4, 2020.

The conditions of the two proposed reaches of the Pilot Project are summarized below:

South Reach

The South Reach has been damaged severely by ocean conditions, eroding sandy beach area resulting in the undermining the parking lot, collapsing pavement, cracking curb, and overwashing sand and cobble onto the parking lot (Figure 2-1 and Figure 2-2). This has led OC Parks to retreat/remove a portion of the parking lot and install sandcubes to protect the remaining parking spaces. Very little dry sandy beach area is currently present seaward of the sandcubes. Several parking spaces have been lost to the retreated parking lot.

North Reach

The North Reach is also currently in an eroded condition (Figure 2-3 and Figure 2-4). The only stable sandy beach area is available within the small corner pocket of the bicycle path and the Park entrance. Wave action has undermined the bike path and Doheny State Beach parking lot pavement. Sandcubes have been installed along the back beach to protect the City of Dana Point stormwater treatment facility. Along the southern edge of Doheny State Beach, the parking lot and turnaround area have been severely undermined by wave action and erosion, causing the loss of viable parking spaces. Sand loss has exposed a cobble foundation.

FIGURE 2-1. SOUTH REACH – DAMAGED PARKING LOT AND ERODED BEACH CONDITIONS

FIGURE 2-2. SOUTH REACH – CONDITIONS SUMMARY

FIGURE 2-3. NORTH REACH – UNDERMINING OF ASPHALT AND ERODED BEACH CONDITIONS

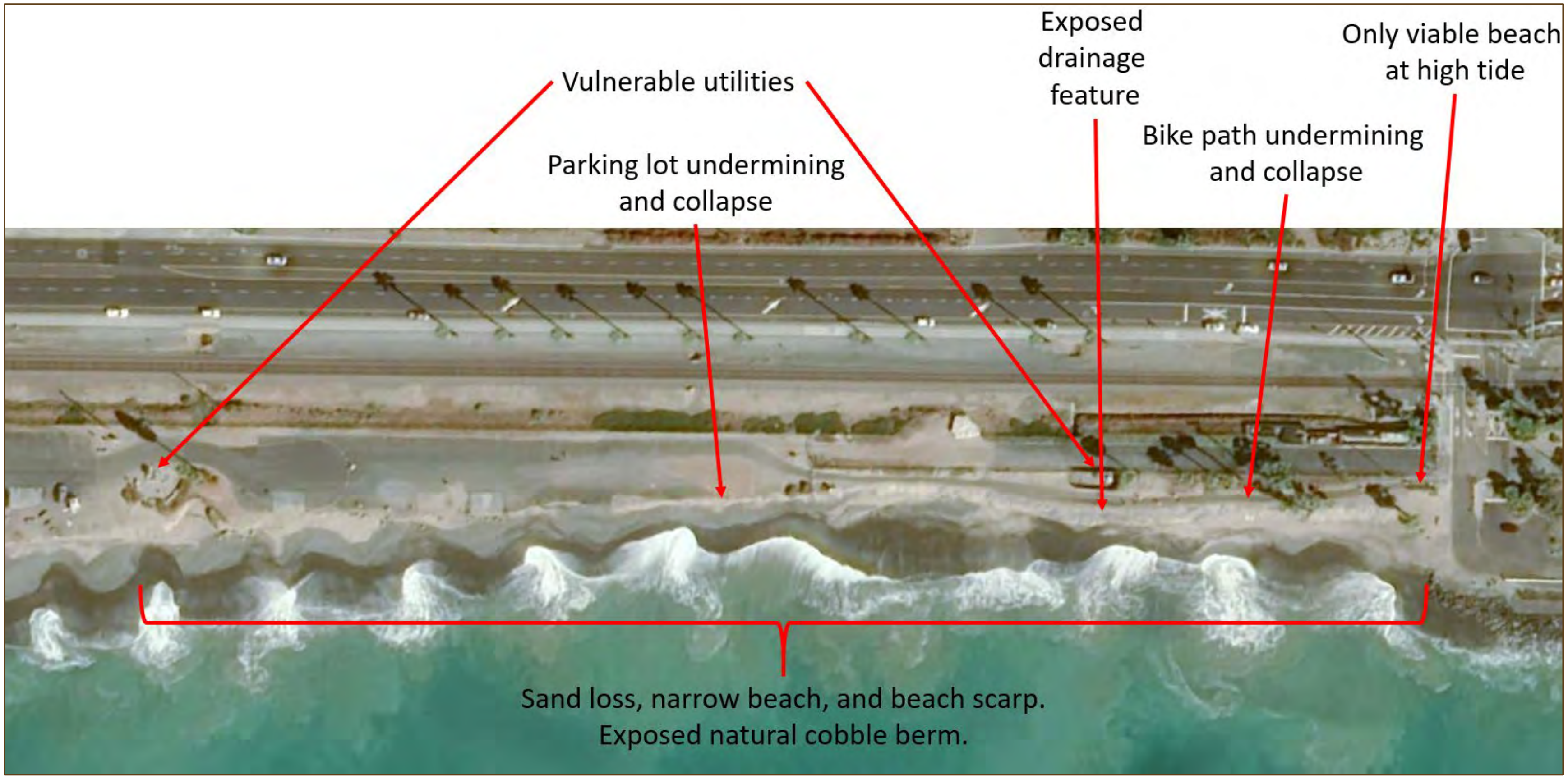


FIGURE 2-4. NORTH REACH – CONDITIONS SUMMARY

3 FEASIBILITY OF COBBLE BERMS FOR SHORELINE PROTECTION

Cobble material (sometimes named gravel or shingle) is found naturally along shorelines in southern California and around the world. Everts & Eldon (2002) describe the nature of cobble beach development:

> *"Cobbles are the end product of a complex weathering process that began in the local mountains. Following many cycles of fluvial and marine transport interspersed with longer periods of burial, they reached the coast. Large cobble and boulder deltas at the outlet of steep-gradient streams and rivers in southern California attest to an upland source, as does the retreat of cobble-containing seacliffs."*

Cobble is found naturally at Capo Beach and Doheny State Beach (Figure 3-1).

FIGURE 3-1. EXISTING COBBLE MATERIAL AT DOHENY STATE BEACH – JUNE 2020

This section assesses the feasibility of cobble berms to provide shoreline protection to County, State Parks, and City facilities. Implementation of cobble berms and living shoreline projects along the California open ocean coastline and technical studies are limited, and thus it is important to emphasize that "feasibility" is to be caveated, i.e., the purpose of the pilot project in the first place is to assess performance of an implemented cobble berm to understand if it may be a potential feasible long-term solution. Observations of cobble dynamics and shoreline protection performance are discussed first, followed by a summary of lessons learned from key related projects, and potential risks.

3.1 Observations of Cobble Performance

In the face of wave action, cobble beach dynamics and net transport work entirely differently than sandy beach dynamics and net transport. Sandy beaches on the California coast are well-documented to typically erode in winter under storm wave conditions. Beach sand typically returns during the summer's relatively calm wave climate, widening the beaches (Elgar et al., 2001). Conversely, cobble material has been documented to accrete at the back beach under storm conditions. Long period swell waves provide a powerful swash that drives cobbles upland and inland (Jennings, 1955). Cobble beaches tend to have a high permeability and porosity (Dean and Dalrymple, 2004), which allows for the infiltration of swash and a consequently reduction of wave and backswash energy (Figure 3-2). The asymmetry of relatively strong swash to weak backswash drives the accretion of cobble, as depicted in Figure 3-3.

Figure 3-2. Cobble Berm at Carlsbad State Beach

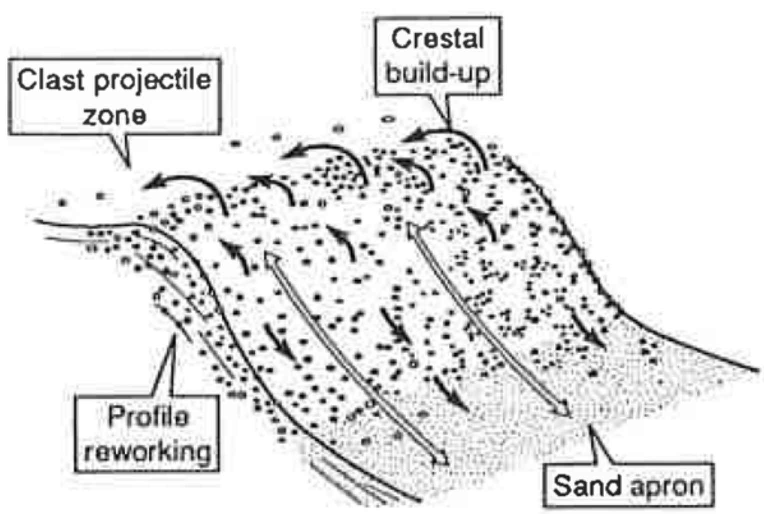


Figure 3-3. Cobble Beach Dynamics Under Storm Wave Conditions (Sherman, 1993)

This phenomenon has been observed in southern California at the naturally occurring cobble berm on beaches north and south of the Batiquitos Lagoon inlet in the cities of Carlsbad and Encinitas (Everts & Eldon, 2002). The cobble berm at these locations showed an out-of-phase seasonal fluctuation in sand and cobble. Specifically, during the winter, the sand retreated from the shoreline and the cobble accumulated, whereas the contrary occurred during the summer. The long-term change in the volume of cobbles may be inversely proportional to the volume of sand in the littoral cell. The cobble berm accreted 12 cy/lf during the strongest El Niño winter in the 20th century and a very intense storm in 1988 (Figure 3-4). The study found that a comparatively small volume of cobbles with a relatively small footprint is needed to provide the same level of protection as a large volume of sand.

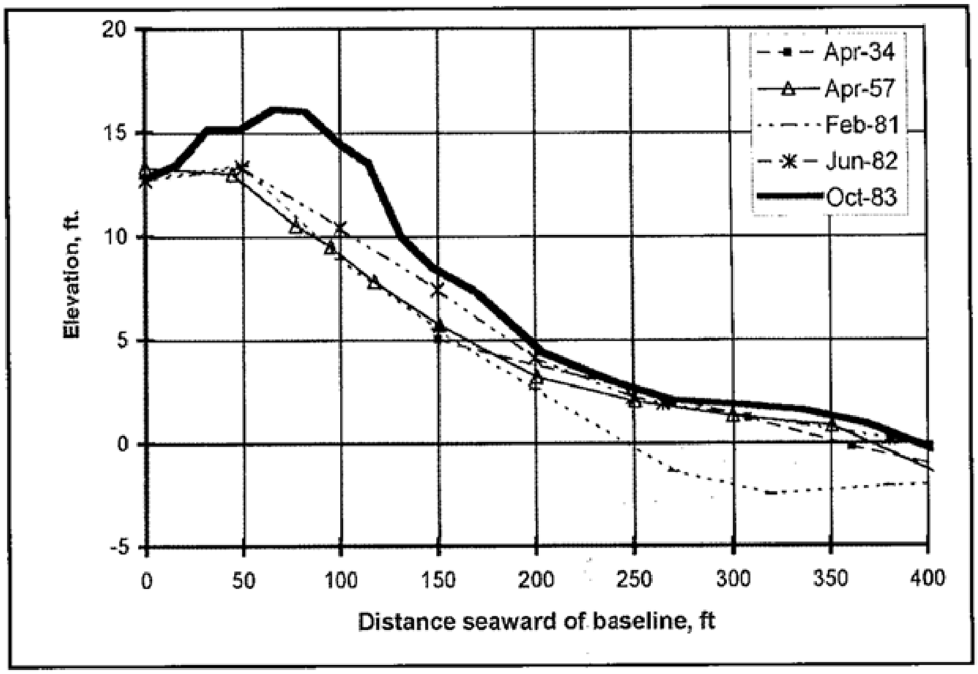


FIGURE 3-4. PROFILES ACROSS THE BATIQUITOS COBBLE BERM ILLUSTRATING ITS STABILITY BETWEEN 1934 AND 1982, AND THE HUGE ACCUMULATION OF COBBLES THAT OCCURRED DURING THE ENSO WINTER OF 1982-83 (EVERTS & ELDON, 2002)

Alongshore transport of cobble is not as well documented in the southern California region. Everts et al. (2002) estimates the longshore transport of cobble to be near zero in the Oceanside Littoral Cell from circumstantial evidence, as compared to the 30,000-100,000 cubic yards (cy)/year southward alongshore sand transport in this region. There are many qualities of cobble beaches which limit the extent of longshore transport. However, an estimate of zero cy/year is questionable given recent observations of cobble transport. Ongoing studies at Scripps Institution of Oceanography aim to enlighten this topic through the high-resolution spatial and temporal mapping of cobble distributions (Matsumoto and Young, 2018). Although not directly comparable, on a beach in New Zealand, Dickson et al. (2011) identified a longshore transport rate of cobble at 2-2.5 meters/day, driven by southerly swell. Storm events had typical wave height of 1.2 to 2.3 meters and wave period of 6.1 to 11.6 seconds. All cobbles showed weight loss due to abrasion from 1 to 14 grams over 207 days.

A series of publications have identified the resilient nature of cobble berms for shore protection, as summarized in Table 3-1.

TABLE 3-1. COBBLE BERM PERFORMANCE INVENTORY

Source	Cobble Berm Description
Bradbury and Powell, 1993	Shingle spits often provide the only natural defense from wave attack to the areas of low-lying land in their lee. They are hydraulically efficient structures, maximizing wave energy dissipation through the high permeability of the shingle. Developed a critical freeboard parameter for design of gravel beach nourishment.
Buscombe and Masselink, 2006	Gravel beaches are steep reflective beach morphology. Gravel material migrates onshore during storm wave scenarios. Identification of scenarios which pull material offshore have not been identified.
Dare, 2003	Cobble berms are inexpensive to construct, natural in appearance, offer shoreline protection, and are flexible under the attack of waves. Storm waves can turn cobbles into projectiles that can result in damage to landside properties. Cobble berms offer less protection than a traditional revetment or seawall, require maintenance, and do not provide the same protection as a sandy beach.
Dickson et al., 2011	Beaches of coarse sand and gravel are known to maintain a high degree of stability under wave attack.
Doria et al., 2016	Cobbles and bedrock sometimes reduce the mobility of eroded shorelines.
Everts et al., 2002	In comparison to sand berms, cobble and boulder berms exhibit superior performance under wave action for equivalent volumes of material. A berm is the nearly flat-topped, high elevation, landward-most segment of a beach that forms when sediment is deposited in the run up-backwash (swash) zone. Sand berms typically erode in the winter and reform the following summer. Natural cobble and boulder berms are longer lasting, and the larger ones are remarkably persistent. Under ideal circumstances, some accrete during even the most extreme storms…A comparatively small volume of cobbles with a relatively small footprint is needed to provide the same level of protection as a large volume of sand.
Lewis, 1931	The swash is identified as always impelling the shingle up-beach, with the only equilibrating factor being beach slope. This is why shingle collects at the bottom of sea cliffs. Storm waves have been known to build gravel berms up to 30 or 40 ft above sea level.
Nicholls and Webber, 1989	Whilst for recreational activities, [shingle] beaches have less appeal than their sand counterparts, they are nonetheless one of the most efficient forms of coast protection…Projects involving shingle nourishment [6 to 45mm], usually from marine sources, are becoming increasingly favored.
Powell, 1989	Steep beaches reflect waves, like revetments. About 10% of wave energy is reflected by Shingle beaches.
Van Wellen et al., 2000	The use of coarse-grained sediment to nourish eroding beaches is increasingly occurring because coarse material, such as gravel, is an efficient and dissipative form of coastal protection.

3.2 LESSONS LEARNED FROM PREVIOUS PROJECTS

Cardiff Beach Living Shoreline

The Cardiff Living Shoreline designed a vegetated sand dune with a buried rock revetment and cobble toe. The 2,900-linear-ft project utilized the import of approximately 30,000 cy of sand and approximately 7,000 cy of 2-ton rock. The dune system was constructed with a crest elevation of approximately +18-21 ft NAVD88 and a cross-shore width of approximately 60 ft. The buried rock revetment was designed as a last line of defense with crest elevation of up to ~19 ft NAVD88. The cobble toe material was obtained through sorting and reuse of on-site material and constructed to be approximately 15 ft wide and 3 ft tall (Figure 3-5). Construction was timed to follow a beach nourishment project, which initially increased beach widths by up to 300 ft.

Since construction in Spring 2018, the project has persisted, experiencing minimal erosion and rapid growth of dune vegetation. Annual maintenance is anticipated through the placement of up to 30,000 cy per year of sand material dredged from the San Elijo Lagoon inlet. This long-term source of maintenance material is considered a critical factor in promoting the long-term success of the project. Based on preliminary modeling of the Cardiff Living Shoreline, the project was predicted to persist through approximately year 2050 (M&N, 2015). The modeling completed for Cardiff Beach was based on XBeach and primarily focused on the performance of the fronting sand berm. The model's estimation of cobble evolution was relatively uncertain; therefore, cobble was considered more qualitatively in its contribution to performance.

The Capo Beach Pilot Project is designed with a similar dune width, and dune crest height is proposed higher, at +22 ft NAVD88. The Capo Beach Pilot Project does not have the benefit of a partnering opportunistic nourishment (beach width) project and rock revetment, which likely significantly contributed to the success of Cardiff Living Shoreline. The Capo Beach Pilot Project may be able to compensate for the lack of a wider sandy beach with a larger cobble berm.

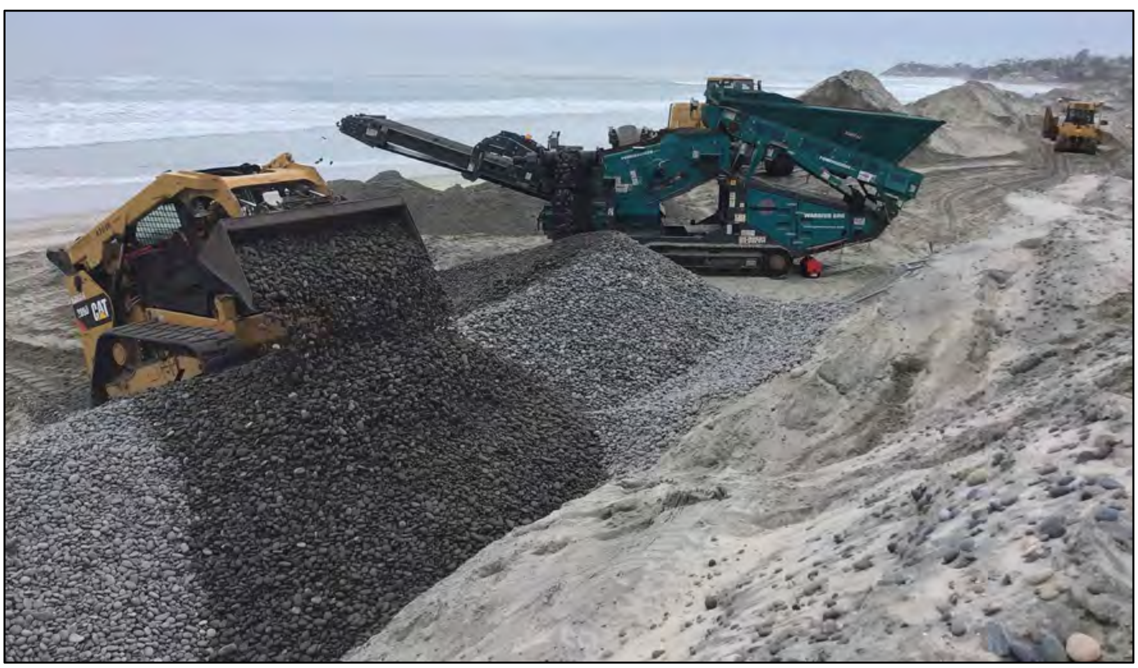


FIGURE 3-5. SORTING OF COBBLE MATERIAL AND COBBLE TOE CONSTRUCTION AT CARDIFF BEACH

Surfer's Point Living Shoreline

A cobble berm test section was constructed and monitored at Surfer's Point prior to the project being fully constructed (City of San Buenaventura, 2003). The test was conducted in September 2000. Two sections of varying berm face slopes were constructed with cobble from the Ventura River for a performance comparison. The section with a 5:1 (H:V) slope held shape throughout the winter storms, whereas the section with a 3:1 (H:V) slope berm face flattened out. A 5:1 (H:V) slope was recommended for the project's berm face for stability.

Given the success of the Surfer's Point project, the City of San Buenaventura extended the cobble berm feature along 800 ft of shoreline to the east of the initial project. The project's goal was to effectively widen the beach and protect the bike path and other infrastructure from costly coastal damage. The project entailed the placement of 4,800 cy of cobble and 1,000 cy of sand topping. In addition, existing concrete and other debris encountered by this work was removed. The project is recognized as a temporary fix (assumed approximately 10 years) that will require periodic maintenance in the form of future cobble nourishment (venturariver.org, 2015).

Design considerations for gravel, cobble, and/or boulder (gcb) berms are provided for the Surfer's Point Project through analysis of five naturally occurring prototype berms (Del Mar, Cardiff, Batiquitos Lagoon, South Carlsbad, and Emma Wood State Beach). Characteristics such as the crest elevation, gcb clast size, berm face slope, porosity, and berm face-to-shore platform were analyzed relative to the prototype berm's short-term and long-term response to a wave climate. A summary of the study's findings are as follows:

- Clast size – Berm stability increases with clast size.
- Size distribution – A more uniform gcb size is more stable than a wide range of sizes.
- Berm porosity – The berm should be limited to cobbles and/or boulders without including sand or gravel to promote water infiltration.
- Crest elevation – Allowance of some overtopping during the most extreme wave events increases the stability of the berm.
- Base elevation of the berm – The lower surface of the berm should be at or below the scour limit of the fronting shore platform. If this scour limit cannot be met, a scour apron should be placed in front of the berm to prevent undermining.

The study finds that a comparatively small gcb volume and footprint is needed to provide the same level of protection as a large sand replenishment. Cobble berms are commonly associated with sandy beaches in southern California and thus would be compatible for artificial use in the region.

The Surfer's Point Living Shoreline project designed a vegetated sand dune and buried cobble berm at an exposed point in Ventura, CA. The project imported a large volume of cobble, amounting to approximately 18 cy per linear foot (cy/lf) of cobble berm length, estimated at approximately 1,000 ft (Figure 3-6). The Surfer's Point project site is comparable to that of the Capo Beach Pilot Project, as it is located along a very exposed and historically eroded reach of shoreline. Surfer's Point is also located downcoast of a river mouth and receives sediment of all sorts of sizes. The littoral cell has a predominant sediment transport direction to the southeast, which directs sediment from the river towards the project.

FIGURE 3-6. CONSTRUCTION OF A COBBLE BERM AT SURFER'S POINT

Surfer's Point was monitored for 5 years post-construction to track beach and dune shape changes. Observations of strong seasonal changes in beach width were found where the beach accreted in summer and eroded in winter, which is typical of southern California beaches. Surfer's Point was constructed prior to, and successfully provided shoreline protection during, the 2015/2016 El Niño storm season. As Capo Beach shares a history of wave exposure and erosion with Surfer's Point, as well as a similarly designed volume of cobble material, the Capo Beach Pilot Project may be anticipated to weather storms on the scale of the 2015/2016 El Niño.

Post-construction maintenance has mostly consisted of sand sweeping, trash removal and landscaping efforts to keep out non-native plants, constituting a few days of maintenance each year. Additionally, sand has been imported in the project vicinity since construction, though this occurs as a beneficial reuse of opportunistic material and not a maintenance action triggered by damage (D. Hubbard, personal communication, Dec. 2020).

Cape Lookout Living Shoreline

Cape Lookout Living Shoreline demonstrated the performance of a cobble berm and dune constructed in 2000 at Cape Lookout State Park, Oregon. The design consisted of a cobble berm and high vegetated back dune reinforced with sand-filled geotextile bags (Figure 3-7). Construction monitoring of the berm and dune showed the crest height to be approximately 3.3 to 6.6 ft below the recommended elevation that was intended to prevent wave overtopping. Although the northern end of the design was overtopped multiple times, the berm and dune have generally remained stable and have effectively protected the campground backing the dune. Long-term monitoring of the project has shown a large reduction in the volume of cobbles following winter storms, as well as loss of sand and vegetation cover of the foredunes. The dune was nourished with sand in the summer of 2008, and the need for maintenance of the dunes was evident a decade after construction. Since then, it has been recommended to raise the dunes to the suggested elevation.

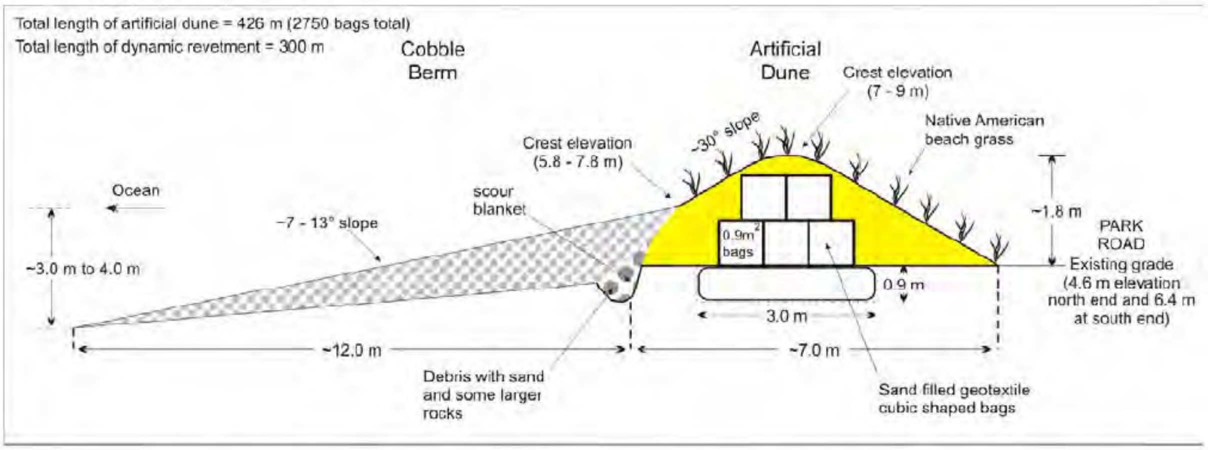


Figure 5. Design for the cobble berm and reinforced foredune to protect Cape Lookout State Park from erosion and flooding. The elevations are referenced to the NAVD 88 datum.

FIGURE 3-7. DESIGN CROSS-SECTION OF CAPE LOOKOUT LIVING SHORELINE (ALLAN AND KOMAR, 2004)

3.3 OTHER CONSIDERATIONS

In addition to the performance (shoreline protection effectiveness) of the cobble berm, other factors that influence project feasibility and need to be considered for implementation of a cobble berm pilot project are:

- Potential for cobble to disperse into nearshore and downcoast and unknown associated impacts to shoreline and marine habitats;
- Ability to retrieve imported cobble in the future if it results in detrimental effects to the shoreline and marine habitats;
- Location and availability of cobble and sand sources to construct Pilot Project;
- Desirability by beach users – cobble material can be difficult to walk and rest on;
- Potential for exposed cobble to become projectile during high wave events and cause damage to property and/or harm to humans;
- Need for emergency action if Pilot Project shoreline protection fails;
- Availability of funding to construct Pilot Project;
- Construction feasibility, such as material import approach (landside vs. waterside), construction timing, environmental windows, staging and storage of materials and equipment, and public access management;
- Monitoring plan to identify the evolution of the pilot project under varying seasonal and storm conditions;
- Maintenance and adaptation plan to develop and implement strategies to resolve issues and capitalize on successes; and
- Consideration of regional shoreline management and potentially sand retention to maintain recreational sandy beach area.

4 CONSIDERED CONCEPTS

As discussed in the preceding sections, Capistrano Beach and its facilities are vulnerable to episodic severe storm/swell events. There is an expectation that in the long-term, the narrowing beach coupled with accelerating SLR and increased storm activity will pose a significant, on-going threat to the County Park facilities. The County is actively pursuing potential solutions to address these threats in the short-term and long-term.

4.1 POTENTIAL PROJECT COMPONENTS

As a part of the M&N (2019) Coastal Resilience study, several potential long-term planning strategies were proposed to provide resilience, maximize shoreline stabilization, and adapt to climate change. Within these strategies are project components, which are part of the proposed Pilot Project. The Coastal Resilience study alternatives' components are summarized below:

Living Shoreline Protection (Buried Cobble Berm)

- Using native and imported cobble, cobble berm would be constructed. A cobble berm is an efficient method for shoreline protection for three key reasons: 1) its ability to withstand erosion in the face of waves and currents (as compared to sand); 2) its high permeability and porosity, which enhances wave energy dissipation and groundwater recharge; and 3) its tendency to increase in elevation and steepness in the face of storm waves, which enhances wave energy reflection (Everts & Eldon, 2002). The cobble would be intended to form a last line of defense as the sand on the seaward slope and crest erodes.
- Imported sand would be required in order to provide a sandy recreational beach area. Without a sufficient sandy beach buffer, regular wave action and storm events would likely displace the cobble and cause some of it to move across the beach profile and downcoast, reducing its ability to protect the County Park.
- Maintenance and additional import of cobble and sand would be required. A sufficient long-term source site(s) for the cobble and sand will require further investigation.

Living Shoreline Protection (Vegetated Dunes)

- Vegetated sand dunes could be constructed through the import of sand, sculpted into dune formations, and planted with vegetation. Cobble would be imported and placed underneath and along the toe of the dune. Beach nourishment would provide short-term protection. Typically, sustainable vegetated dunes require a foreshore beach berm of at least 50 ft to buffer the dunes from seasonal erosion and storm events. Follow-up nourishments would be required to offset the ongoing littoral sediment deficit. Similar to Buried Cobble Berm concept, a sufficient long-term source site(s) for the sand will require further investigation.

Landward Relocation of Park Infrastructure

- Managed retreat would involve reduction in parking lot size, loss of some park amenities, and relocating the existing park facilities and utilities landward. This landward movement of facilities could provide a buffer from the waterline and wave action. Although landward movement of park facilities is highly constrained by the Beach Road accessway, railroad, and PCH, shoreline retreat may be possible by reconfiguring and reducing the park's facilities.

- Alternative parking configurations are possible, and these are being studied as part of the Master Plan. If the parking lot can be reconfigured to convert existing parking to sandy beach, it is likely that there will still be the need for some type of shoreline protection for the remaining parking area (or ultimately for the Beach Road homeowners single accessway, train tracks, and Pacific Coast Highway).

Beach Nourishment

- Beach nourishment serves to widen the sandy beach area fronting the park facilities and thus provide shoreline protection to park facilities. Sand placement has occurred in the past using dredge material from Dana Point Harbor and San Juan Creek. An offshore borrow area or San Juan Creek could be a viable source of beach nourishment material for a larger, potentially regional project. Based on an assumed sand import volume of 100,000 cy, Capistrano Beach could be widened initially by up to 40 ft (based on a rule-of-thumb of 1.5 cy per foot of beach width per linear foot of shoreline).
- Natural wave action, as well as storm events, will cause the initial nourishment sand to move offshore and downcoast over time. Regular renourishment would be required to maintain a sandy beach and provide protection to County and City facilities.

Sandbags

- Sandbags/sandcubes could be placed along the County Park shoreline as in an interim solution. There is the potential for wave overtopping and damage to infrastructure and need for clean-up/maintenance of the parking lot. Replacement of the sandcubes would likely be required over time.

4.2 Preliminary Concept Development

For the proposed near-term Pilot Project, preliminary design concepts were developed for two potential locations, considering the above possible components and the potential for combining components to create a more effective approach. These concepts are summarized by reach below and presented as plan view and cross-section figures in Appendix A. The North Reach preliminary concepts were originally developed within the property limits of Capistrano Beach County Park. Following the preparation of the above concepts, California State Parks was engaged to discuss the potential for collaborating on the Pilot Project and extending the North Reach to incorporate their Doheny State Beach southern parking lot.

Generally, the design concept alternatives at each location are a) buried cobble berm without vegetated sand dunes and b) buried cobble berm with vegetated sand dunes. There are two variations of the latter in the South Reach in which one of the alternatives is more landward than the other based on input from Coastal Commission staff. For all concepts, import of sand is required for construction of a fronting beach berm. For all concepts, the cobble berm would enhance protection of park facilities, dissipating wave energy through its high permeability, reflecting wave energy with its naturally steep profile, and reducing erosion due to its mass. For the alternatives with vegetated dunes, planting could be performed through coordination with local environmental non-profit organizations.

South Reach

- Concept 1 – Buried Cobble Berm.
    - Temporarily excavate the existing beach to construct a cobble berm with imported material, immediately seaward of the existing parking lot. Reuse excavated sand to bury cobble berm as much as possible.
    - Import sand to cover cobble berm and construct a fronting beach berm.
- Concept 2 – Partially Removed Parking Lot, Buried Cobble Berm, and Vegetated Dune
    - Remove approximately 30 ft wide segment of the oceanside parking spaces at the south end of the County parking lot (south of the existing storm drain). Sawcut asphalt within project footprint and dispose offsite.
    - Potentially repurpose/relocate the existing sandcubes fronting the retreated parking lot to a last line of defense along the back beach and/or adjacent to the private property.
    - Temporarily excavate the existing beach and previous parking area to construct a cobble berm with imported material. Reuse excavated sand to bury cobble berm as much as possible.
    - Import sand to cover cobble berm and construct a fronting beach berm.
    - Import sand and plant vegetation to construct a contoured dune along the back beach.
    - Install sand fencing on dune hummocks to help capture wind-blown sand, promoting dune growth. Install K-Rail landward of and parallel to the dune to minimize the deposition of sand within the parking lot. Install public access paths to provide access to/from the water.
- Concept 3 – Fully Removed Parking Lot, Buried Cobble Berm, and Vegetated Dune
    - Remove an approximately 90-ft-wide segment of the oceanside parking spaces at the south end of the County parking lot (south of the existing storm drain). Sawcut asphalt within project footprint and dispose offsite.
    - Temporarily excavate the existing beach and previous parking area to construct a cobble berm with imported material. Reuse excavated sand to bury cobble berm as much as possible.
    - Import sand to cover cobble berm and construct a fronting beach berm.
    - Import sand and plant vegetation to construct a contoured dune along the back beach.
    - Install sand fencing on dune hummocks to help capture wind-blown sand, promoting dune growth.

North Reach

- Concept 1 – Buried Cobble Berm
    - Temporarily excavate the existing beach to construct a cobble berm with imported material, immediately seaward of the bicycle path and State Beach parking lot. Reuse excavated sand to bury cobble berm as much as possible.
    - Import sand to cover cobble berm and construct a fronting beach berm.

- Concept 2 – Buried Cobble Berm and Vegetated Dune
    - Temporarily excavate the existing beach to construct a cobble berm with imported material, immediately seaward of the bicycle path and State Beach parking lot. Reuse excavated sand to bury cobble berm as much as possible.
    - Import sand to cover cobble berm and construct a fronting beach berm.
    - Import sand and plant vegetation to construct a contoured dune along the back beach.
    - Install sand fencing on dune hummocks to help capture wind-blown sand, promoting dune growth. Install public access paths to provide access to/from the water. Maintain the sandy beach accessway near the County Park entrance.
    - The existing sandcubes (partial segment of this reach) would remain in place.

4.3 Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis

Towards identifying a single project reach and preferred concept to carry the Pilot Project forward, the two reaches and two concepts were evaluated for qualitative pros and cons in the form of a strengths, weaknesses, opportunities, threats (SWOT) analysis; see Table 3-1. Strengths and weaknesses are grouped as clear outcomes of the proposed concepts, whereas opportunities and threats are grouped as uncertainties which may or may not resolve over time.

All concepts share two key elements, a buried cobble berm and widened beach utilizing imported and excavated material. As a result, each concept provides many of the same benefits, such as the creation of a protective buffer of natural materials to protect the beach and park assets, and disadvantages such as lack of comprehensive understanding and experience of how cobble processes may affect the coastal resources and/or protect park infrastructure over the long-term. However, the inclusion of a vegetated sand dune in South Reach (Concepts 2 and 3) and North Reach (Concept 2) produces distinguishing pros and cons. Most significantly, the vegetated sand dune will increase the protection of park from SLR and overtopping, as compared to simply the cobble berm concept. Additionally, the dune will provide natural habitat which could support protected avian species. The inclusion of a dune, however, would come at the cost of reduced towel space for the public and potential viewshed impacts for coastal users. Overall, the increased protection and habitat benefits point towards the Buried Cobble Berm and Vegetated Sand Dune to be the preferred design concept.

The North Reach and South Reach share many characteristics, from the benefit that a nature-based Pilot Project brings to protecting public access and infrastructure, to the possible disadvantage that cobble material creates for beach users. However, a few key points distinguish the two reaches. The North Reach (Concepts 1 and 2) has a greater likelihood of success because, given that the area available for implementation is wider and farther inland, the Pilot Project would not be as exposed to wave action as it would in the South Reach (Concepts 1 and 2). The North Reach project can tie into existing site conditions in a more seamless way. The North Reach project has the unique opportunity to be a larger, more viable, collaborative project with California State Parks. Additionally, the South Reach carries greater risk because, with the parking lot retreated, the adjacent residential community would become exposed should the project fail to provide protection. This would open up OC Parks to unknown liability, which is preferred to be avoided. Further investigation of which location is preferred is provided in the following Risk Assessment section.

TABLE 4-1. CONCEPT SWOT ANALYSIS

South Reach Concept 1 Buried Cobble Berm	**South Reach Concept 2** Partially Removed Parking Lot, Buried Cobble Berm, and Vegetated Dune	**South Reach Concept 3** Fully Removed Parking Lot, Buried Cobble Berm, and Vegetated Dune	**North Reach Concept 1** Buried Cobble Berm	**North Reach Concept 2** Buried Cobble Berm and Vegetated Dune
Strengths				
Cobble berm provides protective buffer and last line-of-defense protection of park facilities during eroded beach conditions.				
Cobble berms are naturally resilient to storm waves, found to increase in height and steepness in such conditions.				
Increased beach width and recreational area from sand import.				
Project uses natural materials (sand, cobble) and reuses excavated sand on-site.				
Protective buffer minimizes further loss of the County parking lot.			Protective buffer minimizes further loss of the bicycle path, State parking lot, and City stormwater treatment facility.	
	Rooted vegetation in dune captures and stabilizes wind-blown sand, increasing protection effectiveness.	Rooted vegetation in dune captures and stabilizes wind-blown sand, increasing protection effectiveness.		Rooted vegetation in dune captures and stabilizes wind-blown sand, increasing protection effectiveness.
	Provide natural habitat for flora and fauna.	Provide natural habitat for flora and fauna.		Provide natural habitat for flora and fauna.
			Does not require retreat of any existing Capo Beach infrastructure or public access.	
Weaknesses				
Cobble material can be difficult to walk and rest on, making beach recreation activities less desirable for beach users. Likely only will occur during eroded beach conditions.				
	Re-nourishment (maintenance of beach berm) critical for sustaining vegetated dunes.	Re-nourishment (maintenance of beach berm) critical for sustaining vegetated dunes.		Renourishment (maintenance of beach berm) critical for sustaining vegetated dunes.
	May require watering and revegetation of dunes and public restrictions to prevent trampling.	May require watering and revegetation of dunes and public restrictions to prevent trampling.		May require watering and revegetation of dunes and public restrictions to prevent trampling.
	Reduces parking area and beach access compared to buried cobble berm concept.	Reduces public parking, total 14 parking spaces, and beach access compared to buried cobble berm concept.		Vegetated sand dune reduces beach access compared to buried cobble berm concept.
		Tree removal required.		
Reduced view of ocean for south end parking lot users. Relative viewshed impacts are increased because pedestrians tend to park and lookout across the ocean at the south reach.				
Temporary impact to intertidal benthic organisms by burial during initial cobble placement.				

<table>
<tr><th>South Reach
Concept 1
Buried Cobble Berm</th><th>South Reach
Concept 2
Partially Removed Parking Lot, Buried Cobble Berm, and Vegetated Dune</th><th>South Reach
Concept 3
Fully Removed Parking Lot, Buried Cobble Berm, and Vegetated Dune</th><th>North Reach
Concept 1
Buried Cobble Berm</th><th>North Reach
Concept 2
Buried Cobble Berm and Vegetated Dune</th></tr>
<tr><td colspan="5">Opportunities</td></tr>
<tr><td colspan="3">Smaller project length makes US Army Corps Nationwide Permit (54) Living Shorelines a good fit for a streamlined permitting process.</td><td colspan="2">Relative viewshed impacts are reduced because pedestrians tend to keep moving in this area and would quickly see beyond the vegetated dune.</td></tr>
<tr><td colspan="2">The project protrudes seaward and would be more exposed to waves and erosion. As a result, placed sand is more likely to erode, exposing cobble, providing greater opportunity to study cobble response. This also serves as an opportunity to study the cobble berm functioning as a groin retaining sand along Capo Beach.</td><td colspan="3">Greater likelihood of project success because of the relative setback from the high tide line and consequent less exposure to wave action.</td></tr>
<tr><td></td><td colspan="2">Opportunity for volunteer contribution to planting and maintenance; opportunity for public education and engagement.</td><td></td><td>Opportunity for volunteer contribution to planting and maintenance; opportunity for public education and engagement.</td></tr>
<tr><td colspan="3">.</td><td colspan="2">Implementation along the North Reach would potentially improve shoreline conditions to the south because the dominant southern longshore transport direction will likely increase sediment deposition along Capo.</td></tr>
<tr><td colspan="5">Threats</td></tr>
<tr><td colspan="5">Due to a lack of available science regarding the processes of cobble transport in southern California, it is difficult to anticipate if cobble movement will impact nearshore and downcoast resources as cobble erodes off beach.</td></tr>
<tr><td colspan="5">Damaging storm conditions may erode the project, requiring periodic maintenance and additional import of material.</td></tr>
<tr><td colspan="5">Sources of cobble and sand material for import are currently unknown.</td></tr>
<tr><td colspan="3">Cobble material can be thrown by wave action, becoming damaging projectiles. County parking lot and private roadway use may become vulnerable during such events.</td><td colspan="2">Cobble material can be thrown by wave action, becoming damaging projectiles. Bicycle path use may become vulnerable during such events.</td></tr>
<tr><td></td><td colspan="2">Wind-blown sand from higher elevation vegetated dune can deposit in parking lot and private roadway (maintenance required).</td><td></td><td>Wind-blown sand from higher vegetated dune can deposit on bicycle path (maintenance).</td></tr>
<tr><td></td><td>Retreated parking lot creates potential issue of flanking and erosion of adjacent private residence.</td><td>Any amount of pilot project loss opens the potential for erosion and damage (undermining and wave exposure hazard risks) to adjacent residences and roadway.</td><td colspan="2" rowspan="3"></td></tr>
<tr><td colspan="2">Less likely to succeed because more exposed to wave attack.</td><td></td></tr>
<tr><td></td><td colspan="2">Implementation of vegetated dune within parking lot along the South Reach would necessarily eliminate certain long-term alternatives identified in the Master Plan.</td></tr>
</table>

5 PERFORMANCE RISK ASSESSMENT

This section is intended to quantify the risks associated with implementing the Pilot Project and aid in the selection of a preferred concept if the risks are acceptable.

First, modeling of the Capo Beach shoreline is discussed; the modeling is for both a nourished sand berm condition and an exposed cobble berm condition. This is followed by a vulnerability assessment using a quantitative analysis tool, which compares the potential Pilot Project locations to identify which provides the least risk to the project owner and stakeholders.

5.1 CAPISTRANO BEACH MODELING

Preliminary modeling is ongoing and helps to inform the feasibility and longevity of the Pilot Project. If funding and time permit, more detailed modeling/analyses might also help to inform an understanding of the performance of the overall Pilot Project. However, as discussed further below, resolving cobble response to ocean conditions is seen as relatively uncertain due to the lack of relevant research and tools available, as compared to sand transport which is considered to be much better understood.

The sand berm and cobble berm are addressed in separate modeling/analyses efforts.

Sand Berm

As a part of long-term planning, Moffatt & Nichol is performing modeling/analyses of beach erosion and hypothetical beach nourishment events to assess the anticipated design life of such a project. This analysis also serves to provide data to better understand the longevity of the sand cover and fronting beach berm for this Pilot Project. The modeling also serves to help determine the design width of the sand berm for the Pilot Project over its intended demonstration life.

Historic shoreline analysis of the past 90 years was performed using data from the CoastSat website (UNSW, 2020) and other historic aerials and lidar data. The Capistrano Beach shoreline is shown to have accreted from the mid-1920s to mid-1980s, likely due to major sediment deposition events. Since then, erosion has dominated. Between 1997 and 2006, the shoreline retreated at a rate of 8.6 ft per year (Figure 5-1). After about 2006, the beach berm is generally no longer in existence and the erosion rate is no longer simply measurable due to the non-erodible shoreline (i.e., revetment). This is in general agreement with a recent geotechnical study for a project near Capistrano Beach, which aggregated data from sediment studies spanning from the 1980s-2000s. The study estimated that the sediment budget for the coast between Dana Point and San Mateo (near San Clemente) is in a 56,000 cy per year deficit (erosion) in dry years, and in a 3,000 cy per year surplus (accretion) in wet years (Ninyo & Moore, 2015).

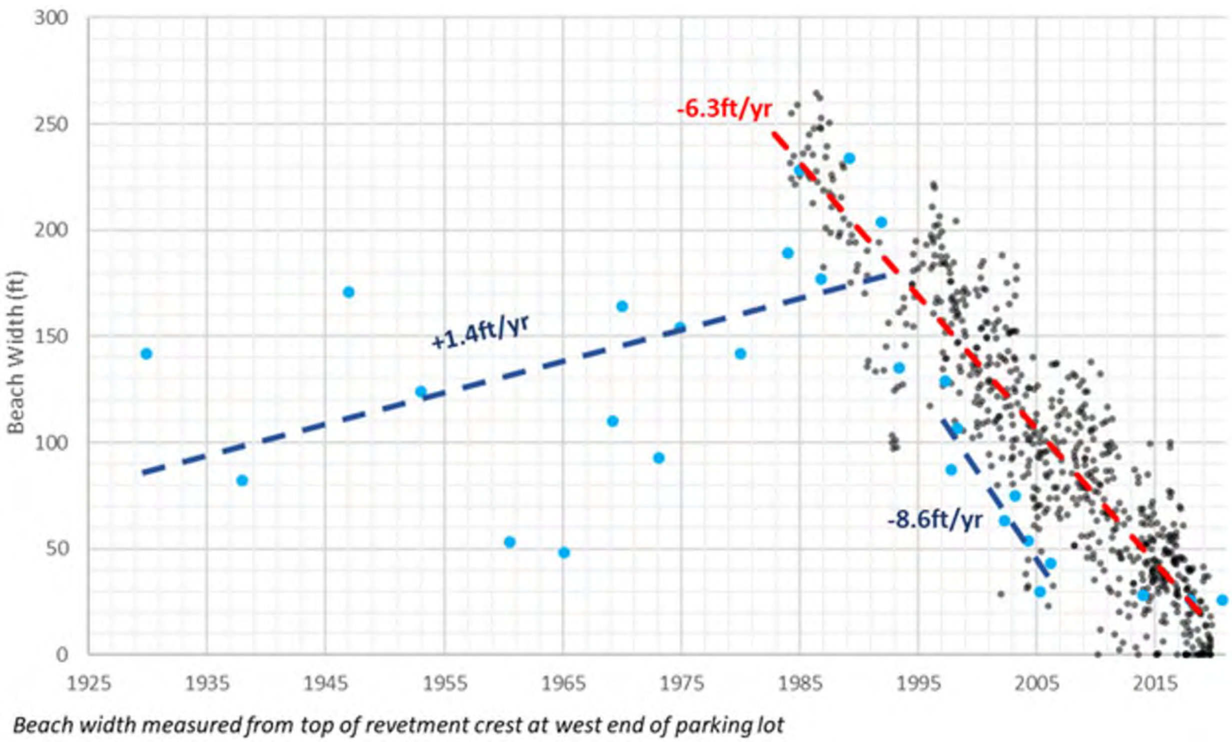


FIGURE 5-1. BEACH WIDTH TRENDS AT CAPISTRANO BEACH

For the purposes of predicting shoreline evolution, the XBeach model was employed. XBeach is a two-dimensional model for wave propagation, long waves and mean flow, sediment transport and morphological changes of the nearshore area, beaches, dunes, and back barrier during storms (Roelvink et al., 2015). XBeach was applied for a potential beach nourishment project, which generated a 150-ft-wide beach berm. Multiple wave/storm event-based scenarios were analyzed: 1-year storm, 20-year storm, 100-year storm, and 100-year storm with 2.5 ft of SLR. Extreme waves representing the 50- and 100-year return period wave heights are approximately 16.0 ft and 17.4 ft coming from the west and south-southwest directions, respectively.

Preliminary XBeach results showed beach width erosion of between 30 and 74 ft for the 1-year storm and 100-year storm with 2.5 ft of SLR, respectively (Table 5-1). Back-to-back 1-year storms demonstrate how a new project will experience severe scarping and erosion during its first storm, but this erosion will slow as the beach profile shifts towards an equilibrium state. This process can be interpreted as the beach eroding to create a gentler profile, which then promotes wave dissipation, and subsequently less erosion. Ultimately, the 150 ft berm was not completely eroded under any modeled conditions. Smaller 50-ft and 100-ft nourishments were also modeled and yielded similar erosion values. Note that these results are strictly preliminary and will continue to be refined.

TABLE 5-1. PRELIMINARY BEACH EROSION ESTIMATES FOR A MODELED 150-FT WIDE BEACH BERM

Storm Scenario	1-year Storm	Two 1-year Storms	20-year Storm	100-year Storm	100-year Storm + 2.5 ft SLR
Beach Erosion / Beach Width Loss (ft)	30	43	50	54	74

Cobble Berm

Processes for cobble (or gravel or shingle) beaches is not as well understood as those controlling sandy beaches. Even less is known about the processes for mixed sand-cobble beaches. While modeling sediment transport and beach morphology for sand is not without its difficulties, there are plenty of models and studies done demonstrating its effectiveness and use. However, for mixed sand-cobble beaches, there are few models proven useful for modeling morphology.

Recently, XBeach has been implemented, with some success, on mixed sand-cobble beaches (McCall et al., 2019, Phillips et al., 2020, Bergillos et al., 2016, Brown et al., 2019, Williams et al., 2015), previously known as XBeach-G. McCall (2019) tested XBeach's capabilities to replicate the DynaRev lab results (Blenkinsopp et al., 2021, Bayle et al., 2020) and "was able to reproduce some of the morphodynamics." Acknowledging that XBeach will not be able to replicate all the beach processes governing the response of a cobble berm project to a storm, a comparative analysis of Pilot Project alternatives should provide value. Therefore, the XBeach analysis of the Pilot Project cobble berm alternatives will focus more on how they perform compared to each other and less on the post-storm beach condition and flood protection capabilities.

The XBeach cobble berm model for Capistrano Beach is currently being developed. The model will include two separate sediment classes to differentiate between the cobble berm and existing beach. For modeling purposes, the cobble berm will be created on top of an eroded beach profile. Any sand cover over the cobble berm will be assumed to be eroded away (non-present). Figure 5-2 shows some preliminary XBeach modeling results with a cobble berm constructed for South Reach Concept 1. The colors represent the calculated median sediment size (D50) at the model grid point, the black line represents the initial beach conditions, and the blue dotted line represents the instantaneous water level at the time of the snapshot.

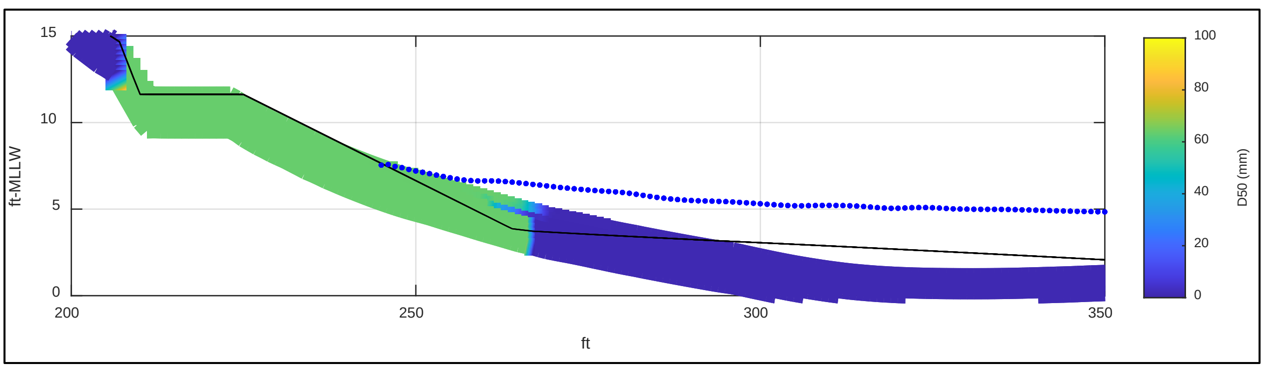


FIGURE 5-2. PRELIMINARY XBEACH MODELING

XBeach modeling results for three Pilot Project locations/concepts will be included as a supplemental appendix to this report. The goal of the memo will be to compare overtopping, runup, and erosion modeled for the three concepts.

5.2 VULNERABILITY ASSESSMENT SCORING TOOL ANALYSIS

The Vulnerability Assessment Scoring Tool (VAST), developed by the U.S. Department of Transportation, was used to quantitatively evaluate the relative vulnerability and risk associated with the potential Capo Beach Pilot Project alternatives. VAST is a tool developed to evaluate risks to transportation facilities from climate stressors such as changes in precipitation, temperature, and SLR.

For the purposes of the Pilot Project, the VAST analysis is steered towards identifying the risk associated with potential project alternatives and their surrounding infrastructure to erosion, flooding, and SLR. The three project alternatives selected for the VAST analysis are all design concepts with vegetated sand dunes at three potential locations; these are listed below and depicted in Figure 5-3.

TABLE 5-2. COBBLE BERM PILOT PROJECT ALTERNATIVES – VAST ANALYSIS

VAST Identification	Description (see Section 4.2 for more detail)
Asset ID 1	South Reach Concept 2 – Partially Retreated Removed Parking Lot, Buried Cobble Berm, and Vegetated Sand Dune
Asset ID 2	South Reach Concept 3 – Fully Removed Parking Lot, Buried Cobble Berm, and Vegetated Sand Dune
Asset ID 3	North Reach Concept 2 – Buried Cobble Berm and Vegetated Sand Dune

The overall vulnerability of each alternative was assessed as a function of exposure, sensitivity, and adaptive capacity. Within this study, exposure, sensitivity, and adaptive capacity are defined as follows:

- **Exposure**: Hazard type and magnitude an alternative is subject to.
- **Sensitivity**: Degree to which implementing an alternative impacts current uses and infrastructure within the project area.
- **Adaptive Capacity**: Degree to which uses and infrastructure within the project area would be at risk if an alternative is damaged.

VAST operates by collecting data on user-defined indicators related to each of these factors. Project characteristics and data used to populate the exposure, sensitivity, and adaptive capacity fields were determined using recommendations made by the VAST guidelines and modified when necessary, using the best judgment of the project team. All data input into VAST are used to create a final vulnerability score from 1-4 (for each alternative), which is weighted according to significance of different factors related to exposure, sensitivity, and adaptive capacity.

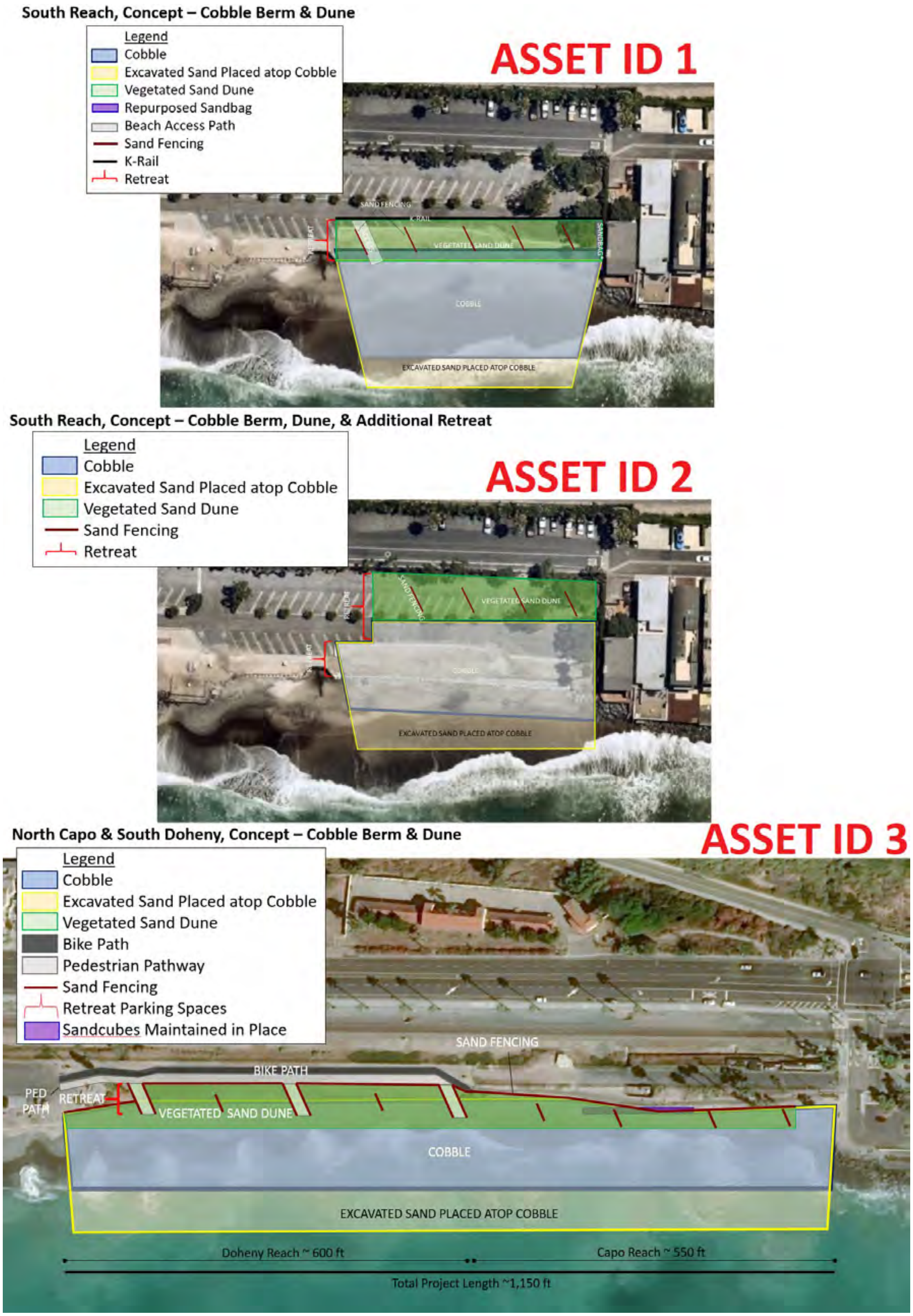


FIGURE 5-3. COBBLE BERM PILOT PROJECT ALTERNATIVES (ASSETS) – VAST ANALYSIS

5.2.1 VAST Approach

The VAST template guides the user through a series of steps towards identifying vulnerability. First, climate stressors and assets are selected. Then the analysis is performed for indicators of exposure, sensitivity, and adaptive capacity. The three vulnerability subcategories are then used to calculate vulnerability. These six steps are summarized in Table 5-3.

TABLE 5-3. VAST ANALYSIS STEPS

Step	Description
1	Select Climate Stressors – Erosion and Flooding under 0 ft and 3.3 ft SLR scenarios.
2	Select Asset Type – Three cobble berm with vegetated dune alternatives are carried forward for VAST analysis. • Asset ID 1 - South Reach - Cobble Berm, Dune, & Partial Parking Lot Retreat • Asset ID 2 - South Reach - Cobble Berm, Dune, & Full Parking Lot Retreat • Asset ID 3 - North Reach - Cobble Berm & Dune
3	Identify Exposure Indicators and Gather Data • Score of 1 = Low Exposure • Score of 4 = High Exposure
4	Identify Sensitivity Indicators and Gather Data • Score of 1 = Low Sensitivity • Score of 4 = High Sensitivity
5	Identify Adaptive Capacity Indicators and Gather Data • Score of 1 = High Adaptive Capacity • Score of 4 = Low Adaptive Capacity
6	Weight Indicators to Calculate Vulnerability • Exposure + Sensitivity + Adaptive Capacity = Vulnerability

Following initial setup of climate stressors and asset types (steps 1 and 2), indicators for each stressor were identified, as shown in Table 5-4 (step 3). Indicators are similar for both flooding and erosion, consisting of an estimate of historic damage and projected hazards from regional modeling efforts. Regional hazard modeling data was obtained from the Coastal Storm Modeling System (CoSMoS) Version 3.0, Phase 2, a multi-agency modeling effort led by the U.S. Geological Survey (USGS) designed to make detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for Southern California (Erikson et al., 2017). All exposure indicators are weighted equally.

TABLE 5-4. VAST ANALYSIS EXPOSURE INDICATORS AND WEIGHTING

Stressor	Indicator	Weight	Data Source
Flooding	Percent length of site historically flooded	50%	MN
	Percent area of project footprint projected to flood under 100-year storm conditions	50%	USGS CoSMoS
Erosion	Percent length of site historically eroded	50%	MN
	Projected shoreline erosion width of project footprint	50%	USGS CoSMoS

Sensitivity and adaptive capacity indicators and weighting are shown in Table 5-5 and Table 5-6, (steps 4 and 5) respectively. Units for each indicator are either a direct quantitative measure based on available date or a categorical rating by the project team based on knowledge of each alternative. Where utilized, ratings generally are input as none, low, medium, or high to align with the final 1-4 scoring scheme. All sensitivity indicators are weighted equally based on the diverse uses and infrastructure at each Pilot Project alternative location. Adaptive capacity indicators related to the protection and function of landward assets were weighted more heavily as these would be the most significant sources of risk if a project alternative were damaged.

TABLE 5-5. VAST ANALYSIS SENSITIVITY INDICATORS AND WEIGHTING

Indicator	Weight	Data Source	Unit
Number of parking spaces lost compared to existing	11%	MN	Count
Critical facilities	11%	MN	Presence / Absence
Landward asset value	11%	MN, OC Parks	$USD
Visitor usage protected by project	11%	MN	Categorical Rating
Viewshed impacts	11%	MN	Categorical Rating
Impact on future long-term planned site uses	11%	MN	Categorical Rating
Visitors served	11%	OC Parks	Count
Bicycle traffic	11%	MN	Categorical Rating
Utility infrastructure	11%	OC Parks	Categorical Rating

TABLE 5-6. VAST ANALYSIS ADAPTIVE CAPACITY INDICATORS AND WEIGHTING

Indicator	Weight	Data Source	Unit
Ability of landward assets to function if exposed to hazards	30%	MN	Categorical Rating
Detour availability and length	10%	MN	Categorical Rating
Available operational redundancy	10%	MN	Categorical Rating
Disruption duration	10%	MN	Categorical Rating
History of maintenance needs/costs	10%	MN, OC Parks	Hours
Requirement to protect landward asset is project is eroded	30%	MN	Categorical Rating

5.2.2 VAST Results

The results of the VAST analysis are summarized in this section. Further details regarding scoring for each individual indicator can be found in Appendix B. The complete VAST assessment spreadsheet, containing all data, assumptions, and results, is provided in Appendix C. The results for exposure, sensitivity, and adaptive capacity for the three locations are below. This is followed by a discussion of vulnerability and risk associated with each of the locations.

Exposure: Asset ID 1 (South Reach – Cobble Berm and Dune) has the highest exposure score for both flooding and erosion due to its location further seaward than the other two locations. Asset ID 2 (South Reach – Cobble Berm, Dune, and Parking Retreat) and Asset ID 3 (North Reach – Cobble Berm and Dune) are roughly equal in terms of hazard exposure, with the North Reach location showing slightly lower exposure to flood hazards under current conditions. The South Reach as a whole is considered more exposed because of high degree of damage it has experienced in recent years (see Section 2). The North Reach is slightly less exposed due to its relative landward setback from the current high tide line. However, under 3.3 ft of SLR, both locations are anticipated to be severely exposed to coastal hazards unless adaptation measures are implemented.

Sensitivity: Asset ID 1 received lower scores for several sensitivity indicators as its footprint has minimal impacts to facilities/amenities. Results also took into account that the South Reach (Asset IDs 1 and 2) sees lower visitor usage and does not support bicycle traffic. Asset ID 2, however, received the highest overall sensitivity score because of the landward asset value category. Should Asset ID 2 fail to provide protection, this would disrupt the access and safety of the highly valuable nearby residential development on Beach Rd. Asset ID 3 received the second highest score because of the sensitivity related to the high use bicycle path and landward asset value of the critical utility infrastructure located just landward of the bicycle path. Overall, Asset ID 2 was the most sensitive.

Adaptive Capacity: Adaptive capacity was a primary factor in separating the North Reach and South Reach alternatives. Both South Reach alternatives received higher scores (indicating less adaptive capacity) for all indicators save for available operation redundancy and potential disruption duration, leading to a large disparity. A key factor in the higher scores for the South Reach are the critical access provided by Beach Rd to the downcoast residential neighborhood, impacting both the more heavily weighted indicators of the ability of landward assets to function and protection requirements if project alternatives are eroded. Should the South Reach concepts fail, and the Beach Rd become exposed, the residential community access would be impacted. Beach Rd is the only access road to the community, and without an available detour, the safety of the community would be threatened. Therefore, Asset ID 1 and Asset ID 2 are the least adaptable (high score) to a failure in the pilot project. Asset ID 3 is most adaptable (low score).

Vulnerability: Exposure, sensitivity, and adaptive capacity were all equally weighted when determining overall vulnerability scores for each Pilot Project alternative (step 6). Final scores for exposure, sensitivity, adaptive capacity, and vulnerability are shown in Table 5-7 (flood hazards) and Table 5-8 (erosion hazards).

The general results for each of the three indicator categories are:

- Exposure: Asset ID 1 (South Reach – Cobble Berm and Dune) is most exposed to coastal hazards, followed by Asset ID 2 (South Reach – Cobble Berm, Dune and Parking Retreat), and the least exposed is Asset ID 3 (North Reach – Cobble Berm and Dune).
- Sensitivity: Asset ID 1 is least sensitive to coastal hazards, followed by Asset ID 3, and Asset ID 2 is most sensitive to hazards.
- Adaptive Capacity: Asset ID 1 and 2 are least adaptable to coastal hazards. Asset ID 3 is most adaptable to coastal hazards.

TABLE 5-7. VAST ANALYSIS FLOOD VULNERABILITY RESULTS

Asset ID	0 ft SLR	3.3 ft SLR	Sens	AC	0ft SLR	3.3 ft SLR
	Exp	Exp			Vul	Vul
1	3.0	4.0	2.3	3.1	2.8	3.1
2	2.5	3.0	3.1	3.1	2.9	3.1
3	2.0	3.0	2.9	1.3	2.1	2.4

Exp = Exposure
Sens = Sensitivity
AC = Adaptive Capacity
Vul = Vulnerability
Red = High; Orange = Moderate; Green = Low

TABLE 5-8. VAST ANALYSIS EROSION VULNERABILITY RESULTS

Asset ID	0 ft SLR	3.3 ft SLR	Sens	AC	0ft SLR	3.3 ft SLR
	Exp	Exp			Vul	Vul
1	3.5	4.0	2.3	3.1	3.0	3.1
2	3.0	3.0	3.1	3.1	3.1	3.1
3	3.0	3.0	2.9	1.3	2.4	2.4

Exp = Exposure
Sens = Sensitivity
AC = Adaptive Capacity
Vul = Vulnerability
Red = High; Orange = Moderate; Green = Low

Final vulnerability scores show a roughly equal vulnerability for the two South Reach Alternatives, with the more seaward alternative (Asset ID 1) slightly less vulnerable to both flooding and erosion hazards. The North Reach alternative (Asset ID 3) is consistently rated as the least vulnerable alternative.

Vulnerability is used as an indicator of the risk associated with each project. By definition, the Pilot Project's effectiveness in providing shoreline projection is uncertain. Therefore, in selecting the preferred approach and location of the Pilot Project, the three assets were analyzed to reveal the potential consequences should the project fail in certain locations. The results of this VAST analysis revealed that the potential consequences of the Pilot Project in the South Reach are more severe. Both flooding and erosion at the South Reach threaten to disrupt Beach Rd and the private residence's safety. In contrast, the North Reach could be similarly exposed to flooding and erosion, but the population and asset value affect by such hazards is significantly less, making it the least vulnerable project.

Asset ID 3 was determined to carry the lowest relative risk for Pilot Project implementation, as shown in the quantitative Figure 5-4 which summarizes the relative exposure, sensitivity, and adaptive capacity scoring of Asset IDs 1, 2, and 3.

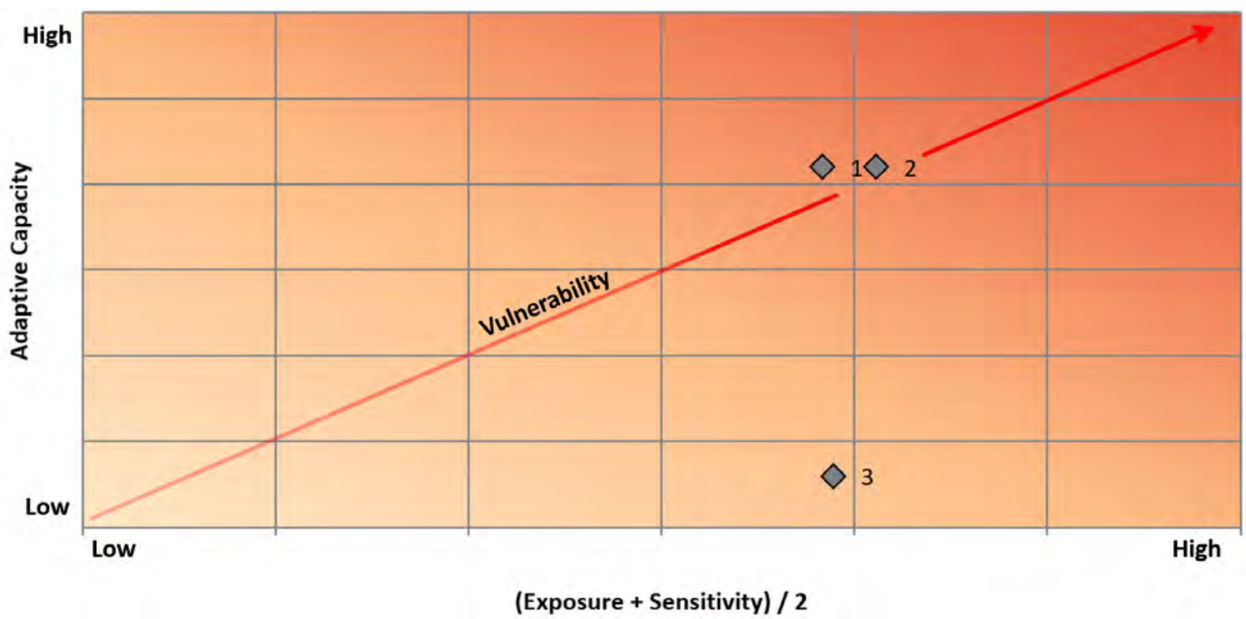


FIGURE 5-4. VAST ASSET VULNERABILILITY – RELATIVE EXPOSURE, SENSITIVITY, AND ADAPTIVE CAPACITY

6 PREFERRED CONCEPT

As indicated by the SWOT analysis, the preferred design concept is a Buried Cobble Berm and Vegetated Sand Dune. As indicated by the VAST analysis, the lowest risk project location is the North Reach. Therefore, the preferred concept is a Buried Cobble Berm and Vegetated Sand Dunes at the North Reach. The total project length for this preferred concept is up to 1,150 lf, with 600 ft in Doheny State Beach, and 550 ft in Capistrano Beach County Park. The North Reach Pilot Project area is depicted in Figure 6-1. Along the transects depicted in the Pilot Project area figure, two cross-sections of the preferred concept are detailed in Figure 6-2.

The North Reach Cobble Berm and Vegetated Dunes preferred Pilot Project includes the following components:

- Cobble Berm
- Sand Berm
- Vegetated Sand Dune
- Retreated Parking Spaces at Doheny State Beach
- Reconfigured Bike Path
- Pedestrian Pathway and Beach Access Paths
- Sand Fencing

Design considerations of each component are summarized in the sections below.

6.1 COBBLE BERM

Although cobble berms have performed well in southern California, there is a lack of quantitative design guidance for their use for coastal protection on a sandy coast. For example, the optimum void ratio has not yet been determined; however, a few design elements have been determined. Larger clasts require less volume to provide coastal protection due to the decreased tendency to mix with sand. Higher cobble berms provide greater protection from property flooding; however, lower berms allow for some overwash that can be beneficial to stabilization. One way to optimize both flood protection and stability is to increase the width of the cobble berm.

Cobble material is defined as rounded stone with a diameter of 64-256 mm, or 2.5-10 in. (Wentworth, 1922). Cobble berms are naturally occurring features located at shorelines adjacent to river mouths or cobble-containing bluffs, which are both sources of cobble to the littoral cell. Due to the relatively large diameter of the cobbles, they are fairly stable at steep slopes and have been documented to accrete cobble during severe wave events (Everts & Eldon, 2002). An example of naturally occurring cobble berms exist on beaches adjacent to the Batiquitos Lagoon as well as at the Project site (during eroded conditions). Cobble berms have been replicated (engineered) in a number of projects along the west coast (Oregon, Ventura, CA, and Encinitas, CA). A cobble berm feature was considered for the Project to increase the stability of the shoreline, protecting infrastructure and dune habitat area against wave attack. The berm would be constructed of existing and imported cobble of a similar size.

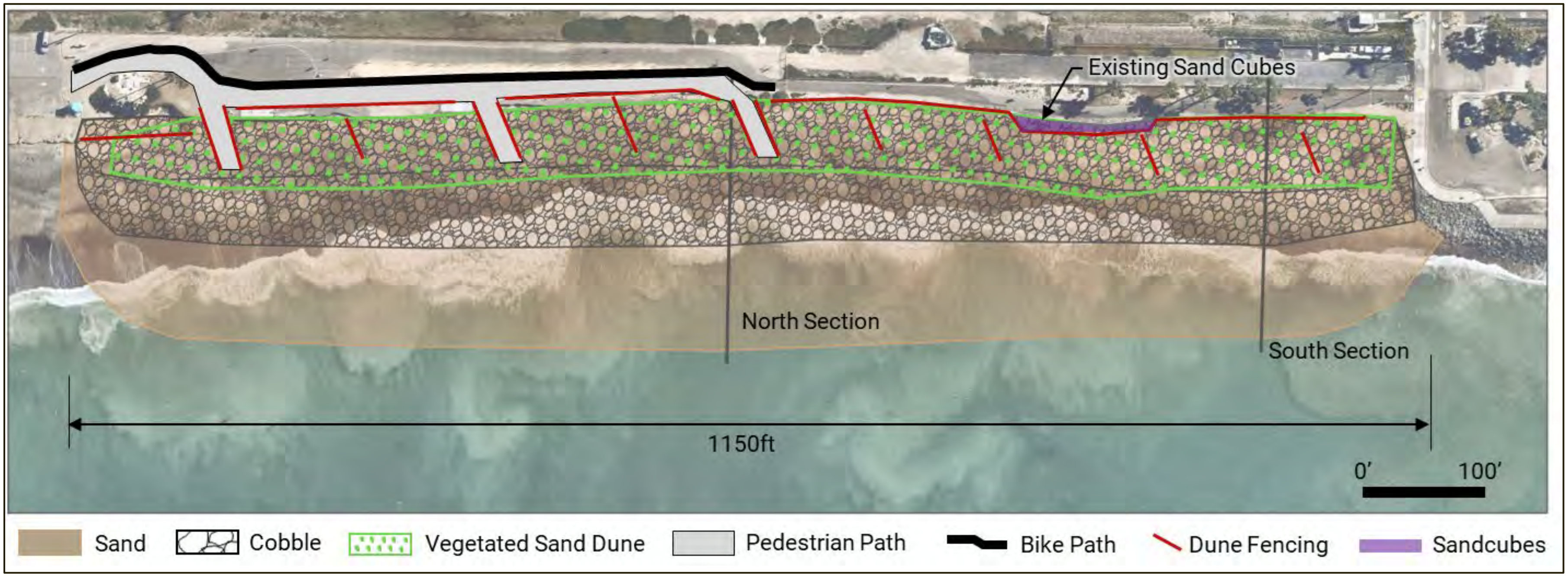
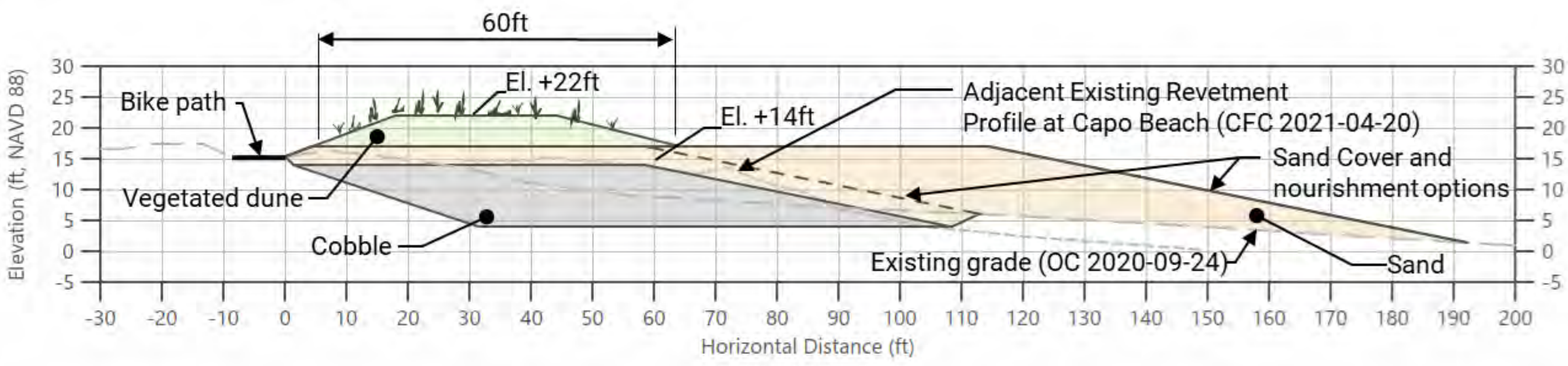


FIGURE 6-1. NORTH REACH COBBLE BERM AND VEGETATED SAND DUNE PILOT PROJECT – PLAN VIEW

South (Capo) Section



North (Doheny) Section

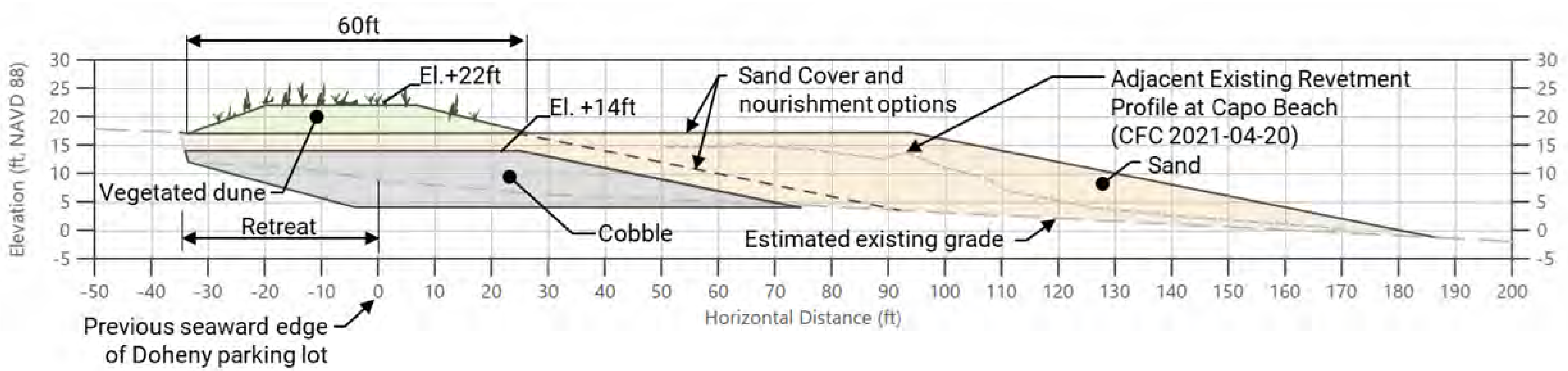


FIGURE 6-2. NORTH REACH COBBLE BERM AND VEGETATED SAND DUNE PILOT PROJECT – CROSS-SECTIONS

Although no engineering best practices have been developed for cobble berms, a handful of cobble berm projects have been completed. A summary of key design parameters of these projects is provided in Table 6-1 to identify trends towards design criteria. Parameters included berm length, width, height, cy per linear foot, crest and base elevation, crest width, side slopes, grain size, and design life.

Because of the ability of cobble berm shape to be adjusted by wave action, parameters which are typically significant for a rock revetment are not considered as important for a cobble berm, such as crest elevation, base elevation, and side slope. One key parameter is the cy per linear foot (cy/lf). In southern California, the greatest observed berm volume was 20 cy/lf in Encinitas, CA. However, on the US East Coast, as well as the coast of England, projects regularly exceed this volume. The Capo Beach Pilot Project is conservatively proposed to be based on 25 cy/lf. Assuming the full North Reach Pilot Project length of 1,150 ft and no use of existing onsite cobble, approximately 28,000-30,000 cy of cobble will need to be imported to construct the Pilot Project. This volume will need to be confirmed as part of the final design.

Excavation of the existing beach will be required in order to install the cobble berm. The excavated material will be used to cover the cobble.

1.1. Sand Berm

A wide sandy beach berm will be critical to maintaining the vegetated dunes. Preliminarily, it is assumed a sustainable vegetated dune will require a foreshore beach berm of at least 50-60 ft wide to buffer the dunes from seasonal erosion and smaller storm events. This sand berm will be constructed to cover the cobble berm, using both excavated and imported sand. Based on 2020 topobathy conditions, it is estimated that sand excavation volumes (for cobble placement) will generate approximately 10 cy/lf of project. An additional 50,000 to 70,000 cy of sand will need to be imported to construct the beach berm (and vegetated dunes). This volume will need to be confirmed as part of the final design and based on beach conditions at the time of construction.

Additionally, as the beach erodes, sand import will also be required for periodic renourishments. Assuming the continued progression of observed average annual erosion rates (8.6 ft/year), the initial 50-60 ft wide beach berm would be completely eroded within approximately 5-7 years. Therefore, renourishments could be needed at least every 5-7 years in the near-term and likely more frequently (or of larger nourishment volume) in the long-term considering the potential erosive impacts of future potential SLR.

6.2 Vegetated Sand Dune

Vegetated sand dunes offer a living shoreline form of coastal protection by raising shoreline elevations to minimize inland flooding, capturing windblown sand, stabilizing sandy shorelines with rooted vegetation and installed fencing, and preserving a bank of sand in case of an erosive event. Vegetated sand dunes were once more common along the southern California coastline, developing naturally along low-lying sand spits at river and estuary mouths. Vegetated dunes have not been known to be present along the Doheny/Capo shoreline. Human development has come to dominate the shoreline across southern California, and few natural dune systems can be found. Dune restoration offers an opportunity to return portions of the coastline to a more natural condition but assumes the presence of a wide sandy beach berm. Dune restoration at Capo Beach has two primary objectives: 1) provide added coastal protection from storm waves and SLR, and 2) enhance native flora and fauna habitat in beach areas.

TABLE 6-1. COBBLE BERM DESIGN ANALYSIS

Location	Length	Width	Height	Volume	CY per Lf	Crest EL	Base EL	Crest Width	Slope	Grain Size	Design Life	Reference
Surfer's Point, Ventura, CA	1800 ft	94-110 ft	8 ft	33000 cy	18	13.5 ft	5.5 ft (at or below scour elevation)	~40 ft	5:1 H:V	4-12 inches (Keep uniform. The larger the less it moves)		City of San Buenaventura, Public Works Department (Buenaventura), 2003
Surfer's Point, Ventura, CA	800 ft			4800 cy	6						10 years	Ventura River Ecosystem. Surfer's Point Case Study. Jenkin, P., 2015
Cardiff Beach, Encinitas, CA	2900 ft	15 ft	3 ft	~2400 cy	1	15 ft NAVD88	12 ft NAVD88	0 ft	2:1 back, 3:1 front	~3-8 inches	Dune system ~30 years	M&N, 2018
Encinitas, CA	5100	20 ft			20	15 ft MLLW						M&N, 1996
Cape Lookout State Park, OR	984 ft	40 ft	11.5 ft			22 ft NAVD88			6:1 H:V			Komar, P.D. and Allan, J.C., 2010
Clatsop County, OR				8000 cy gravel; 18000 cy cobble		22 ft		65 ft	5:1 H:V		30-50 years	Allan, J.C. and Gabel, L.L., 2016
Scituate, MA	1200 ft	120 ft	16 ft	137000 cy	114 (w/ 20 cy above 100-yr WL to comply w/ FEMA 540 Rule)	12 ft NAVD88 (expected to build naturally to +17ft during 50-yr storm)	-4 ft NAVD88	60 ft	4:1 H:V			Applied Coastal Research and Engineering, Inc., 2016
Church Norton, West Sussex, England	656 ft			19619 cy	30					Shingle		Moses, C.A. and Williams, R.B., 2008
Hythe to Folkestone, West Sussex, England	22966 ft			464322 cy	20					Shingle		Moses, C.A. and Williams, R.B., 2008
Tankerton, West Sussex, England	7546 ft			170033 cy	23					Shingle		Moses, C.A. and Williams, R.B., 2008
South Canterbury, New Zealand	984 ft			12818 cy	13							Kirk, R. M., 1992
Capistrano Beach – Pilot Project	**1150 ft**	**110 ft**	**10 ft**	**16000 cy**	**25**	**13-14 ft NAVD88**	**3-4 ft NAVD88**	**65 ft**	**5:1 H:V**	**2.5-10 inches (Wentworth, 1922)**		

The dune will be created from the import of beach compatible sand. The sand will be placed in a hummock profile to mimic a natural dune system. The dunes will then be planted and seeded with native plant seed. Sand gradation of both the receiving beach and the sand source material will be compared and assessed to confirm compatibility prior to construction. Coarse to medium-grained sand (> 0.25 mm median diameter) should be used to foster growth of native plants and use of the area by native fauna. This gradation is similar to the native beach sand and is also ideal from a shore protection perspective. Sand granularity affects permeability, which, in turn, affects the chemical nature of the substrate to which native flora and fauna are adapted. Time and precipitation may be needed to assist in the leaching of salts and other dissolved solids that may be a part of the introduced substrate. Irrigation may also be applied to shorten the time period for this condition to form.

Preliminary design of a vegetated sand dune concept is based upon that of the Cardiff Living Shoreline design (M&N, 2018).

- Crest height is proposed at approximately +22 ft NAVD88.
- Foreslope is designed at 4:1 (H:V); backslope is designed at 3:1 (H:V).
- Dune width is proposed at a minimum of 60 ft. Along the Doheny State Beach retreated parking lot, additional area is available and can be occupied by the dune system. A portion of the dune toe, on its seaward edge, should be considered sacrificial and most likely to require maintenance through adding sand. For the Cardiff Living Shoreline, a 20-foot-wide sacrificial dune toe was included.
- A foreshore beach berm width of at least 50 ft must be maintained.
- Importing sand dune material with medium to coarse grain sand can improve the longevity of dry beach width due to its resistance to wave erosion. Source sand gradation is also a factor that may impact blowing sand. Coarser gradation source materials are less likely to become mobilized by aeolian transport.
- Utilizing the above design components and placing the dune atop the cobble berm and replaced beach sand material, it is estimated that necessary dune import volume will be approximately 6 cy/lf at Capistrano Beach, and 15 cy/lf at Doheny State Beach.

Design of the Cardiff dune was defined through model analysis of storm waves and beach erosion, used to inform crest height and dune width, among other specifications. A similar study would support the convergence on clear dune design criteria at Capo Beach but may not be possible given the required timeline for implementation of this Pilot Project.

Many bird species, such as the California least tern and western snowy plover, use sandy beach habitat to nest and feed. The proposed vegetated sand dune can provide habitat for such threatened and endangered avian species. Examples of successful vegetated dunes within San Diego County include that at the Tijuana River Estuary, Coronado Beach, San Diego River Inlet, and the recently constructed Cardiff Living Shoreline Project at Cardiff State Beach in Encinitas, CA. The California grunion (Leuresthes tenuis) spawn on sandy beaches during the spring and summer months. The construction of a cobble berm is not anticipated to directly affect these events because the berm is proposed to be buried under sandy material suitable to grunion. Should the cobble berm be exposed by erosion, the shoreline may not support grunion spawning at that time. However, loss of beach width due to SLR and long-term erosion is anticipated under a No Project condition (M&N, 2019), which will directly impact the available habitat of the California grunion.

6.3 Retreated Parking Spaces at Doheny State Beach

Along the 600-linear-foot reach at Doheny State Beach, the parking lot and turnaround is proposed to be retreated approximately 20 ft landward (i.e., loss of 20 ft width of parking lot along 600 lf). This reach is currently vulnerable to erosion, as portions along the south end have already experienced undermining and retreat. Asphalt would be sawcut and disposed offsite.

The retreat would remove approximately 25 parking spaces on the seaward side of Doheny State Beach parking lot, including several which have already been lost to parking lot undermining. Additionally, an extended bike path would be shifted to occupy another 25 parking spaces on the landward side, for a total of approximately 50 lost parking spaces.

6.4 Extended Bicycle Path

The reduced parking lot area would encroach on the existing bicycle path through shared vehicle access in Doheny State Beach parking lot. The bike path is proposed to be shifted to the landward side of the parking lot and delineated specifically for bike access.

6.5 Pedestrian Pathway and Beach Access Paths

Between the extended bicycle path and the vegetated sand dune along Doheny State Beach, a pedestrian pathway leading to three beach access paths is proposed. The shore-parallel pedestrian pathway is currently envisioned as a decomposed granite (DG) path, matching that of the Cardiff Living Shoreline. However, other pathway types may be employed.

The three shore-perpendicular beach access pathways would simply be demarcated and unvegetated reaches across the vegetated sand dunes. Beach access orientations would be angled perpendicular to the predominant extreme wind direction. Should ADA access be preferred, a boardwalk or Mobi-Mat could be utilized at one or all beach access paths.

6.6 Sand Fencing

Windblown sand capture is important for the natural growth of the dune system. Also, the potential for wind to blow sand from the created dune features into the bike path is identified as a maintenance concern. Therefore, in addition to vegetation, sand fences are a low-cost method of controlling blowing sand. The Cardiff Living Shoreline includes a 3-ft tall sand fence with ~1-2-in slats placed in parallel with the bike lane/foot trail plus intermittent sand fences in the dune. Rice straw/straw waddles are another material which can be used temporarily to promote the capture of wind-blown sand.

7 SUMMARY/CONCLUSIONS

Capo Beach is in a current state of erosion, and OC Parks (and California State Parks) infrastructure have been flooded, undermined, and damaged. Without action, these public spaces and facilities are at risk of being lost. While hardening the shoreline can protect landward assets, OC Parks is considering a Pilot Project to assess the feasibility of a nature-based approach to shoreline stabilization and enhancement.

This study addressed the feasibility of a cobble berm/living shoreline Pilot Project at Capo Beach primarily in the context of: a) likelihood of providing valuable information for long-term plans; b) likelihood of success in protecting the shoreline; c) risks to existing infrastructure if the Pilot Project protection is not successful and implications for optimized project location; d) identification of preferred nature-based alternative; and e) availability of funding and material sourcing to construct and maintain the Pilot Project.

If implemented, the Pilot Project would inform the future long-term plan for Capo Beach, as well as other open ocean applications regionally and even statewide. The likelihood of success in the Pilot Project protecting the Capo Beach is less clear, although cobble is regarded as a resilient coastal material, and there is a reasonable chance of success.

Uncertainties exist regarding the potential for the imported cobble to move offshore or downcoast. Longshore transport of cobble remains a knowledge gap due to a lack of academic research on this topic in southern California and to modeling limitations; as a result, risks of the constructed Pilot Project to negatively impact the existing shoreline dynamics and marine habitat are uncertain.

In lieu of precise numerical tools and extensive research, the nature of a Pilot Project is to construct an on-the-ground model with the intention of studying its performance to learn lessons for future improvements. Therefore, this project may be constructed with an acceptable high degree of uncertainty, with the intention to learn from and build upon its observed response to coastal conditions. To capitalize on an experimental effort, it is important to design and incorporate long-term monitoring and analysis of the project.

To identify a feasible project location, risks to vulnerable infrastructure associated with the project were characterized by the VAST analysis. The VAST analysis evaluated three project locations: South Reach with partial parking lot removal; South Reach with full parking lot width removed; and North Reach along the Capo Beach bicycle path and part of Doheny State Beach. In selecting the preferred approach and location of the Pilot Project, the three assets (project alternatives) were analyzed to reveal the potential consequences should the project fail in certain locations.

The results of this VAST analysis revealed that the potential consequences of the Pilot Project in the South Reach are more severe as compared to the North Reach. Should flooding and erosion overwhelm the South Reach, access to Beach Road would be threatened. Beach Road is the only access road to the 205 residential units (value greater than $600 million), and any threat to its use becomes a major risk to public safety. Because of the uncertainties in the effectiveness of the Pilot Project, backstops would need to be incorporated into the design (revetment, vertical wall) to reduce the liability for risks undertaken by the County. In contrast, the North Reach could be similarly exposed to flooding and erosion, but the population and asset value affect by such hazards is significantly less, reducing its vulnerability.

The North Reach alternative is consistently rated by VAST as the least vulnerable alternative and is considered the lower risk alternative. Should a project be constructed in the North Reach, the performance and lessons learned can potentially be transferred to the South Reach to develop an appropriate adaptation solution.

This report assessed various nature-based Pilot Project alternatives—two different design concepts and at two different shoreline locations. Based on comparison of strengths, weaknesses, opportunities, threats, and vulnerability assessment of each alternative, the preferred project is a buried cobble berm and vegetated sand dune spanning the northern end of Capo Beach and southern end of Doheny State Beach. Import of sand and cobble will be required. Installation of a beach berm is included in the preferred concept in order to maximize the chances of success for this Pilot Project. Without a maintained wide sandy beach berm, the cobble berm would be tested as a "last line of defense." Although the project is anticipated to be more successful if a wide beach berm is maintained, conditions when this is not possible may serve as the most educational regarding the effectiveness of cobble material for shoreline protection.

For the preferred North Reach Pilot Project, its conceptual design was further developed and key components were identified, including cobble berm, sand berm, vegetated sand dune, removed parking at Doheny State Beach, relocated bicycle path, pedestrian pathway, beach access paths, and sand fencing.

The feasibility of the County to fund construction and maintenance of the Pilot Project is a final key variable. A rough order of magnitude preliminary estimate of probable initial construction cost was calculated based on the conceptual level of design. The estimate ranges from $3 million to $8 million. Significant unknowns which drive the wide range of costs are the source of imported sand, source of imported cobble, and required volumes of sand and cobble. These knowledge gaps require future investigation. The County has applied for grant funding but has not yet been successful in obtaining funding to construct the project. Additional funding will be needed to import sand (and possibly cobble) to maintain the beach berm and dunes over time.

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APPENDIX A PRELIMINARY CONCEPTS

FIGURE A-1. SOUTH REACH – BURIED COBBLE BERM CONCEPT – PLAN VIEW

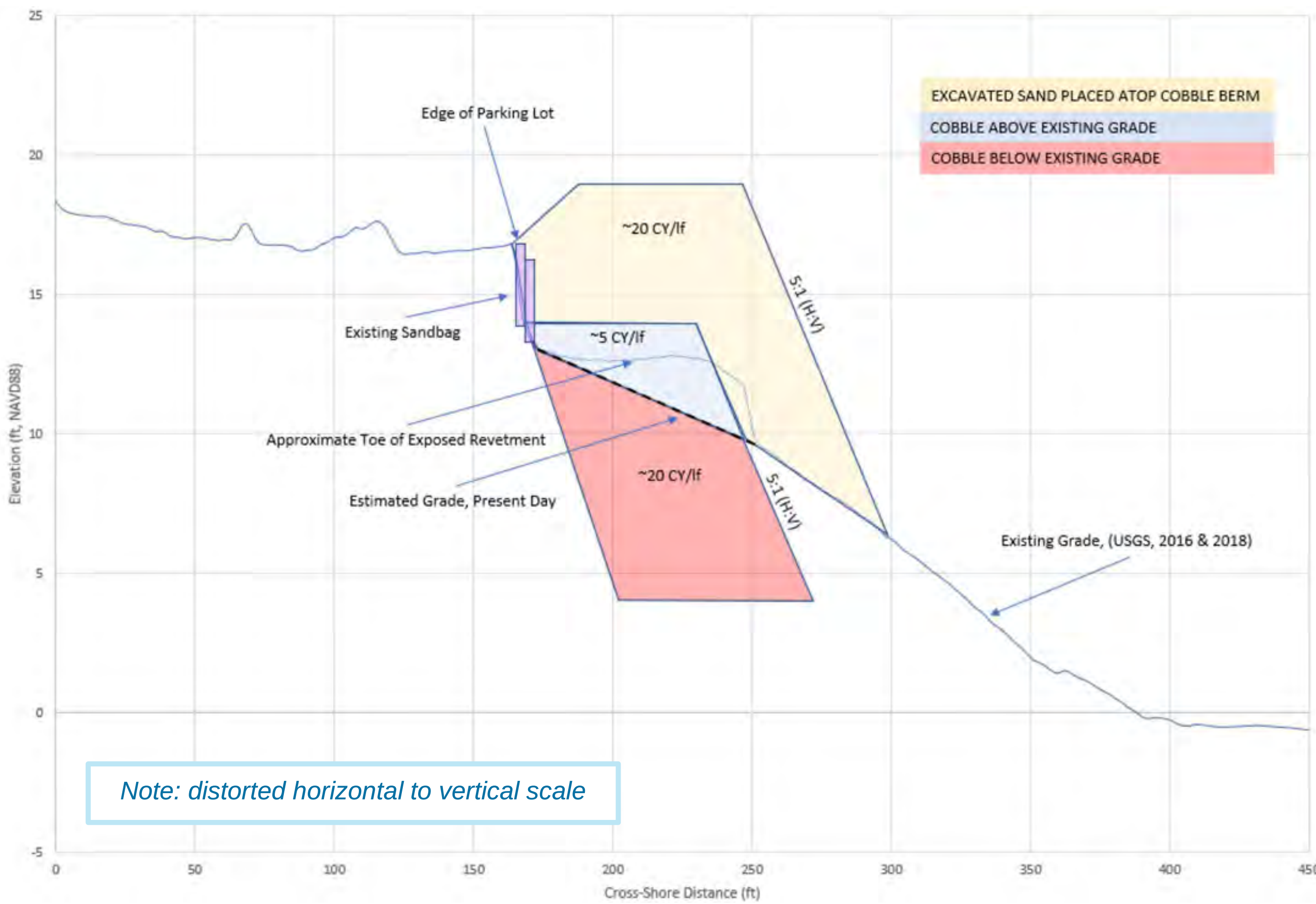


FIGURE A-2. SOUTH REACH – BURIED COBBLE BERM CONCEPT – CROSS-SECTION

FIGURE A-3. SOUTH REACH – PARTIALLY REMOVED PARKING LOT, BURIED COBBLE BERM, AND VEGETATED DUNE CONCEPT – PLAN VIEW

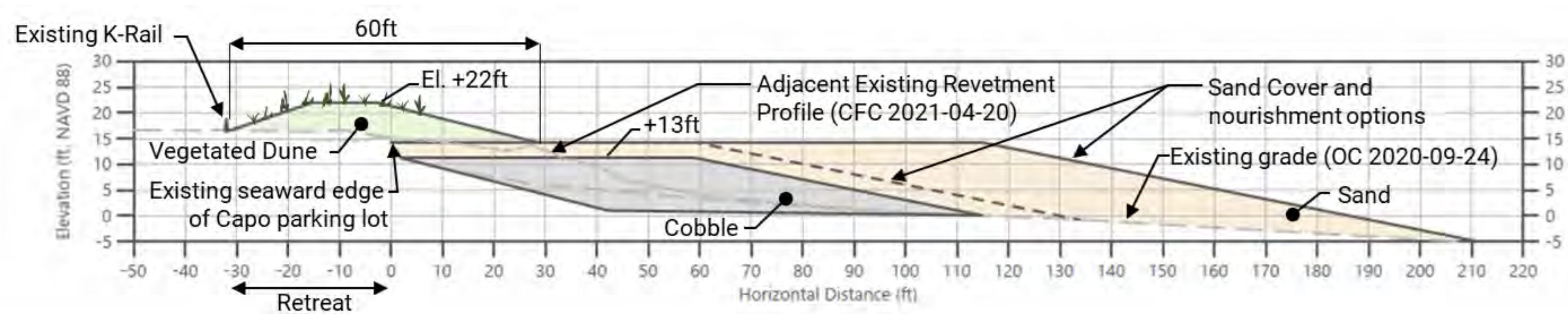


FIGURE A-4. SOUTH REACH – PARTIALLY REMOVED PARKING LOT, BURIED COBBLE BERM, AND VEGETATED DUNE CONCEPT – CROSS-SECTION

Figure A-5. South Reach – Fully Removed Parking Lot, Buried Cobble Berm, and Vegetated Dune Concept – Plan View

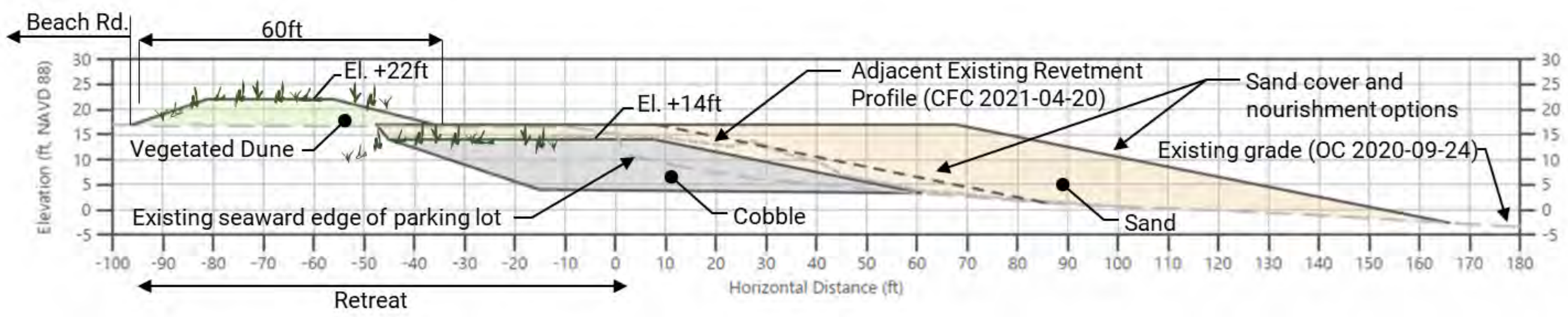


FIGURE A-6. SOUTH REACH – FULLY REMOVED PARKING LOT, BURIED COBBLE BERM, AND VEGETATED DUNE CONCEPT – CROSS-SECTION

FIGURE A-7. NORTH REACH – BURIED COBBLE BERM CONCEPT – PLAN VIEW

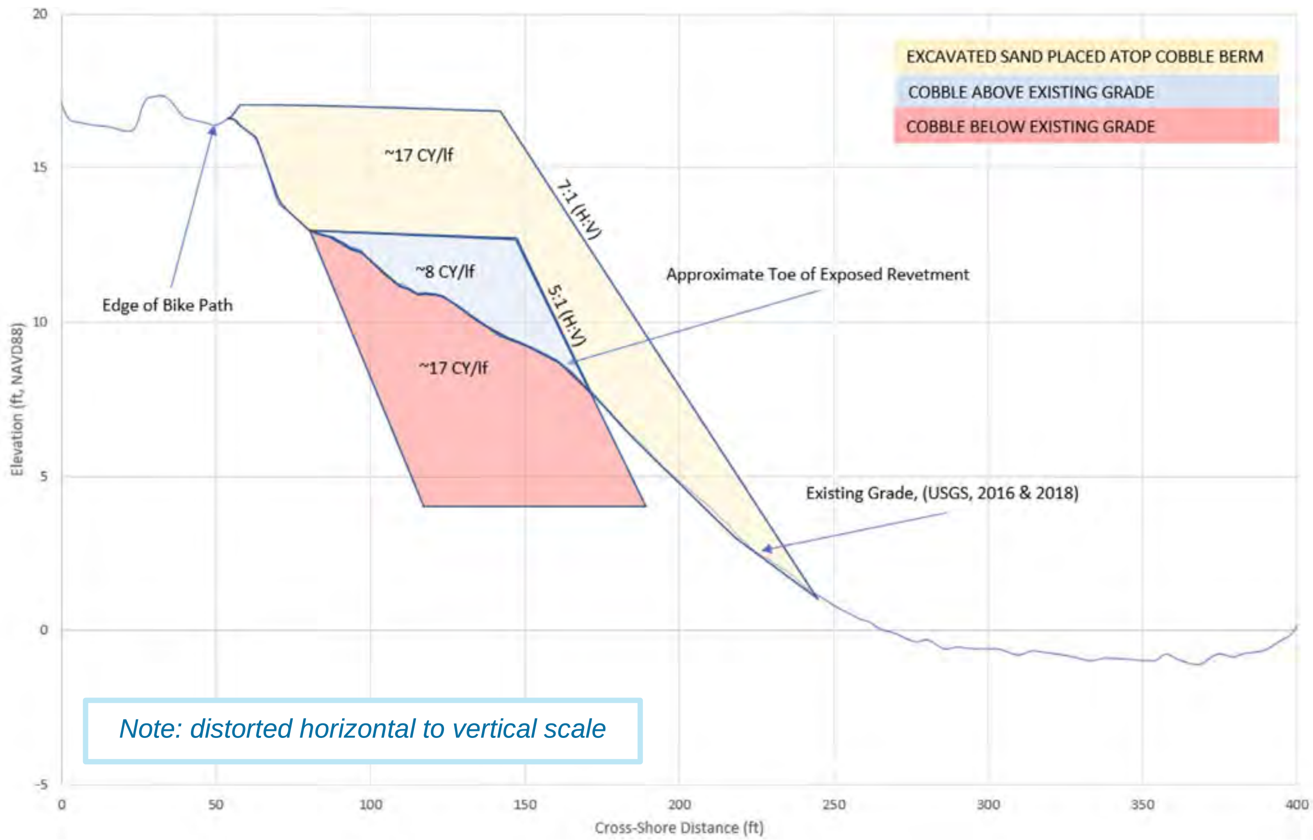


FIGURE A-8. NORTH REACH – BURIED COBBLE BERM CONCEPT – CROSS-SECTION

Figure A-9. North Reach – Buried Cobble Berm and Vegetated Dune Concept – Plan View (Superceded)

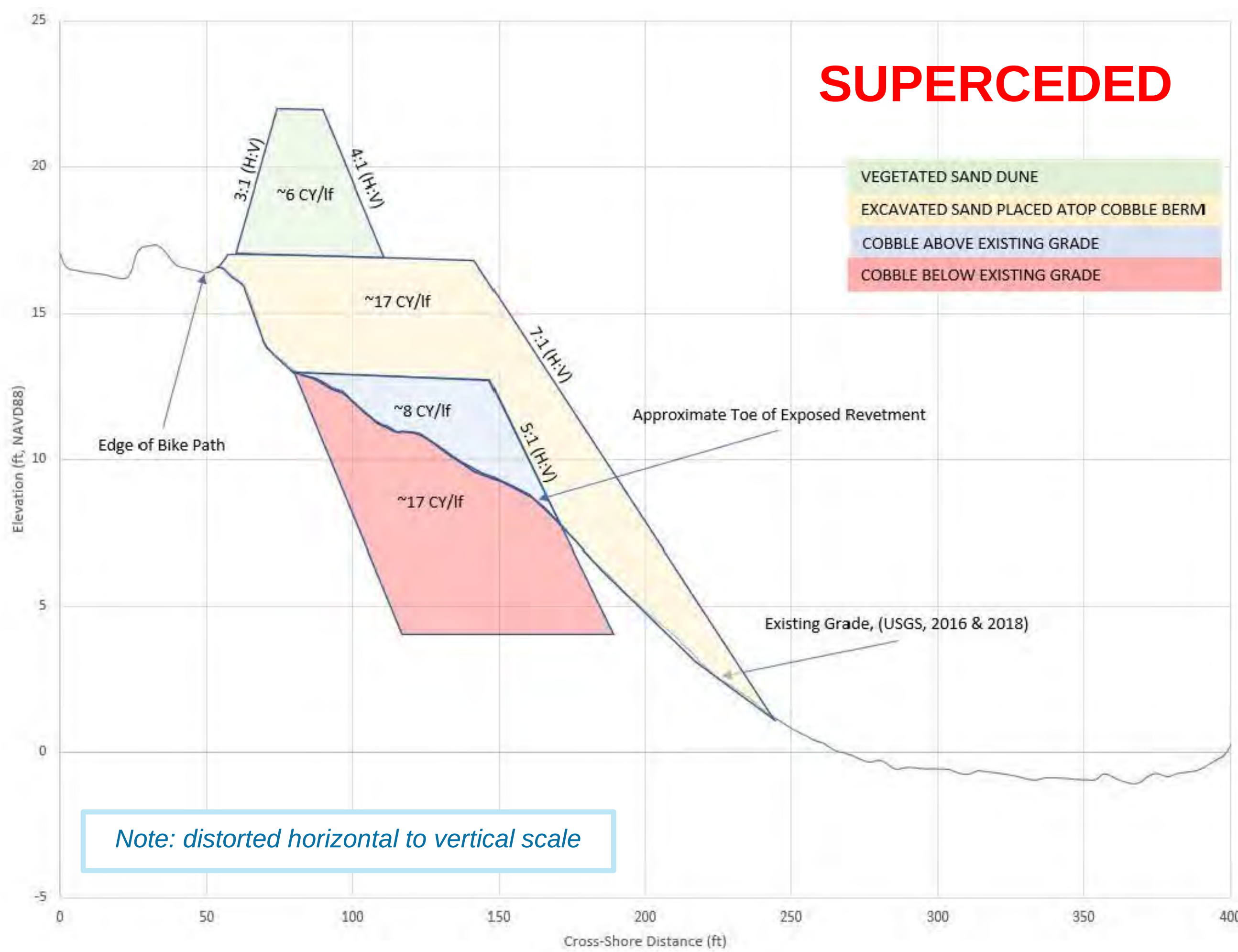


FIGURE A-10. NORTH REACH – BURIED COBBLE BERM AND VEGETATED DUNE CONCEPT – CROSS-SECTION (SUPERCEDED)

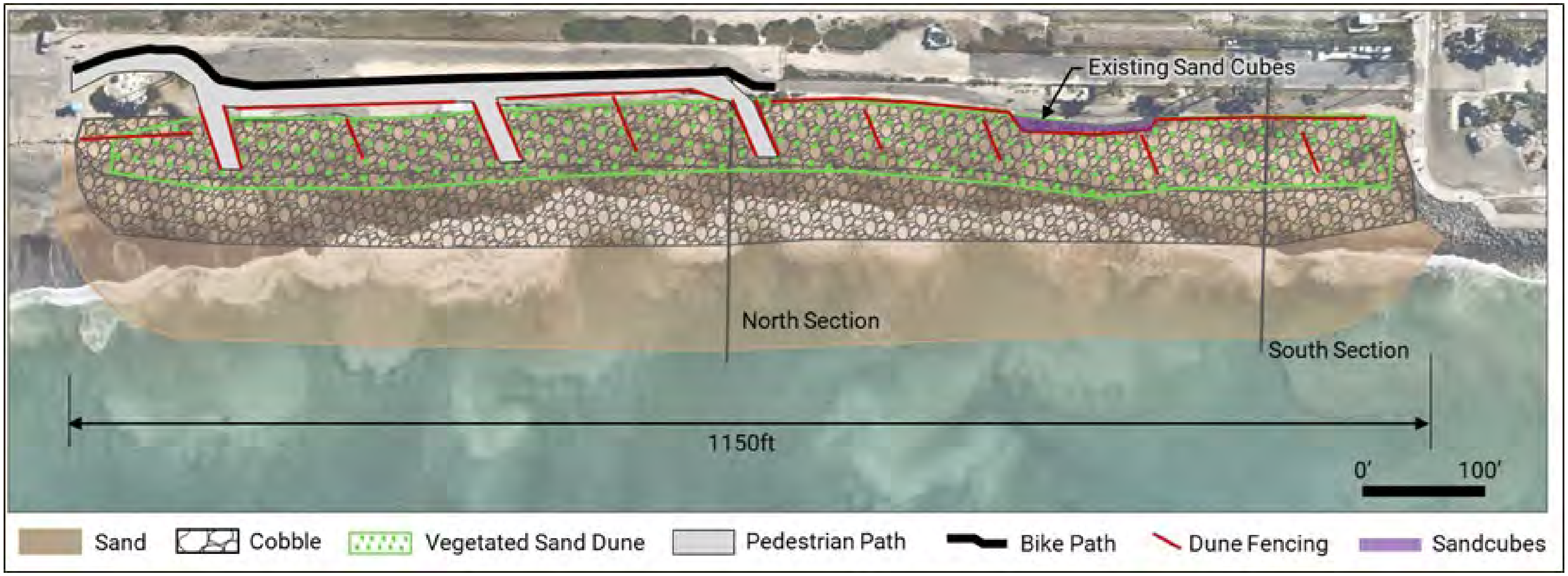
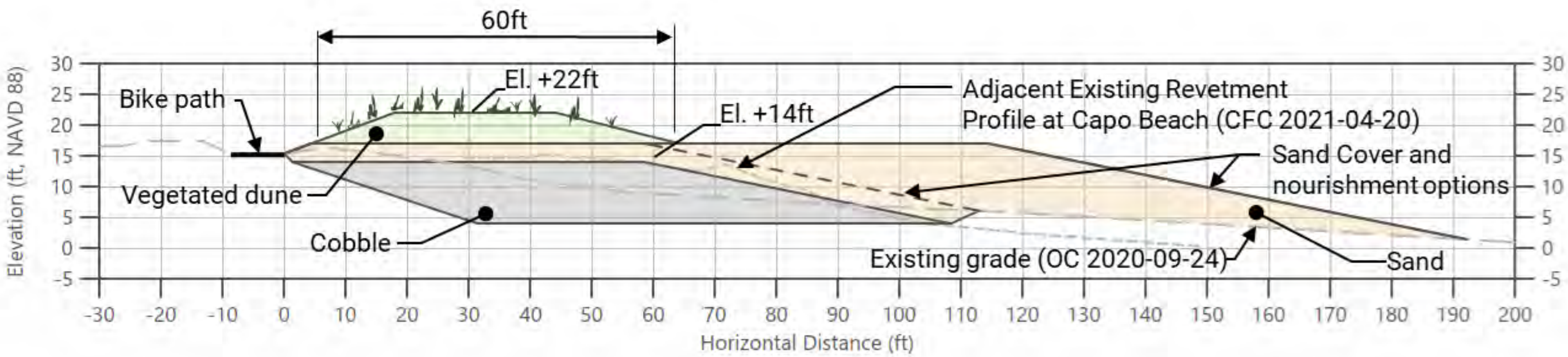


FIGURE A-11. NORTH REACH – BURIED COBBLE BERM AND VEGETATED DUNE CONCEPT – PLAN VIEW

South (Capo) Section



North (Doheny) Section

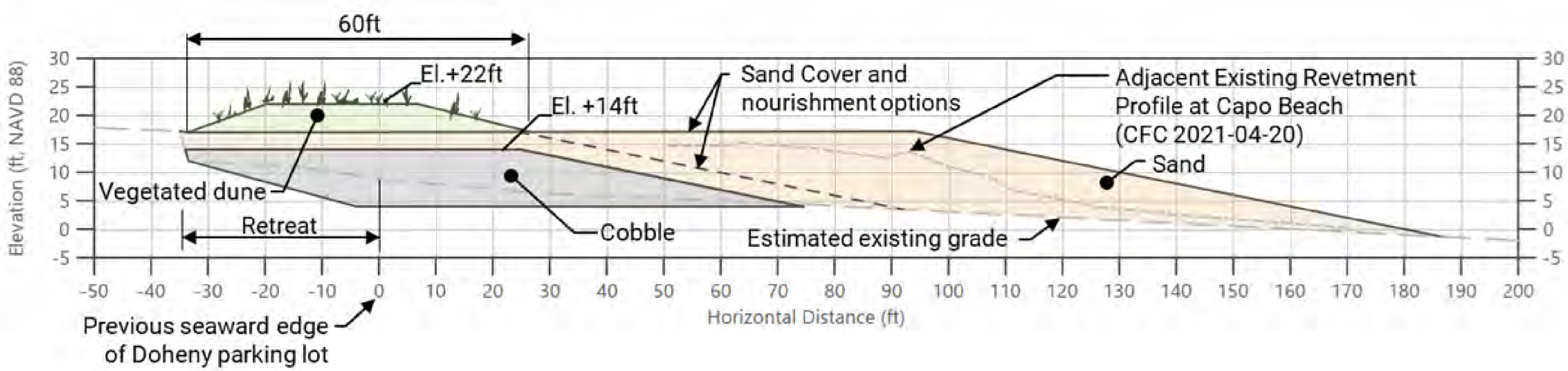


FIGURE A-12. NORTH REACH – BURIED COBBLE BERM AND VEGETATED DUNE CONCEPT – CROSS-SECTIONS

APPENDIX B VAST SCORING TABLES

TABLE B-1. VAST ANALYSIS FLOOD EXPOSURE SCORING

Exposure		Flooding									
		0 ft SLR		3.3 ft SLR		0 ft SLR		3.3 ft SLR		0 ft SLR	3.3 ft SLR
		Percent Length of Site Historically Flooded				Percent Area of Project Footprint Projected for 100-yr Storm Flooding (CoSMoS)				Exposure Scores	
Asset ID	Asset Name	Value	Score	Value	Score	Value	Score	Value	Score		
1	South Reach - Cobble Berm & Dune	100	4	100	4	34	2	79	4	3.0	4
2	South Reach - Cobble Berm, Dune, & Parking Lot Retreat	100	4	100	4	2	1	46	2	2.5	3.0
3	North Reach - Cobble Berm & Dune	50	2	50	2	49	2	83	4	2.0	3.0

TABLE B-2. VAST ANALYSIS EROSION EXPOSURE SCORING

Exposure		Erosion									
		0 ft SLR		3.3 ft SLR		0 ft SLR		3.3 ft SLR		0 ft SLR	3.3 ft SLR
		Percent Length of Site Historically Eroded				Projected Shoreline Erosion Width of (CoSMoS)				Exposure Scores	
Asset ID	Asset Name	Value	Score	Value	Score	Value	Score	Value	Score		
1	South Reach - Cobble Berm & Dune	100	4	100	4	140	3	167	4	3.5	4.0
2	South Reach - Cobble Berm, Dune, & Parking Lot Retreat	100	4	100	4	64	2	92	2	3.0	3.0
3	North Reach - Cobble Berm & Dune	50	2	50	2	175	4	195	4	3.0	3.0

TABLE B-3. VAST ANALYSIS SENSITIVITY SCORING

Sensitivity	Number of Parking Spaces Lost		Critical Facilities		Landward Asset Value		Visitor Usage Protected by Project		Viewshed Impacts		Impact on Future Planned Site Uses		Visitors Served		Bicycle Traffic		Utility Infrastructure		Overall
Asset ID	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Scr
1	0.0	1	0.0	1	643910000	4	2.0	3	2.0	3	2.0	3	350000.0	2	0.0	1	2.0	3	2.3
2	11.0	4	1.0	4	643910000	4	1.0	2	3.0	4	3.0	4	350000.0	2	0.0	1	2.0	3	3.1
3	0.0	1	1.0	4	5000000	1	3.0	4	1.0	2	1.0	2	1000000.0	4	3.0	4	3.0	4	2.9

Val = Value, Scr = score

TABLE B-4. VAST ANALYSIS ADAPTIVE CAPACITY SCORING

Adaptive Capacity	Ability of Landward Asset top Function if Exposed		Detour Availability and Length		Available Operation Redundancy		Disruption Duration		History of Maintenance Needs/Costs		Requirement to Protect Landward Assets if Project is Eroded		Overall
Asset ID	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Val	Scr	Scr
1	3.0	3	4.0	4	1.0	1	8.0	2	3.0	3	3.0	4	3.1
2	3.0	3	4.0	4	1.0	1	8.0	2	3.0	3	3.0	4	3.1
3	1.0	1	1.0	1	3.0	3	8.0	2	1.0	1	0.0	1	1.3

Val = Value, Scr = score

APPENDIX C COMPLETE VAST SPREADSHEET

Step 1. Select Climate Stressors and Asset Types

(1) Stressors and Asset Types > (2) Enter Assets > (3) Browse and Select Indicators > (4) Collect Data > (5) Adjust Scoring > (6) View Results

Back

Use this sheet to configure the rest of the spreadsheet based on the number of climate stressors and asset types you plan to include in your vulnerability screen. You can return to this screen to add climate stressors or asset types at any time. You can use this tool to evaluate vulnerability for any asset types to any climate stressors. However, helpful guidance can be provided for conducting a vulnerability screen for the asset types and stressors used in the Gulf Coast Study (listed in the drop-down menus).

The asset types and stressors you select will be used to structure the vulnerability spreadsheet and provide suggestions of indicators to use.

Once you are done making any changes to this sheet, click the "Update Stressors & Asset Types" button.

Update Stressors & Asset Types

Step 2

Enter Assets

(remember to click the 'Update' button first if you have made changes!)

Step 1a. Select Climate Stressors

A climate stressor is defined in this tool as an external change in climate that may cause damage to the transportation system. Sometimes referred to as climate variables, these may include projected temperature changes, precipitation changes, sea level rise, or severe storms. The vulnerability screening framework implemented in this tool can be used to assess vulnerability to any stressor. However, helpful guidance can be provided for conducting a vulnerability screen for the stressors used in the Gulf Coast Study (listed in the drop-down menu).

Note:

Do NOT insert columns or rows throughout the tool, unless explicitly told you can do so.

Use the yellow cells below to enter the climate stressor(s) you want to include in your vulnerability screen. Use buttons to add or remove stressors.
These stressors will be used to structure the vulnerability analysis and provide suggestions of indicators to use. You may select up to 5 stressors.

Enter the number of stressors you plan to include: 2

	Climate Stressor:	Type (if Other)
Stressor 1	Other	Flooding
Stressor 2	Other	Erosion

Step 1b. Select Asset Types

In this tool, "asset type" refers to a type of transportation asset. These "asset types" can be very broad, along the lines of transportation modes (e.g., "Highways" and "Ports") or very specific (e.g. "docks"). They key factor to consider in deciding how to break out asset types is whether you want to use the same vulnerability indicators for everything in that group. For example, in the Gulf Coast Study, the "asset types" evaluated actually referred to transportation modes -- Highways, Ports, Airports, Rail, and Transit. Different indicators were used to assess vulnerability for each asset type.
The vulnerability screening framework implemented in this tool can be used to assess vulnerability for any asset type. However, helpful guidance can be provided for conducting a vulnerability screen for six "modal" asset types used in the Gulf Coast Study (starred in the drop-down menu).

Use the yellow cells below to enter the asset type(s) you want to include in your vulnerability screen. Use buttons to add or remove stressors.
These types will be used to structure the vulnerability analysis and provide suggestions of indicators to use. You may select up to 6 asset types.

Enter the number of asset types you plan to include: 1

	Asset Type:	Type (if Other)
AType 1	Other	Living Shoreline & Coastal Park

Click the "Update Stressors and Asset Types" button at the top of the sheet once you have entered your stressors and asset types.

Step 2. Enter Specific Assets

You can insert columns here

(1) Stressors and Asset Types > (2) Enter Assets > (3) Browse and Select Indicators > (4) Collect Data > (5) Adjust Scoring > (6) View Results

Back

For each asset type, enter the assets you wish to include in your vulnerability screen. You may enter an unlimited number of assets.

You must provide a unique Asset ID for each asset that you enter. If you do not already have IDs for your asset (e.g., in an existing database)s, a simple convention like "1," "2," "3," can be helpful.

Optional fields for asset latitude and longitude are provided to facilitate interaction with your GIS system, if desired. You can also add any other columns you want to help describe each asset (e.g., mile marker for roads or additional coordinate information for non-point assets).

Which assets to enter? | How to add columns?

Update Assets

Step 3

Browse Indicators

Delete Selected Assets

Living Shoreline & Coastal Park Number entered: 3

Enter a unique ID for each asset	Enter an asset name/descriptor	Enter asset coordinates (optional)	
Asset ID	**Asset Name**	**Latitude**	**Longitude**
1	South Reach - Cobble Berm & Dune	33°27'13.44	117°39'57.57"W
2	South Reach - Cobble Berm, Dune, &	33°27'13.44	117°39'57.57"W
3	North Reach - Cobble Berm & Dune	33°27'21.42	117°40'9.91"W

Step 3b. Select Exposure Indicators

Use this sheet to enter the exposure indicators you plan to use.

- Enter the exposure indicators you want to consider in the yellow cells below. Any indicators you checked off in the Indicator Library appear here. You can also write in any indicator names of your choosing in the yellow cells.
- Enter between 1 and 3 indicators per climate stressor.
- For ideas on indicators, see the Exposure Indicator Library.
- If you want to remove an indicator, simply delete the indicator name from the cell, and adjust the list so that no rows are skipped.

Once you have entered your indicators (or if you change the number of indicators), click the

Update Exposure Indicators

Step 3c
Browse Sensitivity and Adaptive Capacity Indicators

Indicators of Exposure to Flooding

1 Percent Length of Site Historically Flooded
2 Percent Area of Project Footprint Projected for 100-yr Storm Flooding (CoSI
3

Pull an indicator from

Indicators of Exposure to Erosion

1 Percent Length of Site Historically Eroded
2 Projected Shoreline Erosion Width of Project Footprint (CoSMoS)
3

Pull an indicator from

Step 3d. Select Sensitivity and Adaptive Capacity Indicators

Use this sheet to enter the indicators you plan to use to derive sensitivity and adaptive capacity scores.

- Enter the sensitivity and adaptive capacity indicators you want to consider in the yellow cells below. The lists are organized by asset type (across) and climate stressors (down). Any indicators you checked off in the Indicator Library appear here. You can also write in any indicator names of your choosing in the yellow cells or click the "📖" button to pull in indicators from the indicator library.
- You may enter **up to 10** indicators per climate stressor and asset type.
- For ideas on indicators, see the Sensitivity and Adaptive Capacity Indicator Library.
- Once you have selected your indicators, click the button to generate a data collection template for each asset type and move on to the next step, collecting data about your assets.
- If you want to remove an indicator, simply delete that indicator from the list, and adjust the list so that no rows are skipped.

Once you have entered your indicators (or if you make any changes to indicators), click the "Update Indicators" button.

Update Indicators

Step 4a
Collect Climate Data

Sensitivity Indicators

Living Shoreline & Coastal Park

Indicators of Living Shoreline & Coastal Park Sensitivity to Flooding

Write in indicator names or click the "📖" button.

1	Number of Parking Spaces Lost Compared to Existing
2	Critical Facilities
3	Landward Asset Value
4	Visitor Usage Protected by Project
5	Viewshed Impacts
6	Impact on Future Planned Site Uses
7	Visitors Served
8	Bicycle Traffic
9	Utility Infrastructure
10	

Indicators of Living Shoreline & Coastal Park Sensitivity to Erosion

Write in indicator names or click the "📖" button.

1	Number of Parking Spaces Lost Compared to Existing
2	Critical Facilities
3	Landward Asset Value
4	Visitor Usage Protected by Project
5	Viewshed Impacts
6	Impact on Future Planned Site Uses
7	Visitors Served
8	Bicycle Traffic
9	Utility Infrastructure
10	

Adaptive Capacity Indicators

Indicators of Living Shoreline & Coastal Park Adaptive Capacity

Write in indicator names or click the "📖" button.

1	Ability of Landward Asset to Function if Exposed
2	Detour Availability and Length
3	Available Operation Redundancy
4	Disruption Duration
5	History of Maintenance Needs/Costs
6	Requirement to Protect Landward Asset if Project is Eroded
7	
8	
9	
10	

Step 4a. Collect Climate Data

(1) Stressors and Asset Types | (2) Enter Assets | (3) Browse and Select Indicators | (4) Collect Data | (5) Adjust Scoring | (6) View Results

Climate Data | Asset Data

Back

Use this sheet to collect data about the climate stressors used in your vulnerability analysis. This is where you can enter information about the projected changes in your area. You can evaluate vulnerability under two different **climate scenarios** for each climate stressor. For example, you can use the scenarios to determine vulnerability in different time periods (Mid-Century and End-of-century) or for different projections (e.g., 1 foot of sea level rise vs. 3 feet of sea level rise).

First, enter the scenarios you want to use for each climate stressor below. If you do not want to consider multiple scenarios, check the box.

Second, enter climate data for each of your exposure indicators. You will assign exposure scores based on the values you enter here on the exposure scoring sheets (e.g., "5a_Exposure AType1"). If the value for the exposure indicator varies for each asset (e.g., if the indicator is "modeled inundation depth" and each asset experiences a different inundation depth), leave the cells here blank and check the box "Values vary by asset." You can enter the values for each asset on the exposure scoring sheets. If you do not have data about your exposure indicators, and simply want to evaluate vulnerability under "High" and "Low" exposure scenarios, do so on the exposure scoring sheets.

Once you have entered your data (or if you make any changes), click the "Update Climate Data" button.

Update Climate Data

Step 4b

Collect Asset Data
Living Shoreline & Coastal Park

Enter Climate Scenarios

Enter the scenarios you want to use for the climate stressor(s) below. If you do not want to consider multiple scenarios, check the box below the table.

Climate Stressor	Scenario 1	Scenario 2
Flooding	0 ft SLR	3.3 ft SLR
Erosion	0 ft SLR	3.3 ft SLR

☐ I want to consider only one scenario for each climate stressor.

Show Examples

Enter Climate Data

Enter data on the projected changes in each climate stressor exposure indicator. If different assets will have different exposure scores for each indicator, check the box "Values vary by asset."

Flooding

	0 ft SLR	3.3 ft SLR	
Percent Length of Site Historically Flooded			☑ Values vary by asset
Percent Area of Project Footprint Projected for 100-yr Storm Flooding (CoSMoS)			☑ Values vary by asset
0			☑ Values vary by asset

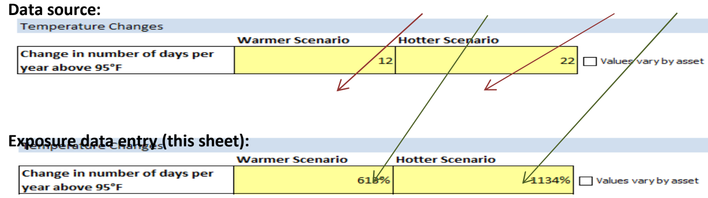
Erosion

	0 ft SLR	3.3 ft SLR	
Percent Length of Site Historically Eroded			☑ Values vary by asset
Projected Shoreline Erosion Width of Project Footprint (CoSMoS)			☑ Values vary by asset
0			☑ Values vary by asset

Example
Climate stressor: *Temperature Changes*
Climate scenarios: *Mid-Century and End-of-Century*
Asset Type: *Any*
Exposure Indicator(s): *Change in total number of days per year above 95°F*
Data source: *U.S. DOT CMIP Climate Data Processing Tool*

Data source:

Exposure data entry (this sheet):



Step 4b. Collect Asset Data -- Living Shoreline & Coastal Park

You can enter columns here

Populate this tab with data about your assets that will serve as sensitivity and adaptive capacity indicators.
Each column represents a data field you will need to collect for each asset, if possible. Column headings in red are indicators that no longer appear on the indicator list. If you have revised the name of the indicator on the indicator list, please make the change here. If you have deleted the indicator, you may delete the column manually from the data collection tempalte, if desired.

Space is available to document your data sources, units, and any other notes about the data field. Possible data sources are suggested for indicators you added from the Indicator Library.

Data collection can be the most time-intensive and challenging aspect of an indicator-based vulnerability assessment. Click the button below for some tips.

Data Collection Tips

Step 5a

Adjust Exposure Scoring

		Sensitivity Indicators								Adaptive Capacity Indicators					
Asset ID	**Asset Name**	**Number of Parking Spaces Lost Compared to Existing**	**Critical Facilities**	**Landward Asset Value**	**Visitor Usage Protected by Project**	**Viewshed Impacts**	**Impact on Future Planned Site Uses**	**Visitors Served**	**Bicycle Traffic**	**Utility Infrastructure**	**Ability of Landward Asset to Function if Exposed**	**Detour Availability and Length**	**Available Operation Redundancy**	**Disruption Duration**	**History of Maintenance Needs/Costs**	**Requirement to Protect Landward Asset if Project is Eroded**
	Data source:															
	Units (if applicable):	# of parking spaces	0=No critical facilities within or immediately landward of project 1=Yes, critical facilities are within or immediately landward of project	$USD	1 = Low 2 = Medium 3 = High	1 = Low Impact 2 = Medium Impact 3 = High Impact	1 = Low 2 = Medium 3 = High	# of visitors per year	0 = none 1 = Low 2 = Medium 3 = High	1 = Low 2 = Medium 3 = High	1 = High 2 = Medium 3 = Low	1 = High 2 = Medium 3 = Low 4 = none	1 = High 2 = Medium 3 = Low	Hours	1 = Low 2 = Medium 3 = High	0 = none 1 = Low 2 = Medium 3 = High
	Notes:	Asset ID 1 will not remove any parking spaces compared to existing conditions. Asset ID 2 will remove ~11 parking spaces compared to existing conditions. Asset ID 3 will not remove any parking spaces compared to existing conditions.	Asset ID 1 does not contain any critical facilities. Landward of Asset ID 1 is 11 parking spaces which are not considered critical. Asset ID 2 is landward of Beach Rd, a critical private roadway providing residential, emergency, and evacuation access to 205 residential units. Asset ID 3 is landward of utility infrastructure considered critical.	Asset ID 1 and Asset ID 2 are seaward of Beach Rd which is the sole access way to 205 residential units. These units total an estimated parcel value of $643,910,000, as reported by Zillow.com. Asset ID 3 is seaward of a bike path and utility infrastructure. The North Reach (Asset ID 3) contains a City owned storm drain/water treatment facility. Utility infrastructure as a whole has a multi-million dollar value.	Asset ID 1 is estimated as Medium because approximately 11 parking spaces are protected by the project. Asset ID 2 is estimated as Low because all public access parking spaces are removed by the project. Asset ID 3 is estimated as High because the existing bike path accommodates many users, in excess of the 11 parking spaces protected in ID 1.	Asset ID 1 is estimated at Medium Impact because the dune crest elevation may impair views for pedestrians accessing the landward parking area. Asset ID 2 is estimated at High Impact because removal of the landward parking area removes the viewshed function of that. Asset ID 3 is estimated at Low Impact because of the transient nature of the users on the landward side. The bike path facilitates travel, and therefore is focused less on viewshed benefits. The dune crest may impact viewshed of pedestrians, however this would only be temporary as they move north or south to areas without a dune.	Asset ID 1 and 2 are located within the area of OC Parks long-term planning area. Asset ID 1 is ranked as medium, as the project would be significant and difficult to remove should the area be targeted for a different use in the future. Assett ID 2 is ranked as high, as removal of parking area would represent a permanent impact to built infrastructure which may otherwise have been incorporated into future planned uses. Asset ID 3 is ranked as low, as the project is consistent with State Parks future planned uses of the site.	Asset ID 1 and 2 are located in the South Reach and are estimated to support 350,000 visitors per year. Asset ID 3 is located in the North Reach spanning both Capistrano Beach and Doheny State Beach is estimated to support 1,000,000 visitors per year. Data was provided by Susan Brodeur of OC Parks in May 2021.	Asset ID 3 is the only of the three assets which contains a bike path, and thus is noted to have high use.	Utilities are present at both sites. Both reaches (all three Assets) contain water main and sewer main utilities. The North Reach (Asset ID 3) additionally contains a City owned storm drain/water treatment facility. Utility infrastructure as a whole has a multi-million dollar value.	Asset ID 1 and 2 are identified as "Low" because the critical roadway (Beach Rd) which is landward of the project cannot tolerate a short period of disruption. Beach Rd must be accessible at all times to maintain the health, safety, and function of the 205 unit residential neighborhood. Asset ID 3 is identified as "High" because the Bike Path and utilities landward of the project can tolerate a short period of disruption.	Asset ID 1 and 2 are identified as NA (Not Applicable) because should the Beach Rd roadway be exposed, no detour is available to its users. Asset ID 3 is identified as 1.7 miles because if Bike Path users were aiming to travel from one end of the project area to the other during an exposed period, they would be able to detour 1.7 miles along Coast Hwy and through Doheny State Beach parking lots.	Asset ID 1 and Asset ID 2 are noted as "High" because additional parking spaces are available adjacent to the project. Asset ID 3 is noted as "Low" because the utilities protected by the shoreline and bike path are considered critical. It is understood that a detour around the Bike Path is available for pedestrians on Coast Hwy.	Disruption is estimated at 8 hours during a storm event. It is assumed that damaging storm conditions would last 4 hours while high tide coincides with an event. It is assumed that emergency cleanup would take 4 hours.	South Reach (Asset ID 1 and 2) is noted as High based on the severity of erosion and maintenance which has occurred, see M&N (2019). Approximately $250K has been spent for sidewalk repair, asphalt repair/striping, and electrical in year 2020. In year 2021, so far, $630K has been spent for sand cubes and an additional $600K is anticipated for rock/sandbags. North Reach is noted as Low, as no major maintenance has been identified at Doheny SB.	Asset ID 1 and 2 are indicated as "High" because OC Parks is sensitive to the potential liability associated with retreating portions of their development and its potential impact on the exposure of Beach Rd and function of the residential community. Asset ID 3 is indicated as "none" because: 1) alternative routes are available to replace the Bike Path function, and 2) no retreat is proposed at the North Reach, and therefore OC Parks is less sensitive to liability regarding any exposure of the city owned utilities.
1	**South Reach - Cobble Berm & Dune**	0	0	$643,910,000	2	2	2	350000	0	2	3	4	1	8	3	3
2	**South Reach - Cobble Berm, Dune, & Parking Lot Retreat**	11	1	$643,910,000	1	3	3	350000	0	2	3	4	1	8	3	3
3	**North Reach - Cobble Berm & Dune**	0	1	$5,000,000	3	1	1	1000000	3	3	1	1	3	8	1	0

Step 5a: Adjust Exposure Indicator Scoring -- Living Shoreline & C(

(1) Stressors and Asset Types > (2) Enter Assets > (3) Browse and Select Indicators > (4) Collect Data > (5) Adjust Scoring [Exposure (1/1) > Sensitivity > Adaptive Capacity] > (6) View Results

Back

Use this sheet to enter exposure information for each asset (if needed), and adjust how exposure is scored.

1. Enter raw data for the indicators in the yellow “Value” columns. The “Value” columns for each indicator will appear either gray or yellow. Gray columns link back to the “5a_Exposure Data” sheet for indicators where each asset has the same value.
2. Adjust the default scoring approach for each indicator (see "Show Scoring Approach"). A higher score means the asset is more exposed.
3. Adjust the weight for each indicator. The weights must add up to 100%.

Repeat the above steps for each stressor, moving to the right in this tab. If you choose to override any calculated exposure scores, those cells will be highlighted. Click the "+" sign in the lower right-hand corner for additional instructions.

Step 5b

Adjust Sensitivity Scoring

		Flooding										Erosion									
		0 ft SLR		3.3 ft SLR		0 ft SLR		3.3 ft SLR		0 ft SLR	3.3 ft SLR	0 ft SLR		3.3 ft SLR		0 ft SLR		3.3 ft SLR		0 ft SLR	3.3 ft SLR
		Percent Length of Site Historically Flooded				Percent Area of Project Footprint Projected for 100-yr Storm Flooding (CoSMoS)				Exposure Scores		Percent Length of Site Historically Eroded				Projected Shoreline Erosion Width of Project Footprint (CoSMoS)				Exposure Scores	
Asset ID	Asset Name	Value	Score	Value	Score	Value	Score	Value	Score			Value	Score	Value	Score	Value	Score	Value	Score		
1	South Reach - Cobble Berm & Dune	100	4	100	4	34	2	79	4	3	4	100	4	100	4	140	3	167	4	3.5	4
2	South Reach - Cobble Berm, Dune, & Parking Lot R	100	4	100	4	2	1	46	2	2.5	3	100	4	100	4	64	2	92	2	3	3
3	North Reach - Cobble Berm & Dune	50	2	50	2	49	2	83	4	2	3	50	2	50	2	175	4	195	4	3	3

Step 5b: Adjust Sensitivity Indicator Scoring -- Living Shoreline & (

Use this sheet to enter adjust how raw data for each sensitivity indicator is converted to a sensitivity score.

1. View data that you have collected for each indicator in the "Value" columns. These values are pulled from the Data Collection sheet.
2. Adjust the default scoring approach for each indicator (see "Show Scoring Approach"). A higher score means the asset is more sensitive.
3. Adjust the weight for each indicator. The weights must add up to 100%.

Click the "+" sign in the lower right-hand corner of this box for additional instructions.

Step 5b

Adjust Sensitivity Scoring (Living Shoreline & Coastal Park, Erosion)

		Number of Parking Spaces Lost Compared to Existing		Critical Facilities		Landward Asset Value		Visitor Usage Protected by Project		Viewshed Impacts		Impact on Future Planned Site Uses		Visitors Served		Bicycle Traffic		Utility Infrastructure		Sensitivity Score
Asset ID	Asset Name	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Score
1	South Reach - Cobble Berm & Dune	0.0	1	0.0	1	643910000.0	4	2.0	3	2.0	3	2.0	3	350000.0	2	0.0	1	2.0	3	2.3
2	South Reach - Cobble Berm, Dune, &	11.0	4	1.0	4	643910000.0	4	1.0	2	3.0	4	3.0	4	350000.0	2	0.0	1	2.0	3	3.1
3	North Reach - Cobble Berm & Dune	0.0	1	1.0	4	5000000.0	1	3.0	4	1.0	2	1.0	2	1000000.0	4	3.0	4	3.0	4	2.9

Use this sheet to enter adjust how raw data for each sensitivity indicator is converted to a sensitivity score.

1. View data that you have collected for each indicator in the "Value" columns. These values are pulled from the Data Collection sheet.
2. Adjust the default scoring approach for each indicator (see "Show Scoring Approach"). A higher score means the asset is more sensitive.
3. Adjust the weight for each indicator. The weights must add up to 100%.

Click the "+" sign in the lower right-hand corner of this box for additional instructions.

Step 5c

Adjust Adaptive Capacity Scoring

		Number of Parking Spaces Lost Compared to Existing		Critical Facilities		Landward Asset Value		Visitor Usage Protected by Project		Viewshed Impacts		Impact on Future Planned Site Uses		Visitors Served		Bicycle Traffic		Utility Infrastructure		Sensitivity Score
Asset ID	**Asset Name**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Score**
1	South Reach - Cobble Berm & Dune	0.0	1	0.0	1	643910000.0	4	2.0	3	2.0	3	2.0	3	350000.0	2	0.0	1	2.0	3	2.3
2	South Reach - Cobble Berm, Dune, &	11.0	4	1.0	4	643910000.0	4	1.0	2	3.0	4	3.0	4	350000.0	2	0.0	1	2.0	3	3.1
3	North Reach - Cobble Berm & Dune	0.0	1	1.0	4	5000000.0	1	3.0	4	1.0	2	1.0	2	1000000.0	4	3.0	4	3.0	4	2.9

Step 5c: Adjust Adaptive Capacity Indicator Scoring -- Living Shorel

Use this sheet to enter adjust how raw data for each adaptive capacity indicator is converted to an adaptive capacity score.

1. View data that you have collected for each indicator in the "Value" columns. These values are pulled from the Data Collection sheet.
2. Adjust the default scoring approach for each indicator (see "Show Scoring Approach"). A higher score means the asset has *lower* adaptive capacity (and higher vulnerability).
3. Adjust the weight for each indicator. The weights must add up to 100%.

Step 6
View Results

		Ability of Landward Asset to Function if Exposed		Detour Availability and Length		Available Operation Redundancy		Disruption Duration		History of Maintenance Needs/Costs		Requirement to Protect Landward Asset if Project is Eroded		Adaptive Capacity Score
Asset ID	Asset Name	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Score
1	South Reach - Cobble Berm & Dune	3.0	3	4.0	4	1.0	1	8.0	2	3.0	3	3.0	4	3.1
2	South Reach - Cobble Berm, Dune, &	3.0	3	4.0	4	1.0	1	8.0	2	3.0	3	3.0	4	3.1
3	North Reach - Cobble Berm & Dune	1.0	1	1.0	1	3.0	3	8.0	2	1.0	1	0.0	1	1.3

Step 6. View Vulnerability Results -- Living Shoreline & Coastal Park

This sheet displays the results of the indicator screen. The **Vulnerability** column shows the weighted average of the exposure, sensitivity, and adaptive capacity scores. The **Damage** column shows the weighted average of the exposure and sensitivity scores, to approximate the likelihood that an asset would be damaged by a stressor.

On this sheet, you can:

- Adjust the vulnerability component weights in the yellow cells. By default, each component contributes 1/3 of the vulnerability score. However, if an asset is not exposed (NE), then it is not considered vulnerable.
- Enter additional information in the yellow cells in Column D that you may want to relate to vulnerability. For example you could enter cost, criticality, or anotherfactor to compare with vulnerability.
- Click the "Show/Hide Details" buttons to show or hide the component scores.
- Click the radio button over any column to sort by that column.

To investigate why a specific asset received it's score, go to the **Asset Score Query** sheet or click the "Source" button above e… of …

How to use these results? **Asset Score Query**

Adjust Vulnerability Component Weights:		Damage Component Weights
Exposure	33%	50%
Sensitivity	33%	50%
Adaptive Capacity	33%	
	100%	

?

Export Results

Results

Sort by...

Source Source Source Source Source Source

Asset ID	Asset Name	?	Flooding: 0 ft SLR Exposure	Flooding: 3.3 ft SLR Exposure	Flooding: Sensitivity	Flooding: Adaptive Capacity	Flooding: 0 ft SLR "Damage"	Flooding: 0 ft SLR Vulnerability	Flooding: 3.3 ft SLR "Damage"	Flooding: 3.3 ft SLR Vulnerability	Flooding: Data Availability Score
1	South Reach - Cobble Berm & Dune		3.0	4.0	2.3	3.1	2.7	2.8	3.2	3.1	100%
2	South Reach - Cobble Berm, Dune, & Parking Lot Retre		2.5	3.0	3.1	3.1	2.8	2.9	3.1	3.1	100%
3	North Reach - Cobble Berm & Dune		2.0	3.0	2.9	1.3	2.4	2.1	2.9	2.4	100%

Asset ID	Erosion: 0 ft SLR Exposure	Erosion: 3.3 ft SLR Exposure	Erosion: Sensitivity	Erosion: Adaptive Capacity	Erosion: 0 ft SLR "Damage"	Erosion: 0 ft SLR Vulnerability	Erosion: 3.3 ft SLR "Damage"	Erosion: 3.3 ft SLR Vulnerability	Erosion: Data Availability Score
1	3.5	4.0	2.3	3.1	2.9	3.0	3.2	3.1	100%
2	3.0	3.0	3.1	3.1	3.1	3.1	3.1	3.1	100%
3	3.0	3.0	2.9	1.3	2.9	2.4	2.9	2.4	100%