BEACH PRESERVATION COMMISSION

# Agenda

June 4, 2024, 11 a.m.
Regular Meeting

Council Chamber
1200 Carlsbad Village Drive
Carlsbad, CA 92008

## Welcome to the Beach Preservation Commission Meeting

We welcome your interest and involvement in the city's legislative process. This agenda includes information about topics coming before the Beach Preservation Commission and the action recommended by city staff. You can read about each topic in the staff reports, which are available on the city website.

### How to watch

**In Person**

City Council Chamber
**1200 Carlsbad Village Drive**

**Online**

Watch the livestream at
**carlsbadca.gov/watch**

### How to participate

If you would like to provide comments to the Beach Preservation Commission, please:

- Fill out a speaker request form, located in the foyer.
- Submit the form to the Clerk before the item begins.
- When it's your turn, the Clerk will call your name and invite you to the podium.
- Speakers have three minutes, unless the presiding officer (usually the chair) changes that time.
- You may not give your time to another person, but groups can select a single speaker as long as three other members of your group are present. Group representatives have 10 minutes unless that time is changed by the presiding officer or the commission.

- **In writing:** Email comments to parksandrec@carlsbadca.gov . Comments received by 10 a.m. the day of the meeting will be shared with the Commission prior to the meeting. When e-mailing comments, please identify in the subject line the agenda item to which your comments relate. All comments received will be included as part of the official record. **Written comments will not be read out loud.**

### Reasonable accommodations

Reasonable Accommodations Persons with a disability may request an agenda packet in appropriate alternative formats as required by the Americans with Disabilities Act of 1990. Reasonable accommodations and auxiliary aids will be provided to effectively allow participation in the meeting. Please contact the City Manager's Office at 442-339-2821 (voice), 711 (free relay service for TTY users), 760-720-9461 (fax) or manager@carlsbadca.gov by noon on the Monday of the meeting to make arrangements. City staff will respond to requests by 4 p.m. on Monday, the day of the meeting, and will seek to resolve requests before the start of the meeting in order to maximize accessibility.

**CALL TO ORDER:**

**ROLL CALL:**

**PLEDGE OF ALLEGIANCE:**

**APPROVAL OF MINUTES:**
Minutes of the Regular Meeting held on April 2, 2024

**PRESENTATIONS:** None.

**CONSENT CALENDAR:** None.
*The items listed under Consent Calendar are considered routine and will be enacted by one motion as listed below. There will be no separate discussion on these items prior to the time the Commission votes on the motion unless members of the Commission or the public request specific items be discussed and/or removed from the Consent Calendar for separate action.*

**PUBLIC COMMENT**: *The Brown Act allows any member of the public to comment on items not on the agenda. Please treat others with courtesy, civility, and respect. In conformance with the Brown Act, public comment is provided so members of the public may participate in the meeting by submitting comments as provided on the front page of this agenda. The Beach Preservation Commission will receive comments at the beginning of the meeting. In conformance with the Brown Act, no action can occur on these items.*

**PUBLIC HEARINGS:** None.

**DEPARTMENTAL REPORTS:**

1. LEGISLATIVE ADVOCACY AND GRANT PROCESS
   Receive a presentation regarding the Intergovernmental Affairs Program, on-going legislative advocacy, process related to grant opportunities, and grant funding priorities. (Staff Contact: Jason Haber, Intergovernmental Affairs Director)

   **Recommendation**: Receive the presentation and provide feedback as appropriate.

2. MAINTENANCE DREDGING PROJECT FOR AGUA HEDIONDA LAGOON
   Receive a report on the upcoming maintenance dredging project for Agua Hedionda Lagoon, to be conducted by Channelside Water Resources (Formerly Poseidon Resources) – the Claude "Bud" Lewis Carlsbad Desalination Plant operator. (Staff Contact: Nick Stupin, Parks & Recreation Department)

   **Recommendation**: Receive the informational report.

**COMMISSION COMMENTARY AND REQUESTS FOR CONSIDERATION OF MATTERS**: *This portion of the agenda is for the Commission to make brief announcements, brief reports of their activities and requests for future agenda items.*

**DIRECTOR'S COMMENTS:**

**ANNOUNCEMENTS:**

**ADJOURNMENT:**

# BEACH PRESERVATION COMMISSION
# Minutes

April 2, 2024, 11 a.m.
Regular Meeting

Council Chamber
1200 Carlsbad Village Drive
Carlsbad, CA 92008

**CALL TO ORDER:** 11:01 a.m.

**ROLL CALL:** Chair Steindlberger, Vice Chair Colby, Commissioners Stark, Corrigan, Norall, and Burrows.
Absent: Commissioner Woolsey.

**PLEDGE OF ALLEGIANCE:** Vice Chair led the Pledge of Allegiance.

**APPROVAL OF MINUTES:**
Minutes of the Regular Meeting held on Dec. 5, 2024

Motion by Chair Steindlberger, second by Commissioner Norall to approve the Minutes of the Regular Meeting held on Dec. 5, 2024, as presented. Motion carried, 4/0/2/1 (Colby, Burrows – Abstain; Woolsey – Absent).

**PRESENTATIONS**: None.

**CONSENT CALENDAR**: None.

**PUBLIC COMMENT:** None.

**PUBLIC HEARINGS:** None.

**DEPARTMENTAL REPORTS:**

1. UPDATE ON CITY OF OCEANSIDE BEACH REPLENISHMENT AND RETENTION PROJECT PRESENTATION - Receive an informational report from Jayme Timberlake, Oceanside's Coastal Zone Administrator, on Oceanside's Beach Sand Nourishment and Retention Project, including a summary of the concluded RE:BEACH Oceanside Coastal Resilience Design Competition. (Staff Contact: Nick Stupin, Parks & Recreation Department)

   **Recommended Action:** Receive the informational report.

   City of Oceanside Coastal Zone Administrator Jayme Timberlake presented a PowerPoint presentation on phase two of its Sand Nourishment and Retention Pilot Project, including an update on the RE:BEACH Oceanside Coastal Resilience Design Global Competition (on file in the Office of the City Clerk).

   Commission received the presentation.

2. BATIQUITOS LAGOON FOUNDATION ACTIVITIES - Receive informational report on activities of Batiquitos Lagoon Foundation. (Staff Contact: Nick Stupin, Parks & Recreation Department)

**Recommendation**: Receive the informational report.

Batiquitos Lagoon Foundation Vice President Deb Mossa presented a PowerPoint presentation and reported on the foundation's conservation, restoration, and enhancement efforts for the Batiquitos Lagoon (on file in the Office of the City Clerk).

Commission received the report.

3. ADAPTIVE MANAGEMENT PLAN FOR THE SOUTH CARLSBAD BOULEVARD CLIMATE ADAPTATION PROJECT - Receive a report on how a 1-mile segment of south Carlsbad Boulevard could be managed to protect people, the environment and infrastructure from the effects of anticipated sea level rise. (Staff Contact: Tom Frank, Transportation Department and Katie Hentrich, Environmental Sustainability Department)

**Recommended Action**: Receive the updated information presentation.

Transportation Director Tom Frank presented the PowerPoint presentation and addressed how the 1-mile segment of south Carlsbad Boulevard could be managed to protect people, the environment and infrastructure from the effects of anticipated sea level rise. The grant project includes two main components. One option is to "retreat now", meaning make all the changes at once. The other option is to use a phased approach where changes would be made incrementally over the next 96 years, as needed (on file in the Office of the City Clerk).

Commission received the report.

Motion by Commissioner Stark, a second by Chair Steindlberger, to approve the retreat now alternative for the project. Motion carried, 6/0/0/1 (Woolsey – Absent).

*Mitch Silverstein, San Diego Policy Coordinator for the Surfrider Foundation, spoke in support of the retreat now alternative.*

4. TRI-ANNUAL REPORT OUT ON WORK PLAN FOR 2024 - Review of the Commission's Work Plan for 2024 and a report out on made towards completing the goals and tasks. (Staff Contact: Nick Stupin, Parks & Recreation Department)

**Recommendation**: Review the work plan and report out on its goals and tasks.

Parks Planning Manager Nick Stupin presented the PowerPoint presentation on the Beach Preservation Commission Tri-Annual report out on the work plan (on file in the Office of the City Clerk).

Commission reviewed the work plan.

Commission discussion ensued regarding the next beach clean-up event and proposed dates.

Motion by Commissioner Norall, a second by Commissioner Corrigan, for the beach clean-up event to be held on July 12, 2024, at 8:30 a.m. Motion carried, 6/0/0/1 (Woolsey – Absent).

**COMMISSION COMMENTARY AND REQUESTS FOR CONSIDERATION OF MATTERS**: *This portion of the agenda is for the Commission to make brief announcements, brief reports of their activities and requests for future agenda items.*

**DIRECTOR'S COMMENTS:**
Parks & Recreation Director Kyle Lancaster introduced new Commissioner Spencer Burrows. He gave a brief update on the permitting process for the Agua Hedionda Lagoon dredging project and mentioned Channel Side is the new name for Poseidon Water Resources. An item on that maintenance dredging project will be docketed for the next regular meeting of the Beach Preservation Commission. Mr. Lancaster also indicated that Parks Services Manager Todd Reese will be taking the Commission meeting facilitator seat on the deist in the coming months.

**ANNOUNCEMENTS:** None.

**ADJOURNMENT:** 12:31 p.m.

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Adriana Alvarez
Senior Office Specialist

BEACH PRESERVATION COMMISSION

# Staff Report

**Meeting Date:** June 4, 2024

**To:** Beach Preservation Commission

**From:** Kyle Lancaster, Parks & Recreation Director

**Staff Contact:** Jason Haber, Intergovernmental Affairs Director
jason.haber@carlsbadca.gov, 442-339-2958

**Subject:** Intergovernmental Affairs Program, ongoing legislative advocacy, process related to grant opportunities, and grant funding priorities

## Recommended Action

Receive a presentation regarding the Intergovernmental Affairs Program of the City of Carlsbad and the city's recent and ongoing legislative advocacy efforts related to parks and recreation and provide feedback as appropriate.

## Executive Summary

The City of Carlsbad City Council Legislative Subcommittee works in coordination with the city's Intergovernmental Affairs Director, City Manager's Office, City Attorney's Office, city departments, legislative consultants and the Carlsbad community to:

a. Receive information and advise the City Council on intergovernmental and legislative matters affecting the city;
b. Continuously monitor state and federal proposed legislation, and:
    i. Review proposed legislation for consistency with the city's Legislative Platform;
    ii. Make recommendations to the City Council to identify high priority bills; and
    iii. Make recommendations to the City Council to adopt advocacy positions on priority bills not addressed by Legislative Platform;
c. Proactively seek to identify local and regional legislative needs and recommend bill sponsorship opportunities to the City Council; and
d. Engage and inform the Carlsbad community (residents, businesses, stakeholder groups) and other governmental agencies on intergovernmental and legislative matters affecting the city.

City Council and Legislative Subcommittee Member Melanie Burkholder and Intergovernmental Affairs Director Jason Haber will provide an update on the city's recent and ongoing advocacy efforts related to beach preservation, including an overview of the city's process for evaluating and pursuing grant opportunities, and the city's current grant funding priorities.

## Exhibits

None.

BEACH PRESERVATION COMMISSION

# Staff Report

**Meeting Date:** June 4, 2024
**To:** Beach Preservation Commission

**From:** Kyle Lancaster, Parks & Recreation Director
**Staff Contact:** Nick Stupin, Parks Planning Manager

**Subject:** Maintenance Dredging Project for the Agua Hedionda Lagoon

## Recommended Action

Receive a report on the upcoming maintenance dredging project for Agua Hedionda Lagoon, to be conducted by Channelside Water Resources (Formerly Poseidon Resources) – the Claude "Bud" Lewis Carlsbad Desalination Plant operator.

## Discussion

### Background

Since 1954, maintenance dredging projects were conducted at intervals of one to four years to remove a flood-tide shoal that forms in the Agua Hedionda Lagoon outer basin (also referred to as the outer basin), to maintain tidal exchange throughout the lagoon and provide cooling water flowrates required for Cabrillo Power operations. Cabrillo Power discontinued operations requiring the cooling water in December 2018. However, maintenance dredging of the outer basin continues to be necessary to maintain tidal exchange throughout the lagoon, and to provide seawater to support the operation of the Claude "Bud" Lewis Carlsbad Desalination Plant. The most recent maintenance dredging project was conducted February 15 - March 27, 2021, and deposited approximately 304,483 cubic yards [cy]of sand back onto Carlsbad beaches (North Beach 121,667 cy; Middle Beach 100,992 cy; South Beach 81,824 cy).

### Overview

Channelside Water Resources plans to conduct an Agua Hedionda Lagoon maintenance dredging and beach nourishment project in 2024-25 to remove a flood-tide shoal in the outer basin of Agua Hedionda Lagoon in order to maintain tidal exchange between the lagoon and the ocean. Similar operations have been performed over the last six decades ranging from 159,000 to 429,000 cy of sand removed from the lagoon – outer basin. The most recent operation, completed in 2021, accounted for 304,483 cy of sand removed. In keeping with past projects, the dredged sand will be placed on adjacent beaches to replenish sand lost since the last dredging project. The beaches to be replenished are; North Beach (from the lagoon's inlet jetty to approximately Pine Avenue), Middle Beach (between the lagoon's inlet and outlet jetties), and South Beach (from the outlet jetty to approximately the Terramar residential development). The dredging project operations will be conducted between October 2024 and April 2025 (permits pending).

Sand placement quantities for each receiver beach are determined based on the conditions reflected in a beach profile survey conducted within 45 days of the commencement of the

dredging project. The currently projected quantity of dredged sand (including contingency) to be placed on Carlsbad beaches is approximately 450,000 cy: 150,000 cy on the North Beach, 166,800 cy on the Middle Beach, and 133,200 cy on the South Beach. All dredging work is anticipated to be completed by April 15, 2025.

The City of Carlsbad is one of several regulatory agencies, including the San Diego Regional Water Quality Control Board, the California Coastal Commission, the California State Lands Commission, the California Department of Parks & Recreation, and the U.S. Army Corps of Engineers, to review plans and issue permits to Channelside Water Resources for the dredging work. On May 28, 2024, Channelside Water Resources staff distributed a first draft of the Agua Hedionda Lagoon - Outer Basin 2024-25 Maintenance Dredge and Beach Nourishment Cycle Sand Disposition Plan (Exhibit 1) to Carlsbad Parks & Recreation staff for review and comment. The Special Use Permit application to the Carlsbad Community Development staff will follow. Channelside Water Resources will be responsible for funding, monitoring and inspecting the maintenance dredging project.

Public Outreach

Channelside Water Resources will present an overview of the maintenance dredging project at the Beach Preservation Commission's regularly scheduled meeting on June 4, 2024. To further inform the public of the project, Carlsbad Parks & Recreation staff and Communications & Engagement staff will coordinate with Channelside Water Resources staff on information to be posted to the city website and distributed via social media. Staff will post and distribute this information - prior to commencement of the dredging project - and will provide updates as needed during the dredging project.

## Exhibits

1. Agua Hedionda Lagoon - Outer Basin 2024-25 Maintenance Dredge and Beach Nourishment Cycle Sand Disposition Plan

# AGUA HEDIONDA LAGOON – OUTER BASIN

# 2024–2025 MAINTENANCE DREDGE

# AND BEACH NOURISHMENT CYCLE

# SAND DEPOSITION PLAN

Prepared by:

Channelside Water Resources LP (formerly
Poseidon Resources LP)
4590 Carlsbad Boulevard
Carlsbad, California 92008

Anchor QEA
9700 Research Drive
Irvine, California 92618

Prepared for:

City of Carlsbad, California
in fulfillment of
**Special Use Permit**

May 2024

# EXECUTIVE SUMMARY

This Sand Deposition Plan has been prepared in fulfillment of Conditions 7, 8, and 9 of the City of Carlsbad Special Use Permit (SUP).

Channelside Water Resources LP plan to conduct maintenance dredging and beach nourishment in 2024–2025 to remove a flood-tide shoal in the Outer Basin (also referred to as the West Basin) of Agua Hedionda Lagoon and maintain tidal exchange between the lagoon and ocean. Similar operations have been performed over the last seven decades. Approximately 400,000 cubic yards (cy) of sand are proposed to be removed from the Outer Basin. In keeping with past operations, the dredged sand will be placed on adjacent beaches: North Beach, Middle Beach, and South Beach. The proposed dredged sand beach placement volumes and ratios within this Sand Deposition Plan are consistent with previous beach nourishment events and use the 2020 Sand Deposition Plan (**Appendix A**) analyses. Final beach placement/nourishment volumes and ratios for this 2024–2025 event will be based upon a 2024 pre-construction beach survey (per SUP requirements) and summarized in a supplement to this document released in late 2024. Dredging and beach nourishment operations are proposed to occur between November 2024 and April 15, 2025.

In 2020, the permitted sand placement quantities for each receiver beach were determined by regulatory agencies, with the cooperation of local residents and stakeholders, and by Dr. Scott Jenkins's beach profile optimization modeling based on the then-current beach condition (defined by May 2020 and October 2020 beach profile surveys). The amount of sand placed on each of the receiver beaches was optimized based on computations of equilibrium beach profiles using 2020 conditions and maximizing recreational beach widths in proportion to use (i.e., North Beach is more heavily recreated than Middle Beach or South Beach), while avoiding impact to sensitive hard-bottom habitat. In addition, the 2020 Sand Deposition Plan (**Appendix A**) was designed to replace sand that had been eroded from the beaches since the 2018 dredge/beach nourishment event.

Erosion losses on all three receiver beaches between the 2018 and 2020 dredge/beach nourishment cycles totaled 366,644 cy, with 60% of the erosion losses occurring on North Beach and 40% occurring on Middle Beach and South Beach. Based on the 2020 composite analysis, North Beach was proposed to receive 51% of dredged sand (approximately 150,000 cy) in 2020–2021, placed with beach slopes approximating an elliptic cycloid equilibrium profile in order to maximize retention time. North Beach nourishment was not to exceed 150,000 cy. Middle Beach and South Beach were to receive 49% of the dredged material (approximately 146,600 cy) with an approximate distribution of 55.6% (81,500 cy) and 44.4% (65,100 cy), respectively. Any surplus dredge quantities in excess of 300,000 cy were to be placed on Middle Beach and/or South Beach.

In actuality, approximately 304,483 cy was hydraulically dredged and placed on all three receiver beaches (North Beach, Middle Beach, and South Beach) in 2020–2021 (conducted from February 15 to March 27, 2021). North Beach received approximately 121,667 cy (40%), Middle Beach received 100,992 cy (33%), and South Beach received 81,824 cy (27%) of the dredged material. This change in both dredge volume and placement ratios was due to project schedule constraints as well as the City of Carlsbad requirement for a pre-construction beach survey within 45 days of dredging to reassess receiver beach conditions.

Per the requirements of the City of Carlsbad SUP in 2020–2021, a 2-year post-placement survey was performed at all three receiver beaches to assess beach and sand conditions. The April 2023 profiles at North Beach are either more eroded than, or roughly coincident to, the May 2020 pre-construction condition in the northern and central portions of the subreach. Similarly, the April 2023 profiles at Middle and South Beaches show that the beach was generally more eroded than the pre-construction (May 2020) conditions (**Appendix B**). The only occurrence of profile accretion was at the two transects located immediately north of the Agua Hedionda north jetties. This outcome suggests that the beach condition has effectively returned to, or eroded beyond, the pre-construction conditions from 2020.

In April 2023, the average mean sea level shoreline position at North Beach was 2 feet wider than the May 2020 pre-construction condition. Middle Beach and South Beach retreated beyond the pre-construction condition over the same period (an average loss of 19 and 21 feet, respectively). Like the profile changes, these findings indicate that the shoreline within the study area has retreated to, or eroded beyond, the pre-construction conditions.

The proposed 2024–2025 placement quantities, locations, and schedule are summarized in **Table ES-1** and depicted in design figures found in **Appendix C**. Similar to the 2020–2021 beach nourishment cycle, the upcoming 2024–2025 cycle proposes a similar volume distribution between the beaches, acknowledging that North Beach has a similar shoreline position in pre-construction surveys between the cycles, indicating that a maximum volume of approximately 150,000 cy should be maintained to protect offshore habitat. Due to a larger dredge quantity within the Outer Basin to reach design depth and the more eroded conditions of Middle Beach and South Beach, a larger volume is proposed for Middle Beach and South Beach compared to that placed in 2021. Per the SUP, a pre-construction beach survey in fall or winter 2024 will be conducted at all three receiver beaches 45 days prior to the dredge cycle to refine these proposed sand placement volumes.

**Table ES-1. Beach Placement Quantities and Schedule[1]**

| Receiver Site | Approximate Placement Quantity (with 2024 bathymetric conditions) | Approximate Placement Quantity (with 20% Contingency) | Approximate Schedule |
|---|---|---|---|
| North Beach[2] | 150,000 cy (37.5%) | 150,000 cy (33.3%) | January to March 2025 |
| North Inlet Jetty to Maple Avenue | 94,500 cy | 94,500 cy | -- |
| Maple Avenue to Pine Avenue | 55,500 cy | 55,500 cy | -- |
| Middle Beach[3] | 139,000 cy (34.5%) | 166,800 cy (37.1%) | November to December 2024 |
| South Beach[3] | 111,000 cy (28.0%) | 133,200 cy (29.6%) | March to April 15, 2025 |
| **Total** | **400,000 cy** | **450,000 cy** | -- |

Notes:
1. Sand placement operations my extend beyond March 2025 if adverse weather conditions or equipment issues are encountered. No sand will be placed on beaches after April 15, 2025, without written approval from appropriate regulatory agencies. Any surplus dredge quantities in excess of 400,000 cy will only be placed on Middle Beach and/or South Beach.

2. Sand placement quantity for North Beach is not to exceed 150,000 cubic yards.

3. Sand placement quantities for Middle Beach and South Beach are approximate. Sand placement on the Middle Beach may be completed prior to initiating sand placement on the North Beach if agreed upon by the City of Carlsbad. This is due to closer proximity to outer lagoon, faster mobilization times, and shorter distance to sand placement beach (Middle Beach).

4. For permitting purposes and to account for future sand deposition in the lagoon, a 20% contingency has been added to the design volume quantity for permit applications.

--: not applicable

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# 1. INTRODUCTION

The rubble mound jetties at the Agua Hedionda Lagoon entrance were constructed in 1954 to maintain a stable inlet for the Encina Power Station (EPS) seawater intake (Shaw 1980). Initial dredging to create the cooling water basin was conducted at the same time. Ongoing maintenance dredging performed during the last seven decades has allowed the lagoon entrance to remain open to tidal exchange.

Since 1994, maintenance dredging has been conducted at intervals of 1 to 4 years to remove floodtide shoaling that forms in the Outer Basin of Agua Hedionda Lagoon to maintain tidal exchange throughout the lagoon and provide cooling water flow rates required for EPS operations. The EPS discontinued operation in December 2018. However, maintenance dredging of the Outer Basin continues to be necessary to maintain tidal exchange throughout the lagoon and provide seawater to support the operation of the Claude "Bud" Lewis Carlsbad Desalination Plant. Between 1999 and 2015, approximately 3 million cubic yards (cy) of sediment were dredged from the Outer Basin and placed on neighboring beaches (Coastal Frontiers Corporation 2017). Individual dredge cycle quantities have ranged from 155,000 to 422,541 cy. The most recent operation, completed in 2021, accounted for 304,483 cy.

Cabrillo Power I LLC (Cabrillo) and Channelside Water Resources LP (Channelside) plan to conduct the next phase of maintenance dredging in 2024–2025. Consistent with past maintenance dredging events, sediment removed from the Outer Basin will be placed on adjacent beaches: North Beach, Middle Beach, and South Beach. The work will be performed in accordance with the stipulations in the following permits:

- City of Carlsbad Special Use Permit (SUP)
- U.S. Army Corps of Engineers Permit SPL-2001-00328-RRS
- California Coastal Commission Coastal Development Permit No. 6-20-0240
- San Diego Regional Water Quality Control Board 401 Water Quality Certification
- California Department of Parks and Recreation Right of Entry Permit
- California State Lands Commission Lease 932.1

This Sand Deposition Plan has been prepared in fulfillment of Conditions 7, 8, and 9 of the City of Carlsbad's previously approved SUP. The following sections provide a project description, summarize the project schedule, describe the sand placement quantity calculations, and summarize the findings.

## 2. PROJECT DESCRIPTION

Dredging will be limited to the Outer Basin of Agua Hedionda Lagoon, which is bordered on the east by the railroad bridge and on the west by Carlsbad Boulevard (**Figure 1**). In accordance with the former 2020–2021 SUP, up to 500,000 cy were previously permitted to be removed from the Outer Basin, but the present 2024–2025 conditions indicate that the dredge amount will be on the order of 400,000 cy, which is slightly above the average range of dredging over the past 20 years (**Table 1**). In keeping with past operations, the dredged sand will be placed on adjacent beaches: North Beach, Middle Beach, and South Beach (**Figure 1**). The amount of sand placed on each of the receiver beaches will be optimized based on computations of equilibrium beach profiles using historical and present conditions balanced against maximizing recreational beach widths in proportion to use (i.e., North Beach is more heavily recreated than Middle or South Beaches), while avoiding impact to sensitive hard-bottom habitat.

### *2.1 Dredging Operations*

Dredging of the Agua Hedionda Lagoon Outer Basin will be performed using a diesel-powered hydraulic dredging hull barge. During operations, the dredge hull would be stabilized by wire cables that are secured to existing anchors on the shore of the lagoon.

### *2.2 Beach Placement Operations*

The dredged material (slurry) will be pumped to each of the receiver beaches (North Beach, Middle Beach, and South Beach; **Figure 1**) through a 20-inch-diameter pipeline. A floating section of pipe will convey the slurry from the dredge to the lagoon shoreline, where it will connect with a land-based pipeline that will deliver the material to the receiver beach. **Figure 2** shows the approximate dredge pipeline routes for each receiver site. When material is placed at North Beach, the pipeline will traverse under the Carlsbad Boulevard Bridge and then north along the back of the beach as far as Pine Avenue. For the Middle Beach and South Beach receiver sites, an existing underground pipe under Carlsbad Boulevard may be used. In the case of South Beach, the pipelines will be extended along the back of the beach at Carlsbad State Beach to reach the south side of the EPS discharge jetty. Depending on shoal conditions, the pipe to Middle Beach may traverse under the Carlsbad Boulevard Bridge and then south for a portion of the discharge time on Middle Beach.

As described previously, the slurry arriving from the dredge discharge pipeline is a mix of sand and water. Temporary dikes and berms will be constructed in the back-beach areas near the discharge points to dewater the slurry and aid in the retention of sand at the receiver beaches. As currently envisioned, two dikes would be constructed: one that is perpendicular to the beach connected to one that is parallel to the beach (forming an "L" shape). The dredged slurry will be discharged behind the dikes. Where sand is not present on the existing beach, an initial quantity of sand will be discharged on the highest portion of the beach and used to construct a dike. Once the sand slurries have been dewatered, the dikes and berms will be spread downslope across the existing beach face to the waterline using conventional earthmoving equipment in order to produce new beach slopes approximating elliptic cycloid equilibrium beach profiles. These methods have been used effectively in the past to maximize the retention of the dredged sands that are placed on the three receiver beaches. The dikes and berms also are used to ensure shoreline ocean turbidity does not exceed the limit as set in the San Diego Regional Water Quality Control Board 401 Water Quality Certifications.

**Table 1. Agua Hedionda Lagoon Maintenance Dredging of the Outer Basin, 1999 to 2021**

| Year | Start Date | Finish Date | Volume Dredged (cy) | Volume Placed (cy) | Placement Beach |
|---|---|---|---|---|---|
| 1999 | 2/1/1999 | 5/1/1999 | 155,000 | 155,000 | North |
| 2000–2001 | 11/1/2000 | 4/1/2001 | 422,541 | 141,346 | North |
| | | | | 195,930 | Middle |
| | | | | 85,265 | South |
| 2002–2003 | 12/2/2002 | 4/3/2003 | 354,266 | 161,525 | North |
| | | | | 131,377 | Middle |
| | | | | 61,364 | South |
| 2004–2005 | 1/5/2004 | 3/5/2005 | 348,151 | 100,487 | North |
| | | | | 170,515 | Middle |
| | | | | 77,149 | South |
| 2006–2007 | 1/7/2006 | 4/7/2007 | 333,373 | 149,168 | North |
| | | | | 121,038 | Middle |
| | | | | 63,167 | South |
| 2008–2009 | 12/8/2008 | 4/9/2009 | 299,326 | 104,141 | North |
| | | | | 102,000 | Middle |
| | | | | 93,185 | South |
| 2010–2011 | 12/10/2010 | 4/11/2011 | 226,026 | 62,030 | North |
| | | | | 93,696 | Middle |
| | | | | 70,300 | South |
| 2014–2015 | 12/14/2014 | 4/15/2015 | 294,661 | 64,968 | North |
| | | | | 156,056 | Middle |
| | | | | 73,637 | South |
| 2017–2018 | 10/17/2017 | 4/18/2018 | 205,482 | 0 | North |
| | | | | 141,172 | Middle |
| | | | | 64,310 | South |
| 2020–2021 | 2/15/2021 | 3/27/2021 | 304,483 | 121,667 | North |
| | | | | 100,992 | Middle |
| | | | | 81,824 | South |
| | | **Total** | **2,943,309** | **2,943,309** | |
| | | **Average** | **294,331** | **--** | |
| | | | **North Beach Total Placement** | **1,060,332** | |
| | | | **Middle Beach Total Placement** | **1,212,776** | |
| | | | **South Beach Total Placement** | **670,201** | |
| | | | ***North Beach Average Placement*** | ***106,033*** | |
| | | | ***Middle Beach Average Placement*** | ***134,753*** | |
| | | | ***South Beach Average Placement*** | ***74,467*** | |


**Figure 1. Project Location Map**


**Figure 2. Dredge Discharge Pipeline Routes**

The discharge point is directed according to this Sand Deposition Plan. Once the material is dewatered, front-end loaders spread the sand on the beach and into the required elliptic cycloid beach profile configuration. As required by Condition 9 of the SUP, the beach berm will be no taller than 6 feet on the eastern aspect and will be groomed and flattened to provide recreational beach space. The elliptic cycloid grading profiles ensure that the dredged sands will be placed in such a manner that the beach profile slopes gradually to the surf zone. In the event that storm events begin to relocate the front aspect of the graded sand slope during the equilibration process, the berm and slope shall be regraded for public safety purposes. Material will not be placed in areas that will block existing drainage. In addition, a minimum 5-foot-wide path of travel will be maintained between sand placement operations and sea walls (both public and private).

Target sand placement quantities for North Beach, Middle Beach, and South Beach were developed in the 2020 Sand Deposition Plan based on computations of equilibrium beach profiles using 2020 conditions, maximizing recreational beach widths in proportion use, while avoiding impact to the sensitive hard-bottom habitat (**Appendix A**). A 2-year post-construction beach transect survey was performed on all three receiver beaches in 2023, which indicates that all three receiver beaches have eroded equivalent to or beyond pre-dredge/beach nourishment conditions from the 2020–2021 dredge event (**Appendix B**).

In 2020, the three receiver beaches were 93,141 cy below their carrying capacity (**see Section 4.2 of Appendix A**), which is the minimum amount of sand volume needed to maintain an equilibrium beach profile in the presence of historic extreme waves, otherwise known as the beach "critical mass" (Jenkins and Inman 2006). In addition, erosion losses on all three receiver beaches between 2018 and 2020 totaled approximately 366,644 cy (**Appendix A**). In 2024–2025, approximately 400,000 cy (450,000 cy for permit request purposes) from the Outer Basin is proposed to be dredged to avoid inlet closure and to replenish the sand on the North Beach, Middle Beach, and South Beach beyond the critical mass. To maintain the greatest retention time of sand on the beach, the sand will be configured as an elliptic cycloid. This approach is based on the latest coastal science and was the approach taken in the 2018 and 2021 beach nourishment cycles, and it will be continued in this Sand Deposition Plan for the 2024–2025 beach nourishment cycle. These computations are detailed in **Appendix A**.

Per the SUP, a pre-construction beach survey in fall or winter 2024 will be conducted at all three receiver beaches 45 days prior to the dredge cycle to refine the proposed sand placement volumes. As described above, no more than 150,000 cy of dredge material is proposed for placement at North Beach. The remaining dredge material, approximately 250,000 cy, is proposed for placement at Middle Beach and South Beach, with an approximate distribution of 55.6% and 44.4% of that volume, or 34.5% and 28% of the total 400,000 cubic yards, respectively (**Table 2**). Any surplus dredge quantities in excess of 400,000 cy will only be placed on Middle Beach and/or South Beach.

**Table 2. Target Placement Quantities[1]**

| Receiver Site | Approximate Placement Quantity (with 2024 bathymetric conditions) | Approximate Placement Quantity (with 20% Contingency) | Approximate Schedule |
|---|---|---|---|
| North Beach[2] | 150,000 cy (37.5%) | 150,000 cy (33.3%) | January to March 2025 |
| North Inlet Jetty to Maple Avenue | 94,500 cy | 94,500 cy | -- |
| Maple Avenue to Pine Avenue | 55,500 cy | 55,500 cy | -- |
| Middle Beach[3] | 139,000 cy (34.5%) | 166,800 cy (37.1%) | November to December 2024 |
| South Beach[3] | 111,000 cy (28.0%) | 133,200 cy (29.6%) | March to April 15, 2025 |
| **Total** | **400,000 cy** | **450,000 cy** | -- |

Notes:
1. Sand placement operations my extend beyond March 2025 if adverse weather conditions or equipment issues are encountered. No sand will be placed on beaches after April 15, 2025, without written approval from appropriate regulatory agencies. Any surplus dredge quantities in excess of 400,000 cy will only be placed on Middle Beach and/or South Beach.

2. Sand placement quantity for North Beach is not to exceed 150,000 cubic yards.

3. Sand placement quantities for Middle Beach and South Beach are approximate. Sand placement on the Middle Beach may be completed prior to initiating sand placement on the North Beach if agreed upon by the City of Carlsbad. This is due to closer proximity to outer lagoon, faster mobilization times, and shorter distance to sand placement beach (Middle Beach).

4. For permitting purposes and to account for future sand deposition in the lagoon, a 20% contingency has been added to the design volume quantity for permit applications.

--: not applicable

### *2.3 Summary of Project Equipment*

The designated staging area for equipment and materials is on Fishing Beach located on the west shoreline of the Outer Basin. The following equipment is proposed to be used:

- Hydraulic dredge
- Slurry discharge pipe
  - Poly and steel pipe within the lagoon (floating)
  - Poly pipe along the shoreline
- Rubber-tired loaders (one full time, second as needed)
- Pickup truck (4x4) for support on the shoreline and public roadways

### *2.4 Access and Pedestrian Control*

Cabrillo and Channelside regard safety of the public and personnel foremost over all other tasks. Portable signage will be used at each discharge location to advise pedestrians of current work. An example of this signage is provided in **Figure 3**, but it will be modified to add Channelside and a revised call number. This signage is relocated as the dredge slurry discharge point moves.


**Figure 3. Example of Public Signage (To Be Revised as Necessary)**

No forms of public access to the shoreline will be blocked during sand deposition operations. Designated access ways over or around obstructions will be provided. Access for public safety vehicles also will be maintained. When discharging to South Beach, the piping is placed through an opening in the discharge channel fencing to ensure pedestrian safety. At no time will piping be placed on the pedestrian sidewalks along Carlsbad Boulevard. A monitor will be stationed at the north and south ends of the active work area to prevent foot traffic in the immediate discharge location. Appropriate signage and construction fencing will be used to identify the discharge location. The beach access areas will be left in a safe condition at the end of each workday. A flag crew will be used while moving or operating equipment on the beach. The pickup truck used to support the operation will use the shoreline and public roadways to avoid interference with pedestrian flow. As stipulated by Condition 9 of the SUP, a minimum 5-foot-wide path of travel will be maintained between sand placement operations and seawalls (both public and private).

Discharge point relocation operations will be conducted during low pedestrian traffic times to the extent possible. In addition, project personnel will be available to answer any questions the public may have about the process.

### *2.5 Contact Information*

The project is being conducted under the supervision of Ms. Isabella Murdy. Her contact information is provided as follows:

Isabella Murdy, Executive Assistant
Channelside Water Resources LP
4590 Carlsbad Boulevard
Carlsbad, California 92008
949-212-1744
imurdy@channelsidedesal.com

Should emergency response be necessary for the dredge/beach nourishment activity, you may contact Ms. Murdy, or follow the Hazardous Materials Business Plan Emergency Notification as provided to the Carlsbad Fire Department.

## 3. PROJECT SCHEDULE

The dredging and sand placement schedule shall be similar to past activities and conform with the requirements stipulated in the California Coastal Commission Coastal Development Permit. The anticipated schedule is shown in **Table 3**. Permit receipt timing may alter this schedule.

**Table 3. Schedule for 2024–2025 Dredge/Beach Nourishment Cycle**

| Activity | Approximate Dates |
|---|---|
| Dredging | November 2024 to April 15, 2025 |
| Sand Placement | -- |
| North Beach | January to March 2025 |
| Middle Beach | November to December 2024 |
| South Beach | March to April 15, 2025[1] |
| **Total Period of Activity** | **November 2024 to April 15, 2025** |

Note:
1. Sand placement operations may extend beyond March 2025 if adverse weather conditions or equipment issues are encountered. No sand will be placed on beaches after April 15, 2025, without written approval from appropriate regulatory agencies.

It is anticipated that all work will be conducted during daylight hours and between Monday and Saturday. If the schedule is delayed by storm activity, work may be conducted during daylight hours on Sundays with appropriate authorization.

## 4. SAND PLACEMENT QUANTITY DETERMINATION

For sand placement quantification, beach profile modeling, beach critical mass capacities, and beach erosion loss calculations, please refer to the 2020–2021 Sand Deposition Plan (**Appendix A**). A similar approach will be used for determining the volumes and placement locations for the upcoming 2024–2025 dredge/beach nourishment cycle. To determine the proper amount of sand to be placed on the beaches, the receiver beaches will be surveyed in late 2024, and the current sand volume will be calculated from the pre-dredge survey to guide the distribution of dredged sand among the beaches. Per the SUP, the pre-construction beach survey is to be conducted no earlier than 45 days prior to construction. The anticipated schedule for this 2024 survey is fall 2024. This report will be amended and resubmitted to appropriate agencies thereafter.

Appendix B contains the *Agua Hedionda Outer Lagoon 2020–2021 Dredge Cycle 2-Year Post-Construction Beach Profile Survey*, performed in 2023. This survey information from all three receiver beaches supports the proposed beach placement ratios at the receiver beaches based on the similarities between the 2020 and 2023 beach conditions and will be confirmed with the pre-construction beach survey in fall 2024.

The minimum carrying capacity of the North Beach, Middle Beach, and South Beach is shown in **Table 4**. Lesser amounts of beach fill will not be able to sustain an equilibrium profile during the highest-energy wave events.

## Table 4. Carrying Capacity and Target Sand Placement Volumes at Each Receiver Beach

| Receiver Site | Minimum Carrying Capacity (Critical Mass, cy)[1] | Placement Volume to Re-Establish Critical Mass (2020) | Proposed Placement Volume in 2020–2021 | Actual Placement Volumes in 2020–2021 | Proposed Placement Volume in 2024–2025 | 2024 Residual Beach Sand Volume | Placement Volume to Re-Establish Critical Mass (2024) | Permitted Sand Placement Volume |
|---|---|---|---|---|---|---|---|---|
| **North Beach** | **135,100** | **53,179** | **150,000** | **121,667** | **150,000** | TBD pre-construction survey | TBD pre-construction survey | TBD pre-construction survey |
| North Jetty to Maple Avenue | 79,500 | 16,470 | 94,500 | 76,650 | 94,500 | TBD pre-construction survey | TBD pre-construction survey | TBD pre-construction survey |
| Maple Avenue to Pine Avenue | 55,600 | 36,709 | 55,500 | 45,017 | 55,500 | TBD pre-construction survey | TBD pre-construction survey | TBD pre-construction survey |
| Middle Beach | 134,600 | 39,962 | 81,500 | 100,992 | 139,000 | TBD pre-construction survey | TBD pre-construction survey | TBD pre-construction survey |
| South Beach | 66,300 | (6,735) surplus | 65,100 | 81,824 | 111,000 | TBD pre-construction survey | TBD pre-construction survey | TBD pre-construction survey |
| **Middle Beach and South Beach** | **200,900** | **33,227** | **146,600** | **182,816** | **250,000** | TBD pre-construction survey | TBD pre-construction survey | TBD pre-construction survey |
| **TOTALS** | **336,000** | **86,406** | **296,600** | **304,483** | **400,000** | -- | -- | -- |

Notes:
1. The minimal carrying capacity was developed in the 2020 Sand Deposition Plan (**Appendix A**) based on the period of record for the most severe wave events between 1998 and 2017 and the median grain size of the proposed dredged material and receiver beaches collected in 2008. No additional volume estimates or modeling was performed to recalculate the critical mass.
TBD: to be determined

## 5. REFERENCES

Coastal Frontiers Corporation, 2017. *SANDAG 2016 Regional Beach Monitoring Program – Annual Report*.

Jenkins, S.A., and D.L. Inman, 2006, "Thermodynamic Solutions for Equilibrium Beach Profiles." *Jour. Geophys. Res.,* v.3, C02003. doi:10.1029/2005JC002899.

Shaw, M.J., 1980. *Artificial Sediment Transport and Structures in Coastal Southern California*. University of California, San Diego, Scripps Institute of Oceanography, SIO Reference No. 80-41.

# APPENDIX A

## Agua Hedionda Lagoon – Outer Basin 2020–2021 Maintenance Dredge/Beach Nourishment Cycle Sand Deposition Plan (November 2020)

# AGUA HEDIONDA LAGOON - OUTER BASIN

# 2020/21 MAINTENANCE DREDGE

# AND BEACH NOURISHMENT CYCLE

# SAND DEPOSITION PLAN

Prepared by:

Poseidon Resources (Channelside) LP
5780 Fleet Street, Suite 140, Carlsbad, CA 92008
and
Michael Baker
INTERNATIONAL

Prepared for:

City of Carlsbad, California
in fulfillment of
**Special Use Permit 06-10X2(A)**

November 2020
(Revised to incorporate November 5, 2020, California Coastal Commission Approval)

# EXECUTIVE SUMMARY

This sand deposition plan has been prepared in fulfillment of Conditions 7, 8, and 9 of the City of Carlsbad Special Use Permit (SUP) 06-10X2(A).

Cabrillo Power I LLC and Poseidon Resources (Channelside) LP plan to conduct maintenance dredging and beach nourishment in 2020/21 to remove a flood-tide shoal in the outer basin (also referred to as the West Basin) of Agua Hedionda Lagoon in order to maintain tidal exchange between the lagoon and ocean. Similar operations have been performed over the last six decades. Approximately 300,000 cubic yards (cy) of sand may be removed from the lagoon – outer basin. In keeping with past operations, the dredged sand will be placed on adjacent beaches: North Beach, Middle Beach, and South Beach. Operations will be conducted between November 2020 and 15 April 2021.

The permitted sand placement quantities for each receiver beach were determined by regulatory agencies with the cooperation of local residents and stakeholders and by Dr. Scott Jenkins' beach profile optimization modeling based on the current beach condition defined by a May 2020 and October 2020 beach profile surveys. The amount of sand placed on each of the receiver beaches was optimized based on computations of equilibrium beach profiles using current conditions and maximizing recreational beach widths in proportion to use (i.e. North Beach is more heavily recreated than Middle or South Beaches), while avoiding impact to sensitive hard bottom habitat. In addition, the proposed sand deposition plan is designed to replace sand that has been eroded from the beaches since the 2018 dredge/beach nourishment event. Erosion losses on all three receiver beaches since the last dredge/beach nourishment cycle in 2018 total 366,644 cy, with 60% of the erosion losses occurring on North Beach and 40% occurring on Middle and South Beach.

Based on this composite analysis, North Beach will receive 51% of dredged sand (approximately 150,000 cy), to be placed with beach slopes approximating an elliptic cycloid equilibrium profile in order to maximize retention time. Middle and South Beach will receive 49% of the dredged material (approximately 146,600 cy) with an approximate distribution of 55.6% and 44.4%, respectively. Any surplus dredge quantities in excess of 300,000 cy will only be placed on Middle and/or South beaches. North Beach disposal will not exceed 150,000 cy. The proposed sand placement quantities and approximate schedule are summarized below.

**Beach Placement Quantities and Schedule[1]**

| Receiver Site | Approximate Placement Quantity | Approximate Schedule |
|---|---|---|
| North Beach[2] | 150,000 cy | January 2021 - March 2021 |
| North Inlet Jetty to Maple Ave | 94,500 cy | |
| Maple Ave to Pine Ave | 55,500 cy | |
| Middle Beach[3] | 81,575.6 cy | November 2020 – December 2020 |
| South Beach[3] | 65,060.2 cy | March 2021- 15 April 2021 |
| **Total** | 296,635.8 cy<br>≅ **300,000 cy** | |

[1]Sand placement operations my extend beyond March 2021 if adverse weather conditions or equipment issues are encountered. No sand will be placed on beaches after April 15, 2021 without written approval from appropriate regulatory agencies. Any surplus dredge quantities in excess of 300,000 cy will only be placed on middle and/or south beaches.

[2] Sand placement quantity for North Beach is not to exceed 150,000 cubic yards.

[3] Sand placement quantities for Middle Beach and South Beach are approximate. Sand placement on the Middle Beach shall be completed prior to initiating sand placement on the North Beach.

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# 1. INTRODUCTION

The rubble mound jetties at the Agua Hedionda Lagoon entrance were constructed in 1954 to maintain a stable inlet for the Encina Power Station (EPS) seawater intake (Shaw, 1980). Initial dredging to create the cooling water basin was conducted at the same time. Ongoing maintenance dredging performed during the last six decades has allowed the lagoon entrance to remain open to tidal exchange.

Since 1994, maintenance dredging has been conducted at intervals of one to four years to remove a flood-tide shoal that forms in the Agua Hedionda Lagoon - Outer Basin to maintain tidal exchange throughout the lagoon and provide cooling water flowrates required for EPS operations. The EPS discontinued operation in December 2018. However, maintenance dredging of the outer basin continues to be necessary to maintain tidal exchange throughout the lagoon and provide seawater to support the operation of the Claude "Bud" Lewis Carlsbad Desalination Plant. Between 1994 and 2015, approximately 3.3 million cubic yards (cy) of sediment were dredged from the outer basin and placed on neighboring beaches (Coastal Frontiers, 2017a). Individual dredge cycle quantities have ranged from 159,000 to 429,000 cy. The most recent operation, completed in 2018, accounted for 205,482 cy.

Cabrillo Power I LLC (Cabrillo) and Poseidon Resources (Channelside) LP (Poseidon) plan to conduct the next phase of maintenance dredging in 2020/2021. Consistent with past maintenance dredging events, sediment removed from the lagoon's outer basin will be placed on adjacent beaches: North, Middle and South Beached. The work will be performed in accordance with the stipulations in the following permits:

- City of Carlsbad Special Use Permit (SUP) 06-10X2(A)
- US Army Corps of Engineers Permit SPL-2001-00328-RRS
- California Coastal Commission Coastal Development Permit No. 6-20-0240
- San Diego Regional Water Quality Control Board 401 Water Quality Certification
- California Department of Parks and Recreation Right of Entry Permit
- California State Lands Commission Lease 932.1

This sand deposition plan has been prepared in fulfillment of Conditions 7, 8 and 9 of the City of Carlsbad SUP. The following sections provide a project description, summarize the project schedule, describe the sand placement quantity calculations, and summarize the findings.

## 2. PROJECT DESCRIPTION

Dredging will be limited to the Agua Hedionda Lagoon – Outer Basin, which is bordered on the east by the railroad bridge and on the west by Carlsbad Boulevard (**Figure 1**). In accordance with the SUP, up to 500,000 cy may be removed from the outer basin, but the present conditions indicate the dredge amount will be on the order of 300,000 cy, which is in the average range of dredging over the past 20 years, **(see Table-1)**. In keeping with past operations, the dredged sand will be placed on adjacent beaches: North Beach, Middle Beach, and South Beach (**Figure 1**). The amount of sand placed on each of the receiver beaches will be optimized based on computations of equilibrium beach profiles using current conditions balanced against maximizing recreational beach widths in proportion to use (i.e. North Beach more heavily recreated than Middle or South Beaches), while avoiding impact to sensitive hard bottom habitat.

### *2.1 Dredging Operations*

Dredging of the Agua Hedionda Lagoon - Outer Basin will be performed using a diesel-powered dredging hull barge. During operations, the dredge hull would be stabilized by wire cables that are secured to existing anchors on the shore of the lagoon.

### *2.2 Beach Placement Operations*

The dredged material (slurry) will be pumped to each of the receiver beaches (North, Middle and South Beach; **Figure 1**) through a 20-inch diameter pipeline. A floating section of pipe will convey the slurry from the dredge to the lagoon shoreline, where it will connect with a land-based pipeline that will deliver the material to the receiver beach. **Figure 2** shows the approximate dredge pipeline routes for each receiver site. When material is placed at North Beach, the pipeline will traverse under the Carlsbad Boulevard Bridge and then north along the back of the beach as far as Pine Avenue. For the Middle and South Beach receiver sites, an existing underground pipe under Carlsbad Boulevard will be utilized. In the case of South Beach, the pipelines will be extended along the back of the beach at Carlsbad State Beach to reach the south side of the EPS discharge jetty. Depending on shoal conditions, the pipe to Middle Beach may traverse under the Carlsbad Boulevard Bridge and then south for a portion of the discharge time on Middle Beach.

As described above, the slurry arriving from the dredge discharge pipeline is a mix of sand and water. Temporary dikes and berms will be constructed in the back-beach areas near the discharge points to de-water the slurry and aid in the retention of sand at the receiver beaches. As currently envisioned, two dikes would be constructed – one that is perpendicular to the beach connected to one that is parallel to the beach (forming an "L"). The dredged slurry will be discharged behind the dikes. Where sand is not present on the existing beach an initial quantity of sand will be discharged on the highest portion of the beach and used to construct a dike. Once the sand slurries have been dewatered, the dykes and berms will be spread downslope across the existing beach face to the waterline using conventional earth moving equipment in order to produce new beach slopes approximating elliptic cycloid equilibrium beach profiles. These methods have been used effectively in the past to maximize the retention of the dredged sands that

## Table-1: Agua Hedionda Lagoon Dredging of the Outer (West) Basin, 1998-2018

| Year | Dredging | | | | | | Disposal | | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | Date | | Volume cubic yard | Influx | | Basin | Volume cubic yard | Location | |
| | Start | Finish | | Days | $Yds^3/Day$ | | | | |
| 1998 | Dec-97 | Feb-98 | 59,072 | 92 | 642 | Middle | 59,072 | M | Modification |
| | Feb-98 | Jul-98 | 214,509 | 150 | 1,430 | Inner | 120,710 | M | Modification |
| | | | | | | | 93,799 | S | |
| 1999 | Feb-99 | May-99 | 155,000 | 304 | 510 | Outer | 155,000 | N | Maintenance |
| 2000-01 | Nov-00 | Apr-01 | *422,541* | 701 | 603 | Outer | 141,346 | N | Maintenance |
| | | | | | | | 195,930 | M | |
| | | | | | | | 85,265 | S | |
| 2002-03 | Dec-02 | Apr-03 | *354,266* | 730 | 485 | Outer | 161,525 | N | Maintenance |
| | | | | | | | 131,377 | M | |
| | | | | | | | 61,364 | S | |
| 2004-05 | Jan-05 | Mar-05 | 348,151 | 704 | 495 | Outer | 100,487 | N | Maintenance |
| | | | | | | | 170,515 | M | |
| | | | | | | | 77,149 | S | |
| 2006-07 | Jan-07 | Apr-07 | 333,373 | 763 | 437 | Outer | 149,168 | N | Maintenance |
| | | | | | | | 121,038 | M | |
| | | | | | | | 63,167 | S | |
| 2008-09 | Dec-08 | Apr-09 | 299,328 | 733 | 408 | Outer | 104,141 | N | Maintenance |
| | | | | | | | 102,000 | M | |
| | | | | | | | 93,185 | S | |
| 2010-11 | Dec-10 | Apr-11 | 226,026 | 736 | 307 | Outer | 62,030 | N | Maintenance |
| | | | | | | | 93,696 | M | |
| | | | | | | | 70,300 | S | |
| 2014-15 | Dec-14 | Apr-15 | 294,661 | 736 | 400 | Outer | 64,968 | N | Maintenance |
| | | | | | | | 156,056 | M | |
| | | | | | | | 73,637 | S | |
| | | | | | | | 0 | N | |
| 2017-18 | Oct-17 | Apr-18 | 205,482 | 734 | 280 | Outer | 141,172 | M | Maintenance |
| | | | | | | | 64,310 | S | |
| **TOTAL** | | | 2,912,407 | | | | 2,912,407 | | |
| **AVERAGE** | | | 291,240 | | | | | | |
| **MAINTENANCE TOTAL** | | | **2,638,828** | | | | | | |


**Figure 1. Project Location Map**

*Note: North Beach receiver site used only during maintenance dredge/beach nourishment cycles when sand placement is dictated by existing beach condition.*


**Figure 2. Dredge Discharge Pipeline Routes**

*Note: North Beach discharge pipeline installed only during maintenance dredge/beach nourishment cycles when sand placement is dictated by existing beach condition.*

are placed on the three receiver beaches. The dikes and berms also are used to ensure shoreline ocean turbidity does not exceed the limit as set in the San Diego Regional Water Quality Control Board 401 Water Quality Certifications.

The discharge point is directed according to the pre-determined sand deposition plan. Once the material is de-watered, front-end loaders spread the sand on the beach and into the required elliptic cycloid beach profile configuration. As required by Condition 9 of the SUP, the beach berm will be no taller than 6 ft on the eastern aspect and will be groomed and flattened to provide towel space. The elliptic cycloid grading profiles ensure that the dredged sands will be placed in such a manner that the beach profile slopes gradually to the surf zone. In the event that storm events begin to relocate the front aspect of the graded sand slope during the equilibration process, the berm and slope shall be regraded for public safety purposes. Material will not be placed in areas that will block existing drainage. In addition, a minimum 5-ft wide path of travel will be maintained between sand placement operations and sea walls (both public and private).

Target sand placement quantities for North, Middle, and South Beach were developed based on computations of equilibrium beach profiles using current conditions and maximizing recreational beach widths in proportion use, while avoiding impact to the sensitive hard bottom habitat. Presently, the three receiver beaches are 93,141 cy below their carrying capacity **(see Section 4.2)**, which is the minimum amount of sand volume needed to maintain an equilibrium beach profile in the presence of historic extreme waves, otherwise known as the beach *critical mass*, (Jenkins and Inman, 2006). In addition, erosion losses on all three receiver beaches since the last beach nourishment cycle in 2018 total 366,644 cy **(see Table 4.)** Therefore, approximately 300,000 cy from the lagoon's outer basin is proposed to be dredged in order to avoid inlet closure and to replenish the sand on the North, Middle, and South Beaches. To maintain the greatest retention time of sand on the beach, the sand will be configured as an elliptic cycloid. This approach is based on the latest coastal science and was the approach taken in 2018 beach nourishment cycle and will be continued in this sand deposition plan for 2020/21 beach nourishment cycle. These computations are detailed in **Appendix-B** and the resulting elliptic cycloid beach fill grading designs that are plotted in **Appendix-C**. However, the grading designs in Appendix-C were modified to accommodate other factors of concern, including maximizing recreational beach widths in proportion to use, while avoiding impact to sensitive hard bottom habitat. These modified grading designs are found in **Appendix-D** and are referred to as *permitted*.

As described above, no more than 150,000 cy of dredge material will be placed at North Beach and the remaining dredge material, of approximately 146,600 cy (146,635.8 cy), will be placed at Middle and South Beach with an approximate distribution of 55.6% and 44.4%, respectively **(see Table 2)**. Any surplus dredge quantities in excess of 300,000 cy will only be placed on Middle and/or South beaches. North Beach disposal will not exceed 150,000 cy.

**Table 2. Target Placement Quantities**

| Receiver Site | Approximate Placement Quantity |
|---|---|
| North Beach | 150,000 cy |
| No. Inlet Jetty to Maple Ave. | 94,500 cy |
| Maple Ave. to Pine Ave. | 55,500 cy |
| Middle Beach | 81,575 cy |
| South Beach | 65,060 cy |
| **TOTAL** | 296,635 cy |

### *2.3 Summary of Project Equipment*

The designated staging area for equipment and materials is on Fishing Beach located on the west shoreline of the outer basin. The following equipment will be utilized.

- Hydraulic dredge;
- Slurry discharge pipe;
  - Poly and Steel pipe within the lagoon (floating);
  - Poly pipe along the shoreline;
- Rubber tired loaders – one full time, second as needed; and
- Pickup truck (4x4), for support on the shoreline and public roadways.

### *2.4 Access and Pedestrian Control*

Cabrillo and Poseidon regard safety of the public and personnel foremost over all other tasks. Portable signage will be used at each discharge location to advise pedestrians of current work. An example of this signage is provided in Figure 3 but will be modified to add Poseidon Resource and a revised the call number. This signage is relocated as the dredge slurry discharge point moves.


**Figure 3. Example of Public Signage**

No forms of public access to the shoreline will be blocked during sand deposition operations. Designated access ways, over or around obstructions, will be provided. Access for public safety vehicles also will be maintained. When discharging to South Beach, the piping is placed through an opening in the discharge channel fencing to ensure pedestrian safety. At no time will piping be placed on the pedestrian sidewalks along Carlsbad Boulevard. A monitor will be stationed at the north and south ends of the active work area to prevent foot traffic in the immediate discharge location. Appropriate signage and construction fencing will be used to identify the discharge location. The beach access areas will be left in a safe condition at the end of each workday. A flag crew will be utilized while moving or operating equipment on the beach. The pickup truck used to support the operation will utilize the shoreline and public roadways to avoid interference with pedestrian flow. As stipulated by Condition 9 of the SUP, a minimum 5-ft wide path of travel will be maintained between sand placement operations and sea walls (both public and private).

Discharge point relocation operations will be conducted during low pedestrian traffic times to the extent possible. In addition, project personnel will be available to answer any questions the public may have on the process.

### *2.5 Contact Information*

The project is being conducted under the supervision of Ms. Josie McKinley. Her contact information is provided below.

Josie McKinley, Director of Project Development
Poseidon Water LLC
5780 Fleet Street, Suite 140
Carlsbad, CA 92008
(760) 655-3989 voice
(310) 991-3032 (cell)
jmckinley@poseidonwater.com

Should emergency response be necessary for the dredge/beach nourishment activity, you may contact Ms. McKinley, or follow the Hazardous Materials Business Plan Emergency Notification as provided to the Carlsbad Fire Department.

## 3. PROJECT SCHEDULE

The dredging and sand placement schedule shall be similar to past activities and conform with the requirements stipulated in the California Coastal Commission Coastal Development Permit. The anticipated schedule is shown in **Table 3**.

**Table 3. Schedule for 2020/21 Dredge/Beach Nourishment Cycle**

| Activity | Approximate Dates |
|---|---|
| Dredging | November 2020 to April 15, 2021 |
| Sand Placement | |
| *North Beach* | January 2021 - March 2021 |
| *Middle Beach* | November 2020 – December 2020 |
| *South Beach* | March 2021- (15April 2021)[1] |
| **Total Period of Activity** | **October 2020 to April 15 2021** |

[1] Sand placement operations my extend beyond March 2021 if adverse weather conditions or equipment issues are encountered. No sand will be placed on beaches after April 15, 2021 without written approval from appropriate regulatory agencies.

It is anticipated that all work will be conducted during daylight hours and between Monday and Saturday. If the schedule is delayed by storm activity, work may be conducted during daylight hours on Sundays with appropriate authorization.

# 4. SAND PLACEMENT QUANTITY DETERMINATION

## *4.1 Beach Profile Surveys*

A post beach profile survey was conducted on 18 April 2018, immediately following completion of the 2017/2018 maintenance dredge and beach nourishment, as required by City of Carlsbad Special Use Permit (SUP) 06-10X2(A). This survey provided a baseline beach condition assessment. A new pre-beach nourishment profile survey was conducted on 13 May 2020 and 2 October 2020 to document the current condition of the beaches, and to determine erosion rates and erosion patterns following the April 2018 baseline survey. Data were obtained on 15 beach profile transects (**Figure 4**). Thirteen of the transects had been surveyed in 2018 on behalf of Cabrillo Power, while two were surveyed for the first time in 2020. Six of the Transects (CB-800 to CB 0850) correspond to historical locations included in the SANDAG Shoreline Monitoring Program and the City of Carlsbad Beach Monitoring Program (Coastal Frontiers, 2017a; 2017b). The data acquisition and reduction methods were comparable to those employed on the beach profile surveys conducted under the aforementioned programs.

Survey control information was provided by Cabrillo prior to the field activities. The coordinates of the control points were confirmed at the time of the survey using real-time kinematic (RTK) GPS techniques.

Survey activities were conducted under ideal conditions, with offshore winds and waves typically less than 3 ft. Data were acquired along each transect from the landward limit of the sandy beach to wading depth, which typically corresponded to 8 to 15 ft below Mean Lower Low Water (MLLW) Datum depending on the prevailing water level. The beach and surf zone were surveyed using a total station and a survey rodman. The total station was used to determine the position and elevation of the beach at each location occupied by the rodman. Each transect was surveyed from the back-beach seaward through the surf zone until the survey rod no longer protruded above the water surface when held erect.

The data from the wading survey were processed using software developed by Trimble. The raw total station data were read by the software, and the coordinates and elevation of each data point were calculated. The electronic total station used to conduct the survey is capable of measuring elevation differences to within ±0.1 ft and ranges to within ±0.5 ft. However, because the swimmer was subjected to waves and currents in the surf zone, the horizontal position perpendicular to each transect (parallel to the shoreline) varied from minimal at short ranges to approximately ±15 ft at the offshore end.

The beach profile plots developed from the 18 April 2018 post-beach nourishment survey and the 13 May 2020 and 2 October 2020 pre-beach nourishment survey data are provided in **Appendix A**.

The range on each profile plot represents the distance in feet seaward of the transect origin measured along the transect alignment. The elevation is given in feet relative to MLLW (1983-2001 Epoch). The beach profile survey data plotted in Appendix-A were loaded into


**Figure 4. Beach Profile Transect Locations**

AutoCad Civil 3-d to create 3-d models of the receiver beaches for 2018 post-beach nourishment condition and 2020 pre-beach nourishment conditions. **Figure-5a** shows the 3-d CAD model of the 2018 post-beach nourishment based on the 18 April 2018 beach profile survey; while **Figure 5b** plots the 3-d CAD model of the 2020 pre-beach nourishment based on the 13 May 2020 beach profile survey. By performing a spatial subtraction of the 2 October 2020 beach model from the 18 April 2018 model, the most current assessment of the erosion that has occurred since the 2018 beach nourishment is determined. **Table-4** presents a detailed break-down of the sand losses that have occurred along each surveyed reach between 18 April 2018 and 2 October 2020. Spatial subtraction of the 2 October 2020 model from the 28 April 2018 model produces an accurate and highly detailed assessment of sand losses, as given in Table-4.

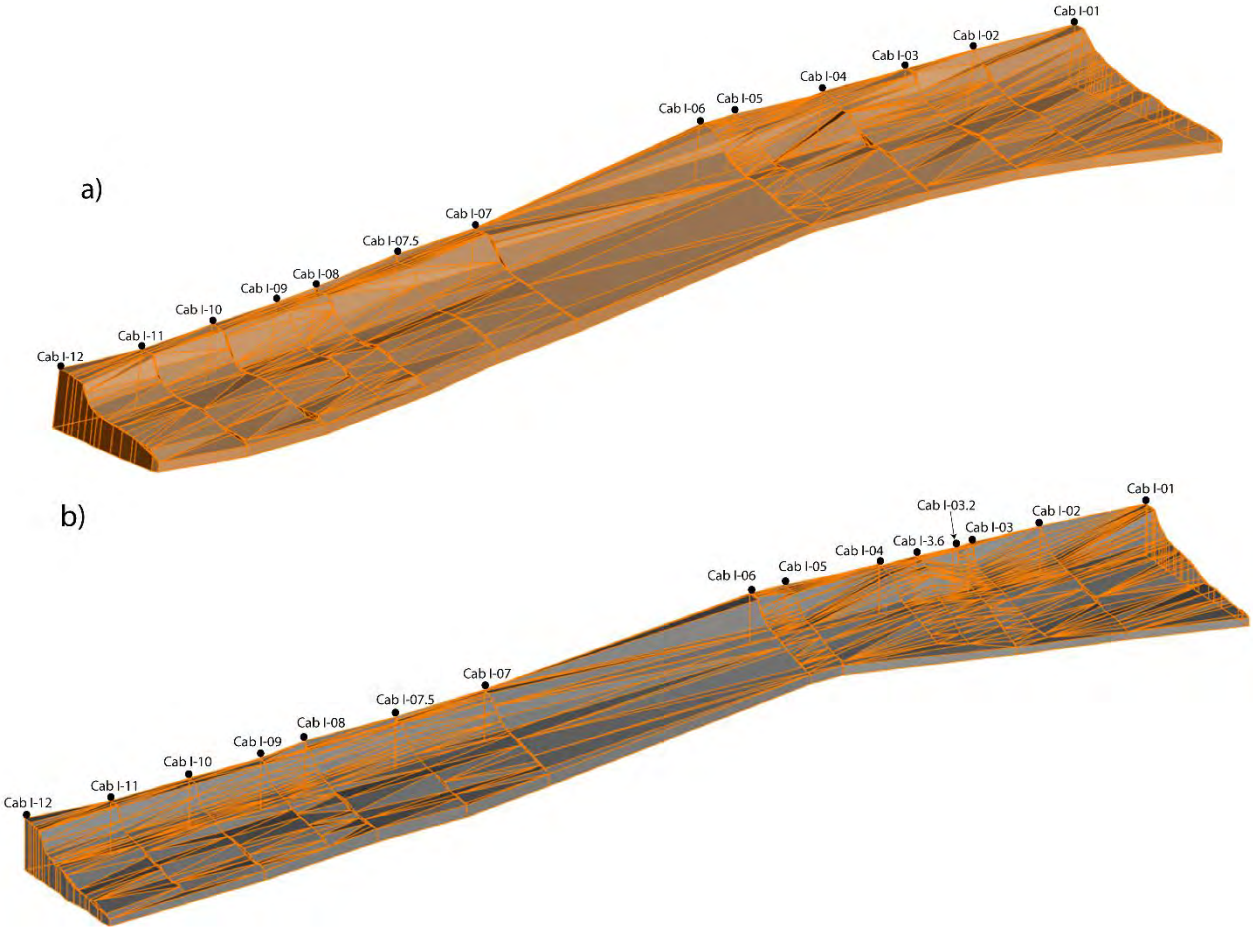


**Figure-5:** Three-dimensional CAD models of the receiver beaches: a) based on the 18 April 2018 post-beach nourishment survey, and b) based on the 13 May 2020 pre-beach nourishment survey.

**Table 4: Sand Losses on the Receiver Beaches Between 22 April 2018 and 2 October 2020**

| **Receiver Beach** | **Profile Range Line** | **Distance between Range Lines** | **Local Sand Loss $ft^3$/ft of shoreline** | **Sand Volume Lost between Range Lines, $ft^3$ & $yds^3$** |
|---|---|---|---|---|
| South Beach | Cab I-01 | | -980 | |
| | | 750.57 | | 622,034.9 $ft^3$ = 23,038.3 $yds^3$ |
| South Beach | Cab I-02 | | -677.5 | |
| | | 513.50 | | 438,785.7 $ft^3$ = 16,251.3 $yds^3$ |
| South Beach | Cab I-03 | | -1031.5 | |
| | | 648.92 | | 695,804.5 $ft^3$ = 25,770.5 $yds^3$ |
| Middle Beach | Cab I-04 | | -1,113 | |
| | | 667.82 | | 869,167.7 $ft^3$ = 32,191.4 $yds^3$ |
| Middle Beach | Cab I-05 | | -1,490 | |
| | | 259.91 | | 386,226.3 $ft^3$ = 14,304.7 $yds^3$ |
| Middle Beach | Cab I-06 | Cab I-06 to South Inlet Jetty = 639.1 ft. | -1,482 | 947,146.2 $ft^3$ = 35,079.5 $yds^3$ |
| | | North Inlet Jetty to Cab I-07 = 460.0 ft | | |
| | | | | |
| North Beach | Cab I-07 | | -1,859 | |
| | | 1399.51 | | 3,211,373.8 $ft^3$ = 118,939.9 $yds^3$ |
| North Beach | Cab I-08 | | -1,595 | |
| | | 350.56 | | 509,188.4 $ft^3$ = 18,858.8 $yds^3$ |
| North Beach | Cab I-09 | | -1,310 | |
| | | 541.45 | | 657,861.7 $ft^3$ = 24,365.2 $yds^3$ |
| North Beach | Cab I-10 | | -1120 | |
| | | 609.00 | | 697,305 $ft^3$ = 25,826.1 $yds^3$ |
| North Beach | Cab I-11 | | -1,170 | |
| | | 728.00 | | 864,500 $ft^3$ = 32,018.5 $yds^3$ |
| North Beach | Cab I-012 | | -1205 | |
| **Total Sand Loss South Beach** | | | | **1,756,625.1 $ft^3$ = 65,060.2 $yds^3$** |
| **Total Sand Loss Middle Beach** | | | | **2,202,540.2 $ft^3$ = 81,575.6 $yds^3$** |
| **Total Sand Loss Cab I-07 to I-10 (No. of Inlet Jetty to Maple Ave)** | | | | **4,378,423.9 $ft^3$ = 162,163.9 $yds^3$** |
| **Total Sand Loss Cab I-10 to I-12 (Maple Ave to Pine Ave** | | | | **1,561,805.0 $ft^3$ = 57,844.6 $yds^3$** |
| **Total Sand Loss North Beach** | | | | **5,940,228.9 $ft^3$ = 220,008.5 $yds^3$** |
| **Total Sand Loss** | | | | **9,899,394.2 $ft^3$ = 366,644.3 $yds^3$** |

Inspection of **Table-4** indicates total erosion losses on all three receiver beaches since the last dredge/beach nourishment cycle in 2018 total 366,644 cy, with 60% of the erosion losses occurring on North Beach and 40% occurring on Middle and South Beach. More sand has been lost to erosion since 2018 on North Beach, (where no sand was placed during the 2018 dredge/beach nourishment cycle), than was lost on Middle and South Beaches combined; i.e. 220,009 cy eroded from North Beach vs only 146,636 cy lost on Middle and South Beach combined (81,576 cy, lost on Middle Beach and 65,060 cy lost on South Beach). This was a significant consideration in posing the 2020/21 sand deposition plan summarized in the Executive Summary. Another point to highlight here is that the definition of the North Beach receiver beach has varied over the years, ever since North Beach disposal has been practiced, beginning in 1998. North Beach disposal originally extended from the north inlet jetty to Maple Ave. Later, City of Carlsbad Special Use Permit (SUP) 06-10X2(A) redefined the North Beach disposal site to be extended to Pine Ave. Therefore, **Table-4** sub-divides the North Beach site between the north inlet jetty at survey range Cab I-07 to Maple Ave. at survey range Cab I-10; and from Cab I-10 to Pine Ave. at Cab I-12. Since the 18 April 2018 post-beach nourishment survey, 162,164 cy of beach sand has been lost between the north inlet jetty and Maple Street, while 57,845 cy has been lost between Maple Street and Pine Ave.

In addition to the erosion losses that have occurred on the receiver beaches since the 2018 beach nourishment cycle, it is necessary to assess the remaining quantities of sand on the receiver beaches before beach nourishment quantities can be formulated. The carrying capacity of a beach is limited by the width of the wave-cut platform in the bedrock on which beach sands have accumulated over geologic time scales. To assess the residual sand volume, it is necessary to estimate the profile of the bedrock and basal conglomerate (aka, wave cut platform) on which the residual sand volume rests. Bed rock/basal conglomerate elevation profiles were derived from the composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0800, CB-0810, CB-0820, CB-0830, CB-0840, and CB-0850. The composite minimums occurred during years when portions of the receiver beaches were stripped of sand by severe erosion, leaving only remnant cobble beaches. The composite minimum profiles representing the wave-cut platform are plotted in Appendix-A in Figures A-1, 6, 8, 9, 13, and 16. These profiles were lofted as a 3-d solid in AutoCad Civil 3-d and embedded inside the 3-d CAD models of the receiver beaches in Figures 5a & b. By performing a spatial subtraction of the 2 October 2020 beach model from the bedrock profile model, a reasonably accurate assessment of the residual sand volume remaining on the receiver beaches can be made. **Table-5** presents a detailed break-down of the residual sand volume that remains as of 13 May 2020 and 2 October 2020 along each surveyed reach of receiver beach.

Inspection of **Table-5** indicates total residual sand volume remaining on all three receiver beaches since the last dredge/beach nourishment cycle in 2018 total 249,594 cy. More residual sand volume remains on the combined Middle Beach and South Beach complex (167,673 cy, Middle Beach = 94,638 cy and South Beach = 73,035 cy) than on North Beach, where remaining sand volume is only 81,921.4 cy. (This finding is likely due to beach stabilization by the 3 jetties along Middle and South Beaches). Thus, it is sensible to place more sand on North Beach during the

**Table 5: Residual Sand Volume on the Receiver Beaches as of 2 October 2020 Survey**

| **Receiver Beach** | **Profile Range Line** | **Distance between Range Lines** | **Residual Sand Volume $ft^3$/ft of shoreline** | **Residual Sand Volume between Range Lines, $ft^3$ & $yds^3$** |
|---|---|---|---|---|
| South Beach | Cab I-01 | | +1610 | |
| | | Cab I-01 to South Discharge Jetty = 1,264 ft. | | 1,971,945 $ft^3$ = 73,035 cy |
| Middle Beach | Cab I-04 | | +1510 | |
| | | North Discharge Jetty to Cab I-06 = 1,576 ft | | 1,806,884 $ft^3$ = 66,921 $yds^3$ |
| Middle Beach | Cab I-06 | | +783 | |
| | | Cab I-06 to South Inlet Jetty = 955.7 ft. | | 748,359 $ft^3$ = 27,717 $yds^3$ |
| | | North Inlet Jetty to Cab I-07 = 460 ft | +510 | 234,600 $ft^3$ = 8,689 $yds^3$ |
| North Beach | Cab I-07 | | +670 | |
| | | 1,750 ft. | | 1,082,375 $ft^3$ = 40,087 $yds^3$ |
| North Beach | Cab I-09 | | +567 | |
| | | 1,878 ft. | | 894,867 $ft^3$ = 33,143 $yds^3$ |
| North Beach | Cab I-012 | | +386 | |
| **Residual Sand South Beach** | | | | **1,971,945 $ft^3$ = 73,035 cy** |
| **Residual Sand Middle Beach** | | | | **2,55,226 $ft^3$ = 94,638 $yds^3$** |
| **Residual Sand Cab I-07 to I-10 No. of Inlet Jetty to Maple Ave.** | | | | **1,701,815 $ft^3$ = 63,030 $yds^3$** |
| **Residual Sand Cab I-10 to I-12 Maple Ave. to Pine Ave.** | | | | **510,062 $ft^3$ = 18,891 $yds^3$** |
| **Total Residual Sand North Beach** | | | | **2,211,878 $ft^3$ = 81,921.4 $yds^3$** |
| **Total Residual Sand** | | | | **6,739,049 $ft^3$ = 249,594 $yds^3$** |

forthcoming 2020/21 dredge/beach nourishment cycle, then on the Middle/ South Beach complex.

### *4.2 Sand Quantity Calculation Methods and Results*

Beaches require a certain minimum sand volume (referred to as the *critical mass*) to sustain and equilibrium form in the presence of historic extreme waves, which is the theoretical minimum carrying capacity for sand. The carrying capacity of a beach is limited by the width of the wave-cut platform in the bedrock on which beach sands have accumulated over geologic time scales. The carrying capacity is also limited by wave climate, and more sand is required to accumulate on the wave cut platform in the presence of higher wave heights. The bedrock profiles Figures A-1, 6, 8, 9, 13, and 16 of Appendix-A indicate the wave-cut platform along Middle and South Beach is about 400 ft. to 500 ft. in width and only 300 ft. to 400 ft. in width along North Beach. The platforms are narrow because they were carved by wave action into erosion resistant bedrock formations during the present high-stand in sea level, and these narrow wave-cut platforms physically cannot hold large quantities of beach sand; and often become fully stripped during periods of high-energy winter waves.

The carrying capacity (or minimal sand volume for each beach) is determined by the critical mass (Jenkins and Inman, 2006 and Jenkins, *et al.*, 2007) based on the elliptic cycloid profile. The critical mass is calculated from maximum wave heights and sand grain sizes according to:

$$V_c = 1.23\times10^{-4}\left(h_c\right)^{2.1}\left(\frac{H_\infty}{\Lambda}\right)^{0.9}$$

$$\text{with: } h_c = \frac{K_e H_\infty}{\sinh kh_c}\left(\frac{D_o}{D_2}\right)^{\psi}$$

$$\text{and: } \Lambda = 2^{2/5} H_\infty^{1/5}\left(\sigma^2 \big/ g\gamma\right)^{1/5}$$

Here $h_c$ is the closure depth; $\psi$ is a non-dimensional empirical parameter, $D_2$ is the shorerise median grain size; and $D_o$ is a reference grain size ; $\sigma = 2\pi / T$ is radian frequency; $k$ is the wave number; $\Lambda$ is the shoaling factor relating breaker height to incident wave height $\Lambda = H_\infty / H_b$ ; $g$ is acceleration of gravity; and $\gamma$ is a factor relating the depth of wave breaking $h_b$ to breaker height, $H_b = \gamma h_b$. For the critical mass calculations determining minimal placement volume, the following values for free parameters were used: $K_e \sim 2.0, \psi \sim 0.33,$ and $D_o \sim 100\mu m$. The minimal carrying capacities (critical mass) for each reach are summarized in **Table-6**.

The minimum sand placement quantities for each receiver beach were determined by comparing the existing beach geomorphology with the critical mass sand volumes determined in **Appendix-**

**B**. The results are summarized in **Table 6**. The volume calculations were performed with surface modeling software using the equations detailed in **Appendix-B**. It should be noted that the minimal carrying capacity for the reach of North Beach between the north inlet jetty and Maple Ave is 79,500 cy, but when the North Beach disposal site is extended further north to Pine Ave, its minimal carrying capacity increase to 135,100 cy.

As indicated in **Table 6**, the residual sand volume above the wave cut platform at the time of the 2 October 2020 beach profile survey is marginally less than the critical mass calculated in **Appendix-B.** Only 53,179 cy of dredged sand would be needed on North Beach to re-establish minimal carrying capacity (critical mass), with most of the deficit (36,709 cy) occurring in the Maple Ave. to Pine Ave. reach vs.; vs. only 16,470 cy required to restore critical mass in the Maple Ave to Pine Ave. reach. Presently Middle Beach requires just 39,962 cy of dredged sand to re-establish minimal carrying capacity (critical mass); while South Beach is over-built, with a surplus of 6,735 cy above its critical mass limit of 66,300 cy. Altogether, 93,141 cy of dredged sands are needed to restore all the receiver beaches to critical mass (i.e. the minimal carrying capacity). However, the sustainability of an open inlet to Agua Hedionda Lagoon requires that more than 93,141 cy must be dredged from the flood tide shoal in the West Basin of the lagoon. Approximately 300,000 cy is proposed to be dredged in order to avoid inlet closure; and that sand must be placed somewhere on the North, Middle, and South Beach. Therefore, the beaches will receive an excess of 203,494.8 cy beyond their minimal carrying capacity during the 2020/21 dredging of the lagoon.

Even with excess sand beyond that needed to restore critical mass, the sand retention times will be maximized by using beach fill profiles that approximate the elliptic cycloid beach profile, **Appendix-B**. The elliptic cycloid profile is the beach shape that can be sustained in an equilibrium state during the most severe wave events. Elliptic cycloid beach-fill profiles for 13 of the 15 surveyed transects are developed in **Appendix-C** using the methodology detailed in **Appendix-B**. Two of the 15 were newly surveyed transects in May 2020 with no previous profile to estimate sand loss. The sand placement volumes derived from the mathematics in **Appendix-B** for these elliptic cycloidal beach fill profiles (referred to as *distribution of dredge fill on receiver beaches based on coastal modeling*) are summarized in **Table-7**. However, factors other than critical mass and elliptic cycloid mathematics entered into the sand placement quantities to be allocated to the 3 receiver beaches to be used for the 2020/21 dredging of the lagoon. Considerations for maximizing recreational beach widths in proportion to use and avoiding impact to sensitive hard bottom habitat were balanced against *distribution of dredge beach fill on receiver beaches based on coastal modeling* results in **Table-7** and **Appendix-C** to achieve what is referred to herein as *permitted distribution of dredge fill on receiver beaches*. Permitted sand placement results in **Table-8** and **Appendix-D** have been derived from discussions/approvals with local residents, stakeholders and regulatory agencies. The increases in mean beach widths derived from these permitted beach fill profiles are listed in **Table-9**. North Beach is the most heavily recreated of the 3 receiver beaches due to ease of access from the Tamarack parking lot. Access to Middle and South Beach is limited by available parking along the west shoulder of Carlsbad Blvd. Therefore, the largest volume of dredged sand (150,000 cy) is allocated to North Beach using the elliptic cycloid beach fill profiles applied to the *permitted sand placement results* per **Appendix-D** which will increase mean beach widths by a modest 33 ft. to 48 ft., resulting in mean beach widths of

**Table 6. Carrying Capacity and Target Sand Placement Volumes at Each Receiver Beach**

| Receiver Site | Minimum Carrying Capacity (Critical Mass)[1] | Sand Volume Lost April 2018 to May 2020 | Sand Volume Lost April 2018 to Oct. 2020 | May 2020 Residual Sand Volume [2] | Oct. 2020 Residual Sand Volume | Placement Volume to Re-establish Critical Mass [2] | Permitted Sand Placement Volume [3] |
|---|---|---|---|---|---|---|---|
| North Beach | 135,100 cy | 164,780 cy | 220,008.5 cy (60% of total) | 125,078 cy | 81,921.4 cy | 53,179 cy | 150,000 cy (51% of total) |
| North Jetty to Maple Ave. | 79,500 cy | 118,248 cy | 162,163.9 cy | 84,176 cy | 63,030.2 cy | 16,470cy | 94,500.0 cy |
| Maple Ave. to Pine Ave. | 55,600 cy | 46,532 cy | 57,844.6 cy | 40,902 cy | 18,891.2 cy | 36,709 cy | 55,500.0 cy |
| Middle Beach | 134,600 cy | 68,435 | 81,575.6 cy | 113,060 cy | 94,638 cy | 39,962 cy | 81,575.6 cy |
| South Beach | 66,300 cy | 62,059 cy | 65,060.2 cy | 76,300 cy | 73,035 cy | 0 cy | 65,060.2 cy |
| Mid + South | 200,900 | 130,494 | 146,635.8 (40% of total) | 189,360 cy | 167,673 cy | 39,962 cy | 146,635.8 cy (49% of total) |
| **TOTALS** | 336,000 cy | 295,274 | 366,644.3 cy | 314,438 cy | 249,594 cy | 93,141 cy | 296,635.8 cy |

Notes:

[1] Determined by critical mass per Appendix-B & Jenkins and Inman, (2006) and Jenkins (2017a, 2017b, 2017c).

[2] Based on difference between critical mass and October 2020 beach profile survey (Section 4.1). Critical mass determined from 1997-2012 composite minimum.

[3] Permitted sand placement volumes should equal the placement volume required to re-establish elliptic cycloidal beach profiles that will maintain equilibrium in the presence of the historic maximum wave heights per Appendix-C and Column-5 in Table 7. However, maintaining recreational beach widths in proportion to use, while avoiding impact to sensitive hard bottom habitat, is an additional important consideration. Therefore, permitted placement volumes per Column- 8 above have been developed based on discussions/approvals with local residents, stakeholders and regulatory agencies.

**Table 7: Required Distribution of Dredge Fill on Receiver Beaches to Achieve Cycloidal Equilibrium Beach Profiles as of 2 October 2020[1]**

| Receiver Beach | Profile Range Line | Distance between Range Lines | Required Beach Fill[1], $ft^3$/ft of shoreline | Beach Fill between Range Lines to Achieve Required Cycloidal Equilibrium Profiles[1] $ft^3$ & $yds^3$ |
|---|---|---|---|---|
| South Beach | Cab I-01 | | +887 | |
| | | 750.57 | | 643,703.4 $ft^3$ = 23,844.2 $yds^3$ |
| South Beach | Cab I-02 | | +828 | |
| | | 513.50 | | 515,136.7 $ft^3$ = 19,079 $yds^3$ |
| South Beach | Cab I-03 | | +1,178 | |
| | | 648.92 | | 465,231.5 $ft^3$ = 17,230.8 $yds^3$ |
| Middle Beach | Cab I-04 | | +256 | |
| | | 667.82 | | 335,836.6 $ft^3$ = 12,438.4 $yds^3$ |
| Middle Beach | Cab I-05 | | +750 | |
| | | 259.91 | | 219,315.0 $ft^3$ = 8,122.8 $yds^3$ |
| Middle Beach | Cab I-06 | Cab I-06 to South Inlet Jetty = 955.7 ft. | +938 | |
| | | 2203.14 | | 599,227.5 $ft^3$ = 22,193.6 $yds^3$ |
| North Beach | Cab I-07 | | +1,505 | |
| | | 1399.51 | | 2,183,410.3 $ft^3$ = 80,867 $yds^3$ |
| North Beach | Cab I-08 | | +1,615 | |
| | | 350.56 | | 521,314.3 $ft^3$ = 19,307.9 $yds^3$ |
| North Beach | Cab I-09 | | +1,359 | |
| | | 541.45 | | 660,621.6 $ft^3$ = 24,467.5 $yds^3$ |
| North Beach | Cab I-10 | | +1,081 | |
| | | 609.00 | | 802,608.4 $ft^3$ = 29,726.2 $yds^3$ |
| North Beach | Cab I-11 | | +1,554 | |
| | | 728.00 | | 1,153,493 $ft^3$ = 42,721.9 $yds^3$ |
| North Beach | Cab I-12 | | +1,565 | |
| **Beach Fill Required for South Beach** | | | | **1,624,065.4 $ft^3$ = 60,150.6 $yds^3$** |
| **Beach Fill Required for Middle Beach** | | | | **1,154,376.4.1 $ft^3$ = 42,754.7 $yds^3$** |
| **Beach Fill Required South of Inlet** | | | | **2,778,442.5 $ft^3$ = 102,905.3 $yds^3$** |
| **Beach Fill Required Cab I-07 to I-10 No. Inlet Jetty to Maple Ave** | | | | **3,365,357.4 $ft^3$ = 124,642.9$yds^3$** |
| **Beach Fill Required Cab I-10 to I-12 Maple Ave to Pine Ave** | | | | **1,956,104.6 $ft^3$ = 72,448.3 $yds^3$** |
| **Beach Fill Required for North Beach** | | | | **5,321,464.8 $ft^3$ = 197,091.3 $yds^3$** |
| **Total Beach Fill Required to Achieve Cycloidal Equilibrium Profiles1** | | | | **8,099,908.2 $ft^3$ = 299,996.6 $yds^3$** |

[1] Required beach fill is based on difference between the 2 October 2020 beach profiles and the elliptic cycloidal beach profiles that will retain the required amount of lagoon sands that will be dredged in equilibrium.

**Table 8: Required Permitted Distribution of Dredge Fill on Receiver Beaches to Achieve Elliptic Cycloidal Equilibrium Beach Profiles While Maintaining Recreational Beach Widths in Proportion to Use[1]**

| Receiver Beach | Profile Range Line | Distance between Range Lines | Required Beach Fill $ft^3/ft$ of shoreline | Beach Fill between Range Lines to Achieve Required Permitted Cycloidal Equilibrium Profiles to be Placed by Dredge Contractor $ft^3$ & $yds^3$ |
|---|---|---|---|---|
| South Beach | Cab I-01 | | +959 | |
| | | 750.57 | | 696,341 $ft^3$ = 25,790 $yds^3$ |
| South Beach | Cab I-02 | | +896 | |
| | | 513.50 | | 557,179 $ft^3$ = 19,079 $yds^3$ |
| South Beach | Cab I-03 | | +1,274 | |
| | | 648.92 | | 503,105 $ft^3$ = 18,633 $yds^3$ |
| Middle Beach | Cab I-04 | | +488 | |
| | | 667.82 | | 640,774 $ft^3$ = 23,732 $yds^3$ |
| Middle Beach | Cab I-05 | | +1,431 | |
| | | 259.91 | | 418,452 $ft^3$ = 15,498 $yds^3$ |
| Middle Beach | Cab I-06 | Cab I-06 to South Inlet Jetty = 955.7 ft. | +1,790 | |
| | | 2203.14 | | 1,143,320 $ft^3$ = 42,345 $yds^3$ |
| North Beach | Cab I-07 | | +1,141 | |
| | | 1399.51 | | 1,655,386 $ft^3$ = 61,311 $yds^3$ |
| North Beach | Cab I-08 | | +1,224 | |
| | | 350.56 | | 395,242 $ft^3$ = 14,639 $yds^3$ |
| North Beach | Cab I-09 | | +1,030 | |
| | | 541.45 | | 660,621.6 $ft^3$ = 18,550 $yds^3$ |
| North Beach | Cab I-10 | | +819 | |
| | | 609.00 | | 614,848 $ft^3$ = 22,772 $yds^3$ |
| North Beach | Cab I-11 | | +1,190 | |
| | | 728.00 | | 883648 $ft^3$ = 32,728 $yds^3$ |
| North Beach | Cab I-12 | | +1,199 | |
| **Beach Fill to be Placed on South Beach** | | | | **1,621,625.4 $ft^3$ = 60,060.2 $yds^3$** |
| **Beach Fill to be Placed on Middle Beach** | | | | **2,202,546 $ft^3$ = 81,575.6 $yds^3$** |
| **Beach Fill to be Placed Between Cab I-07 to I-10 (North Inlet Jetty to Maple Ave)** | | | | **2,551,500 $ft^3$ = 94,500 $yds^3$** |
| **Beach Fill to be Placed Between Cab I-10 to I-12 (Maple Ave to Pine Ave)** | | | | **1,498500 $ft^3$ = 55,500 $yds^3$** |
| **Beach Fill to be Placed on North Beach** | | | | **4,050,000 $ft^3$ = 150,000 $yds^3$** |
| **Total Permitted Beach Fill to be Placed on All Receiver Beaches While Maintaining Recreational Beach Widths in Proportion to Use** | | | | **8,009,167 $ft^3$ = 296,635.8 $yds^3$** |

[1] Recreational beach use requirements determined through discussions/approvals with local residents, stake holders and regulatory agencies.

**Table 9: Permitted Mean Beach Widths After 2020/21 Maintenance Dredging Disposal**

| Receiver Beach | Profile Range Line | Distance between Range Lines | Beach widths 2 October 2020, ft. | *Beach Widths per Permitted Beach Fill as Elliptic Cycloid Profiles, ft. | Increase in Mean Beach Widths, Post-2020/21 Dredging Disposal, ft. |
|---|---|---|---|---|---|
| South Beach | Cab I-01 | | 180 ft. | 281 ft. | 101 ft. |
| | | 750.57 | | | |
| South Beach | Cab I-02 | | 190 ft. | 265 ft. | 75 ft. |
| | | 513.50 | | | |
| South Beach | Cab I-03 | | 170 ft. | 265 ft. | 95 ft. |
| | | 648.92 | | | |
| Middle Beach | Cab I-04 | | 254 ft. | 534 ft. | 280 ft. |
| | | 667.82 | | | |
| Middle Beach | Cab I-05 | | 208 ft. | 473 ft. | 265 ft. |
| | | 259.91 | | | |
| Middle Beach | Cab I-06 | Cab I-06 to South Inlet Jetty=955.7ft | 200 ft. | 420 ft. | 220 ft. |
| | | North Inlet Jetty to Cab I-07 = 460.0 ft | | | |
| | | 2203.14 | | | |
| North Beach | Cab I-07 | | 150 ft. | 192 ft. | 42 ft. |
| | | 1399.51 | | | |
| North Beach | Cab I-08 | | 145 ft. | 178 ft. | 33 ft. |
| | | 350.56 | | | |
| North Beach | Cab I-09 | | 130 ft. | 178 ft. | 48 ft. |
| | | 541.45 | | | |
| North Beach | Cab I-10 | | 150 ft. | 191 ft. | 41 ft. |
| | | 609.00 | | | |
| North Beach | Cab I-11 | | 150 ft. | 195 ft. | 45 ft. |
| | | 728.00 | | | |
| North Beach | Cab I-012 | | 135 ft. | 169 ft. | 34 ft. |

*Based on water elevations at mean sea level

169 ft. to 195 ft., (see **Table-9**). Somewhat smaller amounts are allocated to Middle and South Beach, with Middle Beach receiving 81,575.8 cy and South Beach receiving 65,060.2 cy, in proportion to lesser beach use and available on-site parking. Because of the relatively larger existing residual sand volumes on these beaches, the *permitted* allocations to Middle Beach will increase mean beach widths by as much as 220 ft. to 280 ft., resulting in mean beach widths of 420 ft. to 534 ft.; while mean beach widths at South Beach will increase by as much as 75 ft. to 101 ft., resulting in mean beach widths of 265 ft. to 281 ft. (see **Table-9**). It should be noted that the heavier allocation of dredged sand to North Beach is consistent with beach nourishment plans approved in 1999, 2002 and 2006, (see **Table-1**), and due to the ocean's southern littoral drift, sand will be naturally transported from the North, Middle and South Beaches to beaches located downcoast.

## 5. SUMMARY

Cabrillo and Poseidon plan to conduct maintenance dredging in 2020/21 to remove a flood-tide shoal in the Agua Hedionda Lagoon - Outer Basin in order maintain the tidal exchange between the lagoon and the ocean and provide seawater to support the operation of the Claude "Bud" Lewis Carlsbad Desalination Plant. Similar operations have been performed over the last six decades. Approximately 300,000 cy of sand may be removed from the lagoon – outer basin. In keeping with past operations, the dredged sand will be placed on adjacent beaches: North Beach, Middle Beach, and South Beach. Operations will be conducted between November 2020 and April 2021.

Sand placement quantities for each receiver beach was determined based on an assessment of the minimal sand required to re-establish sand carrying capacity, residual sands remaining on the receiver beaches, and maximizing recreational beach widths in proportion to use, while avoiding impact to sensitive hard bottom habitat. The proposed sand placement quantities and approximate schedule are summarized in **Table-10** on the following page.

**Table 10: Beach Placement Quantities and Schedule[1]**

| Receiver Site | Approximate Placement Quantity | Approximate Schedule |
|---|---|---|
| North Beach[2] | 150,000 cy | January 2021 - March 2021 |
| North Inlet Jetty to Maple Ave | 94,500 cy | |
| Maple Ave to Pine Ave | 55,500 cy | |
| Middle Beach[3] | 81,575.6 cy | November 2020 – December 2020 |
| South Beach[3] | 65,060.2 cy | March 2021- 15April 2021 |
| **Total** | 296,635.8 cy<br>≅ **300,000 cy** | |

[1]Sand placement operations my extend beyond March 2021 if adverse weather conditions or equipment issues are encountered. No sand will be placed on beaches after April 15, 2021 without written approval from appropriate regulatory agencies. Any surplus dredge quantities in excess of 300,000 cy will only be placed on middle and/or south beaches.

[2] Sand placement quantity for North Beach is not to exceed 150,000 cubic yards.

[3] Sand placement quantities for Middle Beach and South Beach are approximate. Sand placement on the Middle Beach shall be completed prior to initiating sand placement on the North Beach.

## 6. REFERENCES

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Jenkins, S. A, (2010), "Hydrodynamic Analysis of Future Dredge Requirements and Inlet Closure Risks for Agua Hedionda Lagoon during Reduced Intake Flow Operations at Encina Power Station", submitted to NRG Cabrillo Power Operations Inc., 129 pp.

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Jenkins, S. A., 2017b, "Beach Equilibrium Analysis of Middle and South Beach Disposal Options for Dredged Sands from Agua Hedionda Lagoon, Carlsbad, CA," submitted to Cabrillo Power I LLC, 72 pp.

Jenkins, S. A., 2017c, "Cabrillo Power I LLC, Encina Power Station, Outer Agua Lagoon Maintenance Dredging Coastal Development Permit.", letter to Ms. Erin Prahler, California Coastal Commission, San Diego Coast District Office, dated 6 September 2017, Poway, CA.

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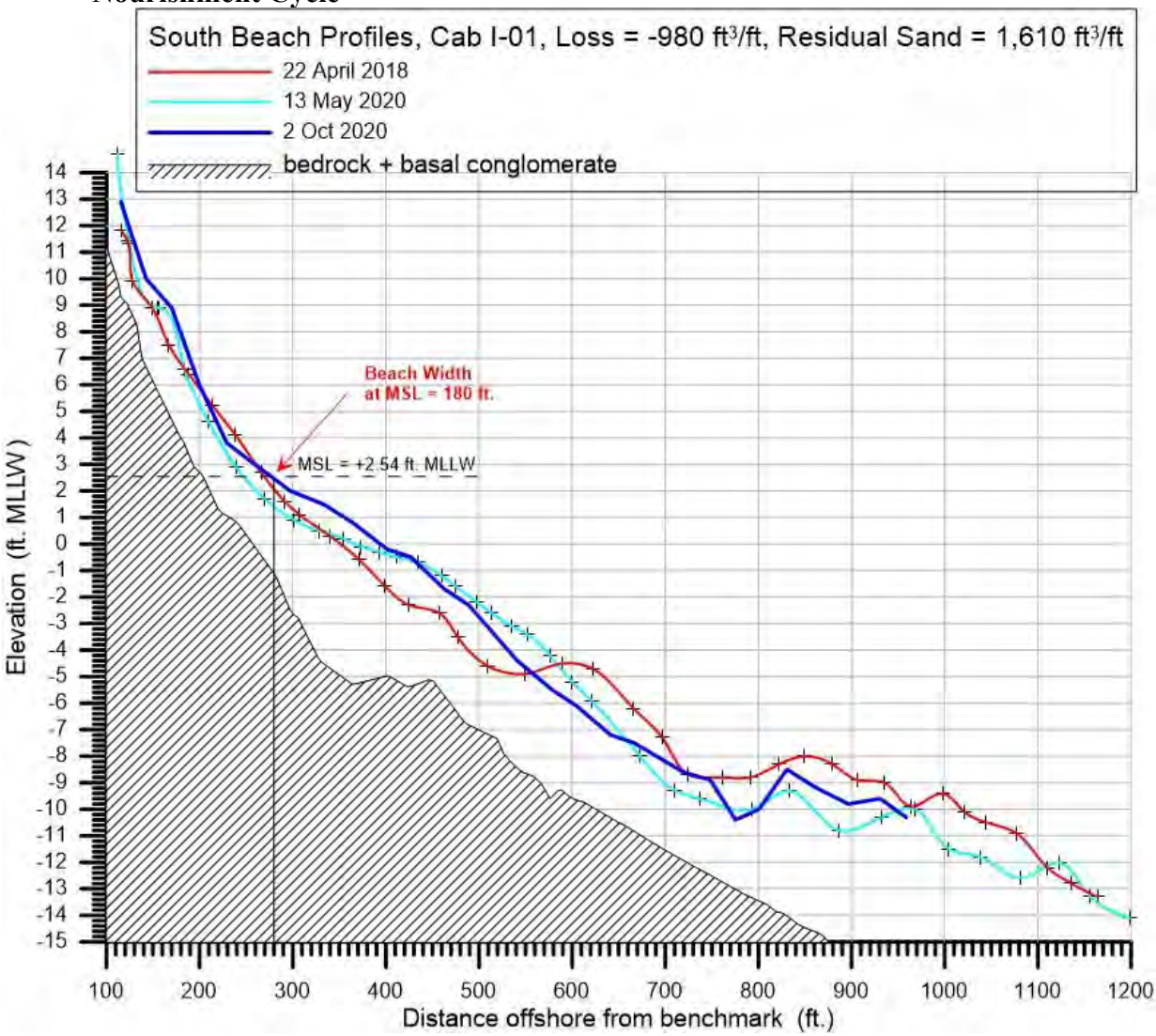
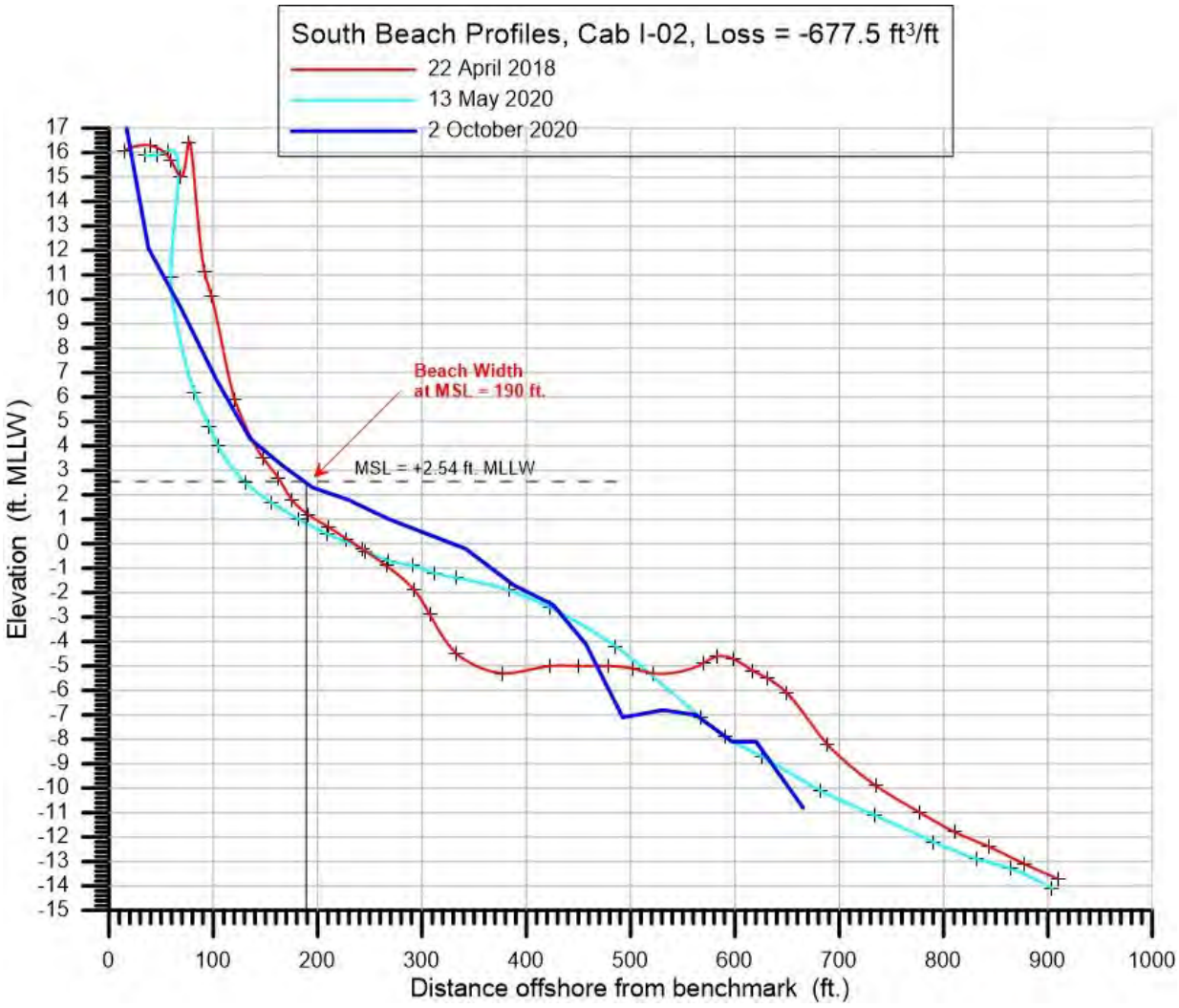
## Appendix-A: Surveys at Beach Disposal Sites Following 2018 Maintenance Dredge/Beach Nourishment Cycle



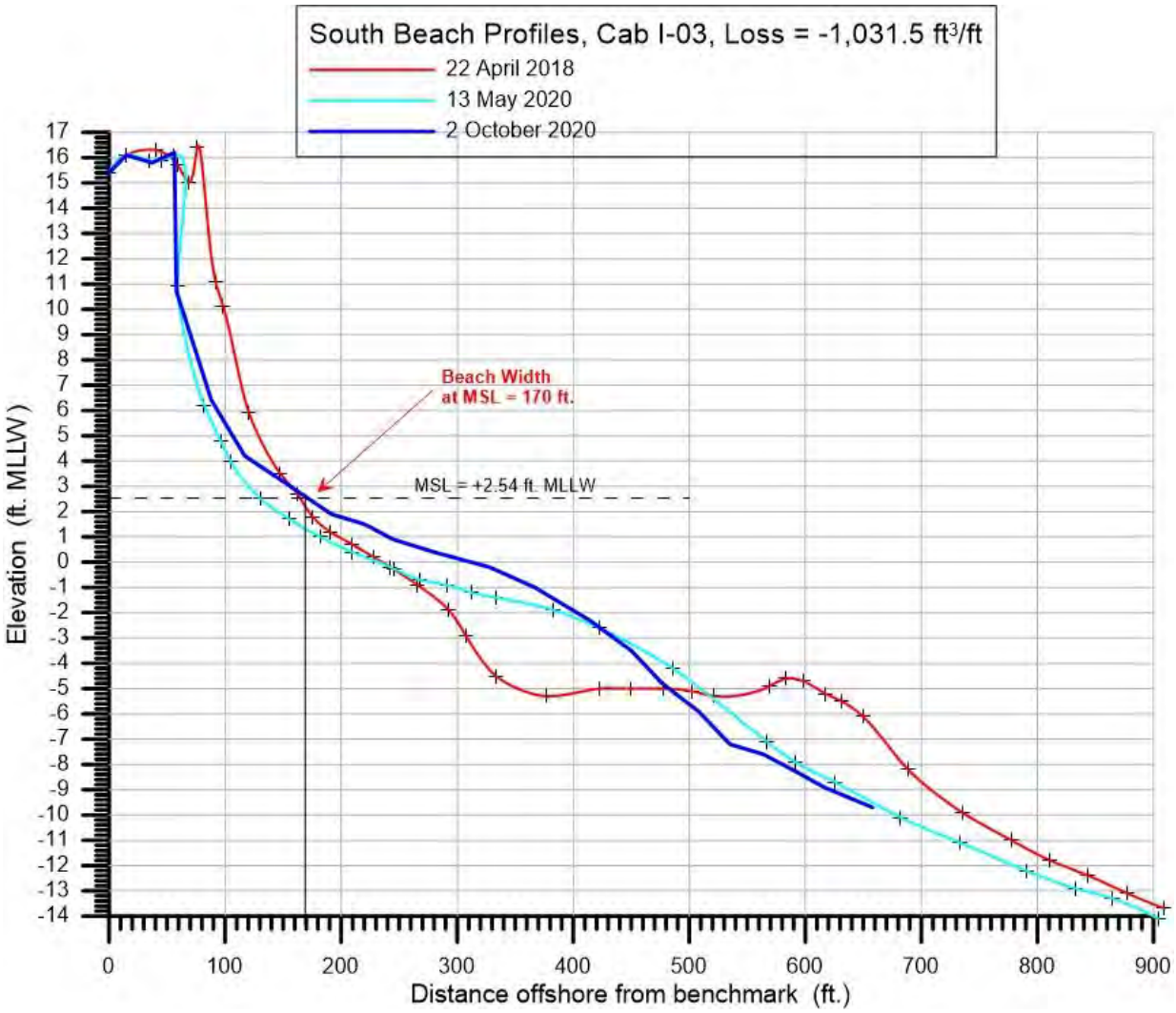

**Coordinates of Benchmark:**
Northing (ft): 1994408.5
Easting (ft): 6228847.4

**Figure A-1:** Measured beach profiles at survey range Cab I-01 on South Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018, (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020, (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line) Bed rock/basal conglomerate (hard bottom) elevation based on composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0800.



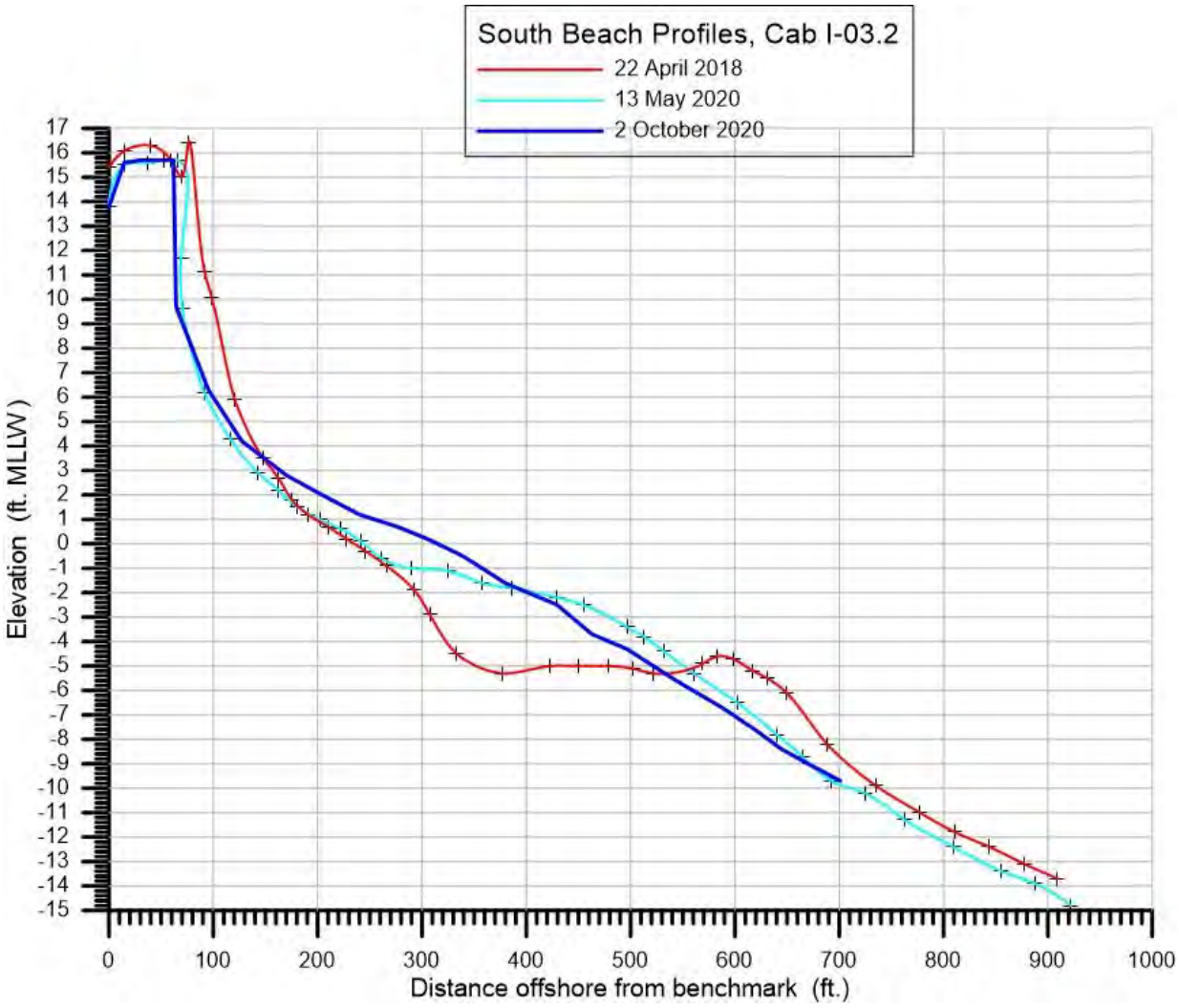

**Coordinates of Benchmark:**
Northing (ft): 1995102.9
Easting (ft): 6228562.5

**Figure A-2** Measured beach profiles at survey range Cab I-02 on South Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018, (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020, (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).



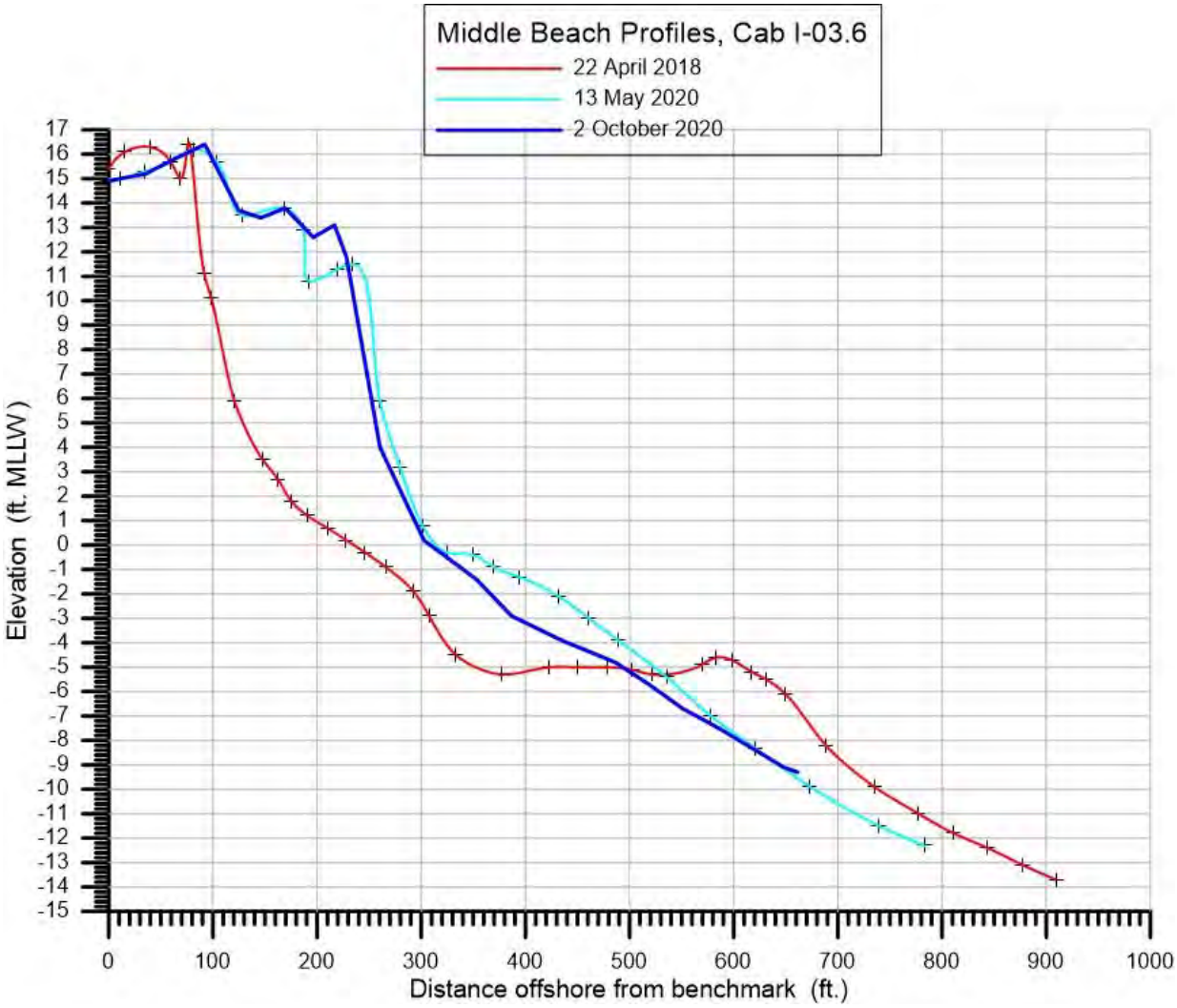

**Coordinates of Benchmark:**
Northing (ft): 1995576.9
Easting (ft): 6228365

**Figure A-3:** Measured beach profiles at survey range Cab I-03 on South Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); and prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).



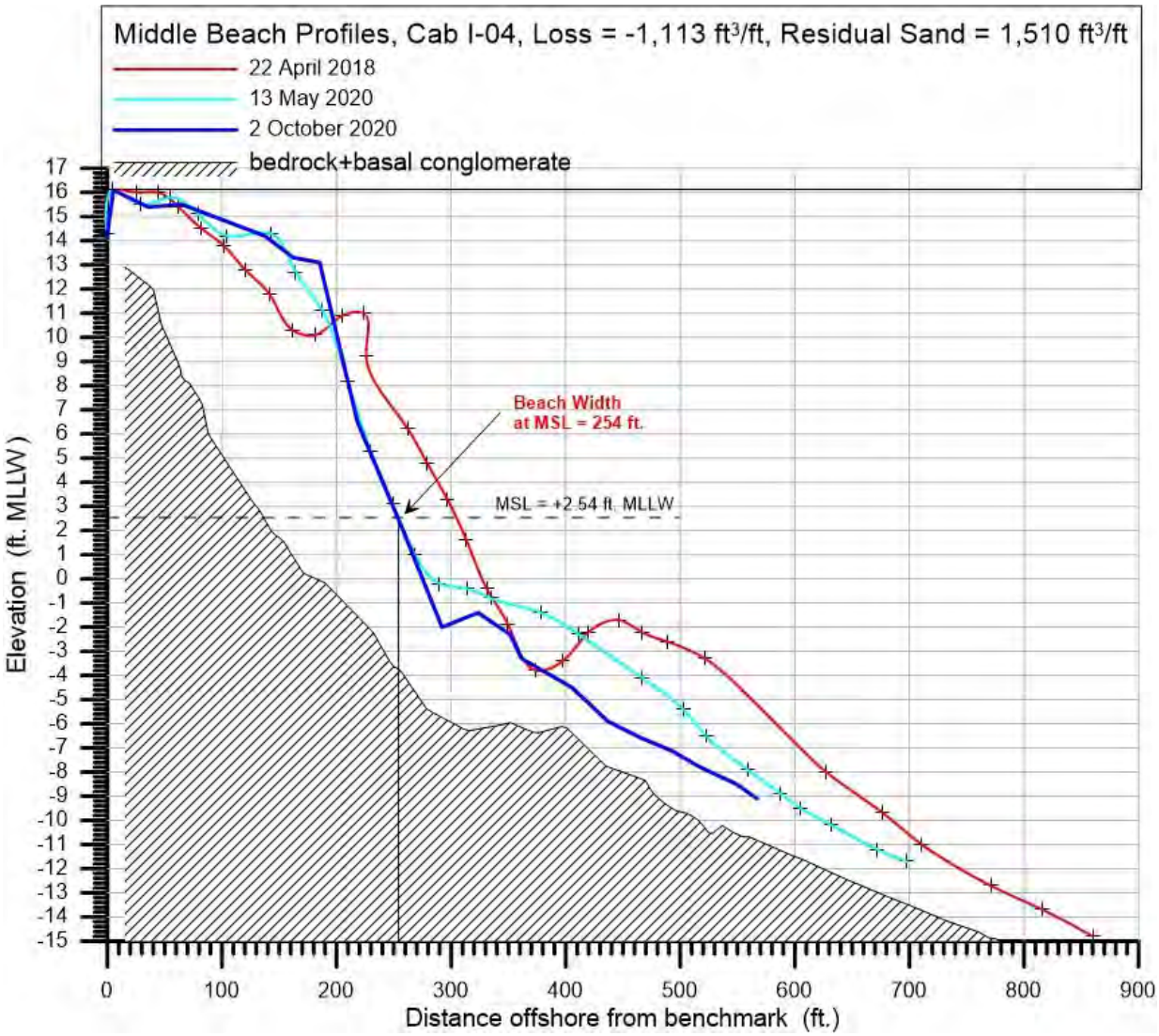

**Coordinates of Benchmark:**
Northing (ft): 1995677.7
Easting (ft): 6228319.9

**Figure A-4** Measured beach profiles at survey range Cab I-03.2 on South Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); and prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).



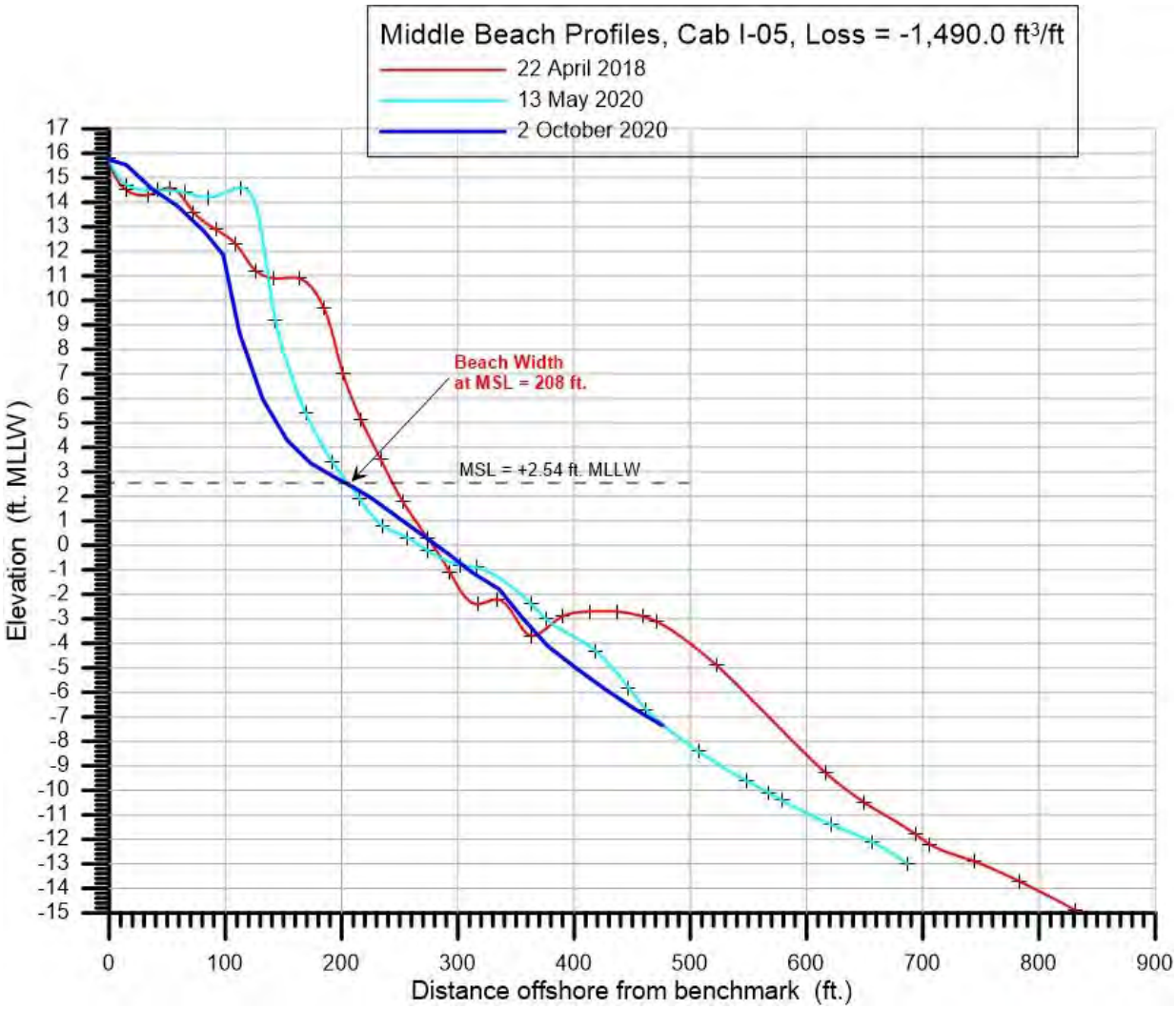

**Coordinates of Benchmark:**
Northing (ft): 1995925.1
Easting (ft): 6228209.1

**Figure A-5:** Measured beach profiles at survey range Cab I-03.6 on Middle Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); and prior to the 2020/2021 maintenance dredge/beach nourishmenton 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).



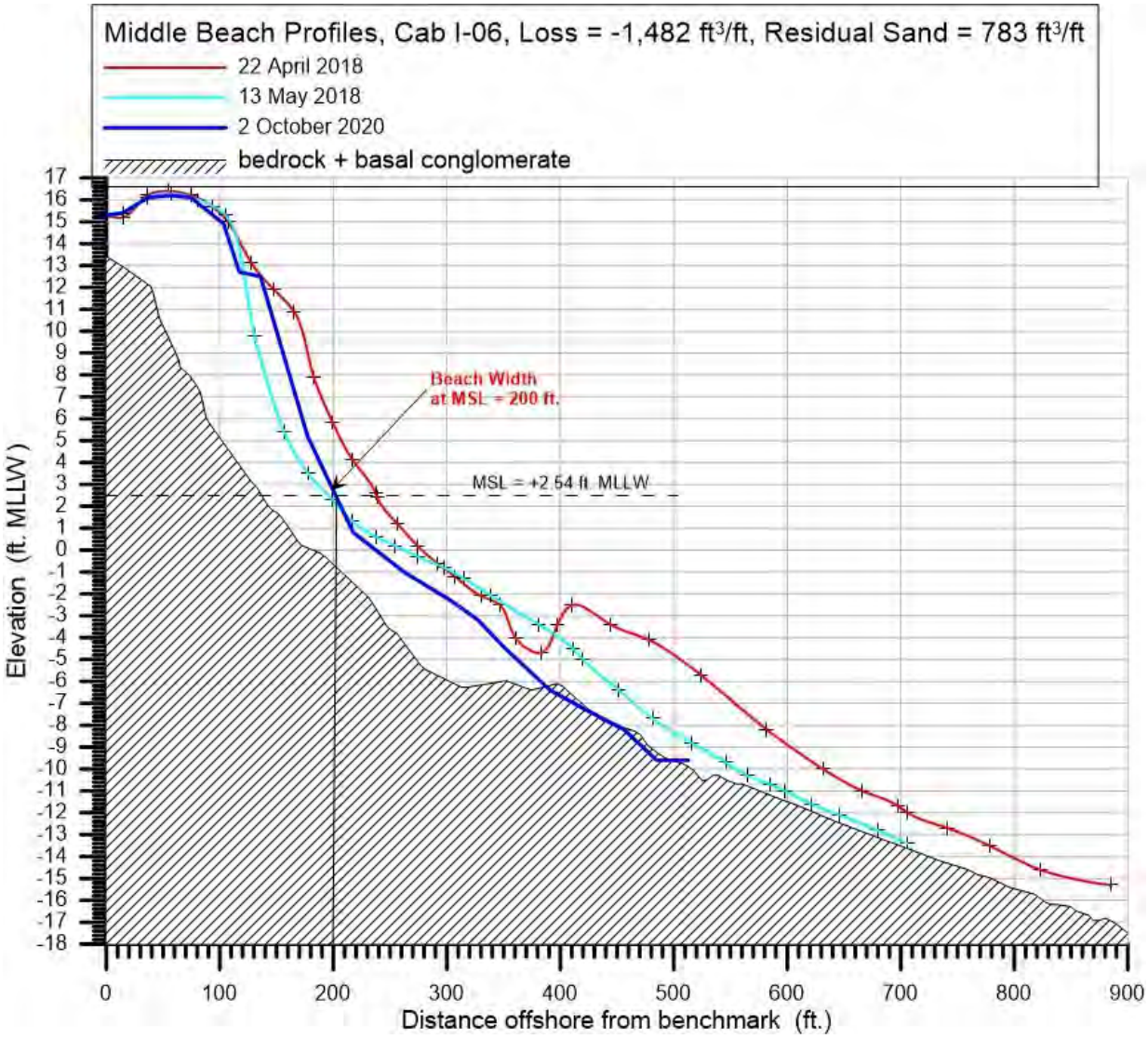

**Coordinates of Benchmark:**
Northing (ft): 1996164.9
Easting (ft): 6228090.5

**Figure A-6:** Measured beach profiles at survey range Cab I-04 on Middle Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018, (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020, (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line) Bed rock/basal conglomerate (hard bottom) elevation based on composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0810.



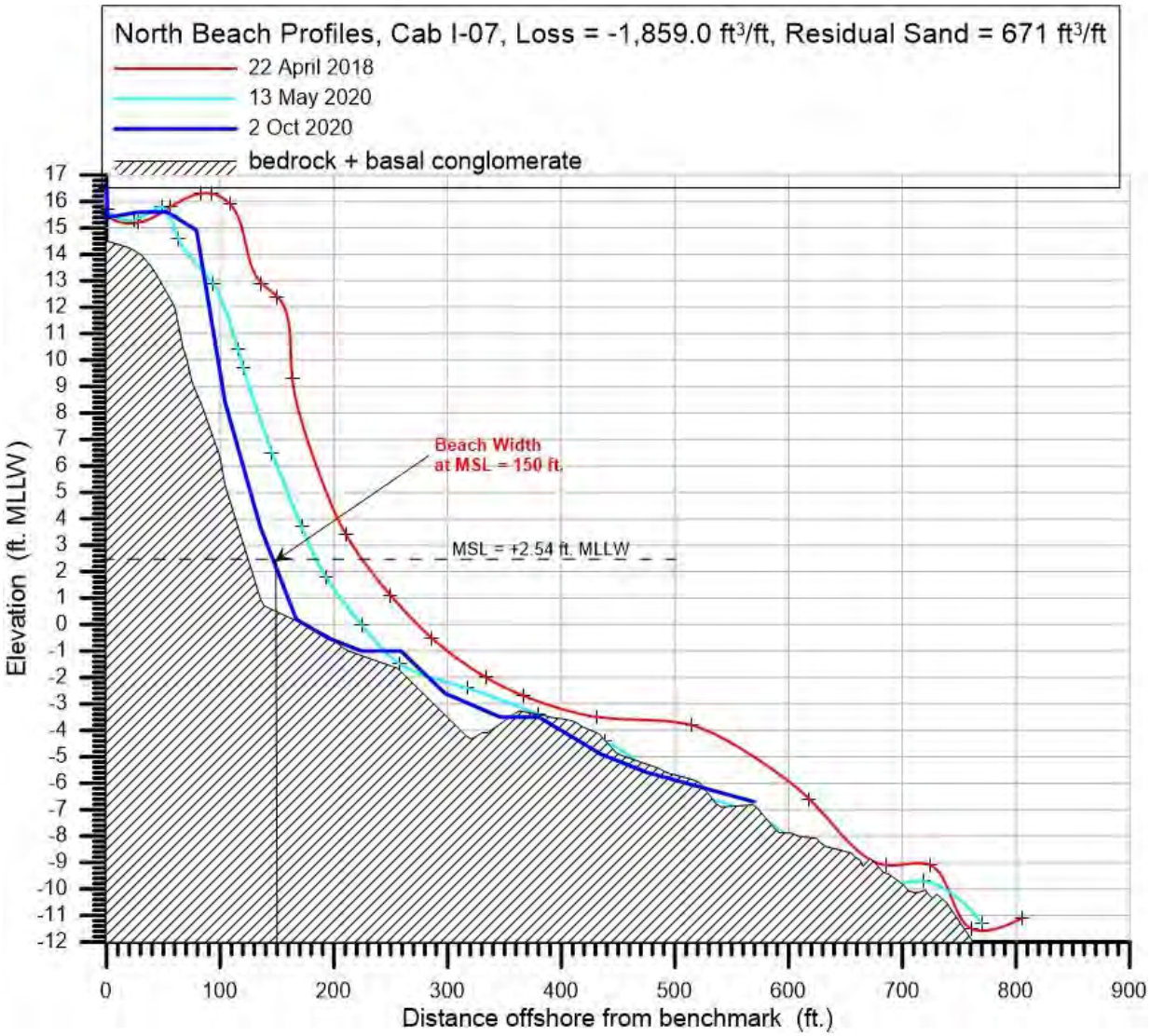

**Coordinates of Benchmark:**
Northing (ft): 1996778.5
Easting (ft): 6227826.9

**Figure A-7:** Measured beach profiles at survey range Cab I-05 on Middle Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); and prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).



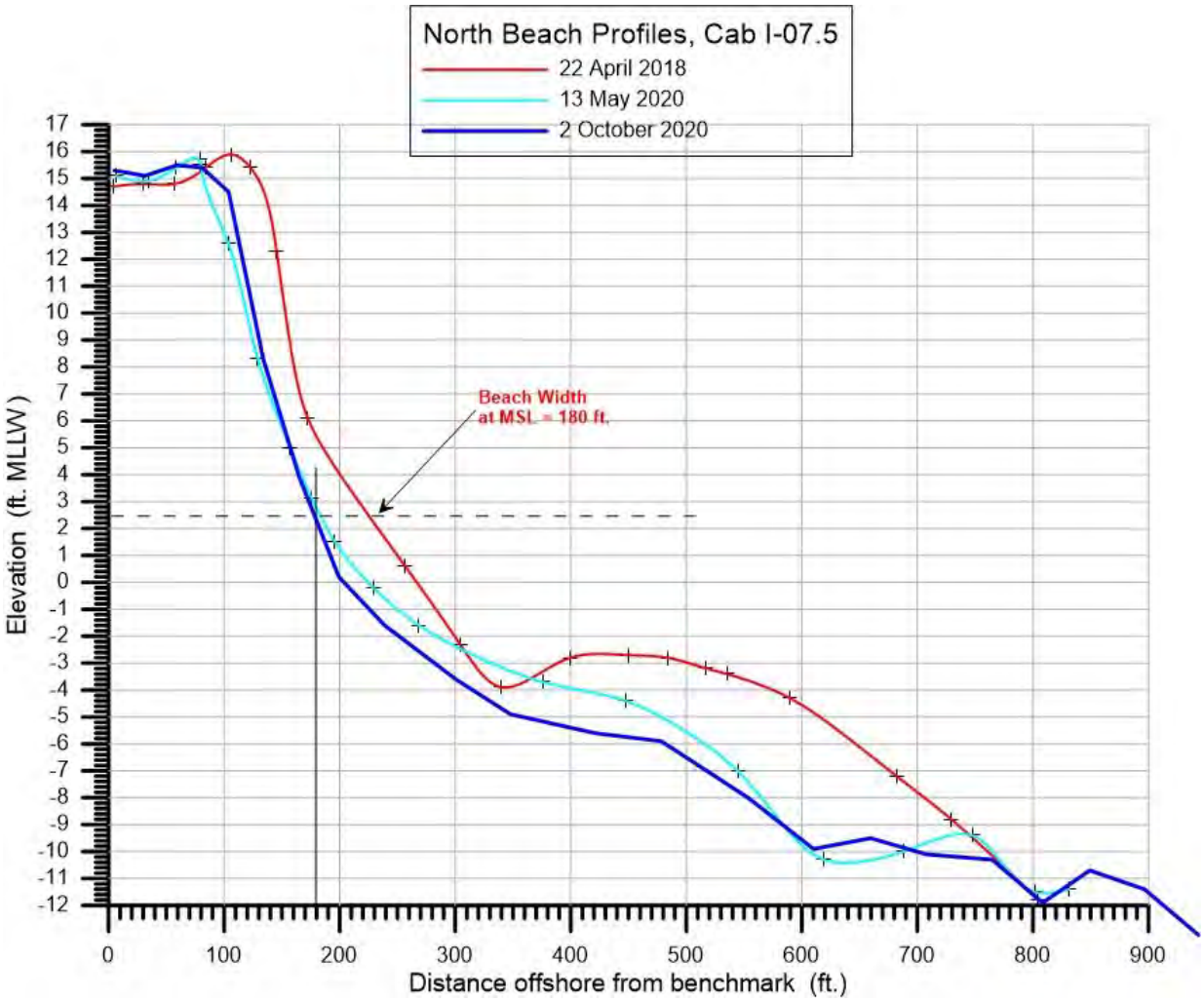

**Coordinates of Benchmark:**
Northing (ft): 1997015.5
Easting (ft): 6227720.2

**Figure A-8:** Measured beach profiles at survey range Cab I-06 on Middle Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018, (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020, (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line) Bed rock/basal conglomerate (hard bottom) elevation based on composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0820.



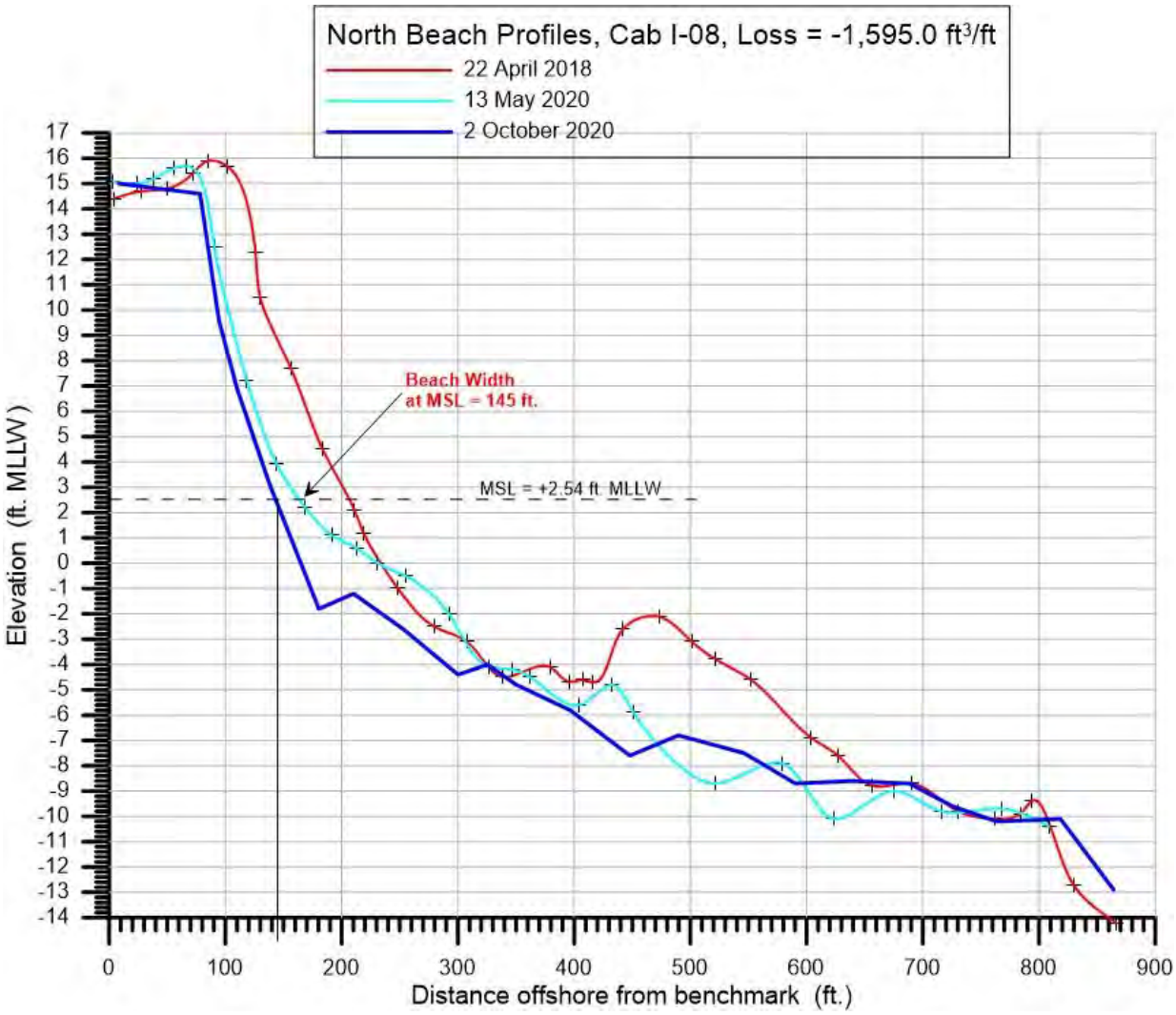

**Coordinates of Benchmark:**
Northing (ft): 1998772.8
Easting (ft): 6226391.4

**Figure A-9** Measured beach profiles at survey range Cab I-07 on North Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018, (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020, (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line) Bed rock/basal conglomerate (hard bottom) elevation based on composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0830.



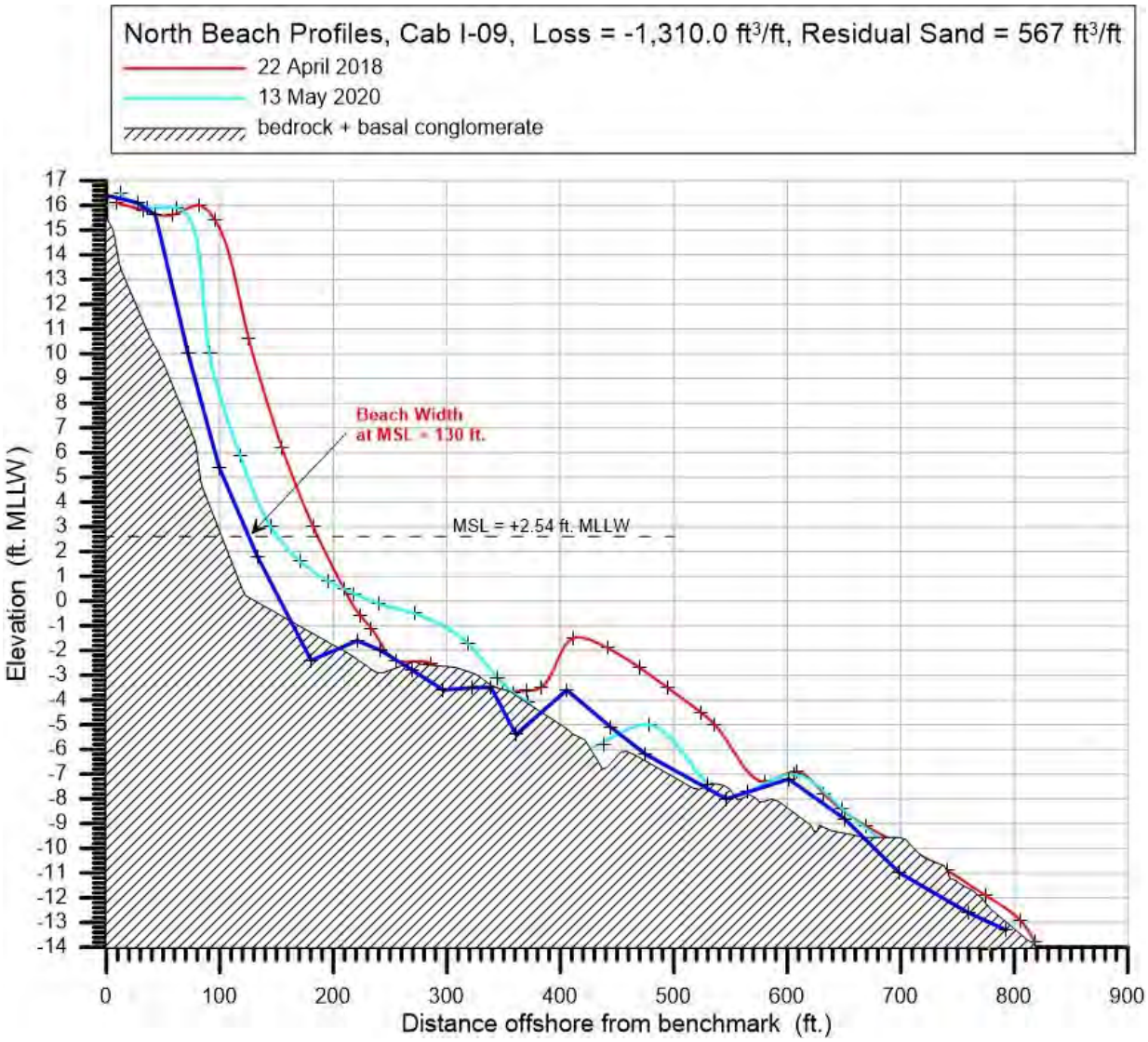

**Coordinates of Benchmark:**
Northing (ft): 1999373.5
Easting (ft): 6226032.4

**Figure A-10:** Measured beach profiles at survey range Cab I-07.5 on North Beach, after the most recent Agua Hedionda Lagoon - Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); and prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).




**Coordinates of Benchmark:**
Northing (ft): 1999973.2
Easting (ft): 6225671.9

**Figure A-11:** Measured beach profiles at survey range Cab I-08 on North Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); and prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).

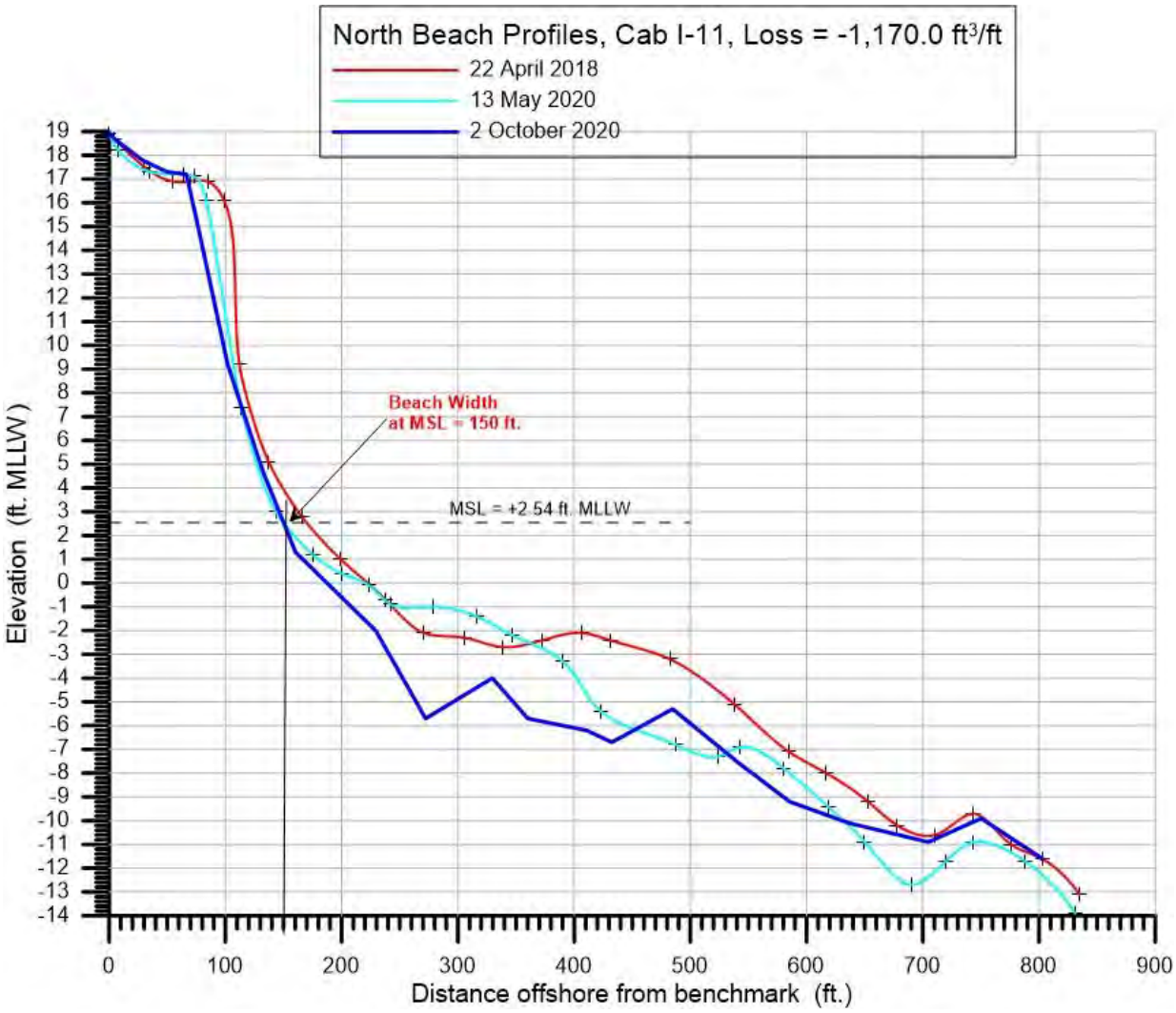



**Coordinates of Benchmark:**
Northing (ft): 2000268.7
Easting (ft): 6225483.3

**Figure A-12:** Measured beach profiles at survey range Cab I-09 on North Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line). Bed rock/basal conglomerate (hard bottom) elevation based on composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0840.

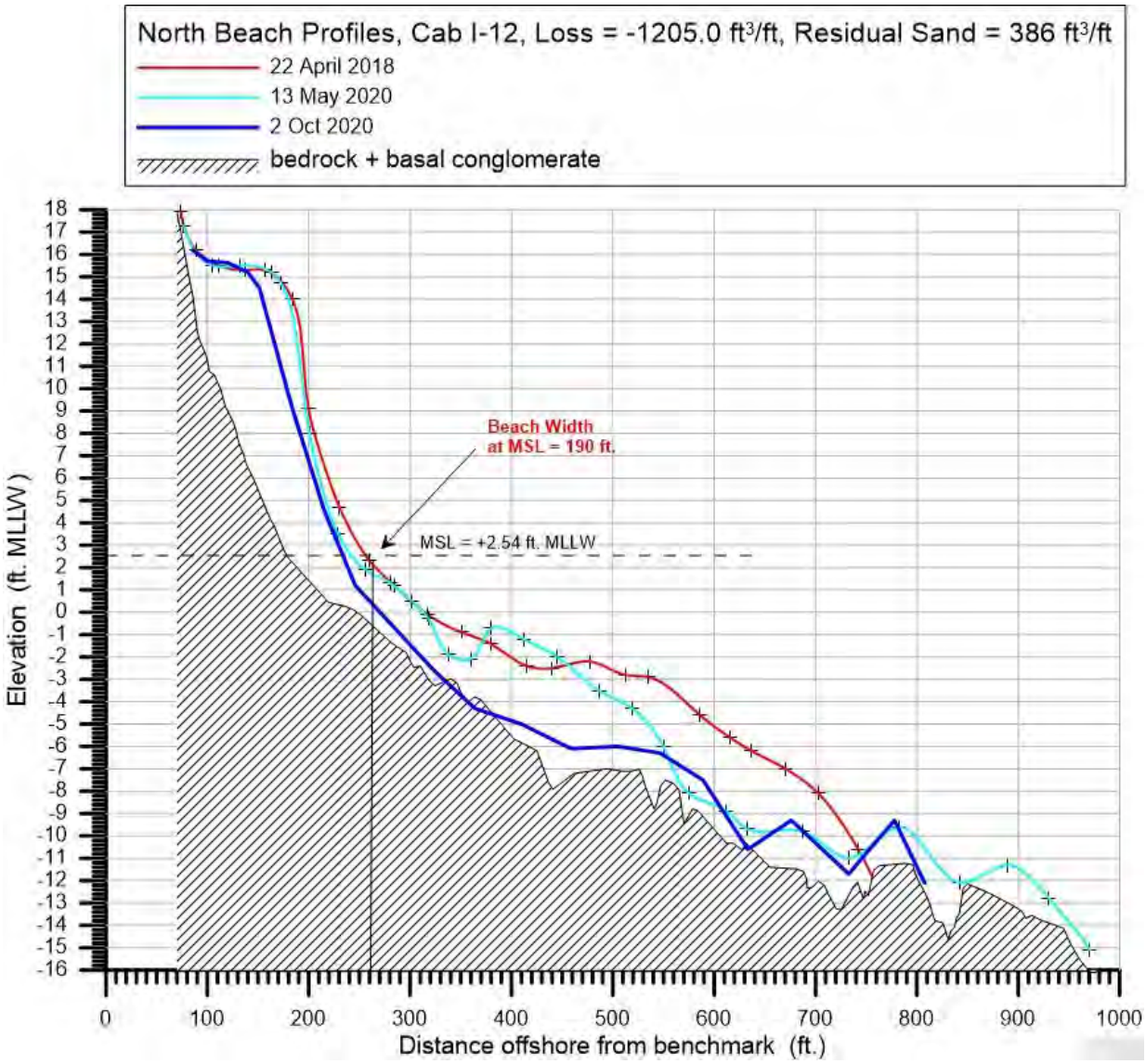

**Coordinates of Benchmark:**
Northing (ft): 2000741.1
Easting (ft): 6225218.1

**Figure A-13:** Measured beach profiles at survey range Cab I-10 on North Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).




**Coordinates of Benchmark:**
Northing (ft): 2001257.9
Easting (ft): 6224917.9

**Figure A-14:** Measured beach profiles at survey range Cab I-11 on North Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018 (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020 (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line).




**Coordinates of Benchmark:**
Northing (ft): 2001823.9
Easting (ft): 6224695.8

**Figure A-15:** Measured beach profiles at survey range Cab I-12 on North Beach, after the most recent Agua Hedionda Lagoon – Outer Basin maintenance dredge/beach nourishment on 22 April 2018, (red line); prior to the 2020/2021 maintenance dredge/beach nourishment on 13 May 2020, (cyan line); and most recent pre-dredging survey on 2 Oct 2020 (dark blue line). Bed rock/basal conglomerate (hard bottom) elevation based on composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0850.

## Appendix-B: Elliptic Cycloid Equilibrium Profiles and Critical Mass

The critical mass is the minimum volume of sediment cover required to maintain equilibrium beach profiles and represents the nominal carrying capacity of a particular beach. When a long-term collection of beach profiles are plotted together over a broad range of wave heights, a well-defined envelope of variability becomes apparent, (Figure 11a). This envelope of profile variability is referred to as the *critical mass envelope*, and the volume of sand within critical mass envelope, $V_c$, increases with increasing wave height and period but decreases with increasing beach grain size, as shown in Figure B-1b. The critical mass envelope is always limited by the breadth of the wave cut platform which forms a hard-bottom boundary condition on the critical mass envelope. The best way to calculate the critical mass is to find the volume between the wave cut platform (or its layer of basal conglomerate) and the elliptic cycloid equilibrium profile that corresponds to the native beach grain size in combination with the wave height and period of the extreme event wave in the period of record. The volume integral between the surfaces of the wave cut platform and the extremal event elliptic cycloid then gives the critical mass volume.

The extremal elliptic cycloid equilibrium profile is a curve that is traced by a point on the circumference of a rolling ellipse, see Figure 12b. It is calculated from Jenkins and Inman (2006) using the following:

$$h = \frac{\pi\varepsilon\ x}{2I_e^{(2)}}\left(\frac{1-\cos\theta}{\theta-\sin\theta}\right)+Z_1 \qquad (1)$$

Note this has the same basic formulation of the original Dean (1977 and 1991) solutions in the U.S. Army Corps of Engineers *Coastal Engineering Manual* Here $Z_1$ is the elevation of the berm crest (see Figure 12a) given by Hunt's Formula [*Hunt*, 1959; *Guza and Thornton*, 1985; *Raubenheimer and Guza*, 1996]:

$$Z_1 = -\Gamma H_b \qquad (2)$$

In equation (2), $\Gamma$ is the runup factor taken herein as $\Gamma = 0.76$, and $H_b$ is the breaking wave height. The cycloid in (1) is based on the elliptic integral of the second kind that has an analytic approximation, $I_e^{(2)} = \sqrt{(2-e^2)/2}$, where $e$ is the eccentricity of the ellipse given by $e = \sqrt{1-b^2/a^2}$, with, semi-major and semi-minor axes are $a$, $b$, (see Figure 12b). The wave parameter, $\varepsilon$, in equation (1) is given by:

$$\varepsilon = \sigma\left(\frac{H_b}{\gamma\, g}\right)^{1/2} \cong \frac{\sigma^{4/5}}{2^{1/5}}\left(\frac{H_\infty}{g\gamma}\right)^{2/5} \qquad (3)$$

here $\sigma = 2\pi/\text{period}$ is radian frequency, $H_\infty$ is incident wave height, $g$ is the acceleration of gravity, and $\gamma$ is the wave breaking criteria taken as $\gamma = 0.8$. The rolling angle of the ellipse is:

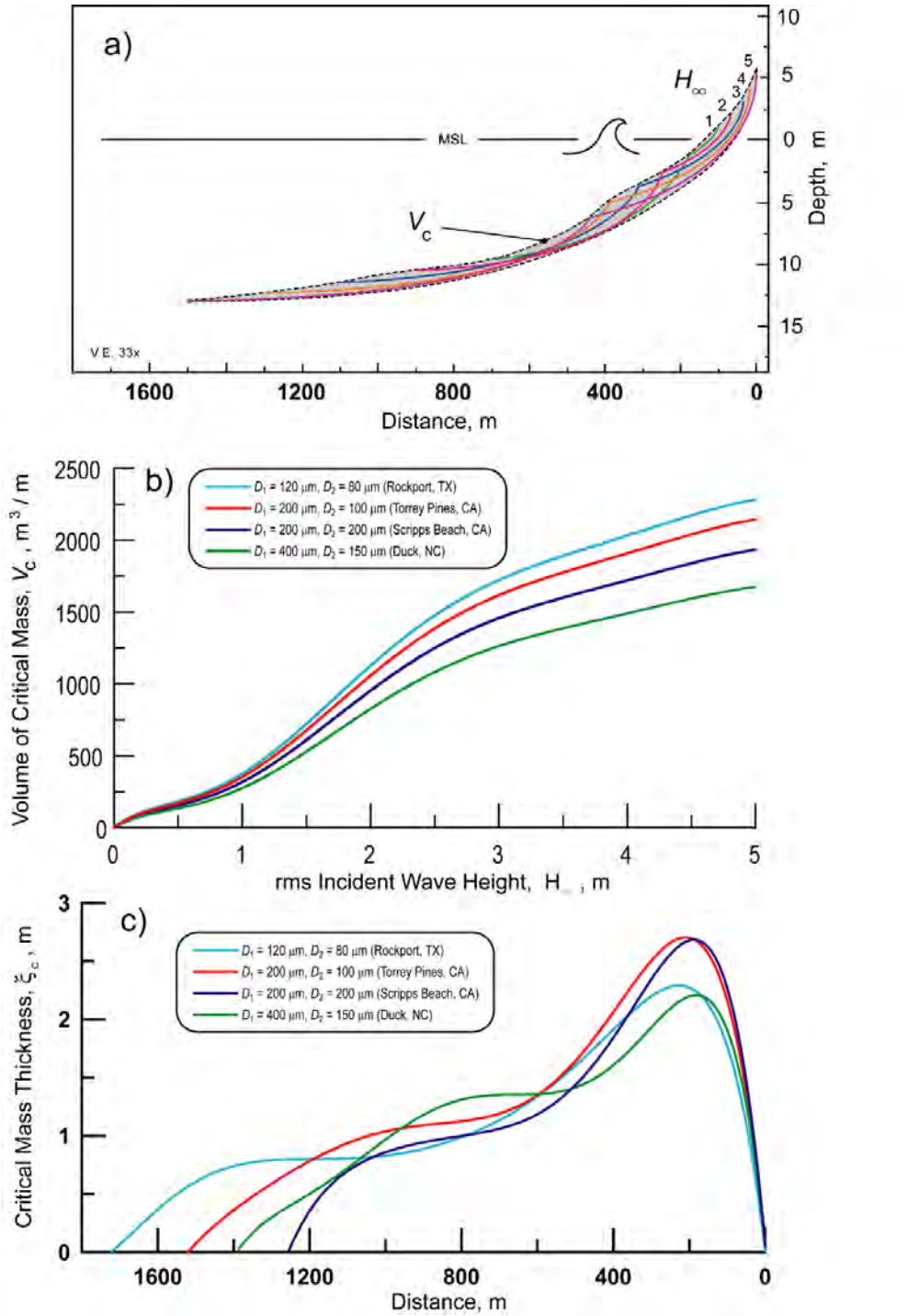



**Figure B-1**: Features of the critical mass of sand: a) critical mass envelope for waves ranging from 1m to 5m in height; b) volume of critical mass as a function of wave height and sediment grain size; c) variation in the thickness of the critical mass as a function of distance offshore.

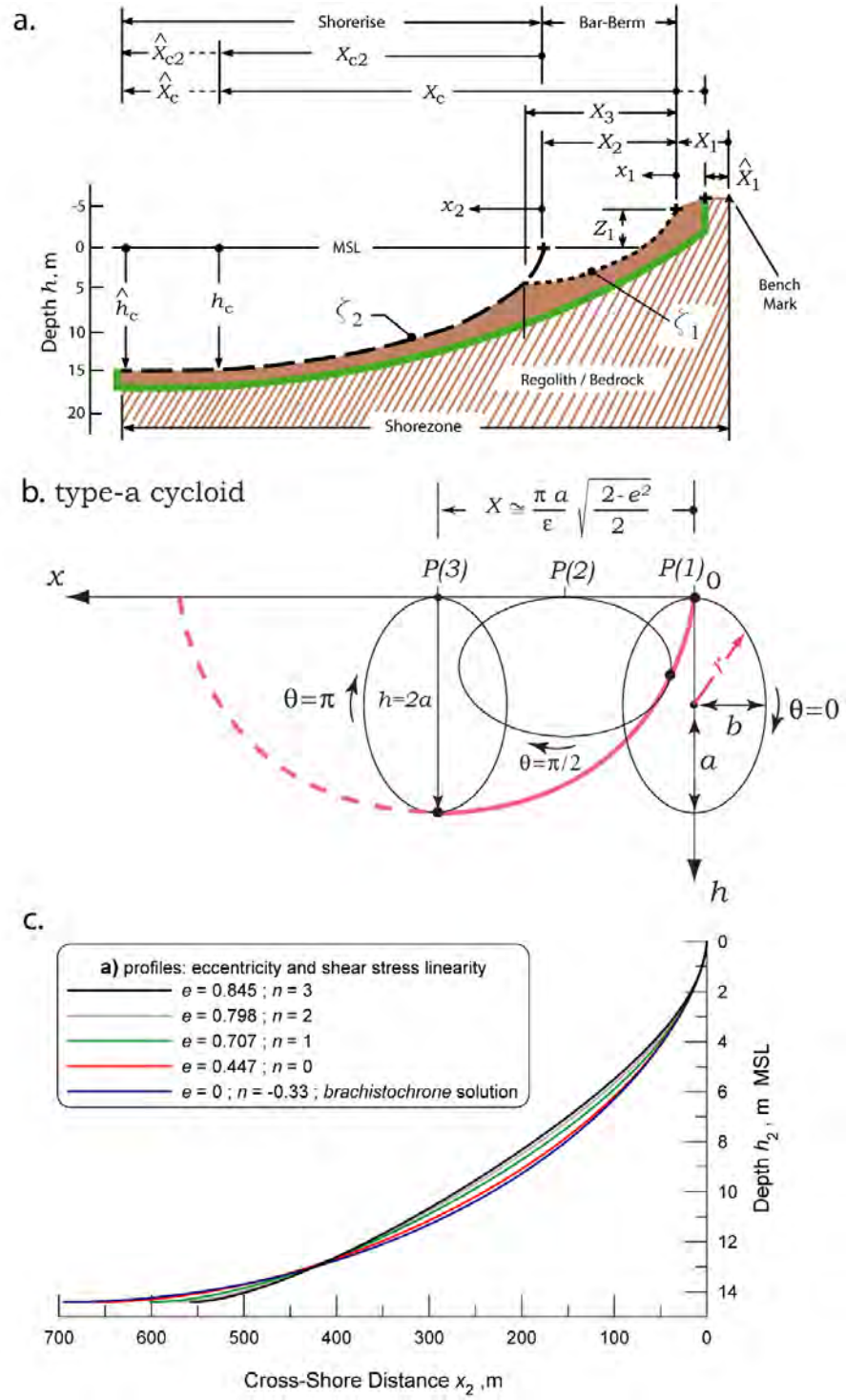



**Figure B-2.** Equilibrium beach profile theory: a) nomenclature, b) mathematical basis for an elliptic cycloid, c) Typical range of elliptic cycloids on a 700 m wide wave-cut platform.

$$\theta = \arccos\left[1 - 2\left(\frac{H_\infty}{\Lambda\gamma\, h_c}\right)^{\alpha}\right] \qquad (4)$$

where $\Lambda$ is the shoaling factor relating breaker height to incident wave height, $\Lambda = H_\infty / H_b$, which for shoaling Airy waves, becomes $\Lambda = 2^{2/5} H_\infty^{1/5}\left(\sigma^2 / g\gamma\right)^{1/5}$. The closure depth, $h_c$ in equation (4) is grain size and wave period dependent and is given by:

$$h_c = \frac{K_e H_\infty}{\sinh kh_c}\left(\frac{D_0}{D_{50}}\right)^{\psi} \qquad (5)$$

where $k = \sigma / \sqrt{gh_c}$ is the shallow water form of the wave number, $K_e$ and $\psi \sim 2.0$ are non-dimensional empirical parameters, set at $K_e = 2.0$ and $\psi \sim 0.33$; $D_{50}$ is the median grain size; and $D_0$ is a reference grain size taken as $D_0 = 100\ \mu$ m. Equation (5) is transcendental and is solved numerically within the CEM.

Calculation of the extremal elliptic cycloid equilibrium profiles at North, Middle and South Beach requires knowledge of the characteristic median grain size, $D_{50}$, of the dredged sediments to be placed there. Recent sediment grain size analyses by Merkel, (2008) based on three sampling locations on the flood tide bar in the West Basin of Agua Hedionda Lagoon (Samples L1 – L3) were compared against native sediments on the three receiver beaches (RB1-RB3). These grain size distributions are plotted in Figure B-3. Note Middle and South Beach is represented by samples RB1. Grain sizes at the lagoon sample sites and beach sites were similar with median grain sizes of 0.32 millimeters (320 microns) on the food tide bar in the West Basin of Agua Hedionda, while residual sediments that still remained on Middle and South Beach prior to disposal of material from the 2008/09 dredging averaged 0.374 millimeters (374 microns).

To determine the highest waves to reach to effect North, Middle and South Beach disposal sites, the waves measured at ½ hour sampling intervals at CDIP Station 043 were back refracted into deep water from the monitoring location off Camp Pendleton, and then forward refracted into North, Middle and South Beach. An example of this procedure is shown in Figure B-4 for a wave occurring 8 January 2002. This effort produced a continuous wave record throughout the historic period when North, Middle and South Beach disposal of Agua Hedionda dredged sands was practiced, (1998-2015). The highest energy wave (extremal) event occurred in January 2007, when a Gulf of Alaska storm brought 4.8 m high waves approaching Carlsbad at $276^0$ with a 15 second periods, (Figure B-5). This extreme event wave was used to calculate the extremal elliptic cycloids and critical mass on North, Middle and South Beach.

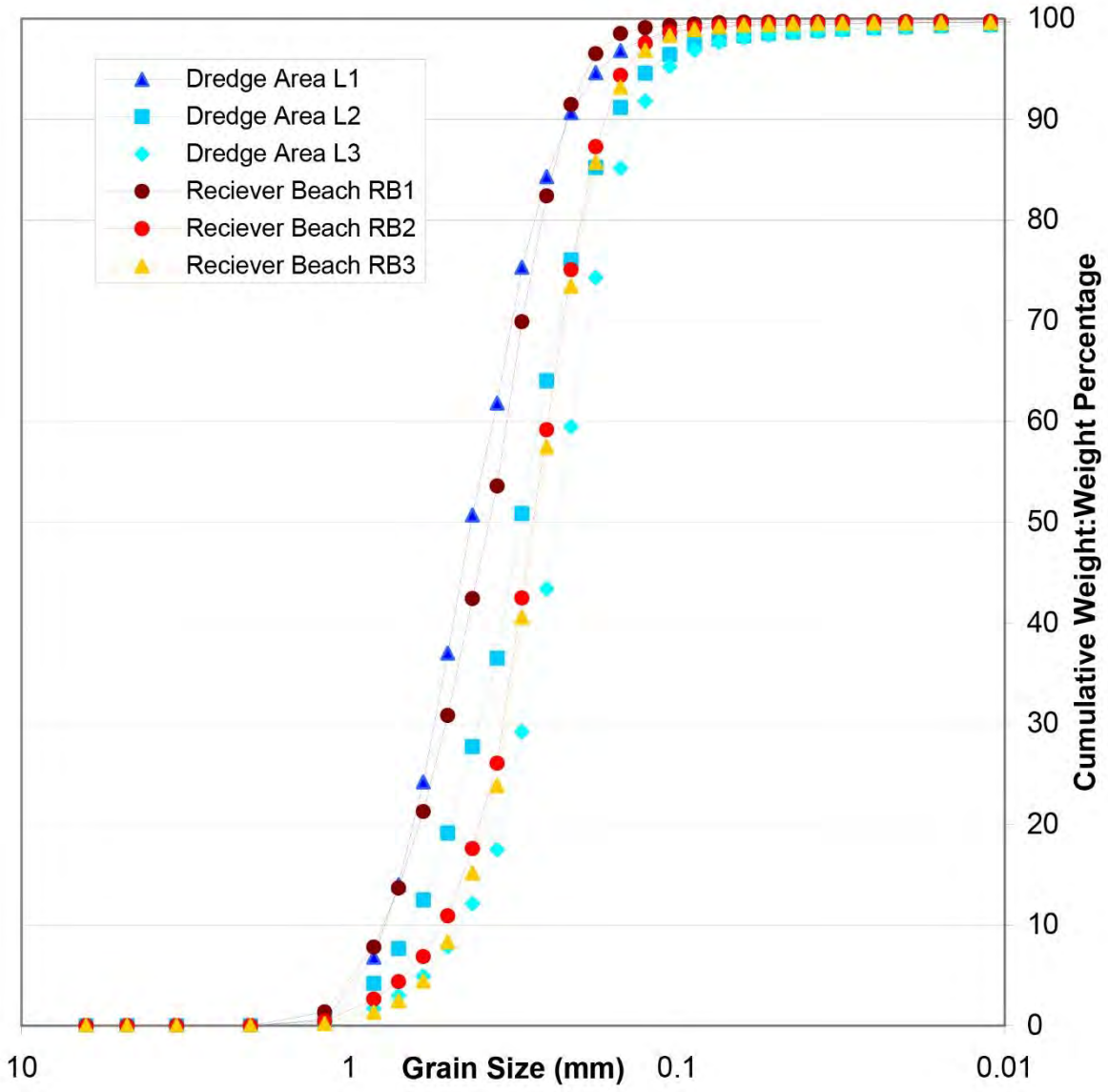



**Figure B-3:** Grain size distributions form Agua Hedionda Lagoon (Samples L1 – L3) and from the receiver beaches (RB1-RB3). Note Middle and South Beach is represented by samples RB1, (from Merkel, 2008).

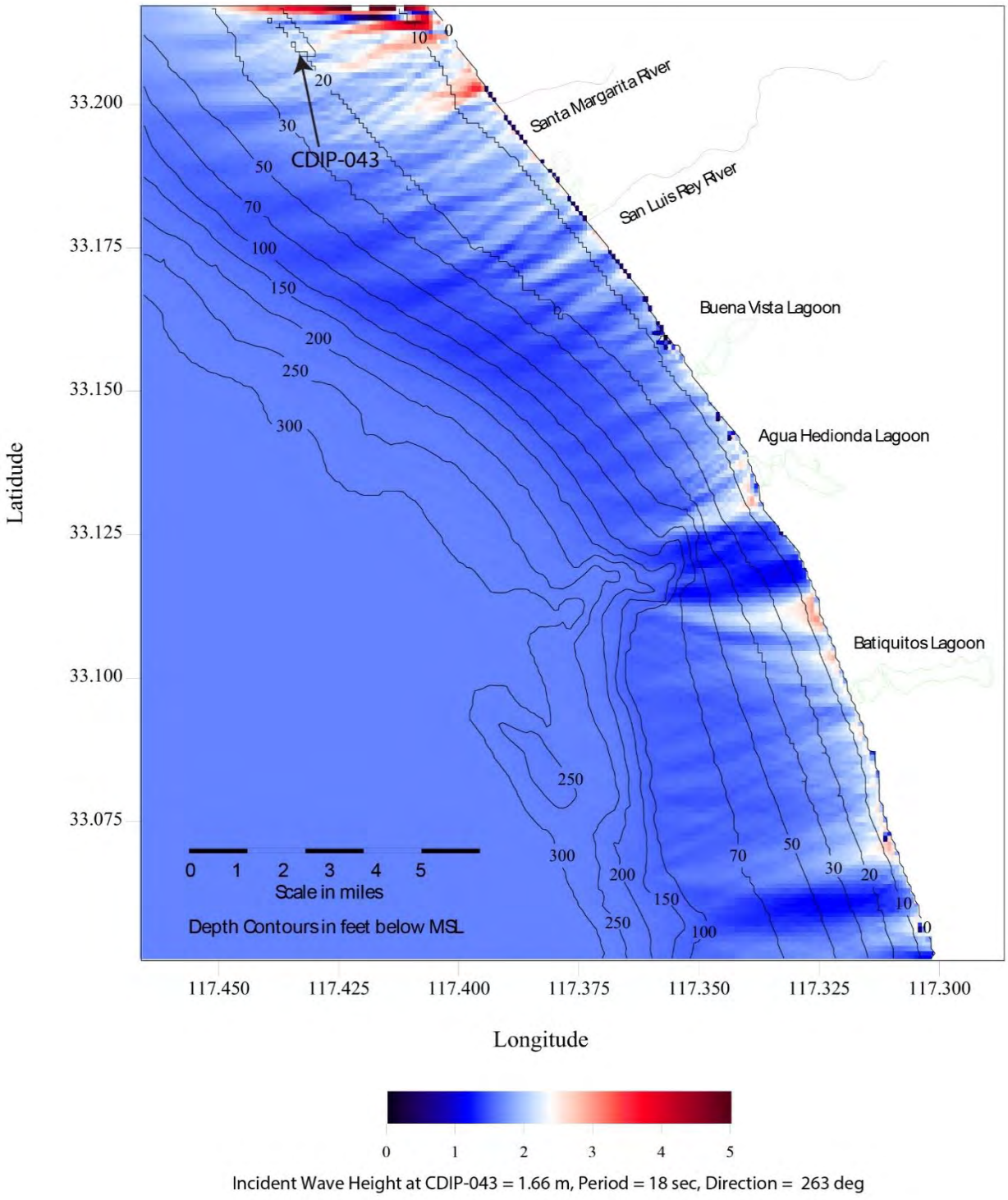



**Figure B-4:** Regional wave shoaling during 8 January 2002 from back-refraction of wave monitoring data at CDIP Station # 043 in 20 m local water depth offshore of Camp Pendleton.

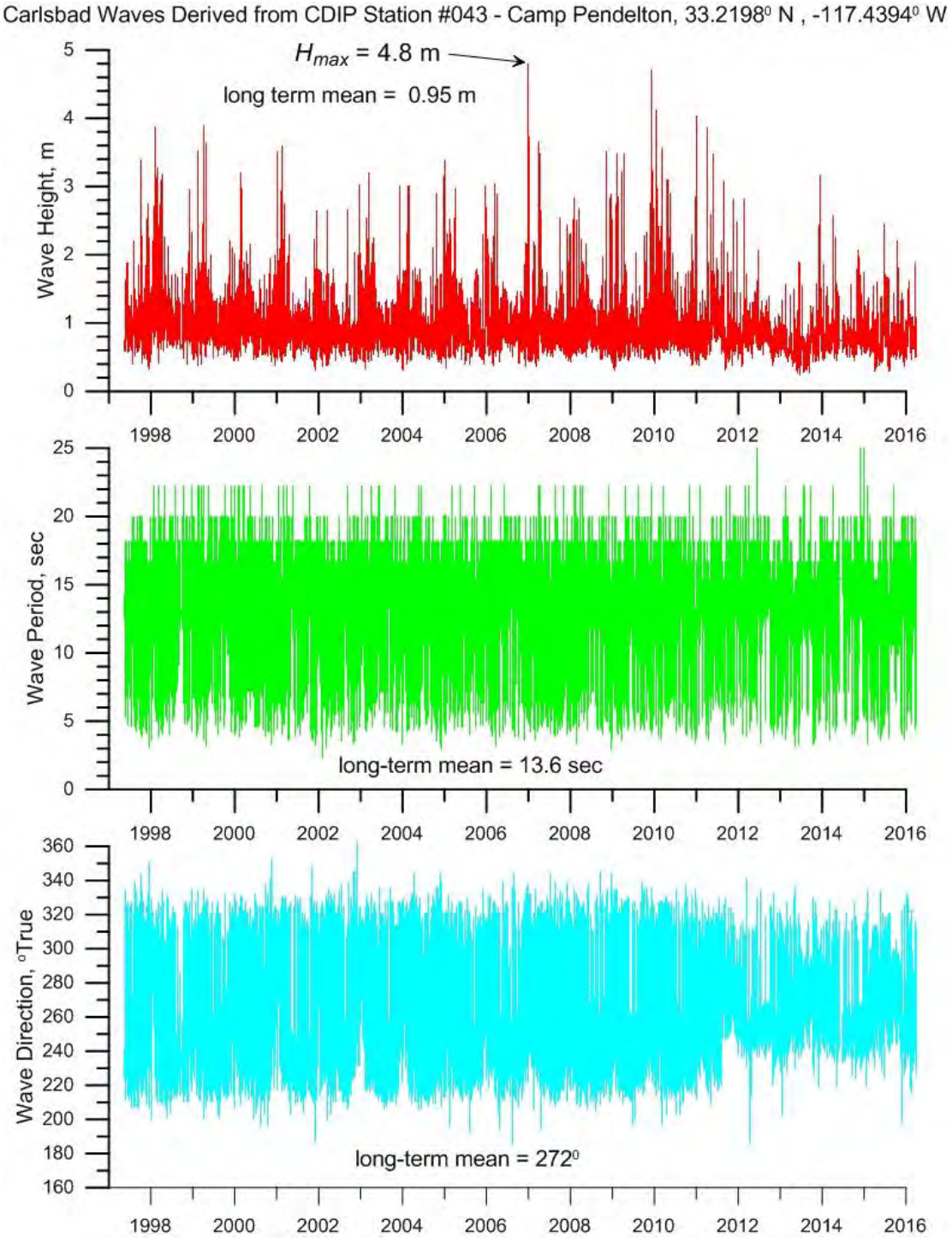



**Figure B-5:** Shoaled significant wave heights, periods and directions at Carlsbad State Beach based on back refraction of wave monitoring data from CDIP Station 043 at Camp Pendleton for the period of record of Middle and South Beach disposal, 1998-2017.

To calculate the critical mass of North, Middle and South Beach, we combine the extremal waves with the $D_{50}$ grain size values from Figure B-3 to solve equations (1) – (5) for the extremal elliptic cycloid profile. These extremal cycloid profiles are plotted in Appendix-C These profiles represent the beach shape that can be sustained in an equilibrium state during the most severe wave events of the period of record, 1998-2017. These profiles form the top of the critical mass envelope, while the most eroded profile (from composite minimum of SANDAG surveys 1997 -2012, (S97-S12) at transect CB-0800 - 850) define the bottom of critical mass envelope. When lofted in the AutoCad Civil 3-d software, the volume tool calculates the total critical mass envelope to hold of 336,000 cubic yards along all of the receiver beaches combined; with 135,100 cubic yards on North Beach, 134,600 cubic yards on Middle Beach and 66,300 cubic yards on South Beach. These volumes represent the minimal carrying capacity of the North, Middle and South Beach disposal sites, respectively. Lesser amounts of beach fill will not be able to sustain an equilibrium profile during the highest energy wave events; and without an equilibrium profile, the beach will not dissipate all the incident wave energy, and the excess wave energy will erode the beach. If North, Middle or South Beach are over-nourished with more than the critical mass of sand, then two processes will intervene: a) the excess sand will spill off the wave cut platform and be re-suspended over the rocky outcrops and hard bottom substrate offshore of the receiver beaches; and/or b) the excess sand will be swept away by the net longshore transport (littoral drift) which flows from north to south throughout the Oceanside Littoral Cell, thereby reducing sand residence time.

## Appendix - C: Distribution of Dredge Fill on Receiver Beaches Based on Coastal Modeling - Beach Fill Profiles

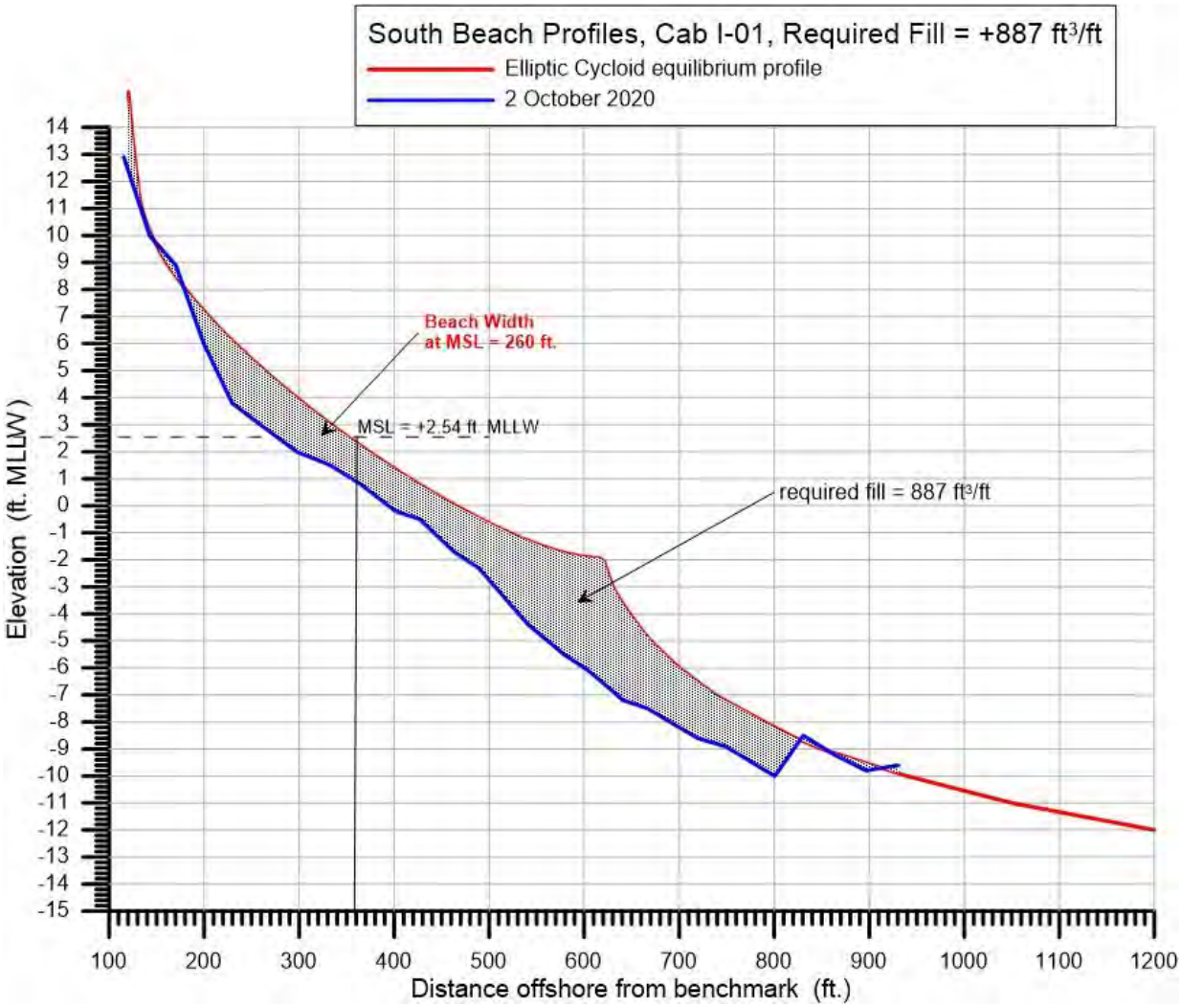



**Figure C-1:** Required beach fill based on coastal modeling at range line Cab I-01 on South Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

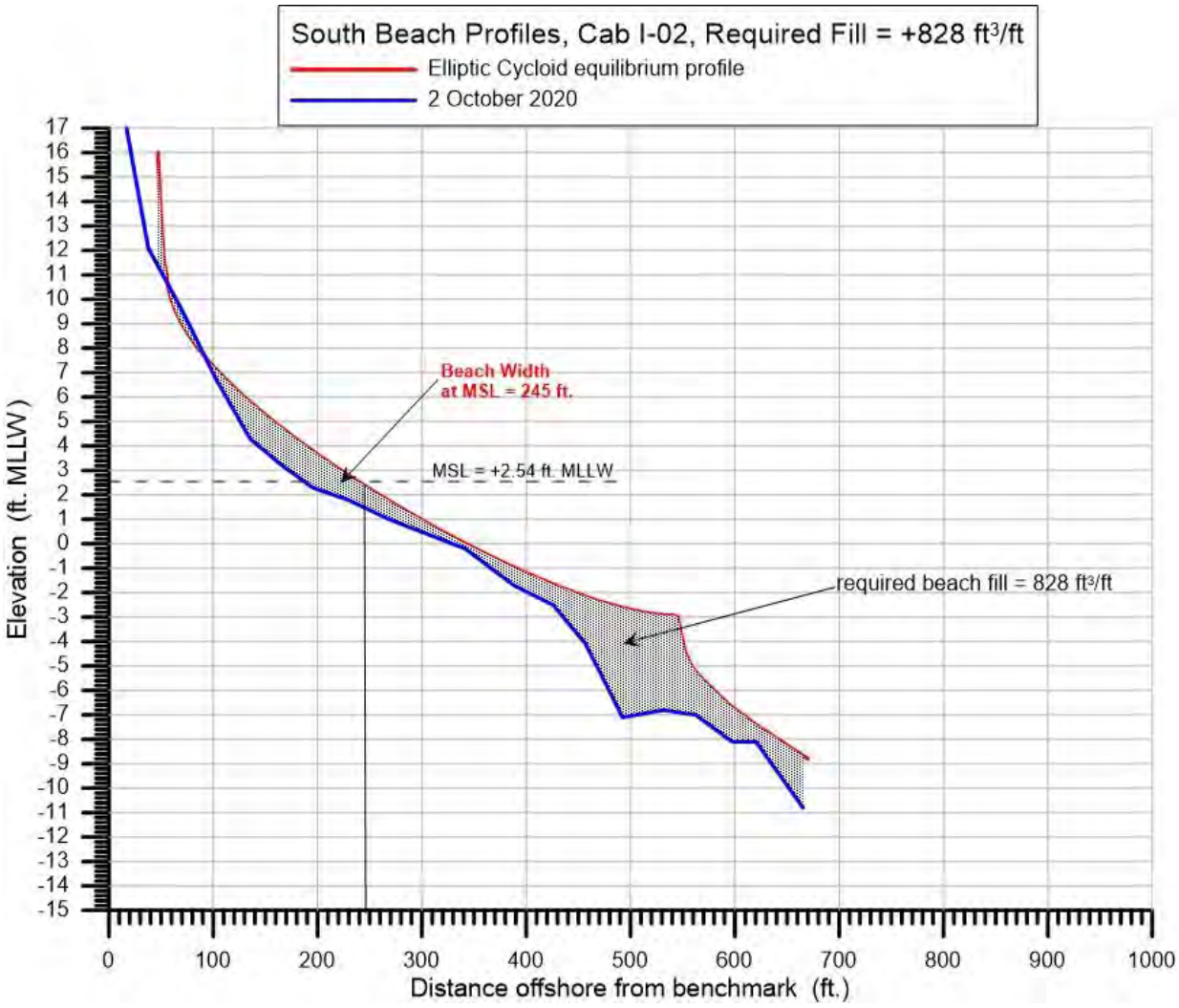



**Figure C-2:** Required beach fill based on coastal modeling at range line Cab I-02 on South Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

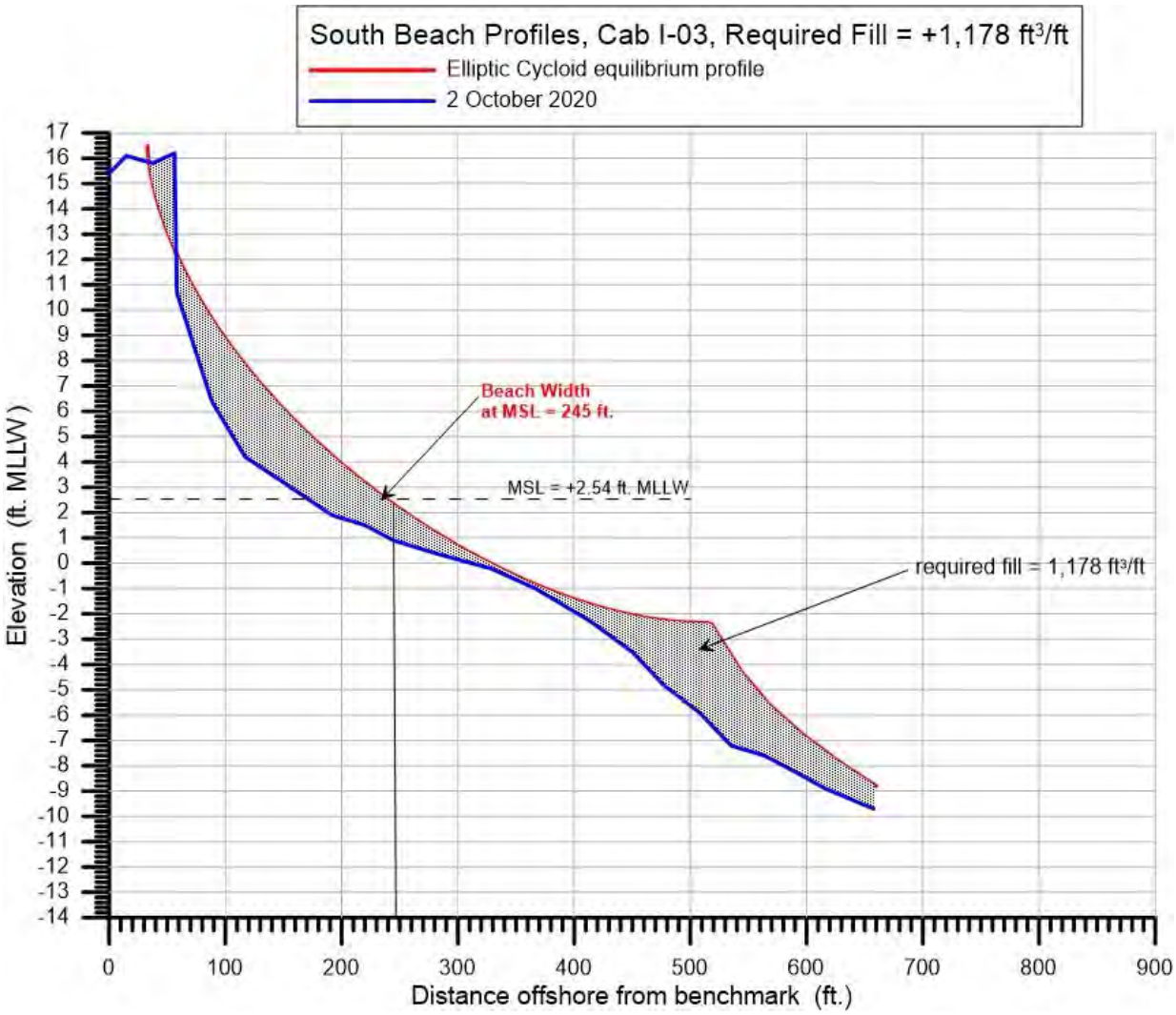



**Figure C-3:** Required beach fill based on coastal modeling at range line Cab I-03 on South Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

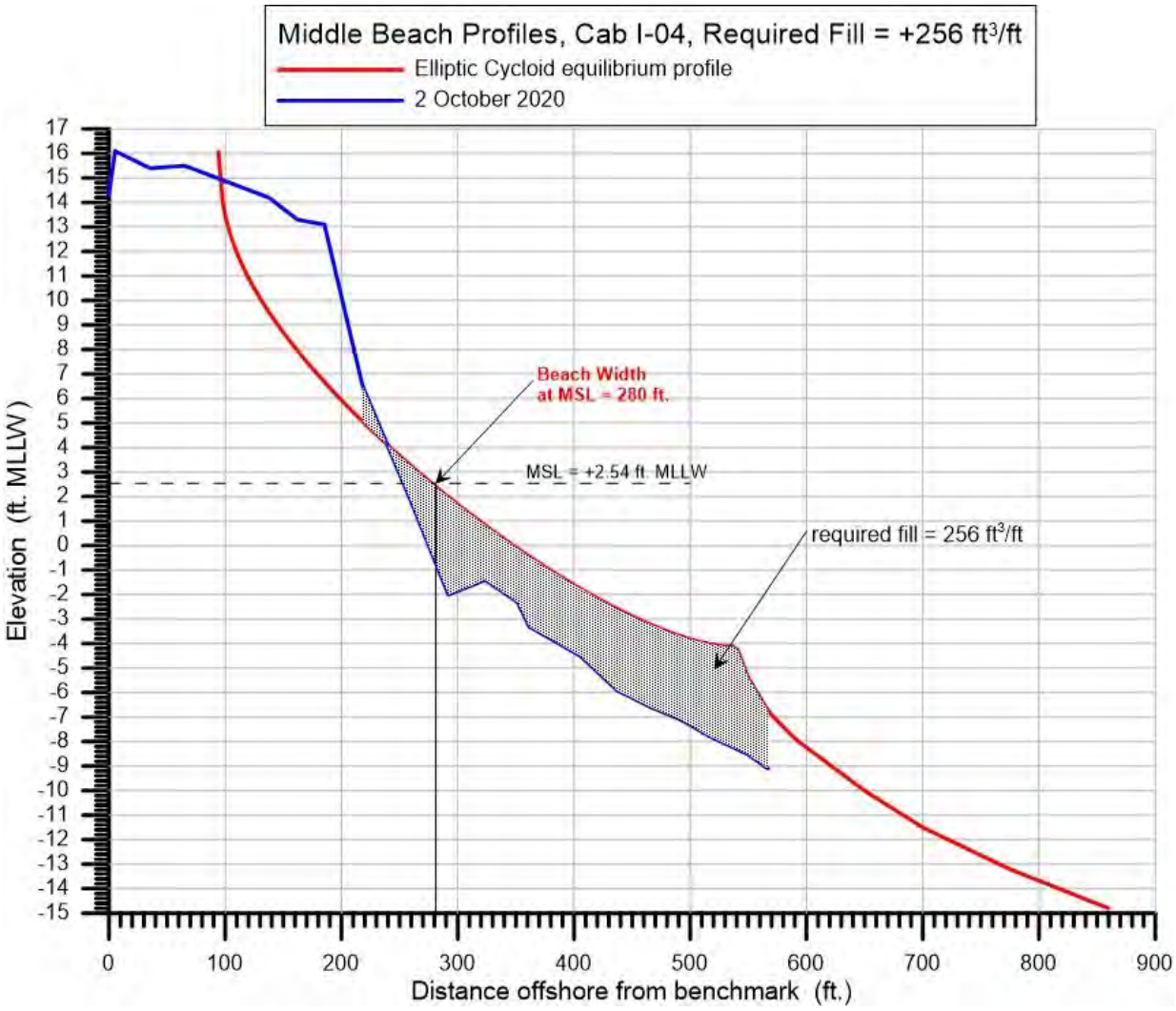



**Figure C-4:** Required beach fill based on coastal modeling at range line Cab I-04 on Middle Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

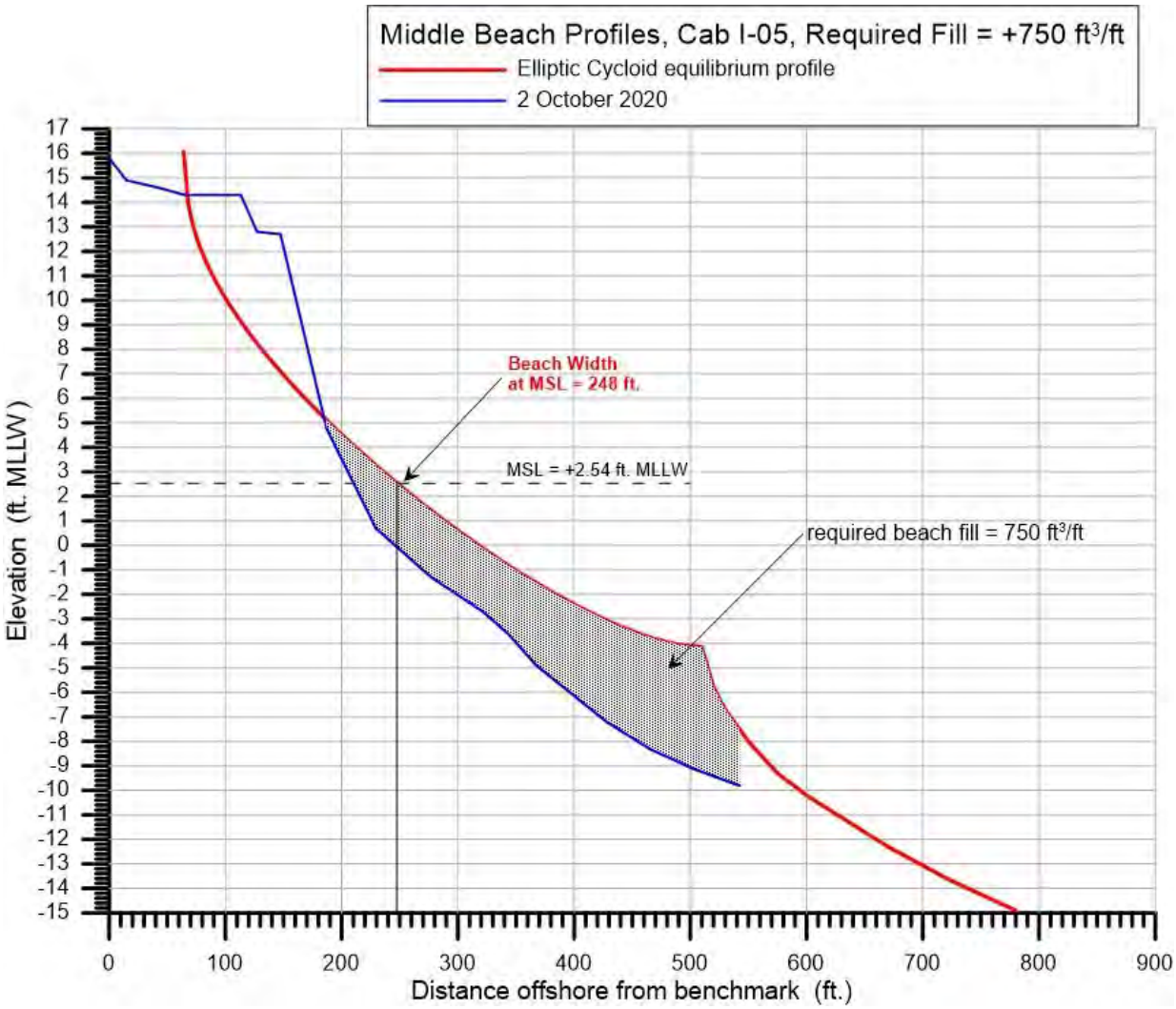



**Figure C-5:** Required beach fill based on coastal modeling at range line Cab I-05 on Middle Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

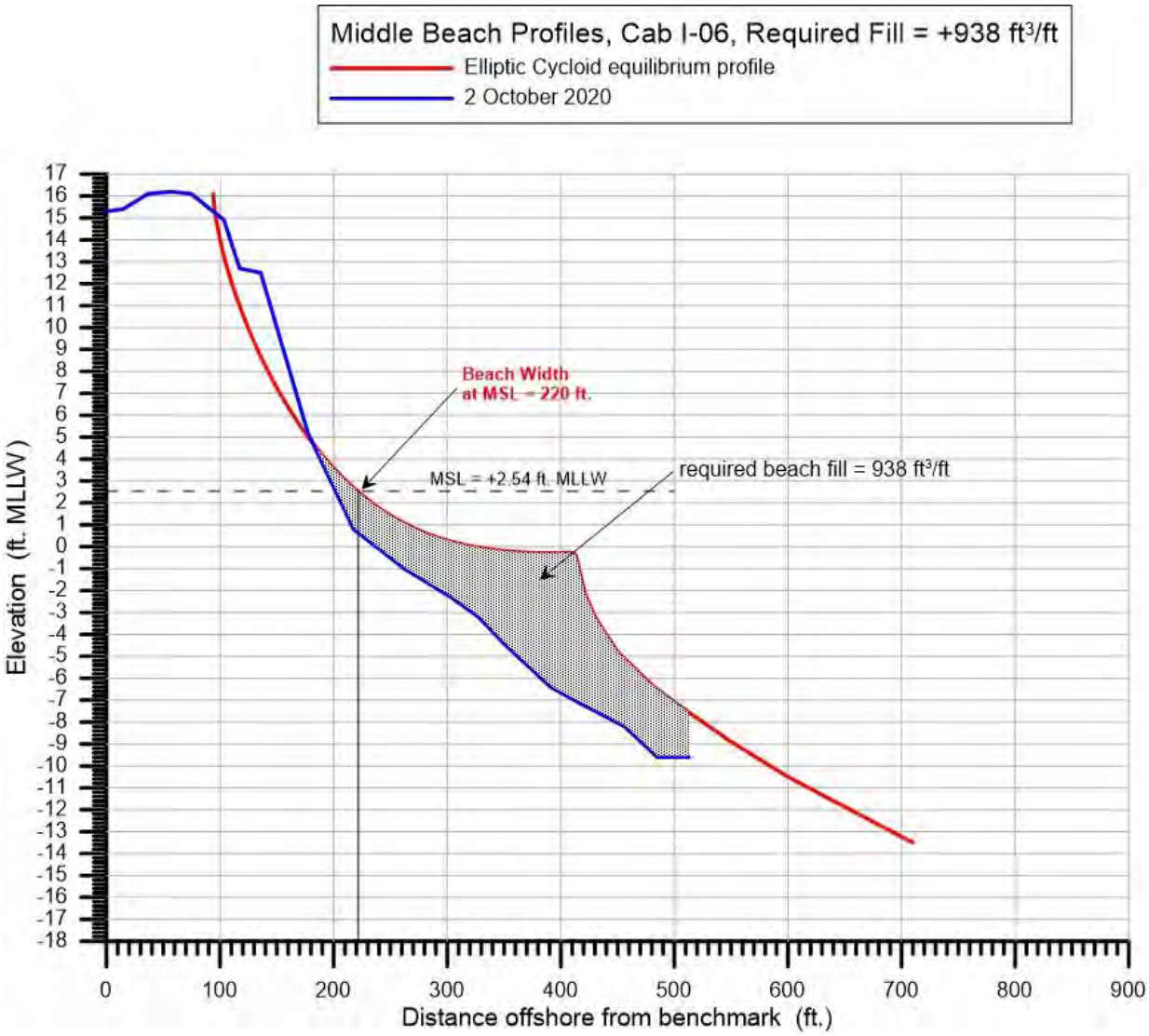



**Figure C-6:** Required beach fill based on coastal modeling at range line Cab I-06 on Middle Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

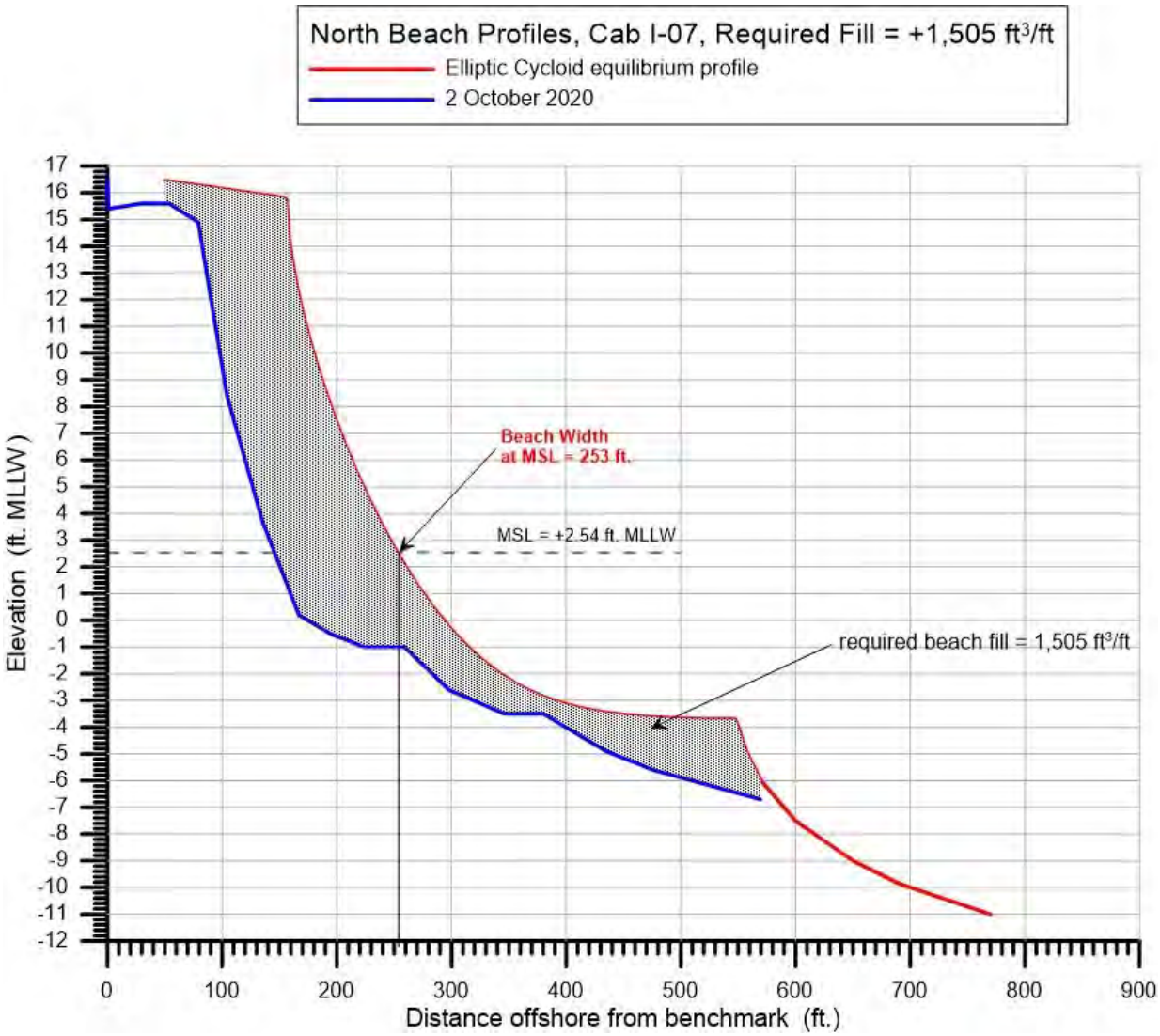



**Figure C-7:** Required beach fill based on coastal modeling at range line Cab I-07 on North Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

Appendix

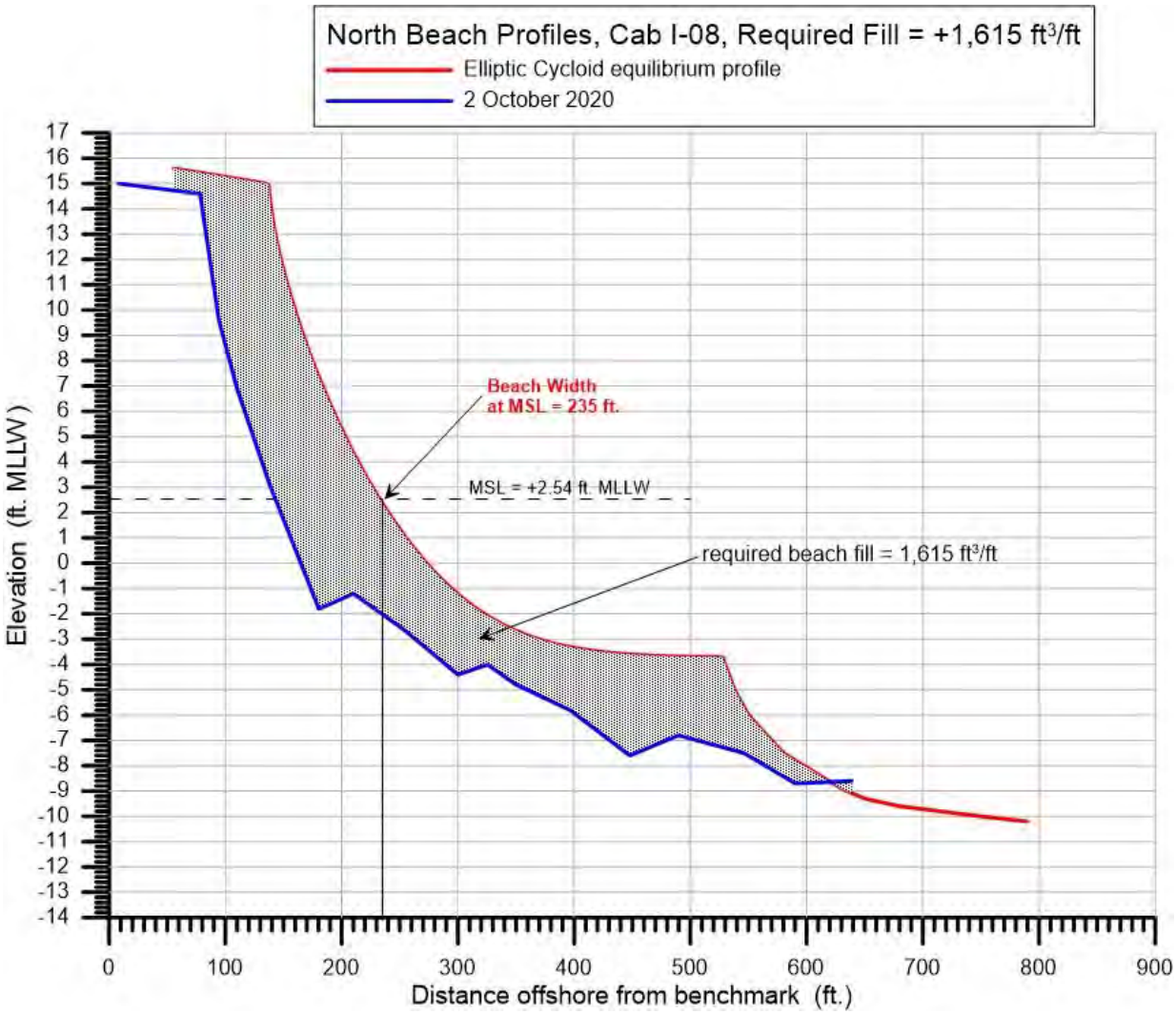



**Figure C-8:** Required beach fill based on coastal modeling at range line Cab I-08 on North Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.


**Figure C-9:** Required beach fill based on coastal modeling at range line Cab I-09 on North Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

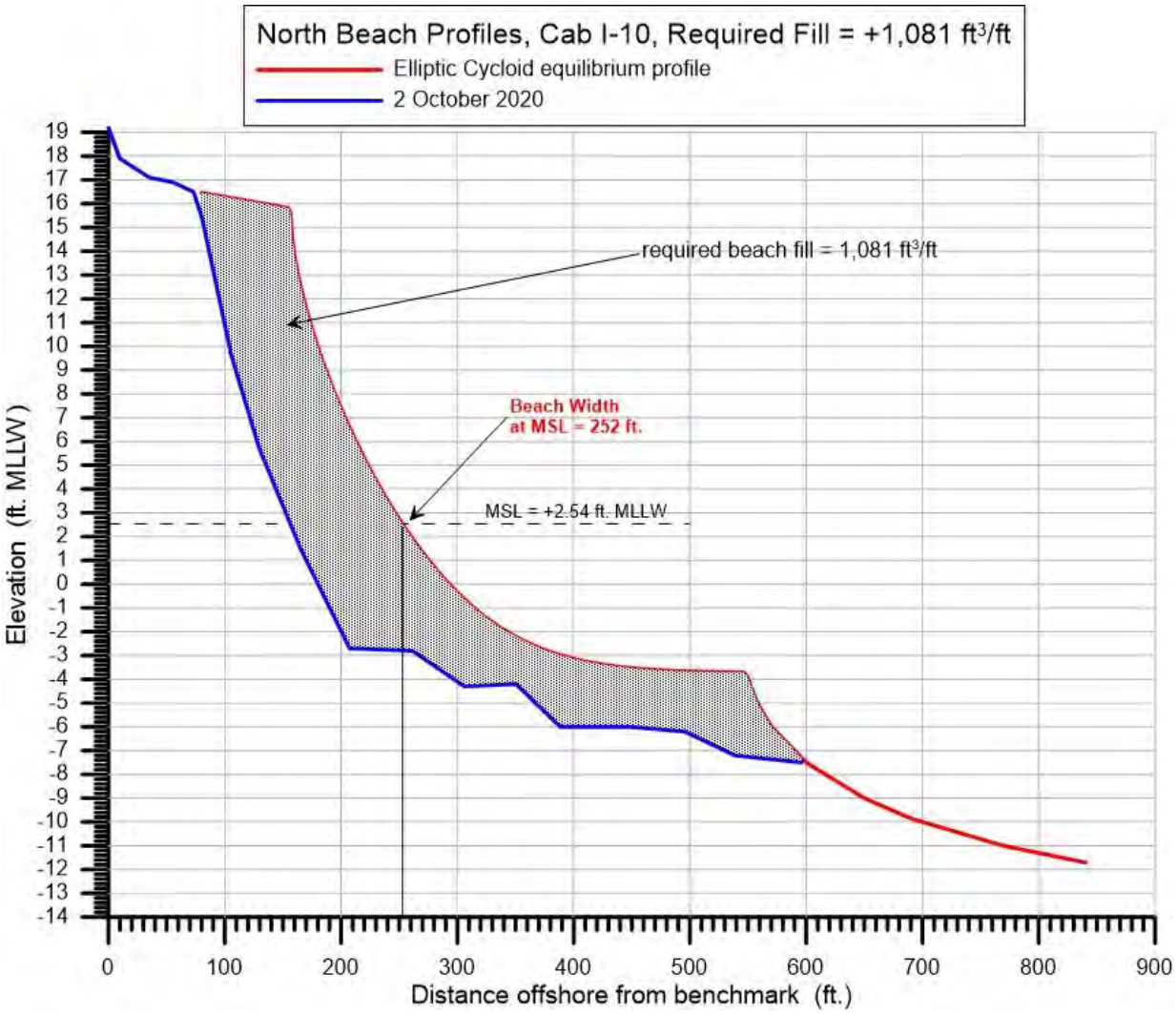



**Figure C-10:** Required beach fill based on coastal modeling at range line Cab I-10 on North Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

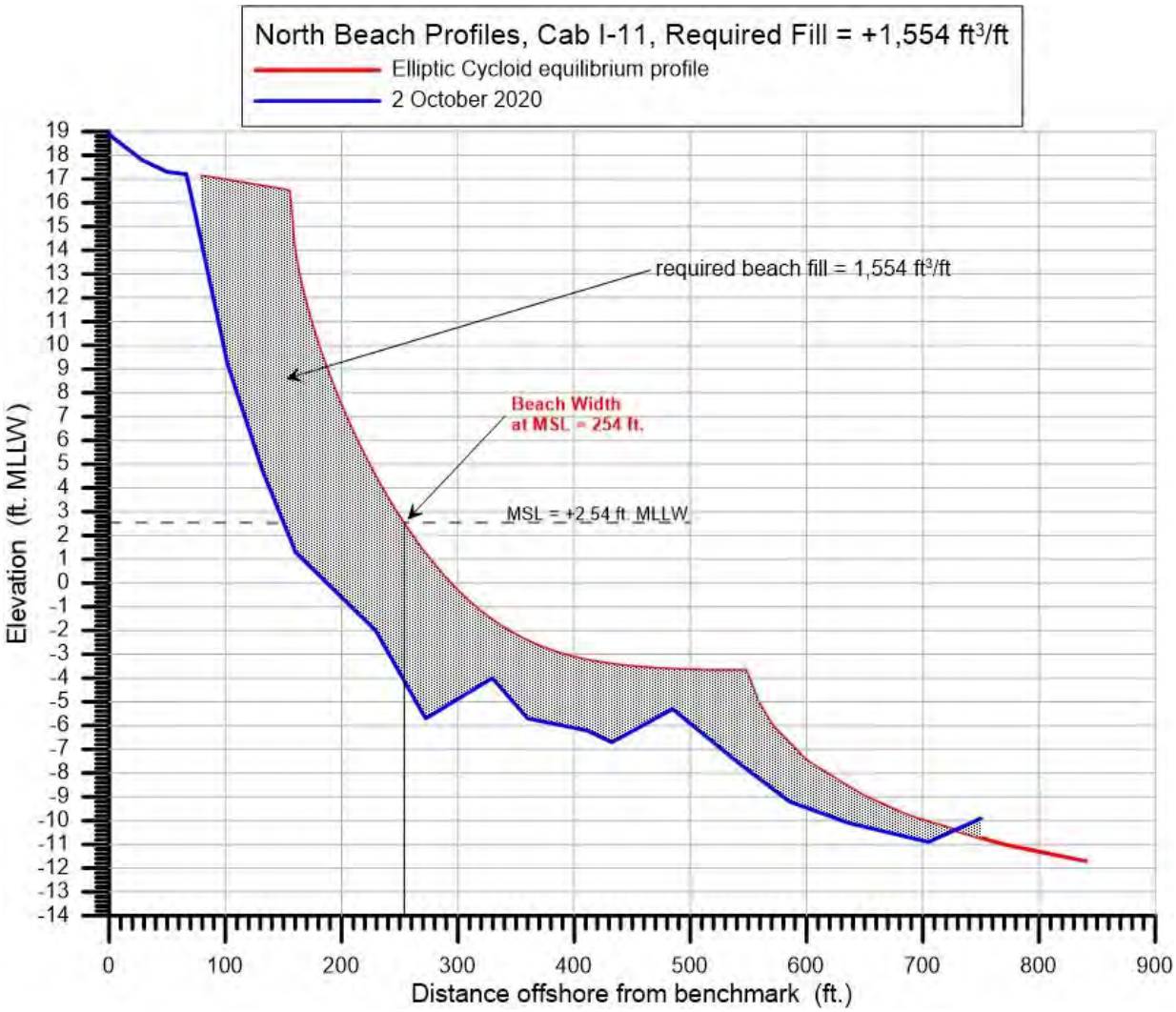



**Figure C-11:** Required beach fill based on coastal modeling at range line Cab I-11 on North Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

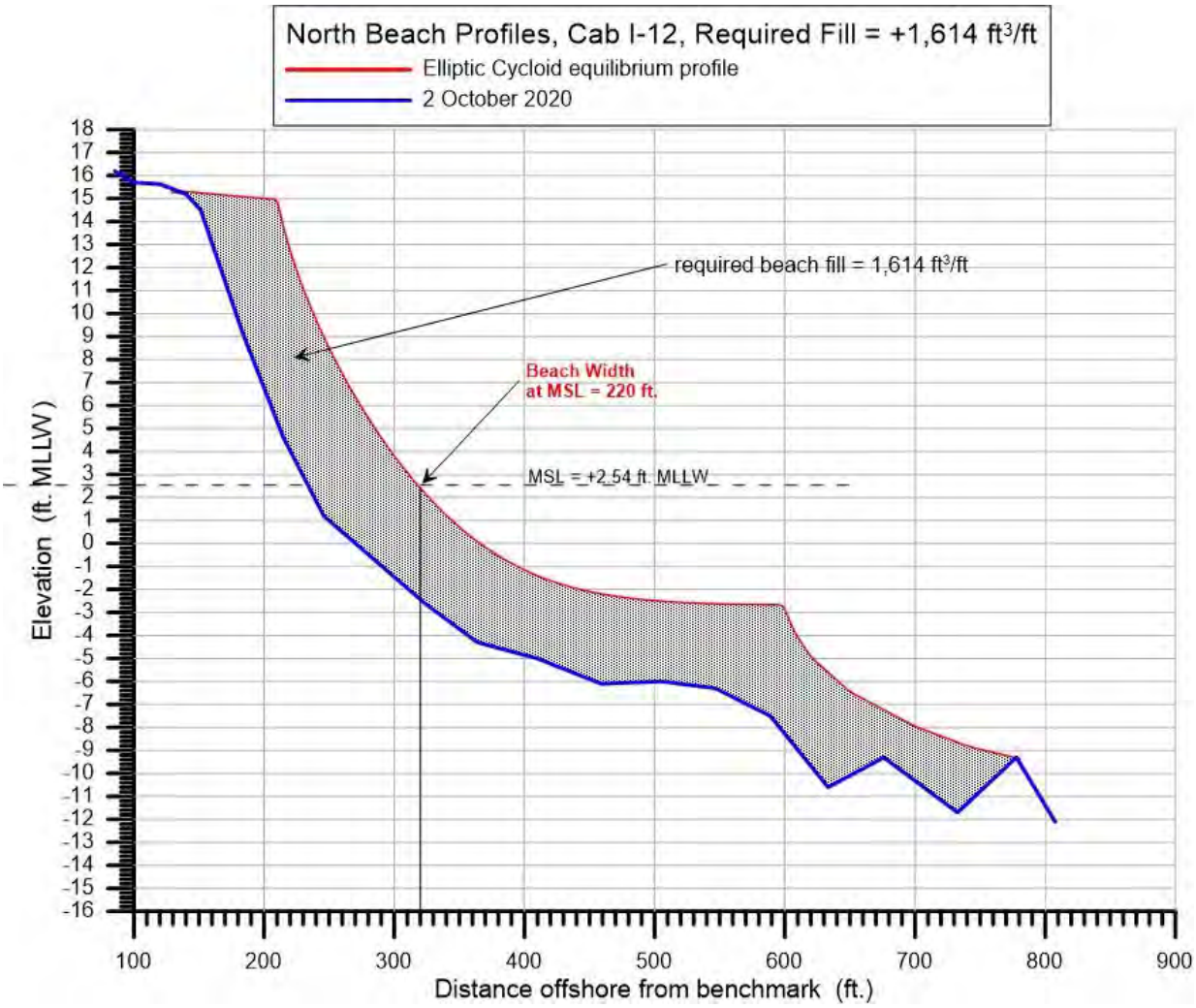



**Figure C-12:** Required beach fill based on coastal modeling at range line Cab I-12 on North Beach configured as the extremal elliptic cycloid profile that will maintain equilibrium in the presence of historic extreme waves with 4.8 m wave height and 15 second wave period, cf. Figure B-5.

## Appendix - D: Permitted Distribution of Dredge Fill on Receiver Beaches Based on Coastal Modeling - Beach Fill Profiles

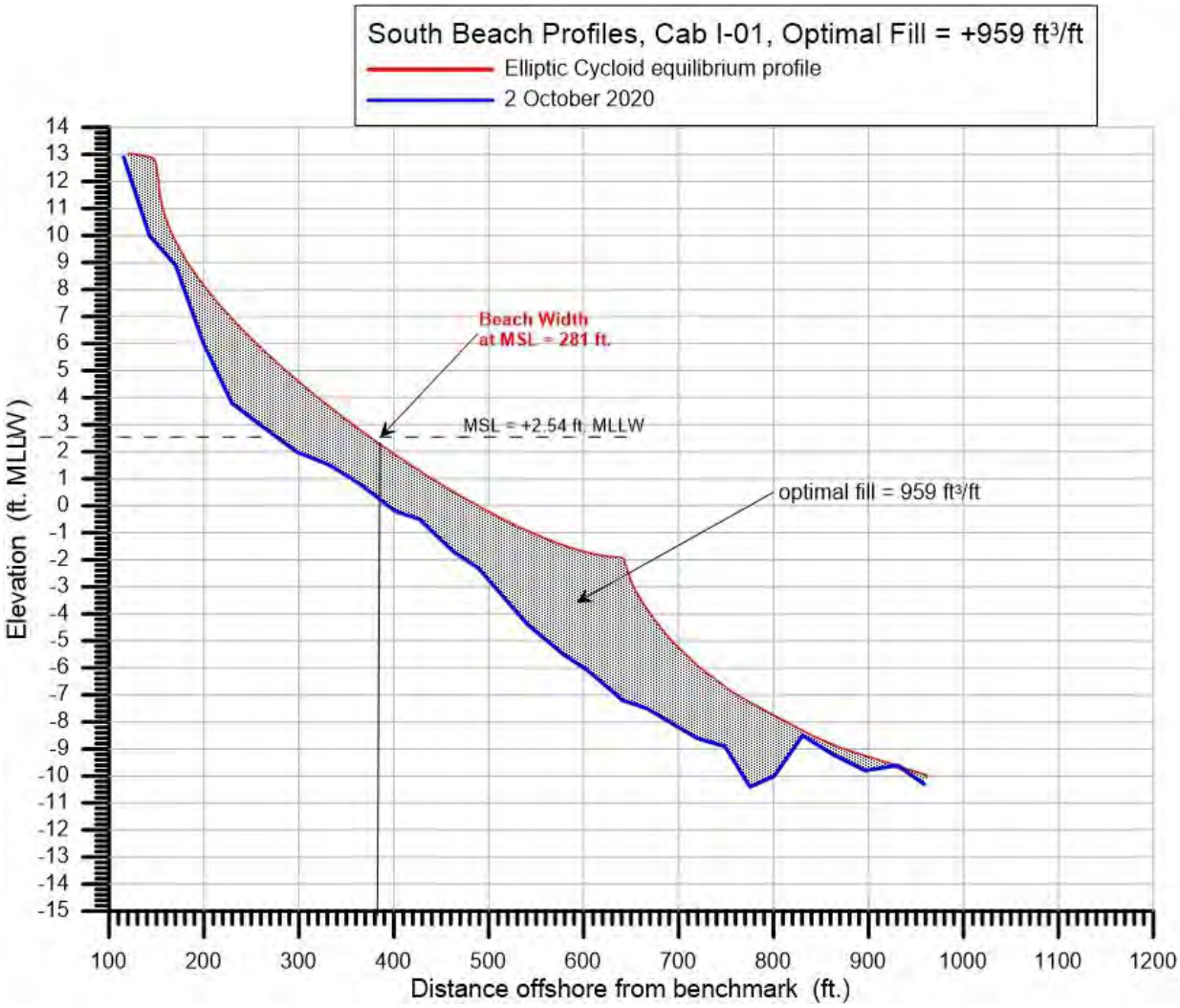



**Figure D-1:** Permitted beach fill at range line Cab I-01 on South Beach based on fill distribution as elliptic cycloid equilibrium profiles.

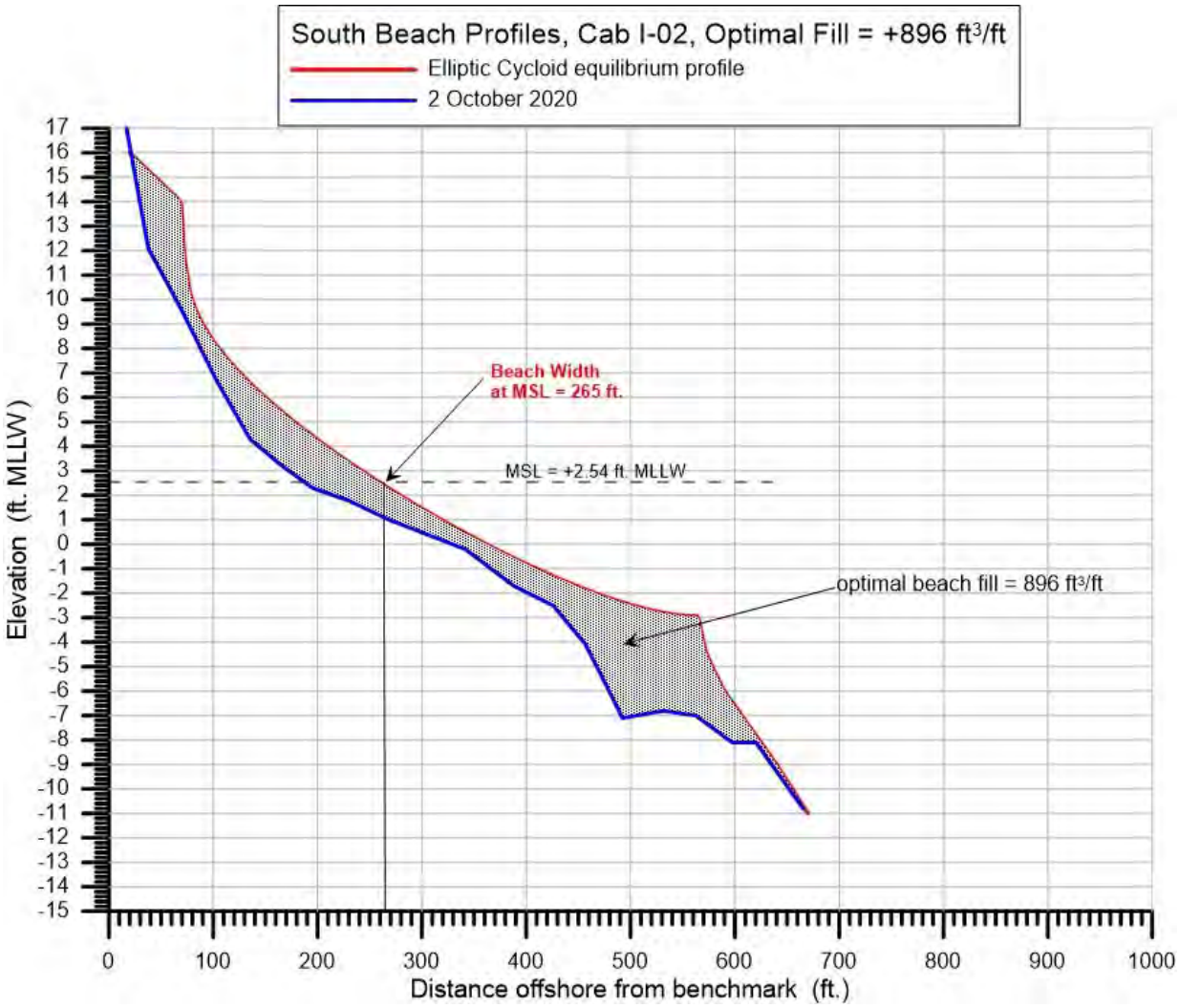



**Figure D-2:** Permitted beach fill at range line Cab I-02 on South Beach based on fill distribution as elliptic cycloid equilibrium profiles.

Appendix

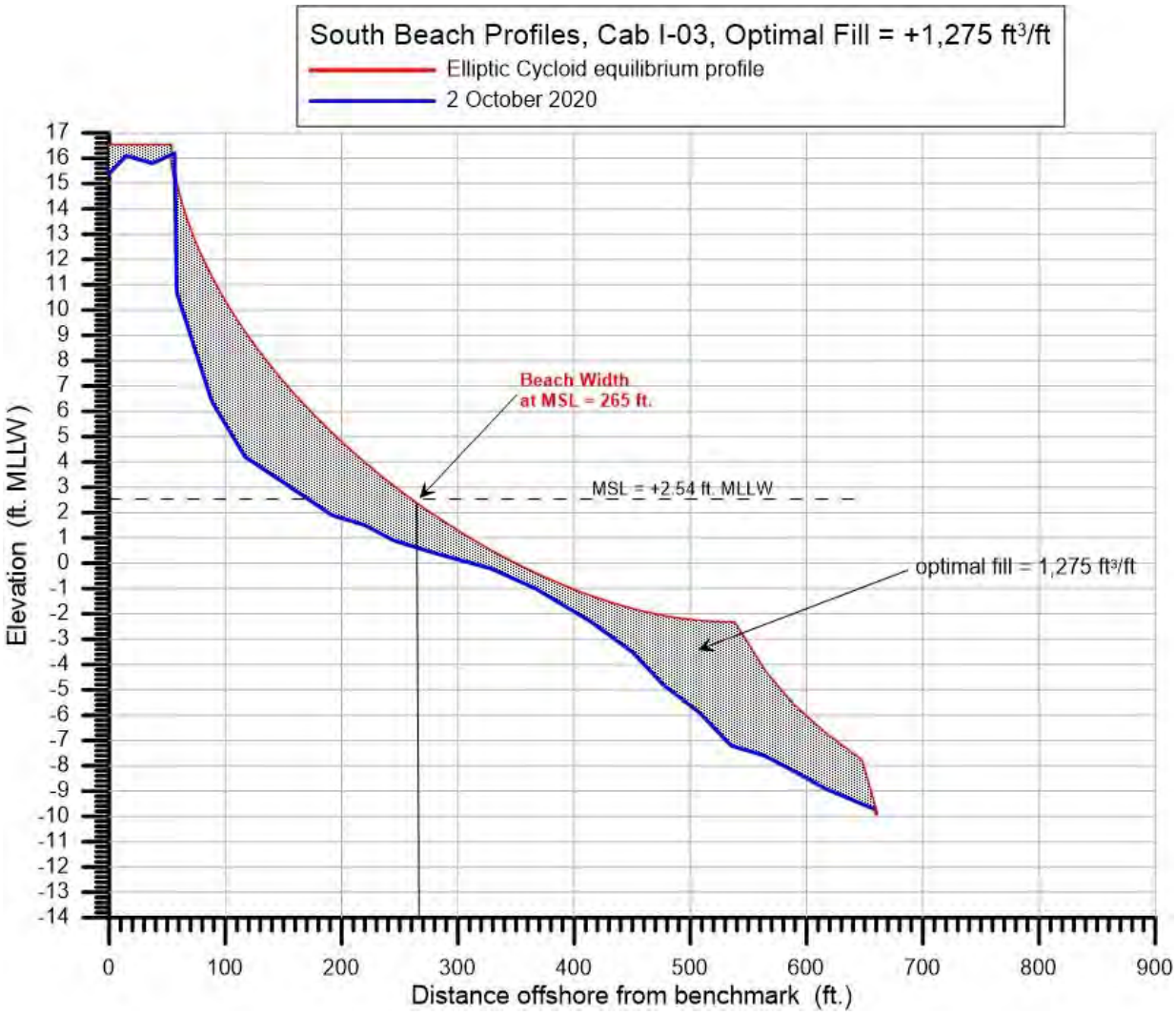



**Figure D-3:** Permitted beach fill at range line Cab I-03 on South Beach based on fill distribution as elliptic cycloid equilibrium profiles.


**Figure D-4:** Permitted beach fill at range line Cab I-04 on Middle Beach based on fill distribution as elliptic cycloid equilibrium profiles.

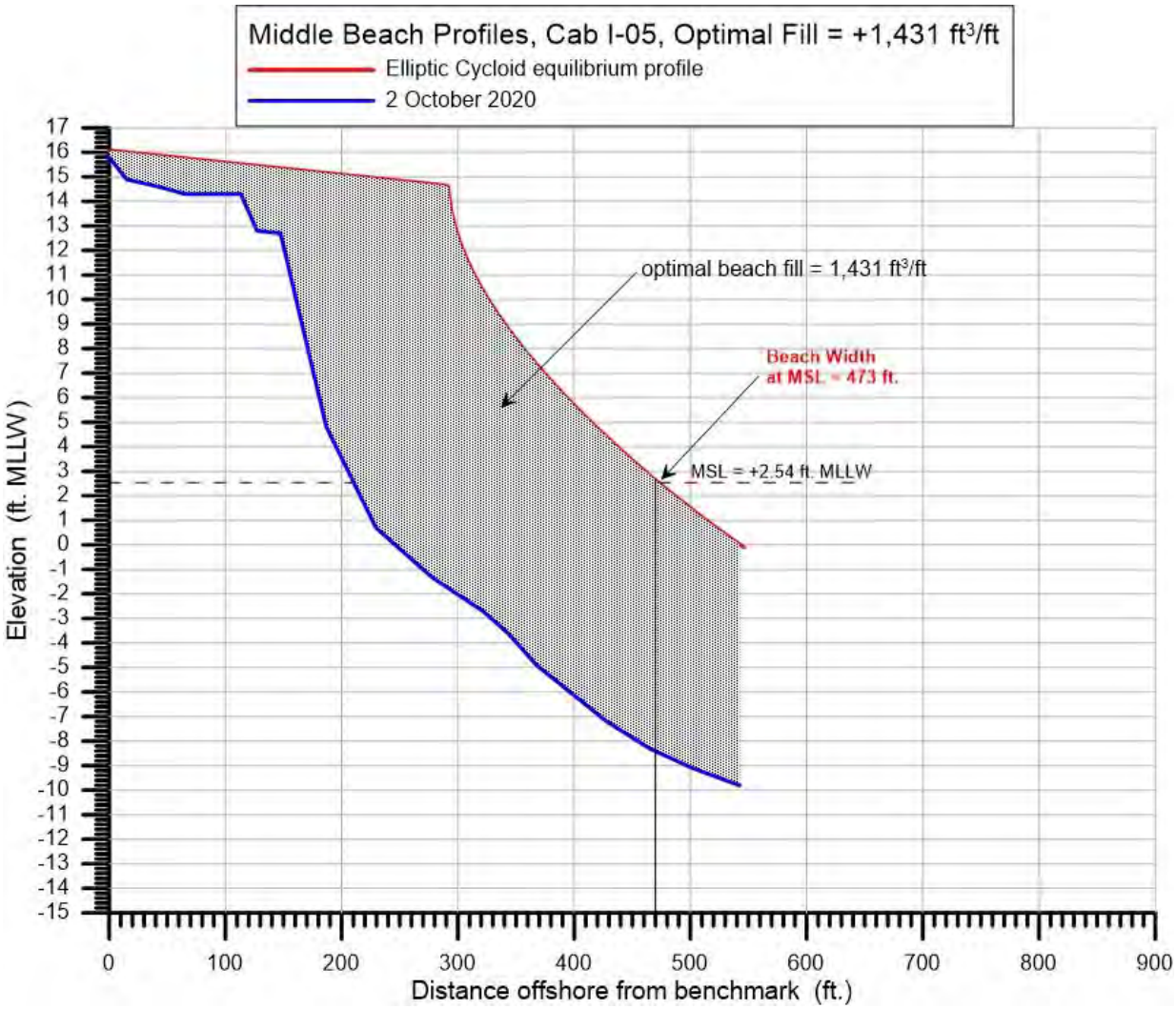



**Figure D-5:** Permitted beach fill at range line Cab I-05 on Middle Beach based on fill distribution as elliptic cycloid equilibrium profiles.

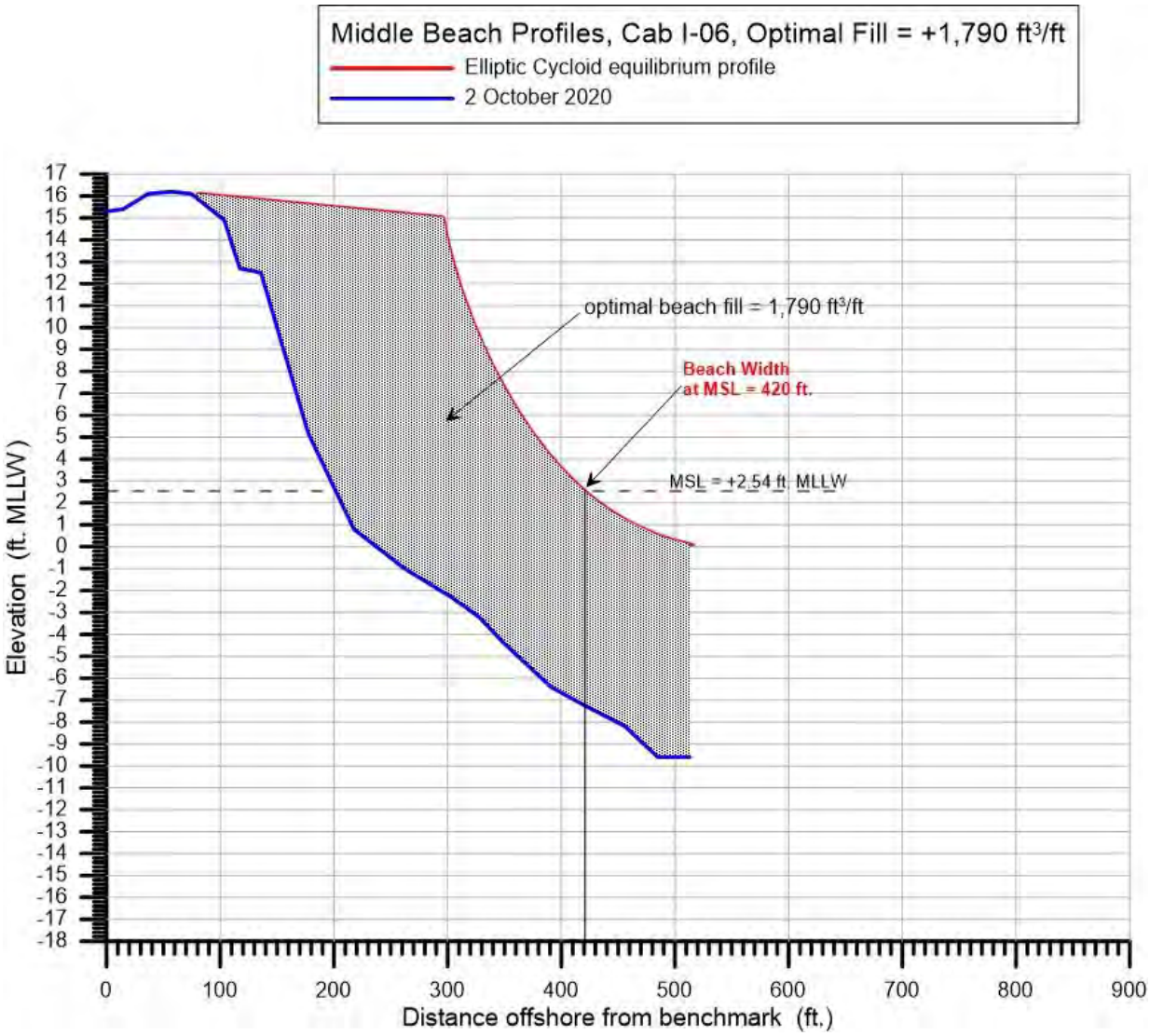



**Figure D-6:** Permitted beach fill at range line Cab I-06 on Middle Beach based on fill distribution as elliptic cycloid equilibrium profiles.

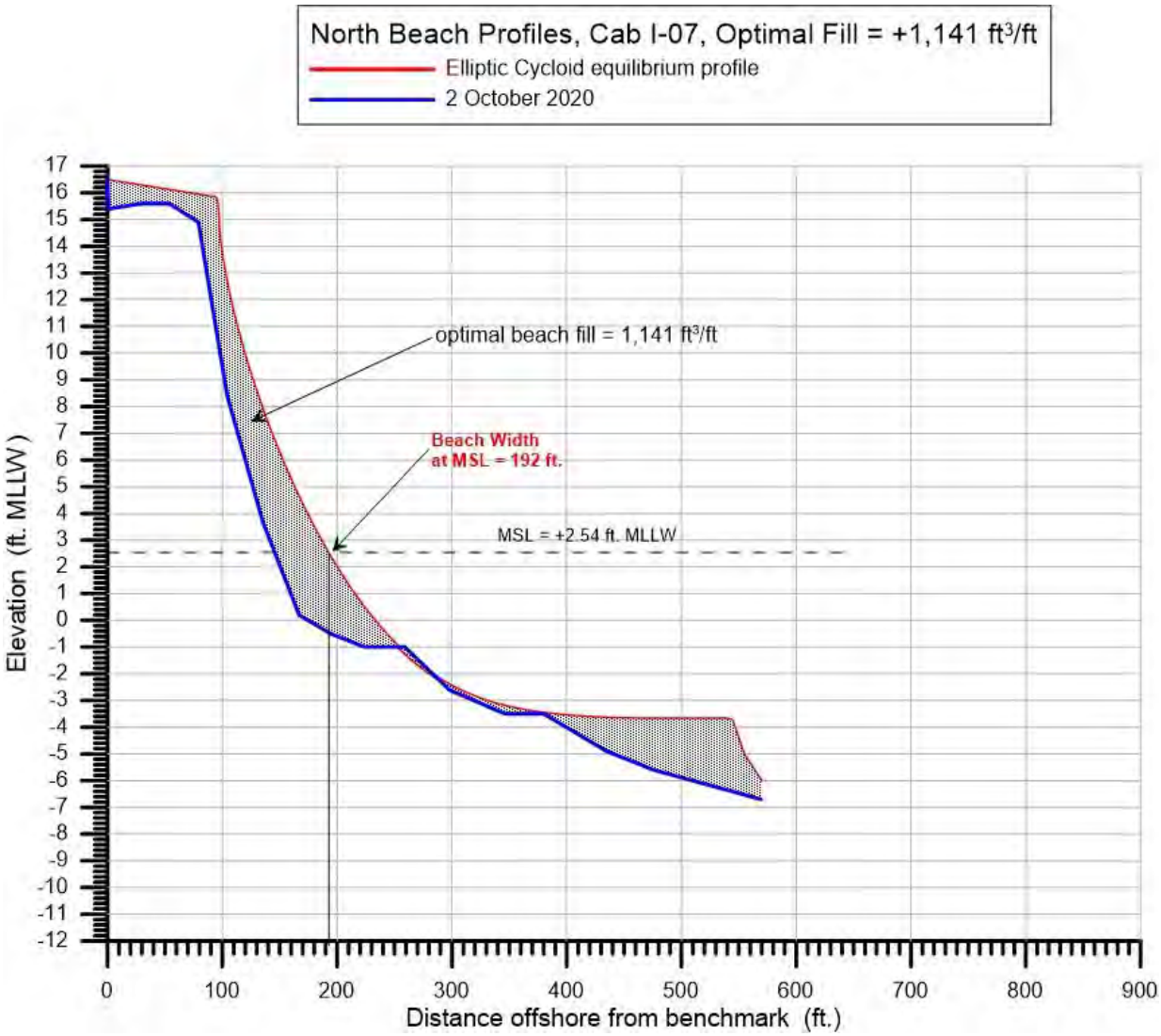



**Figure D-7** Permitted beach fill at range line Cab I-07 on North Beach based on fill distribution as elliptic cycloid equilibrium profiles.

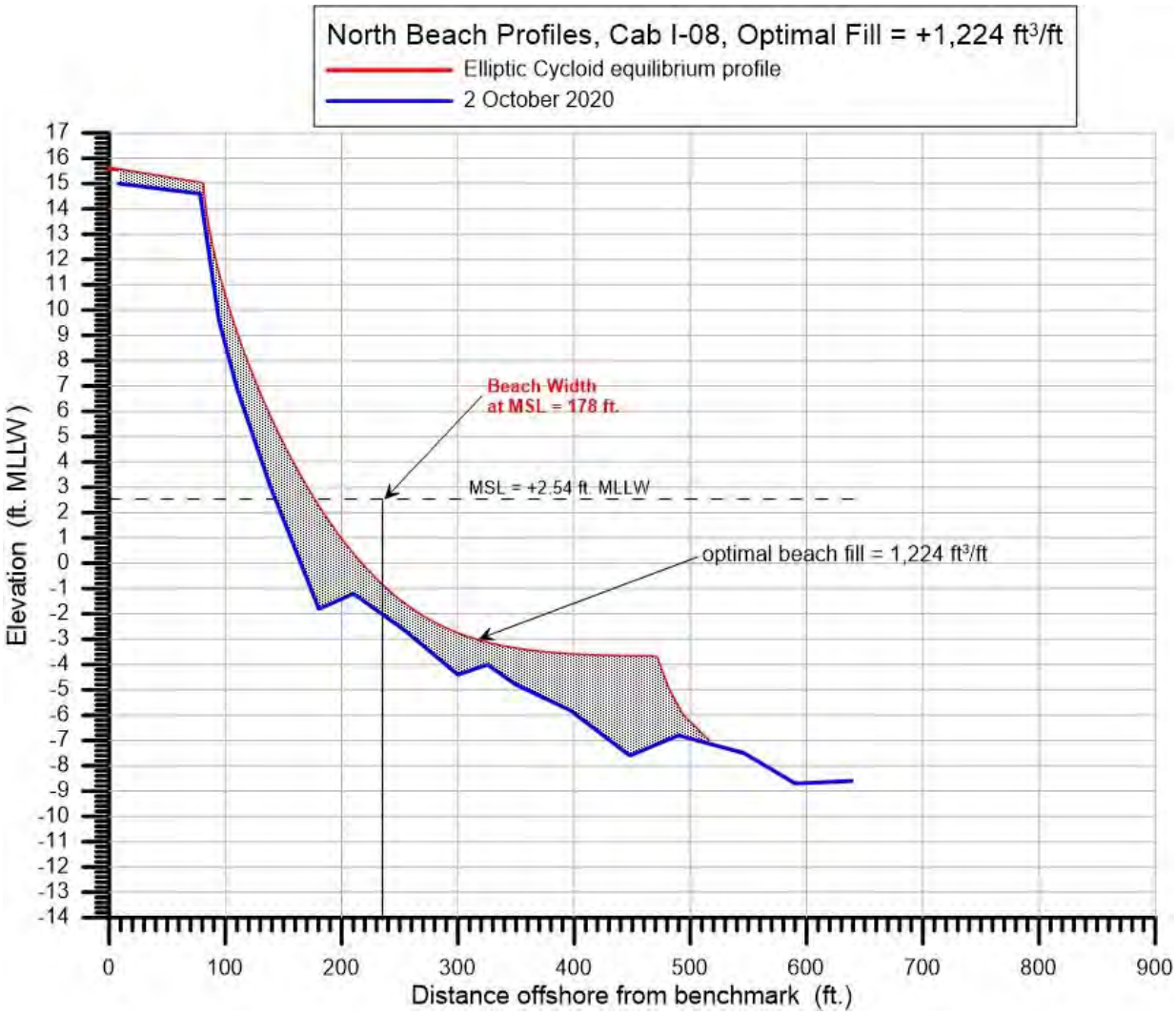



**Figure D-8:** Permitted beach fill at range line Cab I-08 on North Beach based on fill distribution as elliptic cycloid equilibrium profiles.


**Figure D-9:** Permitted beach fill at range line Cab I-09 on North Beach based on fill distribution as elliptic cycloid equilibrium profiles.

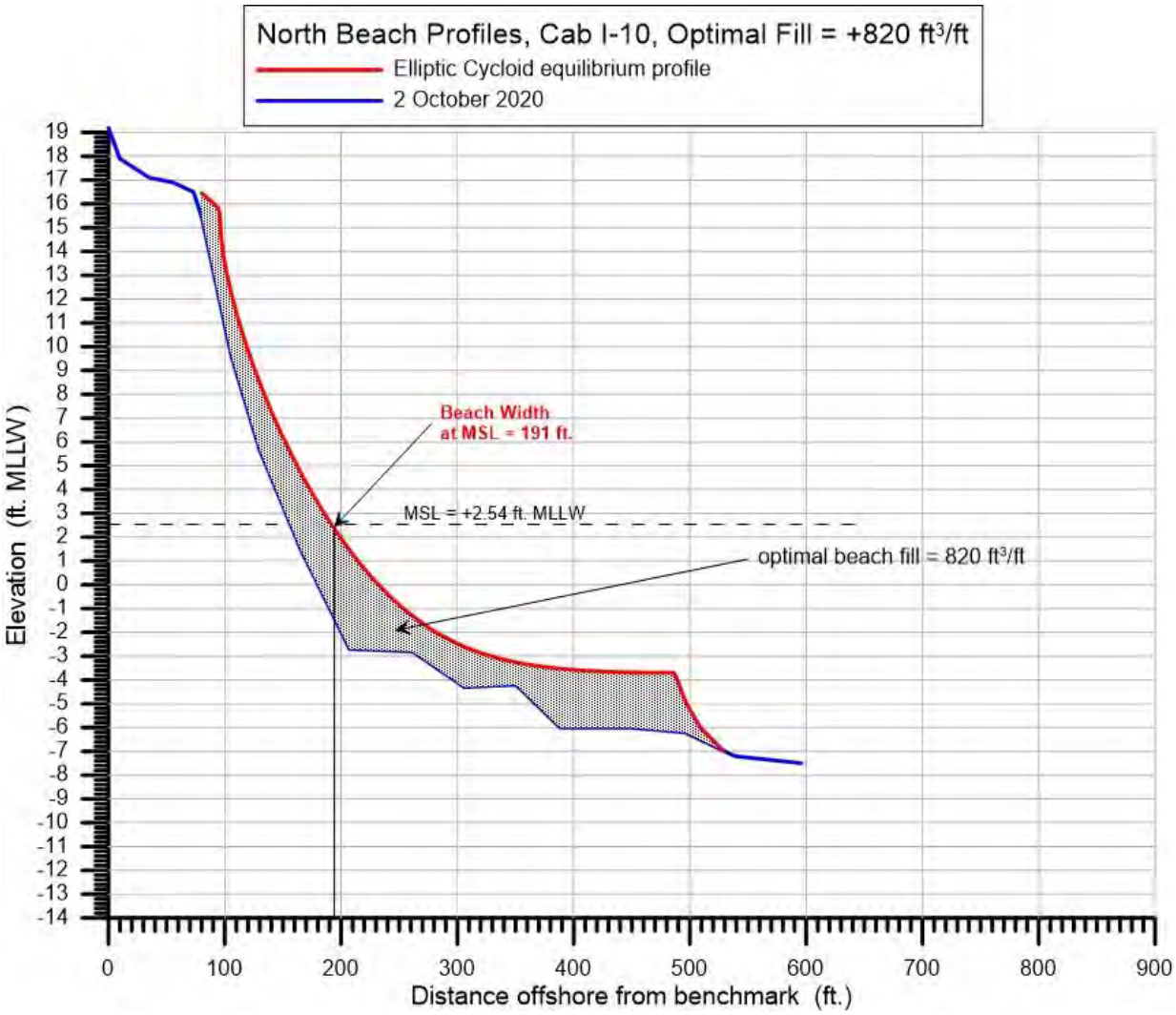



**Figure D-10:** Permitted beach fill at range line Cab I-10 on North Beach based on fill distribution as elliptic cycloid equilibrium profiles.

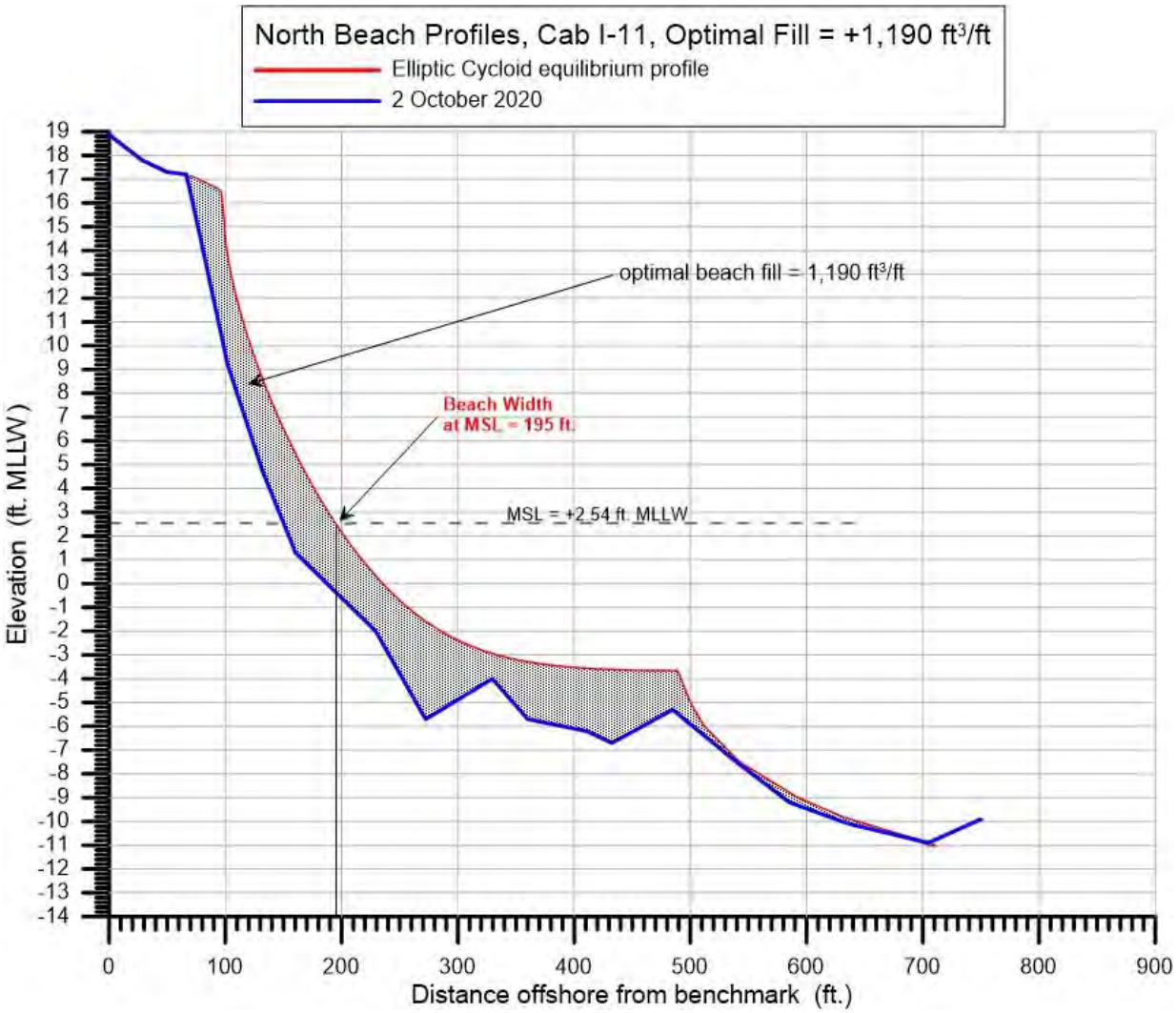



**Figure D-11:** Permitted beach fill at range line Cab I-11 on North Beach based on fill distribution as elliptic cycloid equilibrium profiles.

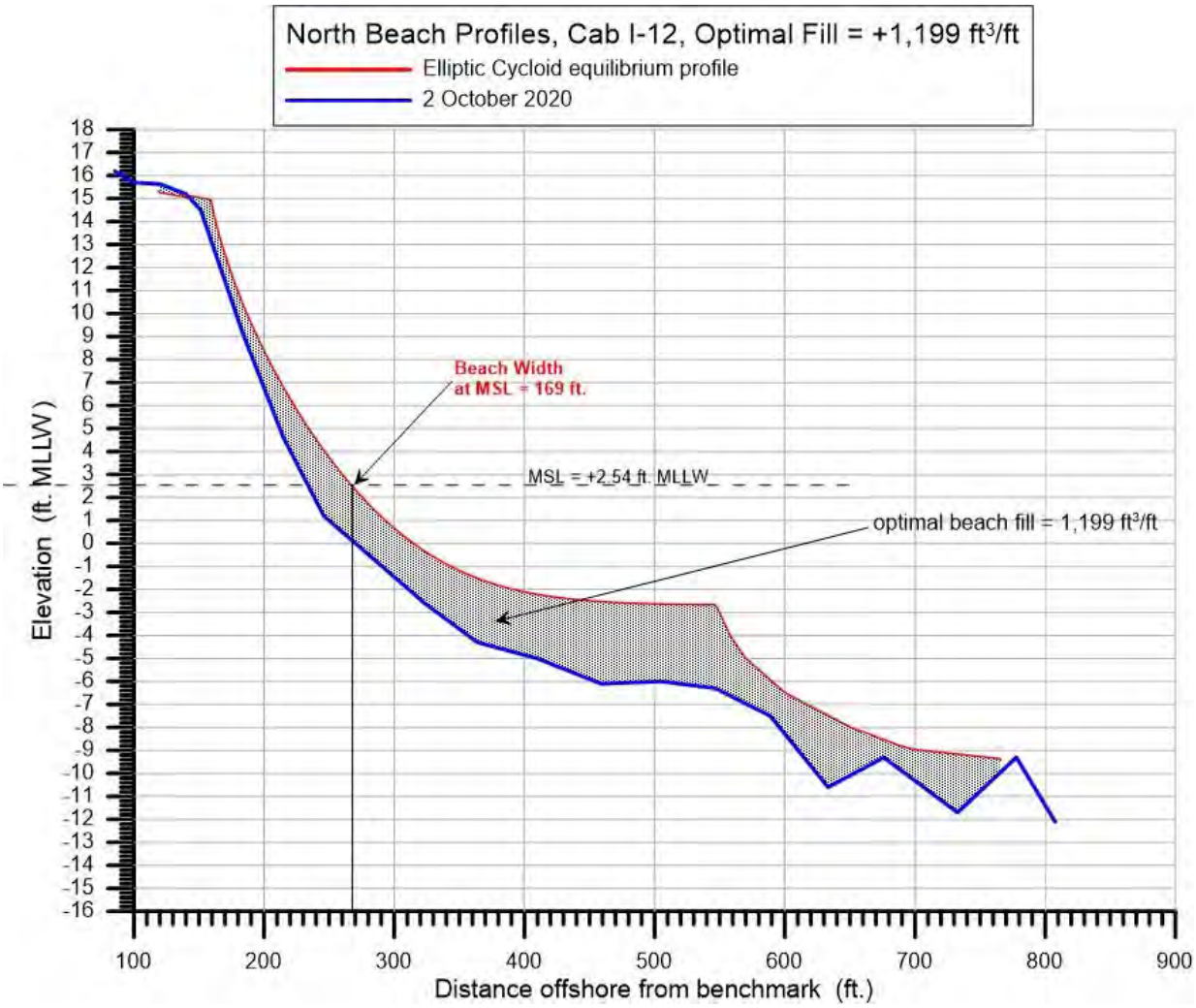



**Figure D-12** Permitted beach fill at range line Cab I-12 on North Beach based on fill distribution as elliptic cycloid equilibrium profiles.

# APPENDIX B

## Agua Hedionda Outer Lagoon 2020–2021 Dredge Cycle
## 2-Year Post-Construction Beach Profile Survey (June 2023)

June 8, 2023
CFC-1177

Josie McKinley
Poseidon Water
5780 Fleet Street, Suite 140
Carlsbad, CA 92008

**Subject: Agua Hedionda Outer Lagoon 2020-2021 Dredge Cycle**
**Two-Year Post-Construction Beach Profile Survey**

Ms. McKinley:

This letter report presents the methods and results of a beach profile survey conducted to document the condition of the beach approximately two years after beach nourishment activities were completed as part of the Agua Hedionda Outer Lagoon 2020-2021 Dredge Cycle. The survey was conducted on April 25 and 26, 2023 by Coastal Frontiers Corporation.

The sections that follow provide an overview of the monitoring program, summarize the beach nourishment activities conducted in the study area, describe the survey activities, present the results, and describe the short and long-term changes that have occurred in the area. Beach profile plots accompany this report in Appendix A. Mean Sea Level (MSL) shoreline positions derived from the profile data are provided in Appendix B. Appendix C contains site-specific photos, which match the locations and perspectives of photos previously captured during beach construction activities.

The vertical datum used throughout this report is National Ocean Service (NOS) Mean Lower Low Water (MLLW) for the 1983-2001 Tidal Datum Epoch. Horizontal positions are given in U.S. Survey Feet relative to California State Plane Zone 6, NAD 83 (2011), 2010.00 epoch.

## BACKGROUND

Poseidon Water conducted maintenance dredging in 2021 to remove a flood-tide shoal in the Agua Hedionda Outer Lagoon. The dredged sand was placed on three adjacent beaches: North Beach, Middle Beach, and South Beach (Figure 1).

Dredging activities were undertaken by Pacific Dredge and Construction, LLC from February 15 through March 27, 2021. It is estimated that 304,483 cy were dredged from the lagoon, based on progress surveys conducted by Coastal Frontiers throughout the dredging operations (Coastal Frontiers, 2021). North Beach received 121,667 cy (40%), Middle Beach received 100,992 cy (33%), and South Beach received 81,824 cy (27%) of the dredged material.

## BEACH PROFILE SURVEYS

The objective of the current monitoring program is to develop a quantitative understanding of the coastal changes that have occurred near the three receiver sites since beach nourishment activities were conducted in early 2021.

Five beach profile surveys were conducted in support of the project (Table 1). Pre-Construction surveys of North, Middle and South Beaches were conducted on May 12 and 13 and October 2, 2020. A Post-Construction survey was conducted on April 13, 2021 immediately following beach nourishment activities. A follow-up survey was conducted approximately one year later, on May 4 and 5, to assess whether the beaches had returned to their pre-deposition conditions. The most recent survey, conducted on April 25 and 26, 2023, captured the condition of the beach approximately two years following completion of the beach construction activities for the same purpose.

**Table 1. Beach Profile Survey Dates**

| Survey | Survey Date | |
|---|---|---|
| Pre-Construction | May 12-13 | 2020 |
| Pre-Construction | October 2 | 2020 |
| Post-Construction | April 13 | 2021 |
| One-Year Post-Construction | May 4-5 | 2022 |
| Two-Year Post-Construction | April 25-26 | 2023 |

### ***Data Acquisition***

Beach profile data were obtained on the 15 transects shown in Figure 1. Data were acquired along each transect from the landward limit of the sandy beach to wading depth, which typically corresponded to roughly 10 to 13 ft below Mean Lower Low Water (MLLW) datum depending on the prevailing water level at the time of the survey. The beach and surf zone were surveyed using a total station and a survey rodperson. The total station was used to determine the position and elevation of the beach at each location occupied by the rodperson. Each transect was surveyed from the back beach seaward through the surf zone until the survey rod no longer protruded above the water surface when held vertically.

### ***Data Reduction***

Data from each survey were collected and processed using software developed by Spectra Precision. The raw total station data were input to the software, and the coordinates and elevation of each data point were calculated. The data were subsequently inserted into a computer-aided design (CAD) file for analysis and preparation of the data products.

The electronic total station used to conduct the survey is capable of measuring elevation differences to within ±0.1 ft and ranges to within ±0.5 ft. However, because the swimmer was subjected to waves and currents in the surf zone, the horizontal position perpendicular to each transect (parallel to the shoreline) varied from minimal at short ranges to approximately ±15 ft at the offshore end.


**Figure 1. Beach Profile Transect Locations**

## RESULTS

The Two-Year Post-Construction survey data are included in a digital archive (*.zip) attached to the electronic submittal of this report. The archive contains ASCII files comprising: (1) range and elevation for each profile; and (2) northing, easting, and elevation triplets (n,e,z) for the entire survey. Elevations are provided in feet relative to National Ocean Service (NOS) Mean Lower Low Water (MLLW) for the 1983-2001 Tidal Datum Epoch. Horizontal positions are given in U.S. Survey Feet relative to California State Plane Zone 6, NAD83(2011)2010.00 epoch.

Beach profile plots illustrating the data obtained as part of each survey are provided in Appendix A. The range on each profile plot represents the distance in feet seaward of the transect origin measured along the transect alignment.

Mean Sea Level (MSL) shoreline positions are provided in Attachment B. The shoreline position was computed as the horizontal distance, in feet, between the transect origin (typically a permanent marker located near the back beach) and the point at which the beach profile intersected the plane of the MSL datum. In the study area, MSL lies 2.73 ft above MLLW. Notwithstanding the use of MLLW as the elevation reference for the profile data, MSL was adopted as the shoreline reference since it is considered to provide a more accurate indicator of changes in beach configuration. MSL shoreline position changes are tabulated below in Table 2, while illustrations of these changes are contained within Appendix B.

Site photos are provided in Appendix C to qualitatively document the beach condition approximately two years following beach nourishment activities. The location and perspective of each photo matches those images previously provided in weekly progress reports during beach construction. Those weekly progress reports are contained within the final survey report provided following the 2020-21 Dredge Cycle construction activities (Coastal Frontiers, 2021).

## OBSERVATIONS

### ***Profile Changes (Appendix A)***

While the Fall 2020 (October 2, 2020) Pre-Construction survey was performed within the closest temporal proximity to the beach nourishment activities, the preceding Spring 2020 (May 12-13, 2020) Pre-Construction survey was selected as the basis for comparison to remain seasonally consistent with the subsequent spring surveys.

#### *North Beach*

Sediment gains resulting from the project are evident at six of the seven North Beach monitoring transects (Cab I-07 through Cab I-11) through comparison of the Pre-Construction (May 2020) and Post-Construction (April 2021) profiles. The northernmost transect (Cab I-12) was the only location where above-water

(subaerial) losses occurred. These losses were limited to the upper beach profile above approximately +8 ft, MLLW.

A trend of profile erosion is evident during the two-year period following beach nourishment activities (April 2021 to April 2023). The sole exception occurred at the southern end of the sub-reach (Transect Cab I-07), where above-water gains prevailed during this period. Sediment losses generally occurred from the seaward edge of the berm to roughly -5 ft, MLLW. The April 2023 profile is more eroded than, or roughly coincident to, the May 2020 Pre-Construction condition in the northern and central portions of the sub-reach (Transects Cab I-12 through Cab I-08). In contrast, the April 2023 profile shows sediment gains relative to the pre-construction condition at the southern end of the sub-reach (Transects Cab I-07.5 and Cab I-07). This outcome is likely attributable to accumulation of sediment on the updrift side of the Agua Hedionda intake channel jetties.

*Middle Beach*

At Middle Beach (Transects Cab I-03.6 through Cab I-06), sediment gains resulting from the beach nourishment are evident through comparison of the May 2020 Pre-Construction and April 2021 Post-Construction profiles.

Over the two-year period following beach nourishment activities (April 2021 to April 2023), erosion occurred at all four sites within the Middle Beach sub-reach. The April 2023 above-water beach condition was more eroded than that documented during the May 2020 Pre-Construction survey at all transects.

*South Beach*

Within the South Beach sub-reach (Cab I-03.2 through Cab I-01), sediment gains resulting from the project are evident through comparison of the May 2020 Pre-Construction and April 2021 Post-Construction profiles at all four sites.

A trend of profile erosion subsequently prevailed at all four sites during the two-year period following beach nourishment activities (April 2021 to April 2023). At the time of the April 2023 survey, the profiles at all four sites within the South Beach sub-reach (Cab I-03.2 through Cab I-01) show that the beach was generally more eroded than the Pre-Construction (May 2020) condition.

***MSL Shoreline Position Changes (Table 2, Appendix B)***

1. Pre- to Post-Construction Period Shoreline Changes (May 2020 to April 2021): During the roughly one-year period encompassing beach nourishment activities (May 2020 Pre-Construction to April 2021 Post-Construction), shoreline gains predominated at the three receiver beaches (Figure B2). The MSL shoreline position increased at 14 of the 15 sites (Transect Cab I-06 being the sole exception).

At North Beach, the MSL shoreline increased 39 ft, on average. The shoreline position at Middle and South Beaches advanced an average of 26 and 37 ft, respectively.

2. Two-Year Post-Construction Period Shoreline Changes (April 2021 to April 2023): In April 2023, two years after nourishment activities were completed, MSL shoreline losses prevailed at all but one site in comparison to the April 2021 Post-Construction condition. The exception occurred at Tamarack Beach (Cab I-07 / CB-0830), which was essentially unchanged (Table 2, Figure B3).

   Shoreline retreat at North Beach ranged from 16 to 67 ft. These changes produced an average shoreline loss of 37 ft over the two-year period. Losses at Middle Beach ranged from 19 to 65 ft, while losses at South Beach ranged from 53 to 64 ft. On average, the shoreline at Middle Beach retreated 45 ft, while South Beach eroded 58 ft.

3. Pre- to Two-Year Post-Construction Shoreline Changes (May 2020 to April 2023): The April 2023 shoreline position at North Beach was 2 ft wider, on average, compared to the May 2020 Pre-Construction condition. At Middle Beach, the average shoreline position decreased 19 ft over the same three-year period. Similarly, the shoreline at South Beach retreated 21 ft (Table 2, Appendices B4).

**Table 2. Mean Sea Level Shoreline Position Changes**

| Sub-Reach | Transect | MSL Shoreline Position Change (ft) | | |
|---|---|---|---|---|
| | | Pre- to Post-Construction | Two Years Post-Construction | Pre-Construction to Two Years Post-Construction |
| | | May 2020 to April 2021 | April 2021 to April 2023 | May 2020 to April 2023 |
| | | ~1 Year | ~2 Years | ~3 Years |
| North Beach | **Cab I-12** (CB-0850) | 21 | -31 | -10 |
| | **Cab I-11** | 47 | -50 | -3 |
| | **Cab I-10** | 57 | -67 | -10 |
| | **Cab I-09** (CB-0840) | 58 | -56 | 2 |
| | **Cab I-08** | 47 | -43 | 4 |
| | **Cab I-07.5** | 27 | -16 | 11 |
| | **Cab I-07** (CB-0830) | 17 | 1 | 18 |
| | **AVERAGE** | **39** | **-37** | **+2** |
| Middle Beach | **Cab I-06** (CB-0820) | -1 | -19 | -20 |
| | **Cab I-05** | 14 | -33 | -19 |
| | **Cab I-04** | 41 | -63 | -22 |
| | **Cab I-03.6** | 49 | -65 | -16 |
| | **AVERAGE** | **26** | **-45** | **-19** |
| South Beach | **Cab I-03.2** | 32 | -64 | -32 |
| | **Cab I-03** | 30 | -53 | -23 |
| | **Cab I-02** | 45 | -54 | -9 |
| | **Cab I-01** | 40 | -61 | -21 |
| | **AVERAGE** | **37** | **-58** | **-21** |

Notes: (1) **Red** indicates shoreline loss.
**Green** indicates shoreline gain.
**Black** indicates essentially no change (change of 10 ft, or less).

**Long-Term Changes**

Among the fifteen monitoring transects surveyed as part of the current monitoring program, four of the sites have been surveyed semiannually since 1988 on behalf of the City of Carlsbad and the San Diego Association of Governments (SANDAG, 2022).

Three of the sites are located within the North Beach sub-reach (Cab I-12/CB-0850, Cab I-09/CB-0840, and Cab I-07/CB-0830), while one site exists at Middle Beach (Cab I-06/CB-0820). No coincident data are available within the South Beach sub-reach as part of either the SANDAG or City of Carlsbad programs.

These publicly available beach profile data were acquired in a similar manner as the current monitoring program. In consequence, the results are directly comparable, and are used as the basis for evaluating long-term changes relative to the 2020-2021 Dredge Cycle beach nourishment.

The Spring 2012 survey (conducted May 7 - 11, 2012) was selected as the basis of comparison to (1) remain seasonally consistent with the 2020-21 Dredge Cycle Spring beach surveys, and (2) to serve as the baseline pre-condition prior to the influence of SANDAG's Regional Beach Sand Project II (RBSP II) beach nourishment, conducted in November and December 2012 at North Carlsbad.

During the eleven-year period between the Spring 2012 and Spring 2023 surveys, over one million cubic yards of beach quality sediment were delivered to Carlsbad-area beaches (Table 3). Nourishment within the study area consisted of the RBSP II in 2012. Sediment bypassing at Agua Hedionda Lagoon was conducted in 2015, 2018, and 2021.

**Table 3. Carlsbad Nourishment and Bypassing Quantities (cy), 2012 to Present**

| Receiver Site | 2021 Bypassing [1] Feb. 15, 2021 to Mar. 27, 2021 | 2018 Bypassing [2] Feb. 16, 2018 to Apr. 13, 2018 | 2015 Bypassing [3] Dec. 31, 2014 to Apr. 15, 2015 | 2012 RBSP II [4] Nov. 24, 2012 to Dec. 7, 2012 | TOTAL |
|---|---|---|---|---|---|
| **North Beach** | 121,667 | 0 | 64,968 | 219,000 | 405,635 |
| **Middle Beach** | 100,992 | 141,172 | 156,056 | 0 | 398,220 |
| **South Beach** | 81,824 | 64,310 | 73,637 | 0 | 219,771 |
| **TOTAL** | **304,483** | **205,482** | **294,661** | **219,000** | **1,023,626** |

Notes: [1] Coastal Frontiers, 2021
[2] Coastal Frontiers, 2018
[3] Henika, 2015
[4] Coastal Frontiers, 2013

Figure 2 presents a time series of the weighted average MSL shoreline change at the time of each Spring survey relative to the Spring 2012 condition for the North Beach sub-reach. The uneven spacing between transects was accounted for by weighting each value according to the alongshore distance associated with the corresponding transect. The initial shoreline advance in response to the RBSP II beach nourishment was sustained through 2017, despite strong El Niño conditions during the 2015-16 winter. It is noteworthy that the sediment contributions from lagoon bypassing in 2015 likely contributed to the longevity of the gains. From 2017 through 2020, persistent erosion prevailed, with the average shoreline position retreating to below pre-RBSP II levels. North Beach did not receive nourishment material as part of the 2018 Agua Hedionda Lagoon bypassing. In 2021, shoreline advance prevailed as a result of the most recent bypassing activities. However, by the time of the April 2023 survey, the shoreline retreated below the baseline pre-RBSP II level and essentially matched the 2020 Pre-Construction condition.

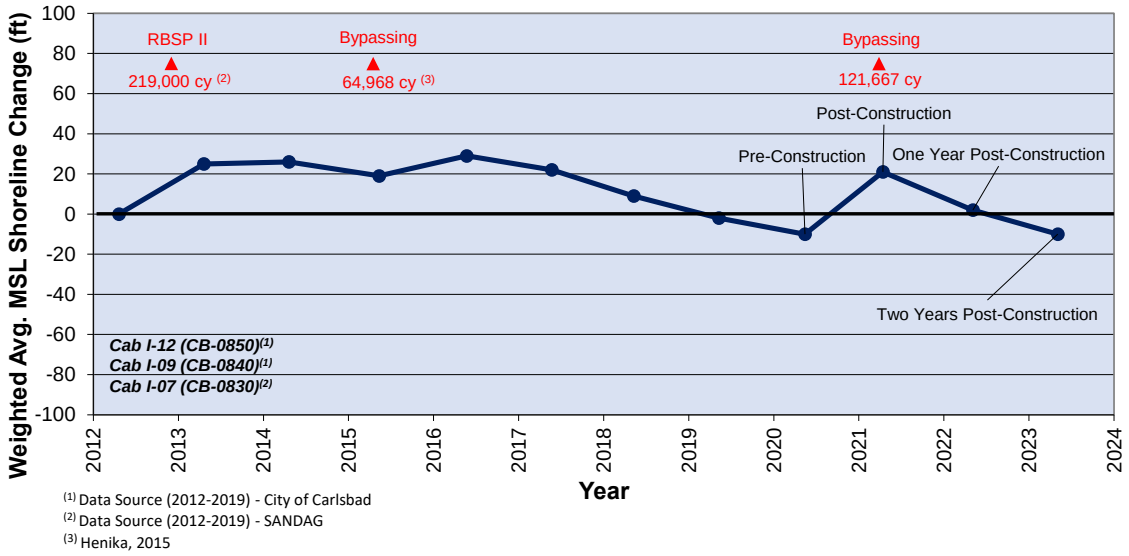



**Figure 2. Time Series of Weighted Average MSL Shoreline Change Relative to Spring 2012 Condition in the North Beach Sub-Reach**

A time series of shoreline position changes relative to Spring 2012 for the sole historical transect at Middle Beach (Transect Cab I-06/CB-0820) is provided in Figure 3. Middle Beach did not receive direct nourishment as part of the RBSP II. As such, modest shoreline loss prevailed during the first two years of the period. Substantial shoreline advance occurred in 2015 in response to the Agua Hedionda Lagoon bypassing activities. However, by Spring 2016 these gains were erased by the energetic wave activity that occurred during the strong 2015-16 El Niño. The shoreline advanced again in 2018 as an apparent result of the next phase of lagoon bypassing. While the shoreline retreated in 2019, the losses were not as severe as those noted during the 2015-16 El Niño season. Shoreline changes were modest from 2019 through 2021 despite the current bypassing efforts. The apparent lack of shoreline gains attributable to the 2021 bypassing may be due

to the limited spatial coverage, with only one historical transect located within the sub-reach. Modest losses occurred in 2022, followed by relative stability in 2023. However, the shoreline position remained above the baseline pre-RBSP II level at the time of the 2023 survey.

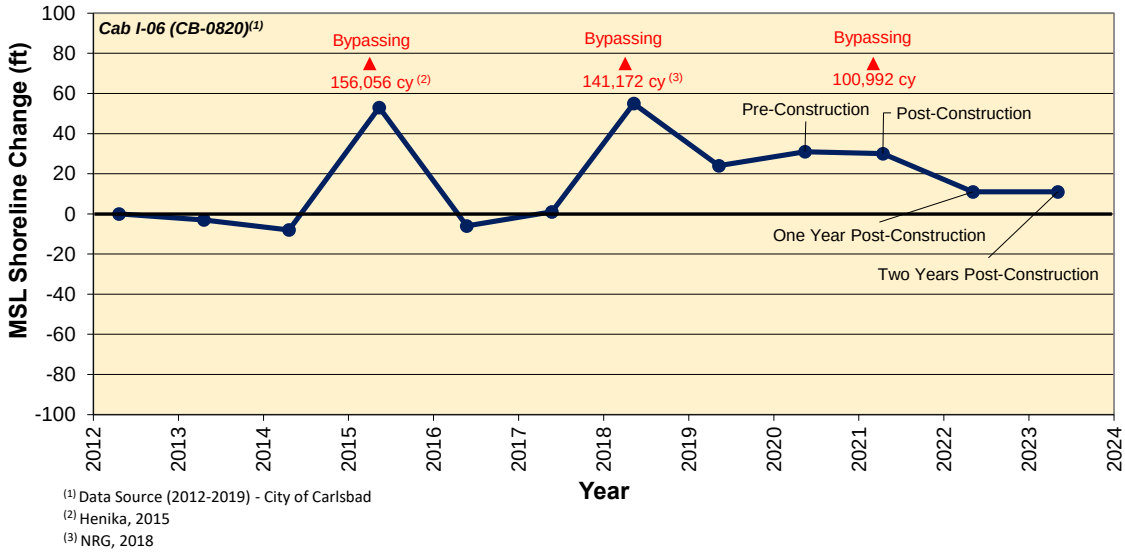



**Figure 3. Time Series of MSL Shoreline Change Relative to Spring 2012 Condition in the Middle Beach Sub-Reach**

As noted previously, similar long-term data have not been collected within the South Beach sub-reach.

**Key Findings**

The latest profiles (April 2023) at North Beach are either more eroded than, or roughly coincident to, the May 2020 Pre-Construction condition in the northern and central portions of the sub-reach. Similarly, the April 2023 profiles at Middle and South Beaches show that the beach was generally more eroded than the Pre-Construction (May 2020) condition. The only occurrence of profile accretion was at the two transects located immediately north of the Agua Hedionda north jetties. This outcome suggests that the beach condition has effectively returned to, or eroded beyond, the Pre-Construction condition.

In April 2023, the average MSL shoreline position at North Beach was 2 ft wider than the May 2020 Pre-Construction condition. Middle and South Beaches retreated beyond the Pre-Construction condition over the same period (an average loss of 19 and 21 ft, respectively). Like the profile changes, these findings indicate that the shoreline within the study area has retreated to, or eroded beyond, the Pre-Construction condition.

We have sincerely appreciated the opportunity to assist Poseidon Water. Please feel free to reach out to me personally if we can clarify any questions that may arise.

Sincerely,
Coastal Frontiers Corporation

Lee Dodds
Coastal Scientist II

Enclosures: Appendix A – Beach Profile Plots
Appendix B – MSL Shoreline Positions
Appendix C – Site Photos
Digital Data Deliverables

## REFERENCES

Coastal Frontiers, 2022, "SANDAG 2021 Regional Beach Monitoring Program Annual Report", Moorpark, CA, 114 pp. + Appendices.

Coastal Frontiers, 2021, "Agua Hedionda Outer Lagoon 2020-2021 Dredge Cycle Beach Profile and Outer Lagoon Surveys", Moorpark, CA, 9 pp. + Appendices.

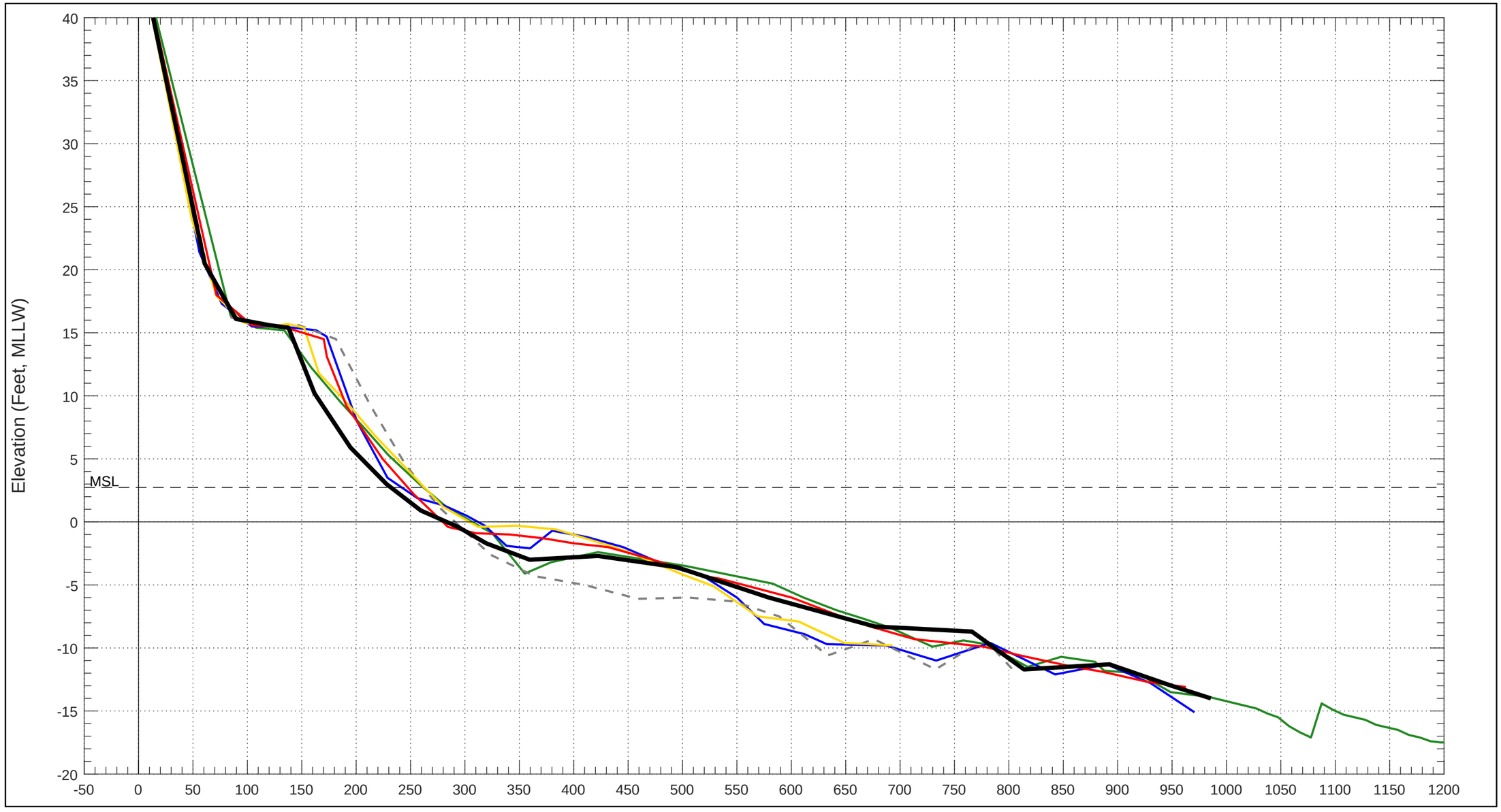
Coastal Frontiers, 2018, "Encina Power Station Outer Lagoon 2018 Dredge Cycle Pre- and Post-Condition Beach Profile and Outer Lagoon Surveys", Moorpark, CA, 8 pp. + Appendices.

Coastal Frontiers, 2013, "SANDAG 2013 Regional Beach Monitoring Program Annual Report", Moorpark, CA, 136 pp. + Appendices.

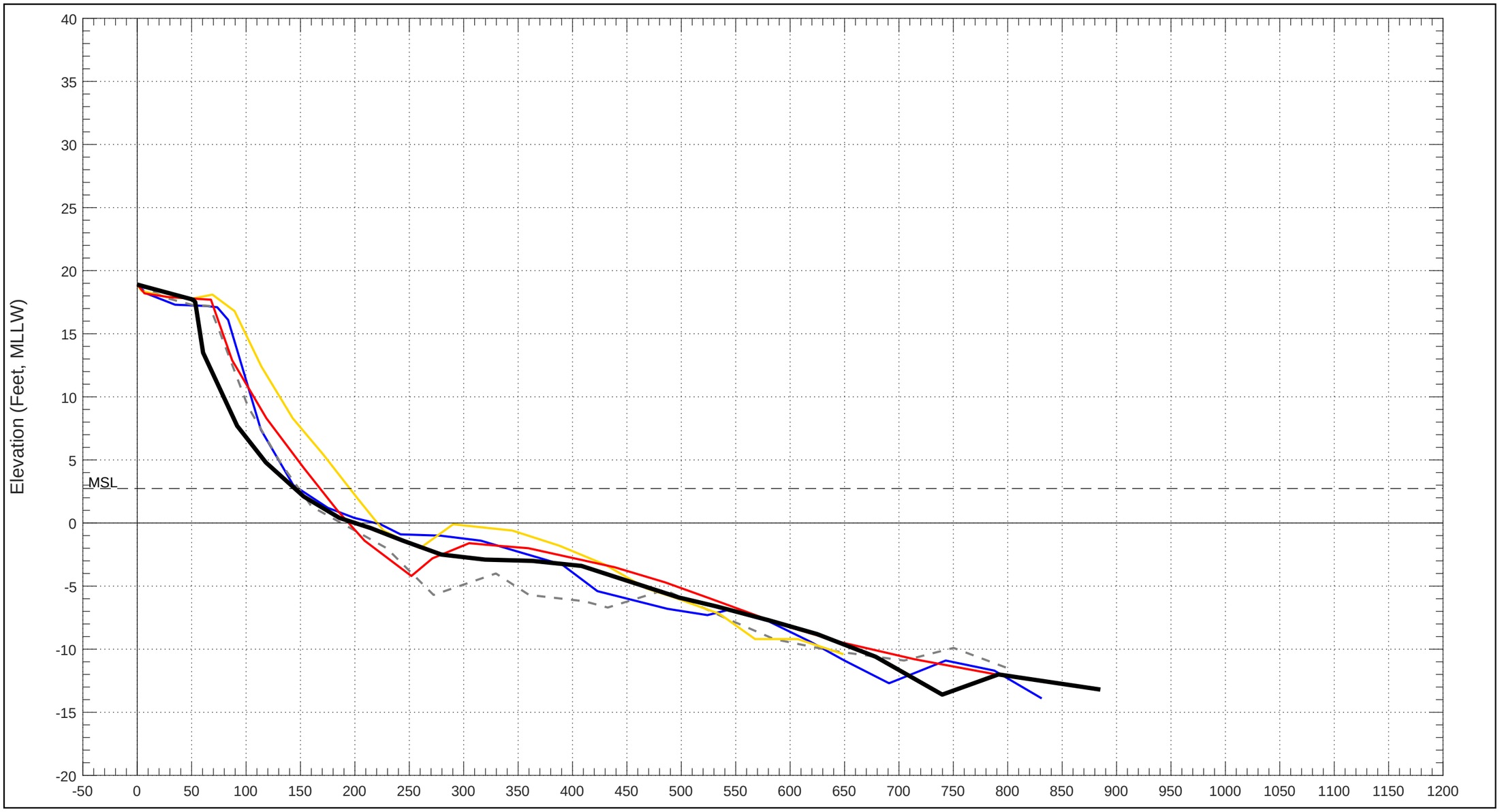
Henika, S., 2015, personal communication, Outer Agua Hedionda Dredge 2014/2015 Spoils Summary, NRG Encina Power Station, Carlsbad, CA.

# Appendix A
# Beach Profile Plots

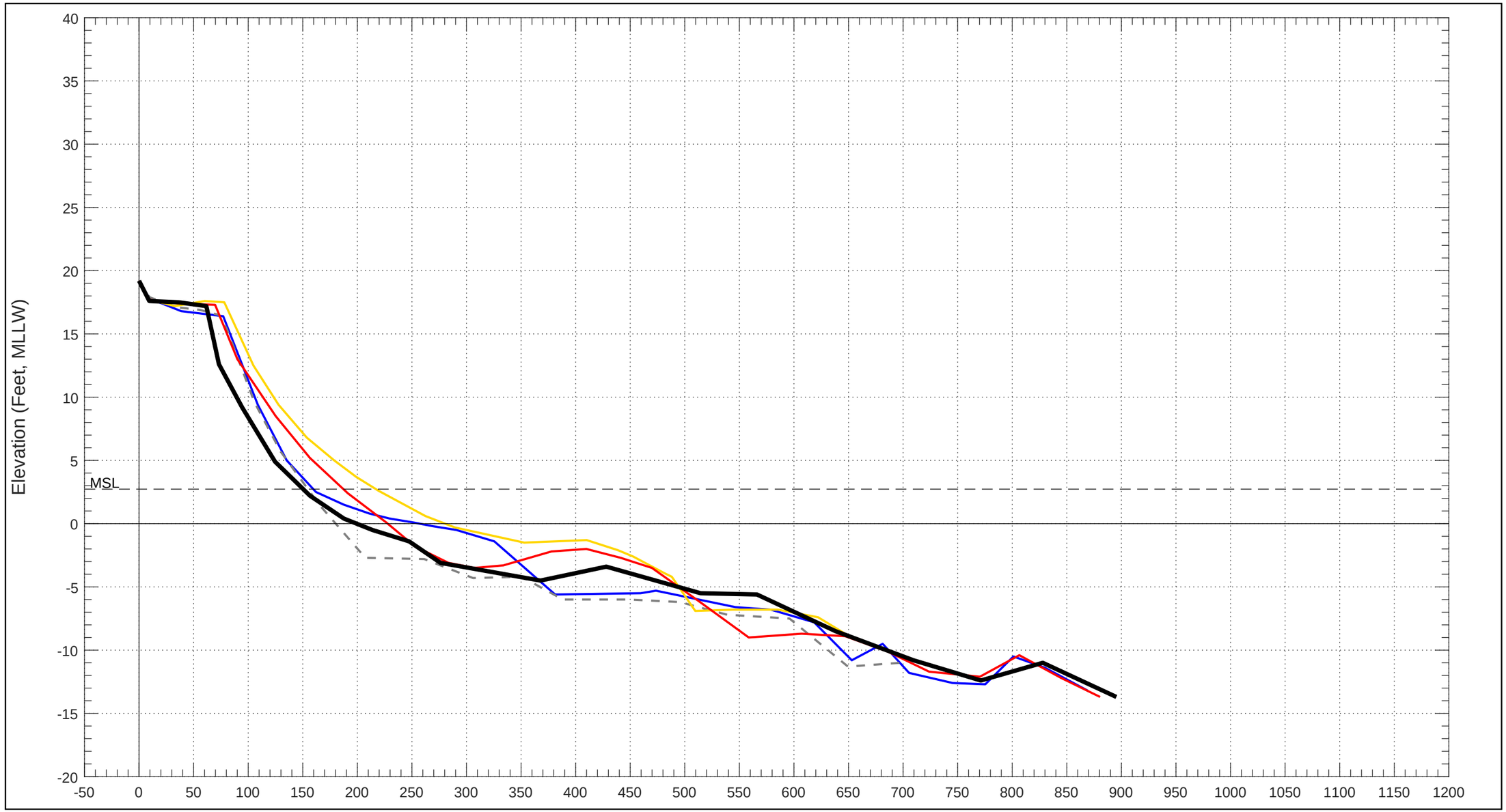
Transect  Cab I-12, Nearshore

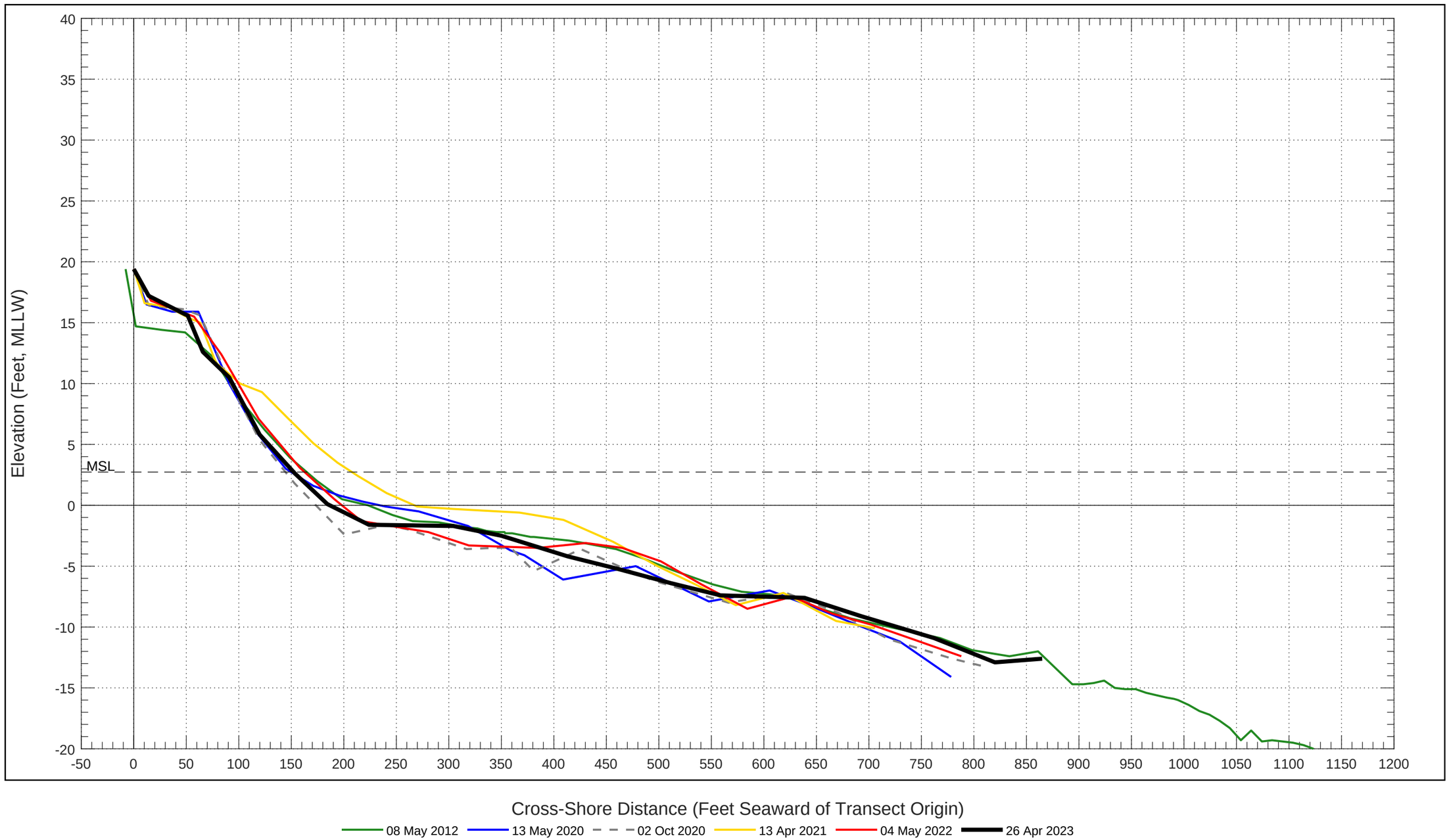


Transect  Cab I-11, Nearshore

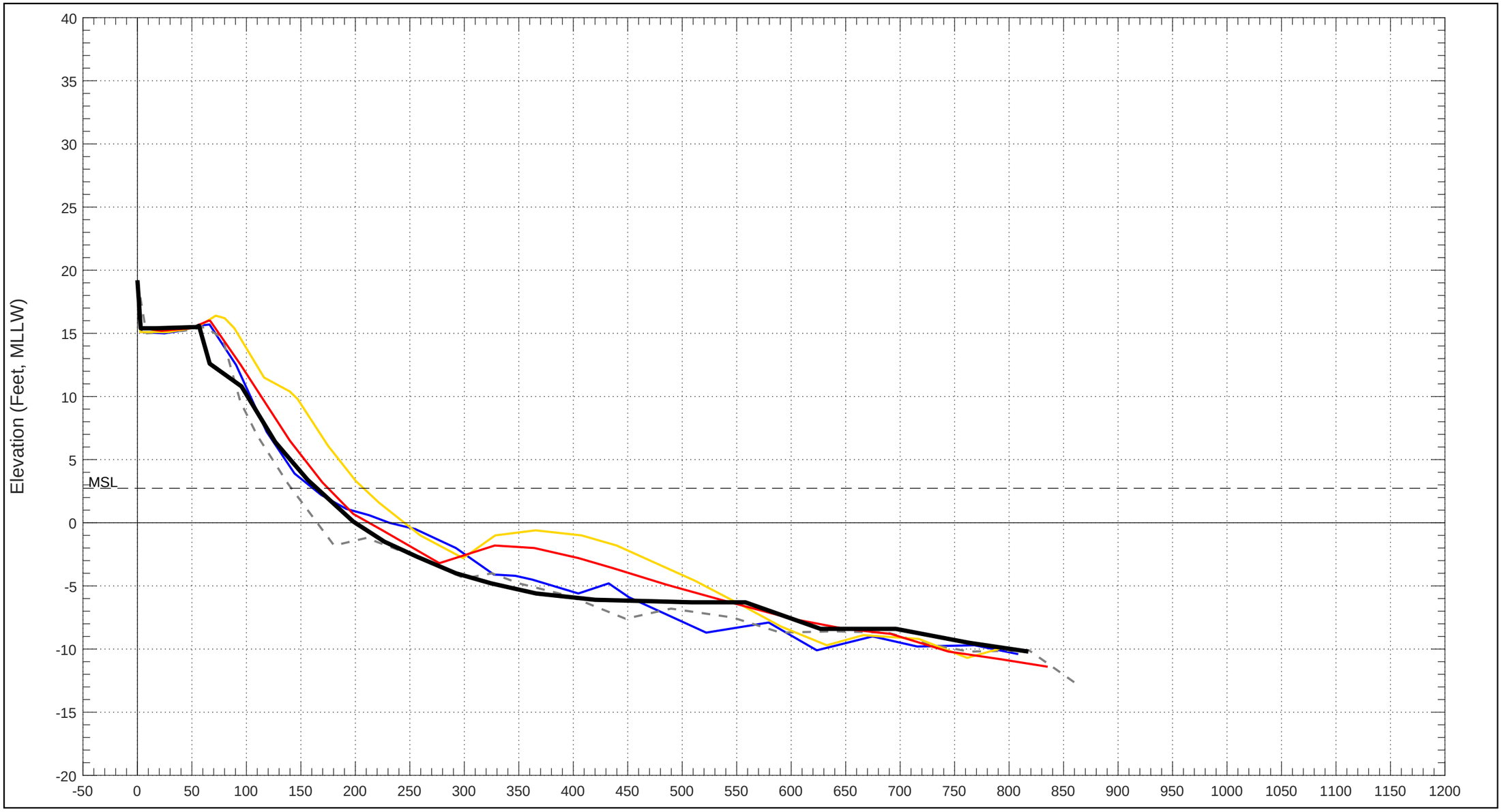


Transect  Cab I-10, Nearshore

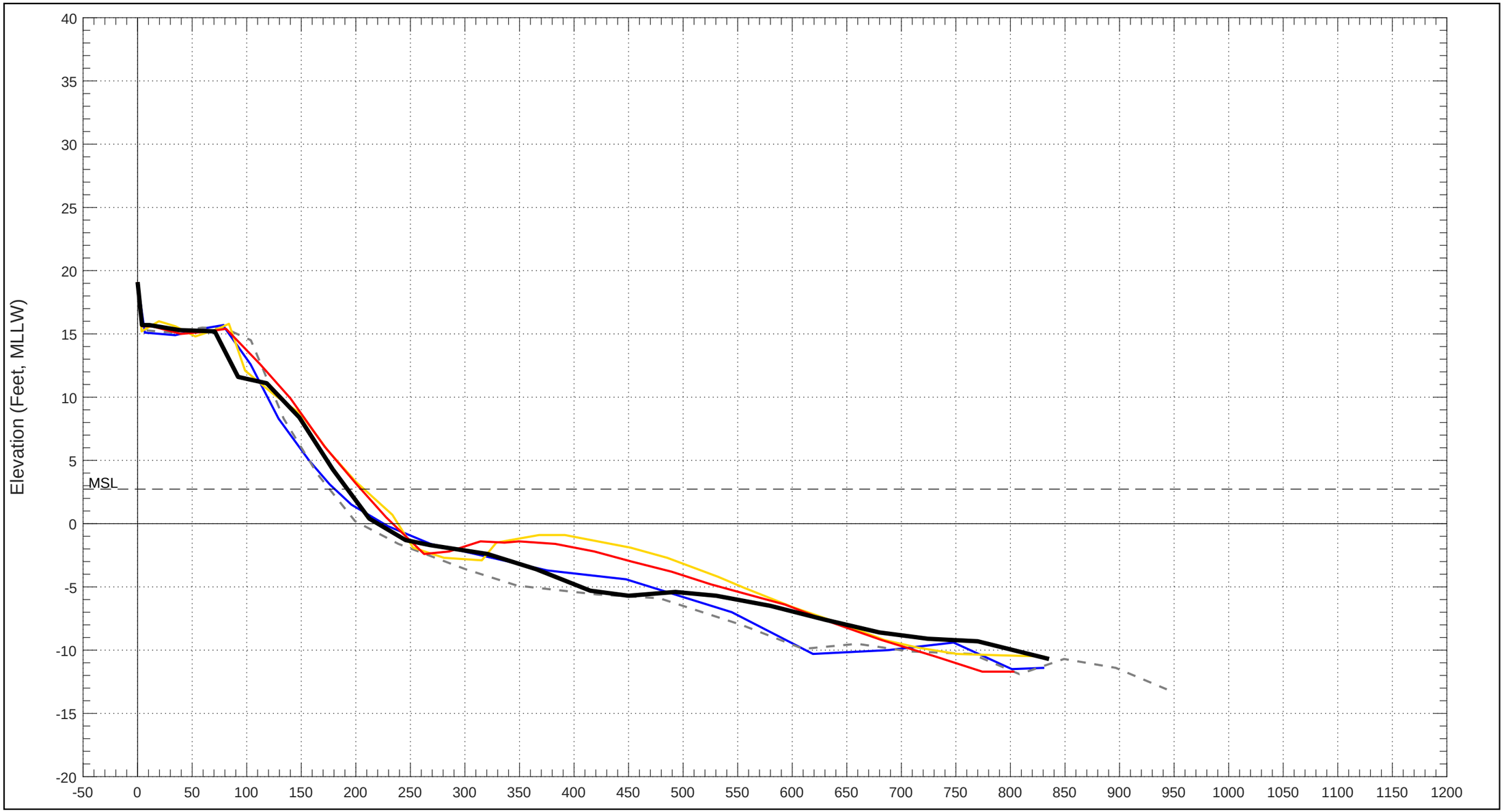



Transect Cab I-09, Nearshore
Elevation (Feet, MLLW)
MSL
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
Cross-Shore Distance (Feet Seaward of Transect Origin)
08 May 2012
13 May 2020
02 Oct 2020
13 Apr 2021
04 May 2022
26 Apr 2023

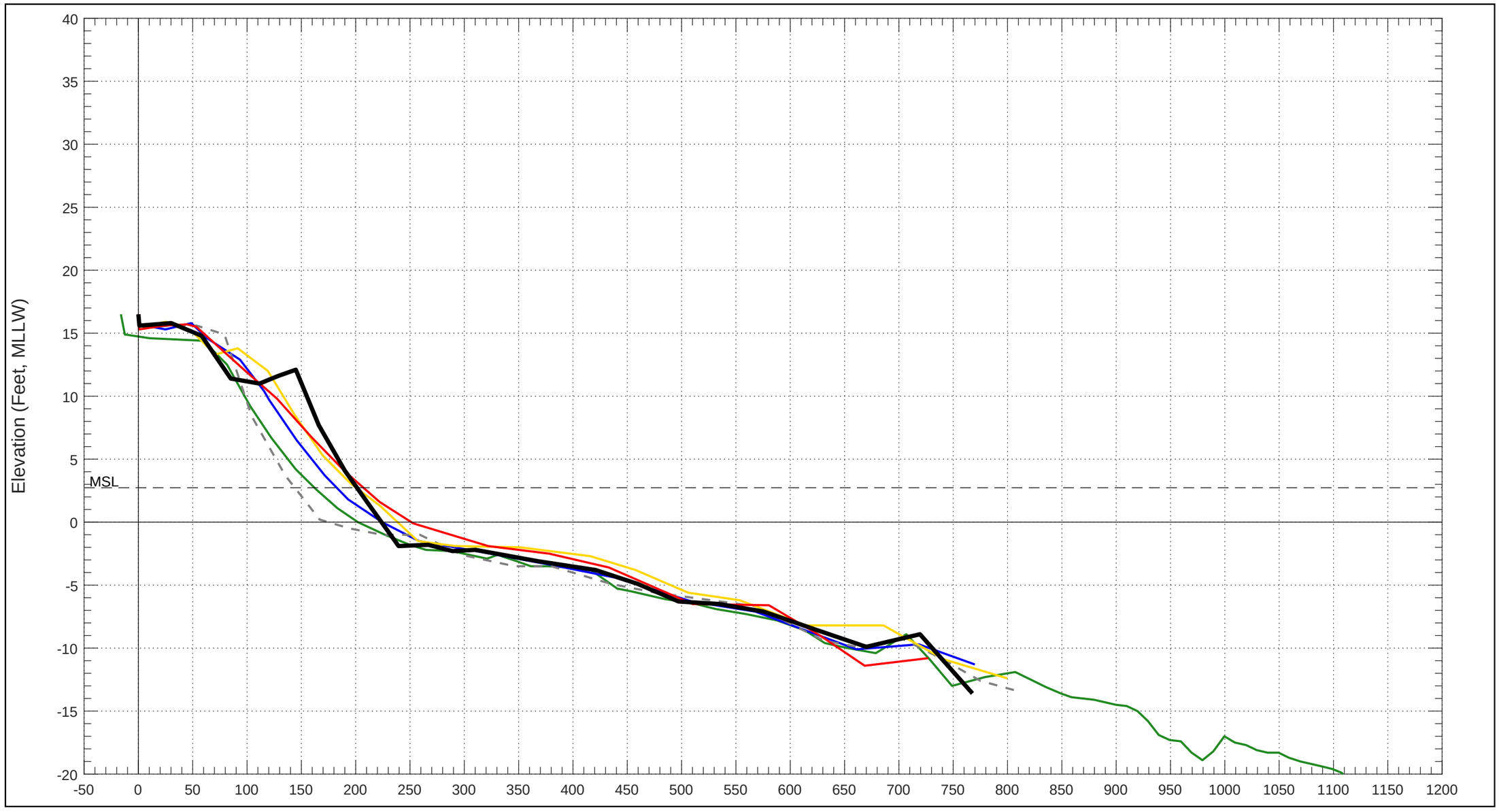
Transect  Cab I-08, Nearshore



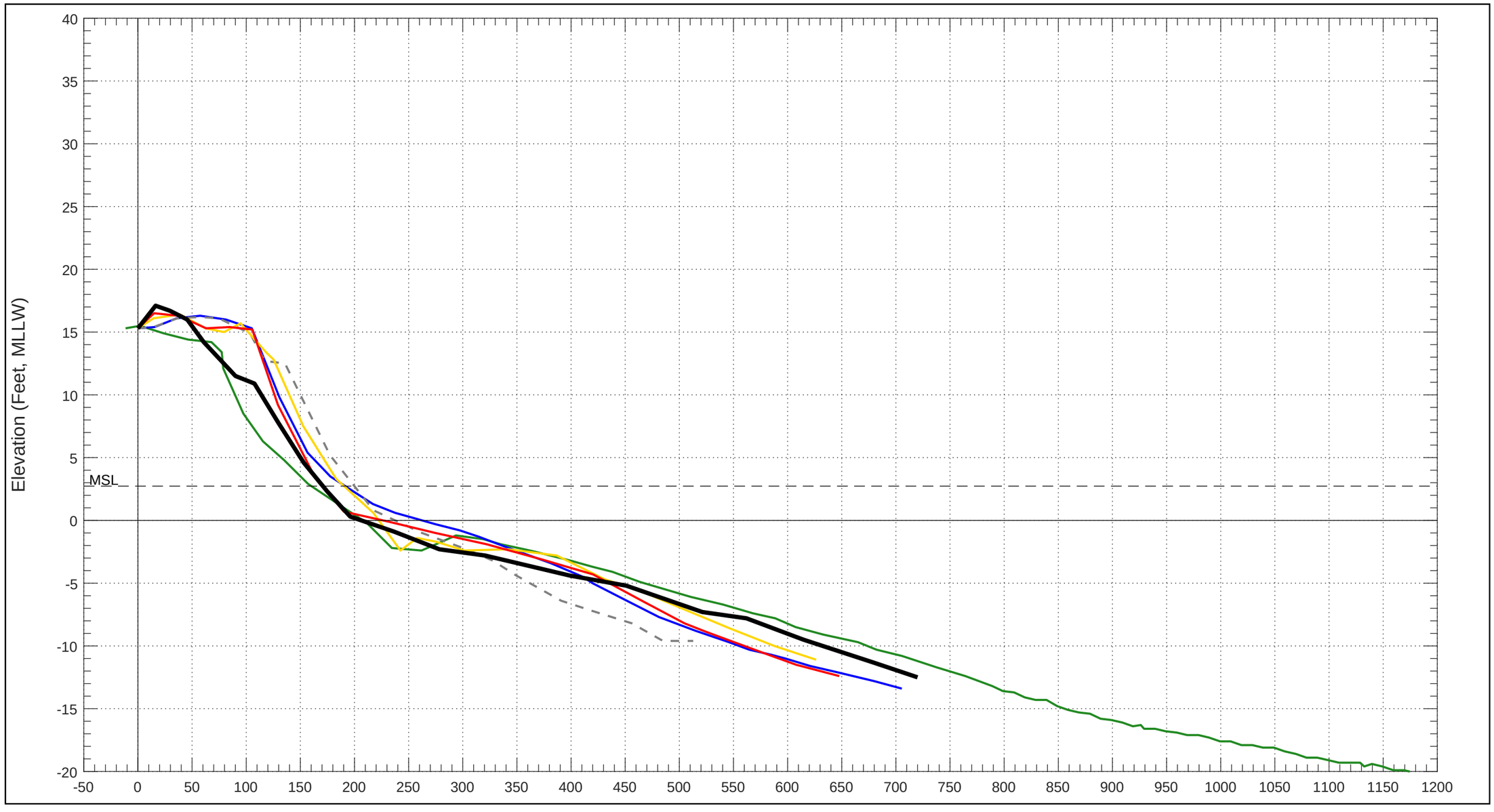
Transect  Cab I-07.5, Nearshore



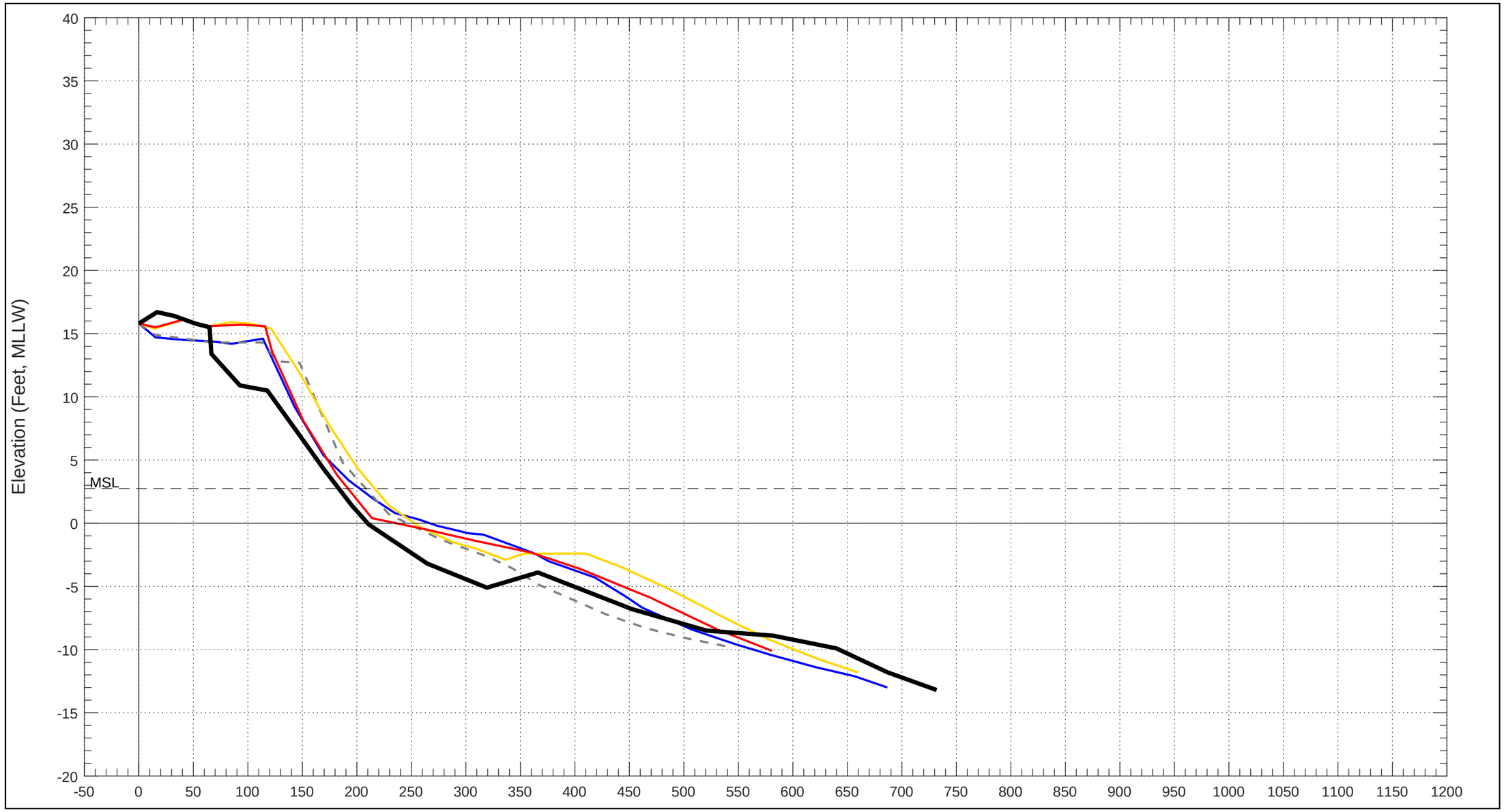
Transect  Cab I-07, Nearshore



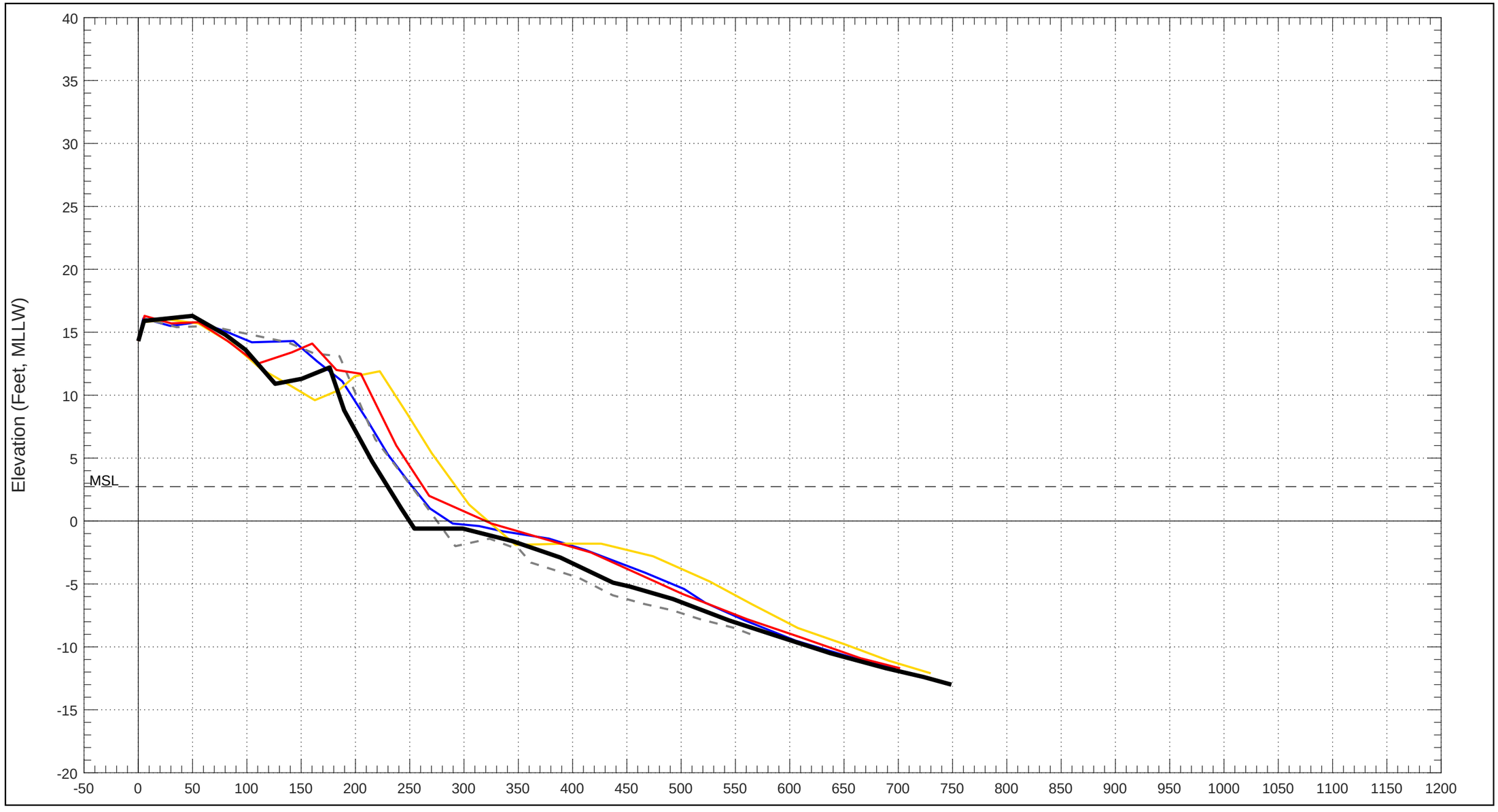
Transect  Cab I-06, Nearshore



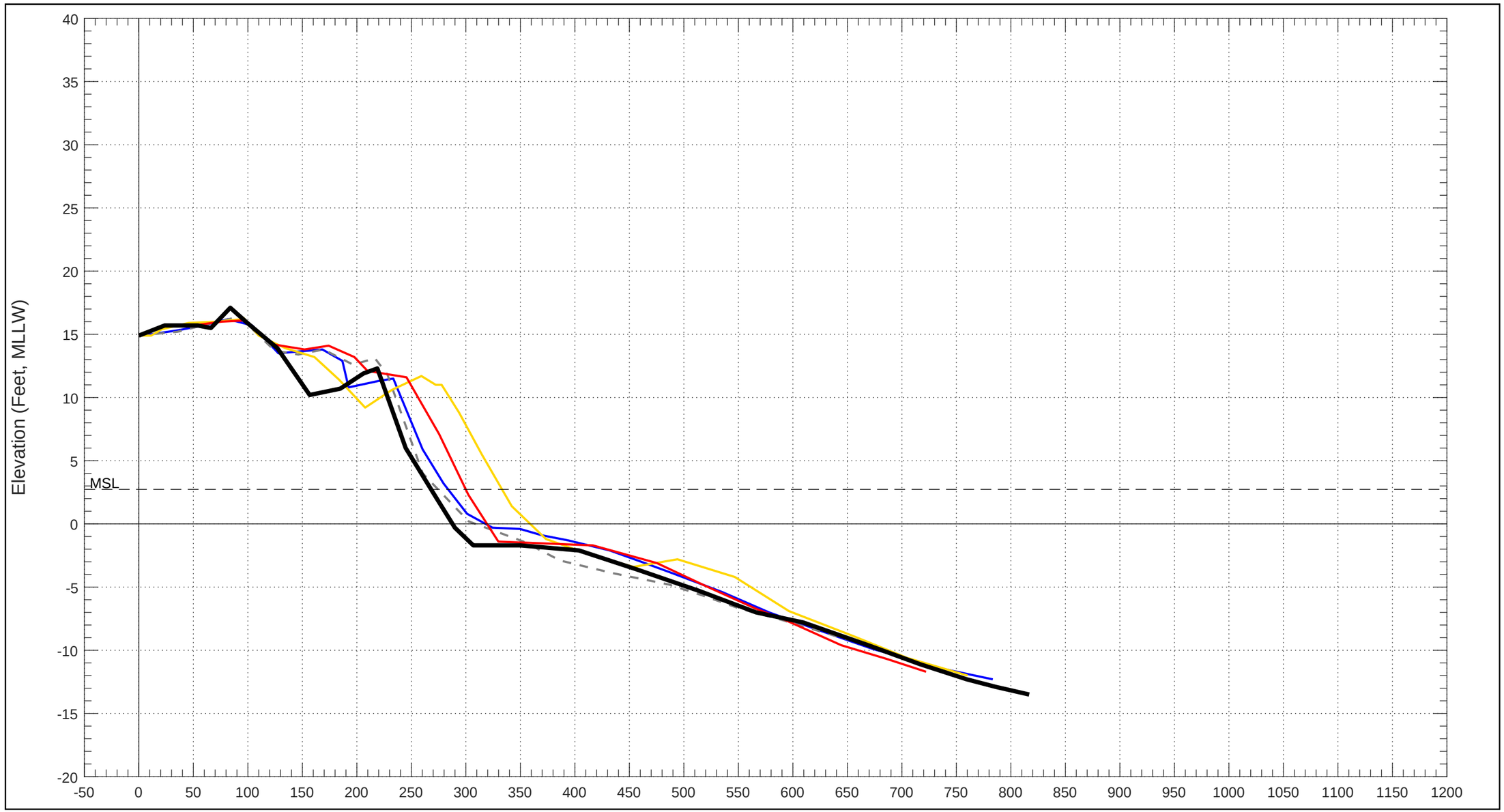
Transect  Cab I-05, Nearshore



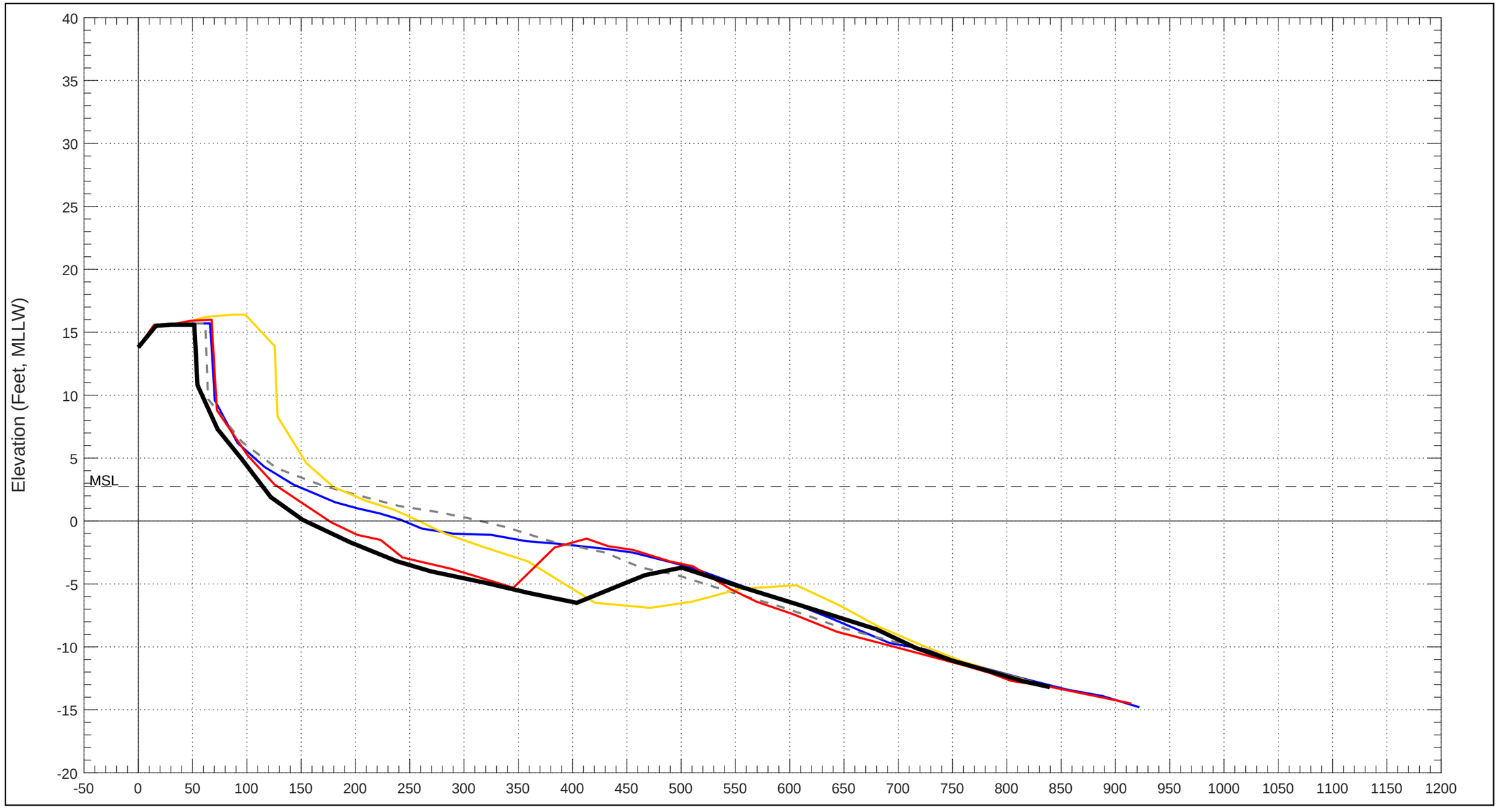
Transect  Cab I-04, Nearshore



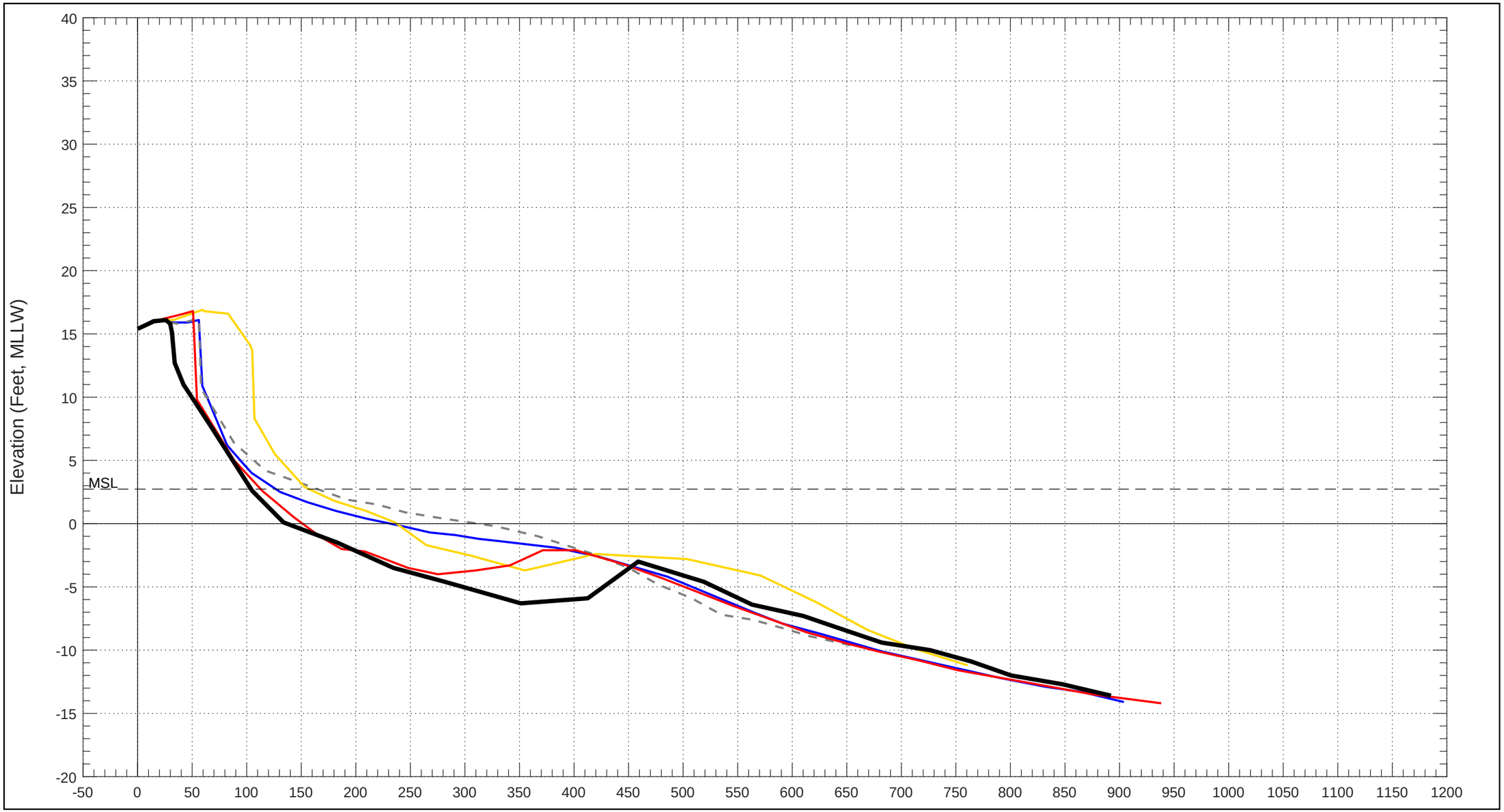
Transect  Cab I-03.6, Nearshore



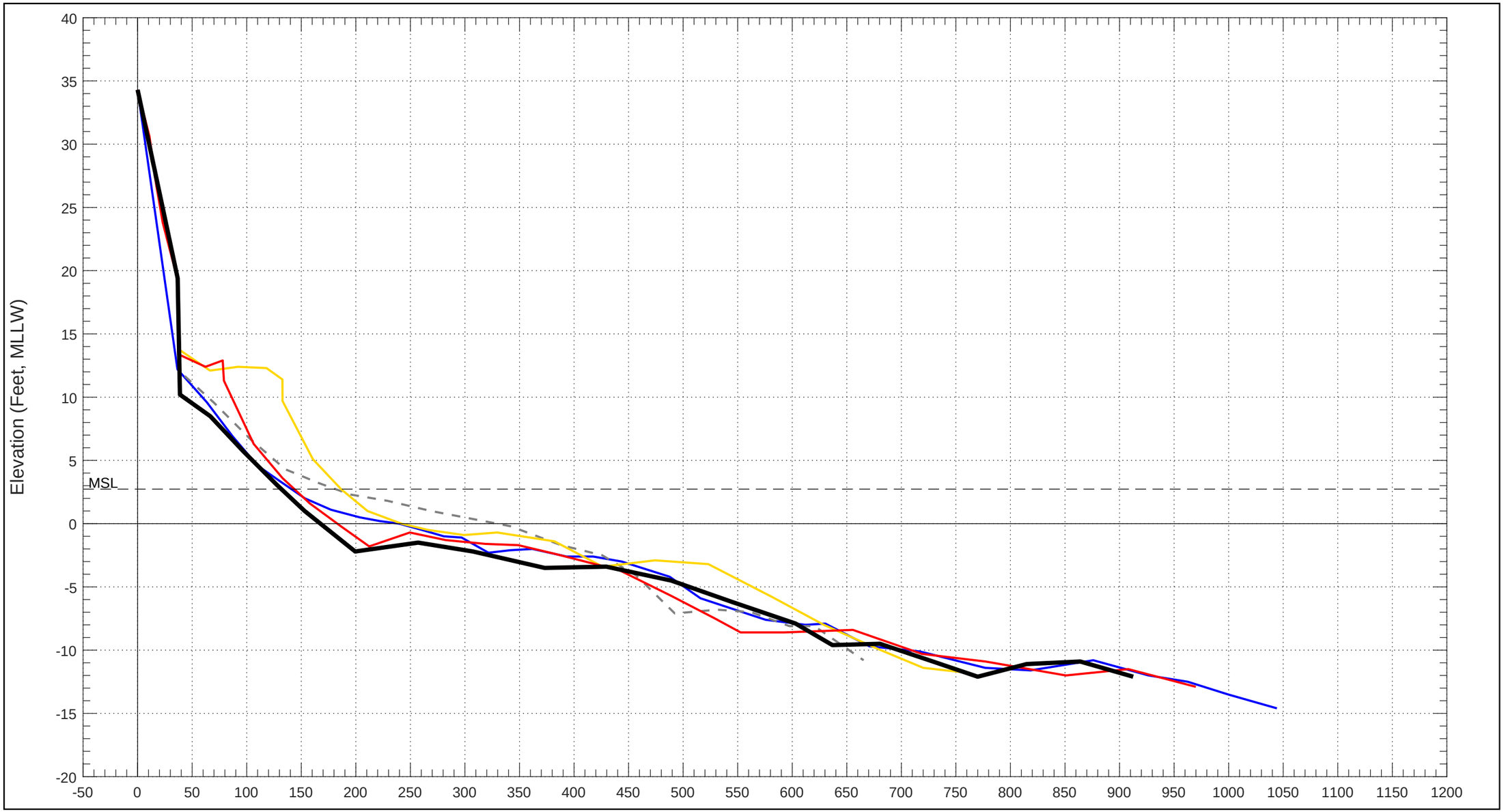
Transect  Cab I-03.2, Nearshore



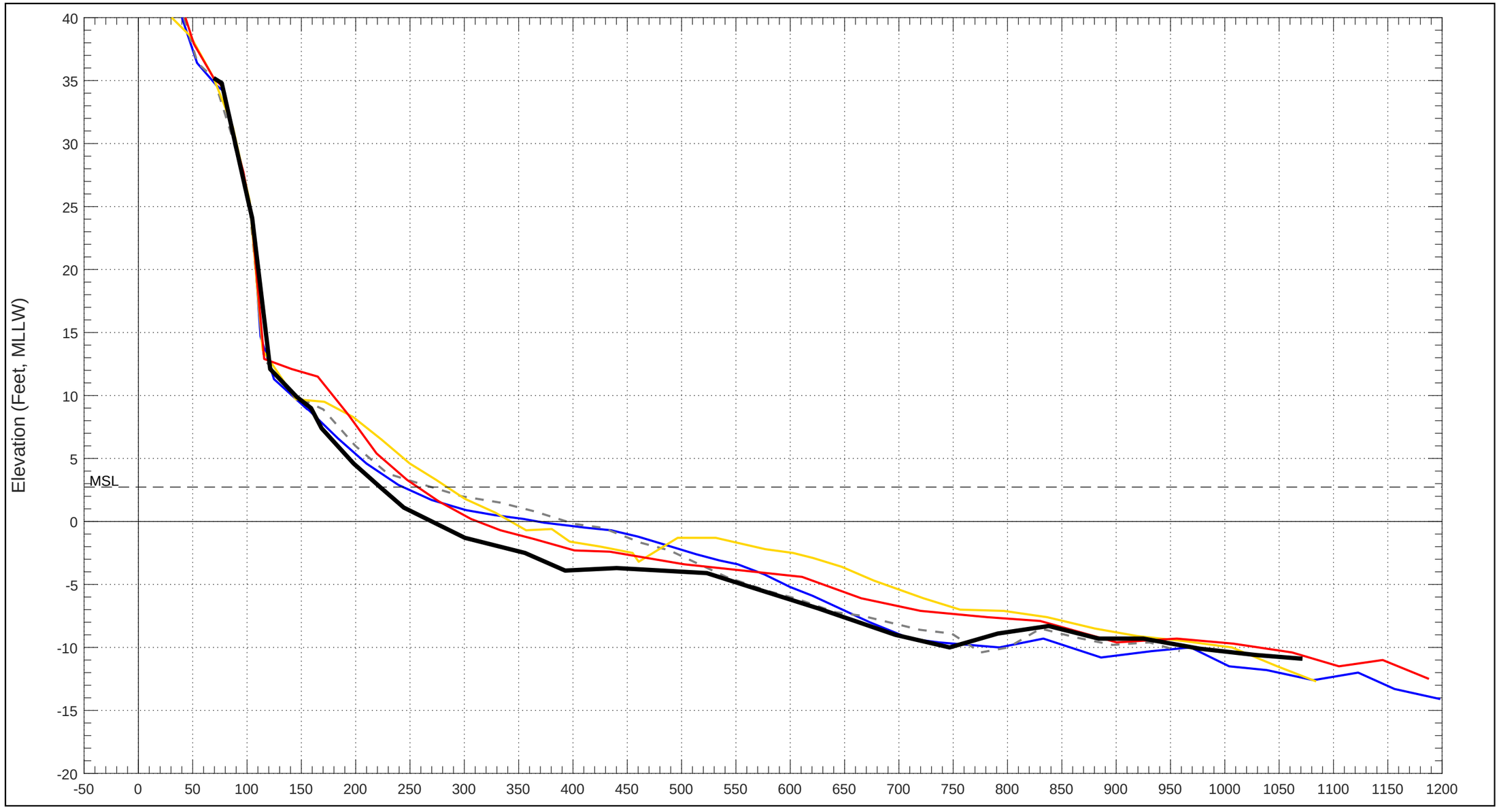
Transect  Cab I-03, Nearshore



Transect  Cab I-02, Nearshore



Transect  Cab I-01, Nearshore



# Appendix B
# Mean Sea Level Shoreline Positions

**Table B1 - MSL Shoreline Positions**

| Sub-Reach | Transect | MSL Shoreline Position (ft) | | | | |
|---|---|---|---|---|---|---|
| | | Two-Year Post-Construction (April 25-26, 2023) | One-Year Post-Construction (May 4-5, 2022) | Post-Construction (Apr 13, 2021) | Pre-Construction (Oct 2, 2020) | Pre-Construction (May 12-13, 2020) |
| | | Spring 2023 | Spring 2022 | Spring 2021 | Fall 2020 | Spring 2020 |
| North Beach | **Cab I-12** (CB-0850) | 232 | 247 | 263 | 262 | 242 |
| | **Cab I-11** | 145 | 168 | 195 | 148 | 148 |
| | **Cab I-10** | 150 | 187 | 217 | 155 | 160 |
| | **Cab I-09** (CB-0840) | 152 | 163 | 208 | 144 | 150 |
| | **Cab I-08** | 165 | 175 | 208 | 141 | 161 |
| | **Cab I-07.5** | 192 | 205 | 208 | 176 | 181 |
| | **Cab I-07** (CB-0830) | 201 | 207 | 200 | 144 | 183 |
| Middle Beach | **Cab I-06** (CB-0820) | 171 | 171 | 190 | 200 | 191 |
| | **Cab I-05** | 184 | 192 | 217 | 208 | 203 |
| | **Cab I-04** | 230 | 262 | 293 | 252 | 252 |
| | **Cab I-03.6** | 268 | 300 | 333 | 274 | 284 |
| South Beach | **Cab I-03.2** | 115 | 128 | 179 | 173 | 147 |
| | **Cab I-03** | 104 | 113 | 157 | 165 | 127 |
| | **Cab I-02** | 132 | 144 | 186 | 181 | 141 |
| | **Cab I-01** | 223 | 257 | 284 | 270 | 244 |

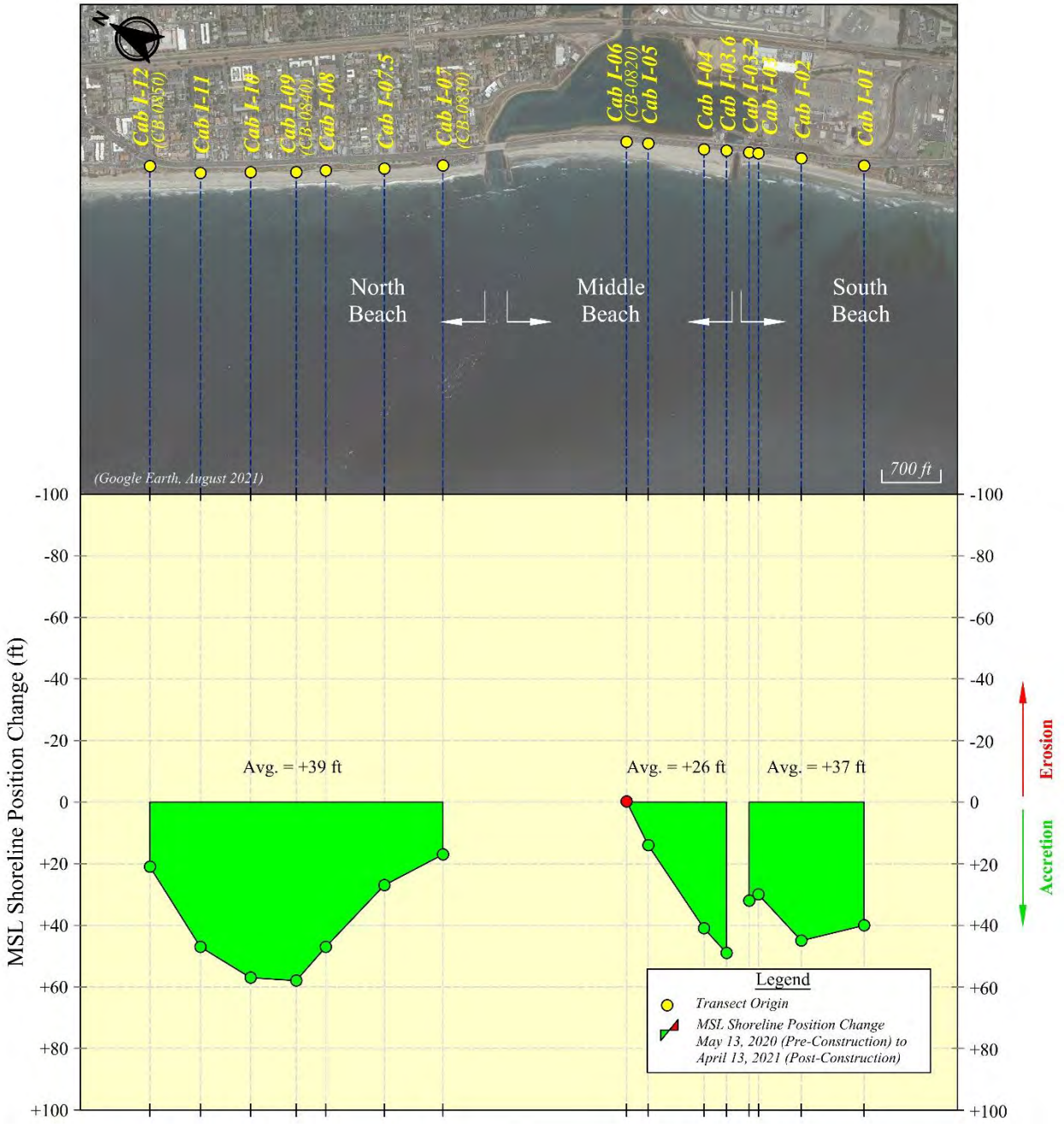



**Figure B2 - MSL Shoreline Position Change**
**Pre-Construction to Post-Construction**

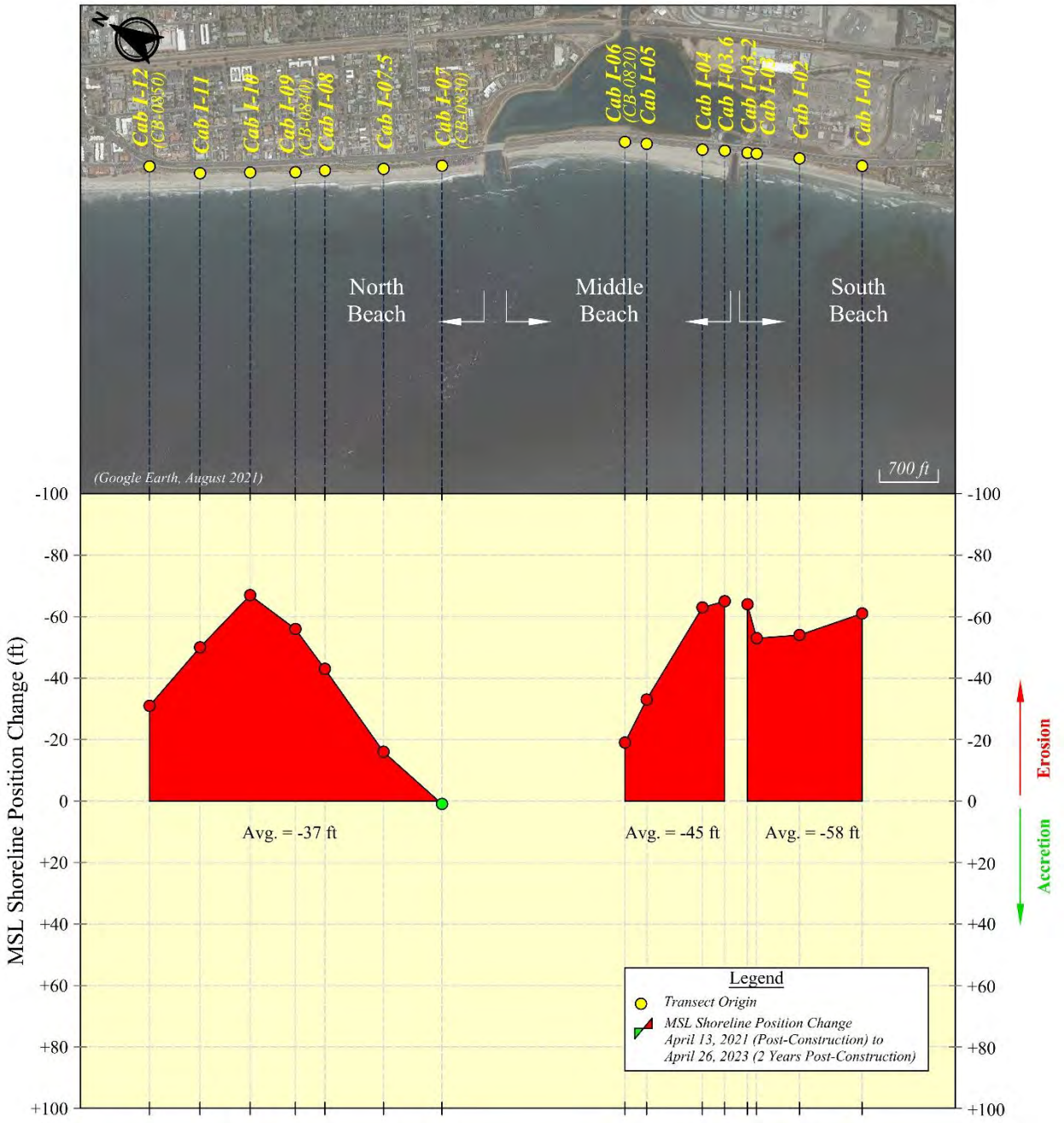



**Figure B3 - MSL Shoreline Position Change**
**Post-Construction to Two Years Post-Construction**

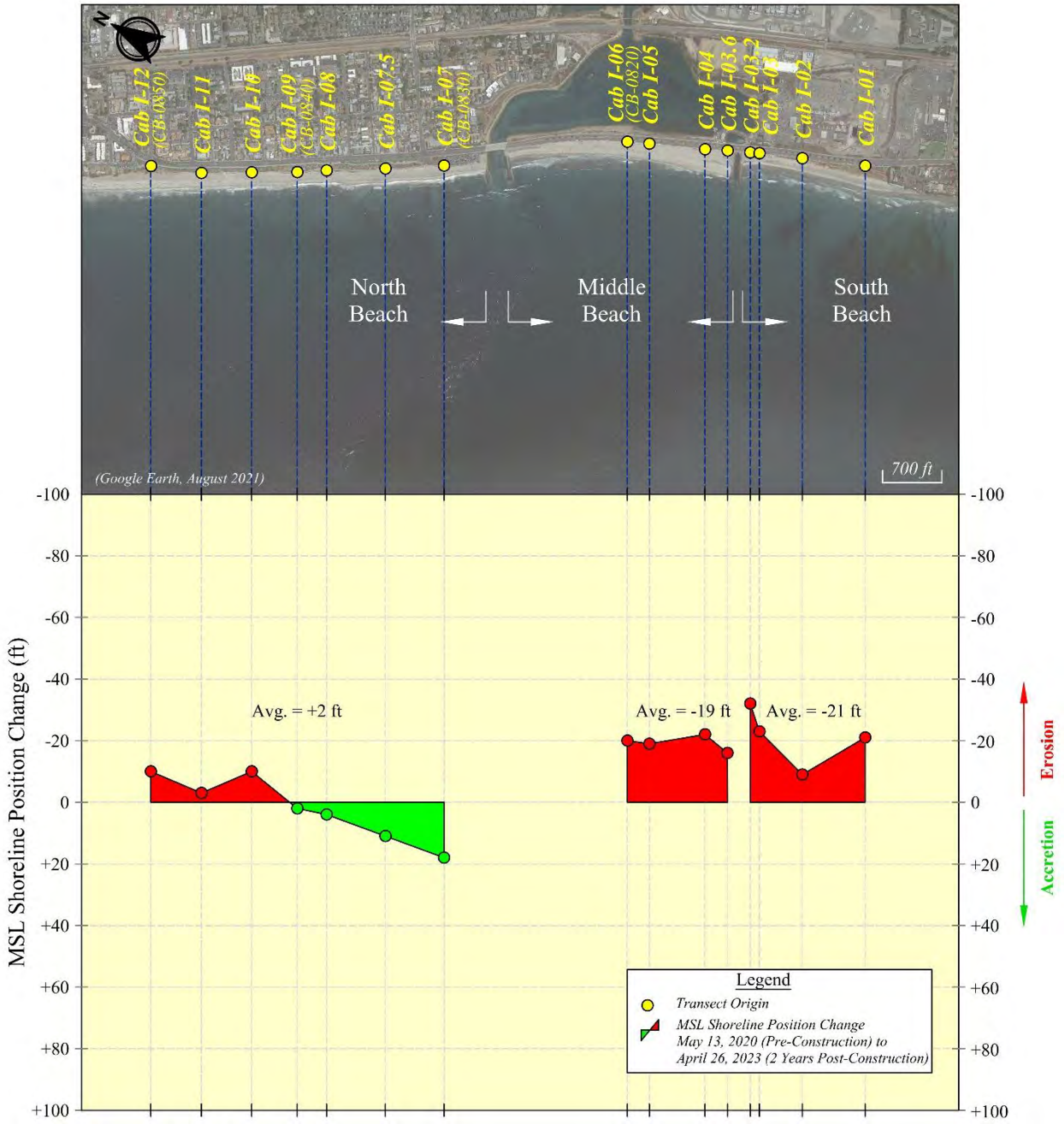



**Figure B4 - MSL Shoreline Position Change**
**Pre-Construction to Two Years Post-Construction**

# Appendix C
# Site Photos

**Photos**

**N. Carlsbad 1 (looking south from north end of seawall) – April 25, 2023**

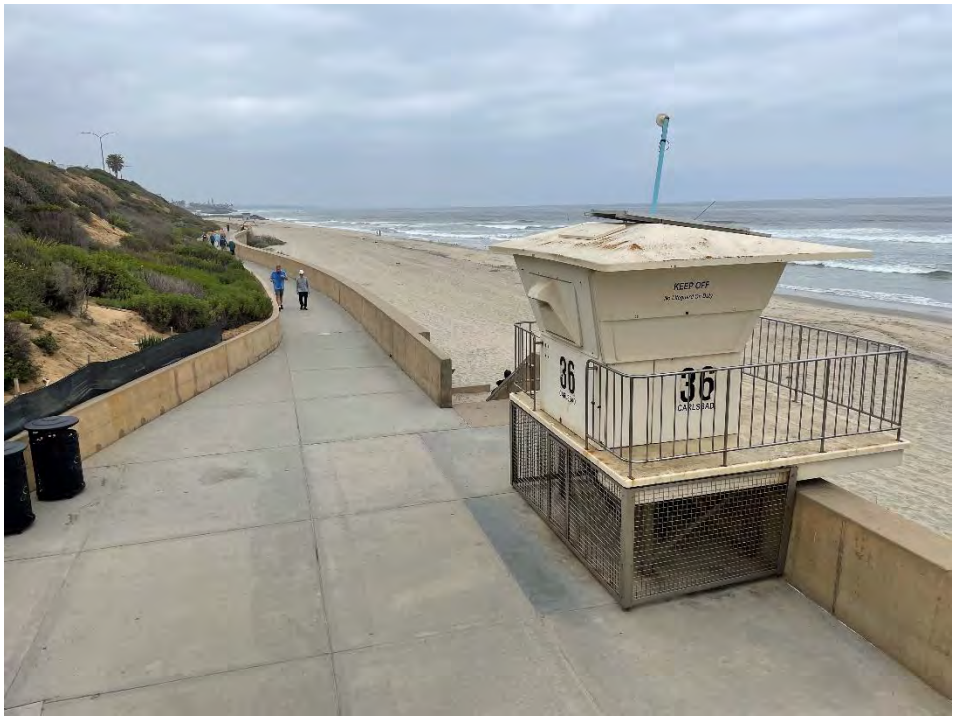
**N. Carlsbad 2 (looking north from vicinity of Tower 36) – April 25, 2023**

**Photos (continued)**

**N. Carlsbad 3 (looking south from vicinity of Tower 36) – April 25, 2023**

**N. Carlsbad 4 (looking north from vicinity of Tower 36 stairway) – April 25, 2023**

**Photos (continued)**




**N. Carlsbad 5 (looking south from vicinity of Tower 36 stairway) – April 25, 2023**

**N. Carlsbad 6 (looking north from Agua Hedionda Inlet North Jetty) – April 25, 2023**

**Photos (continued)**

**Middle Beach 1 (looking south from Agua Hedionda Inlet South Jetty) – April 25, 2023**

**Middle Beach 2 (looking north from Agua Hedionda Outlet North Jetty) – April 25, 2023**

**Photos (continued)**

**S. Carlsbad 1 (looking south from Agua Hedionda Outlet South Jetty) – April 25, 2023**

**S. Carlsbad 2 (looking south from prior location of groin) – April 25, 2023**

# APPENDIX C

## Agua Hedionda Outer Lagoon 2024–2025 Dredge Cycle
## Proposed Dredge Design Figures

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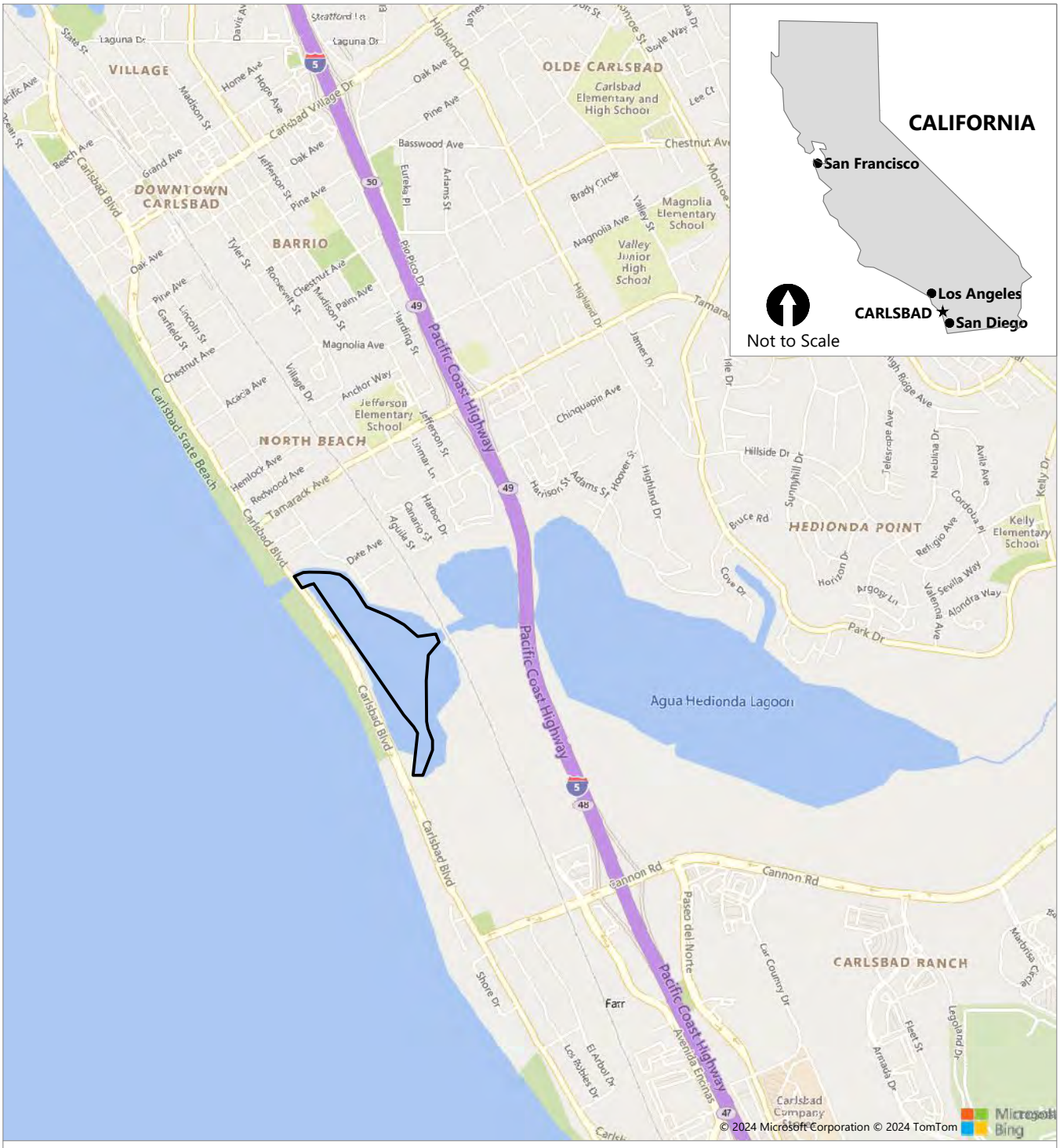


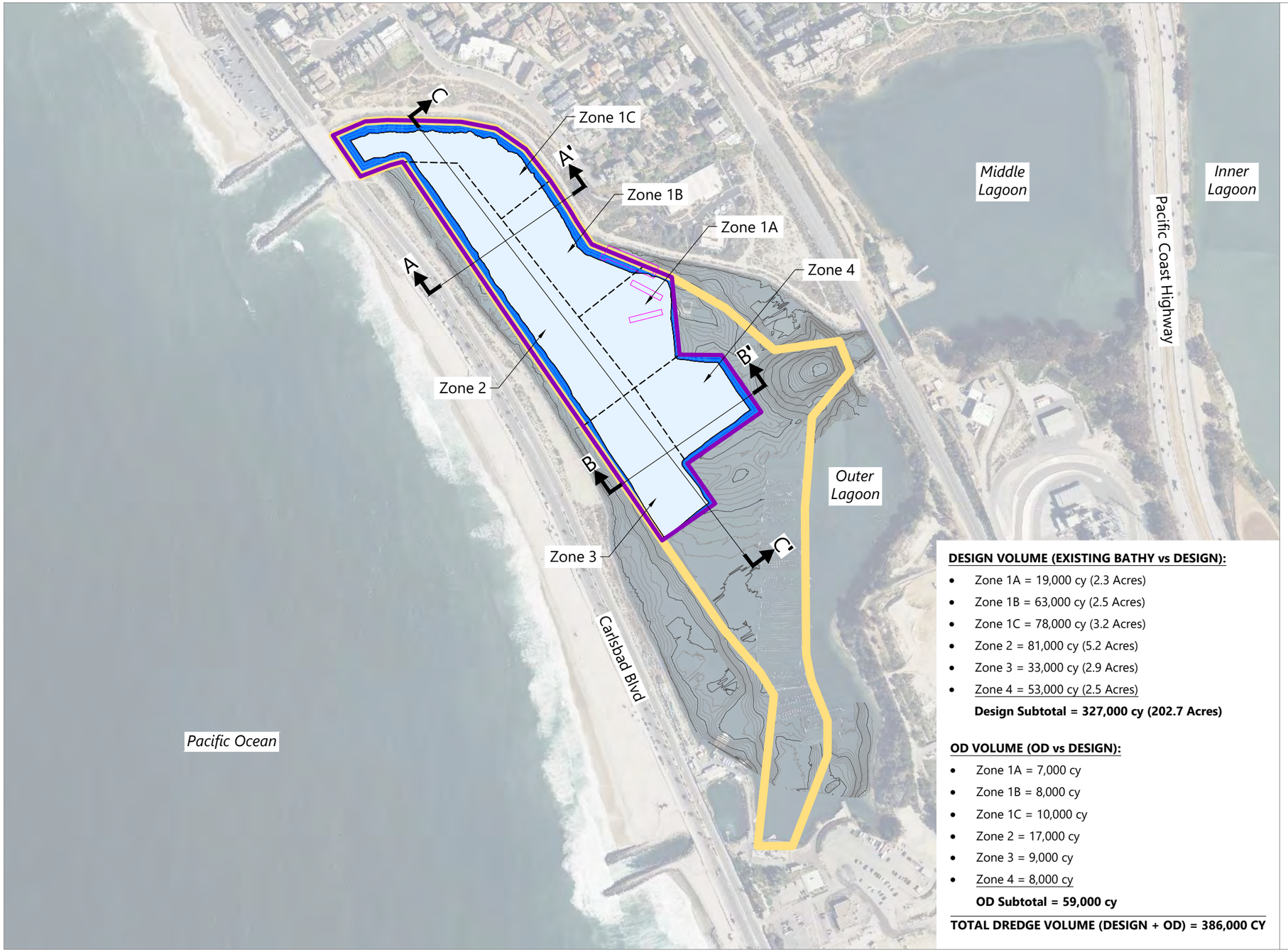

**SOURCE:** ©2024 Microsoft Corporation ©2024 Maxar ©CNES (2024) Distribution Airbus DS
**HORIZONTAL DATUM:** California State Plane, Zone VI, NAD83, U.S. Survey Feet

Publish Date: 2024/04/04 9:42 AM | User: jbigsby
Filepath: K:\Projects\0648-Poseidon\Agua Hedionda Lagoon Maintenance Dredging\0648-RP-001 (Vicinity Map).dwg Figure 1

ANCHOR QEA

**Figure 1**
**Vicinity Map**

Preliminary Dredge Design
Agua Hedionda Lagoon Maintenance Dredging




**LEGEND:**

- Existing Contours (1' & 5' Intervals)
- Proposed Contours (1' & 5' Intervals)
- Proposed Dredge Extents
- Zone Boundary
- Previously Permitted Dredge Limits
- Dredge Obstacle

**DESIGN VOLUME (EXISTING BATHY vs DESIGN):**

- Zone 1A = 19,000 cy (2.3 Acres)
- Zone 1B = 63,000 cy (2.5 Acres)
- Zone 1C = 78,000 cy (3.2 Acres)
- Zone 2 = 81,000 cy (5.2 Acres)
- Zone 3 = 33,000 cy (2.9 Acres)
- Zone 4 = 53,000 cy (2.5 Acres)

**Design Subtotal = 327,000 cy (202.7 Acres)**

**OD VOLUME (OD vs DESIGN):**

- Zone 1A = 7,000 cy
- Zone 1B = 8,000 cy
- Zone 1C = 10,000 cy
- Zone 2 = 17,000 cy
- Zone 3 = 9,000 cy
- Zone 4 = 8,000 cy

**OD Subtotal = 59,000 cy**

**TOTAL DREDGE VOLUME (DESIGN + OD) = 386,000 CY**

**NOTES:**

1. Existing bathymetry based on survey conducted January 12, 2024 by Coastal Frontiers Corp.
2. Preliminary dredge volumes assume a dredge depth elevation of -22 ft MLLW, with two feet of overdredge (OD) and 2 horizontal to 1 vertical (2H:1V) side slopes to existing grade.

0 400
Feet

**SOURCE:** Aerial ©2024 Microsoft Corporation ©2024 Maxar ©CNES (2024) Distribution Airbus DS
**HORIZONTAL DATUM:** California State Plane, Zone VI, NAD83, U.S. Survey Feet
**VERTICAL DATUM:** MLLW

Publish Date: 2024/04/04 9:43 AM | User: jbigsby
Filepath: K:\Projects\0648-Poseidon\Agua Hedionda Lagoon Maintenance Dredging\0648-RP-002 (Site Plan & Sections).dwg Figure 2

ANCHOR QEA

**Figure 2**
**Site Plan**

Preliminary Dredge Design
Agua Hedionda Lagoon Maintenance Dredging

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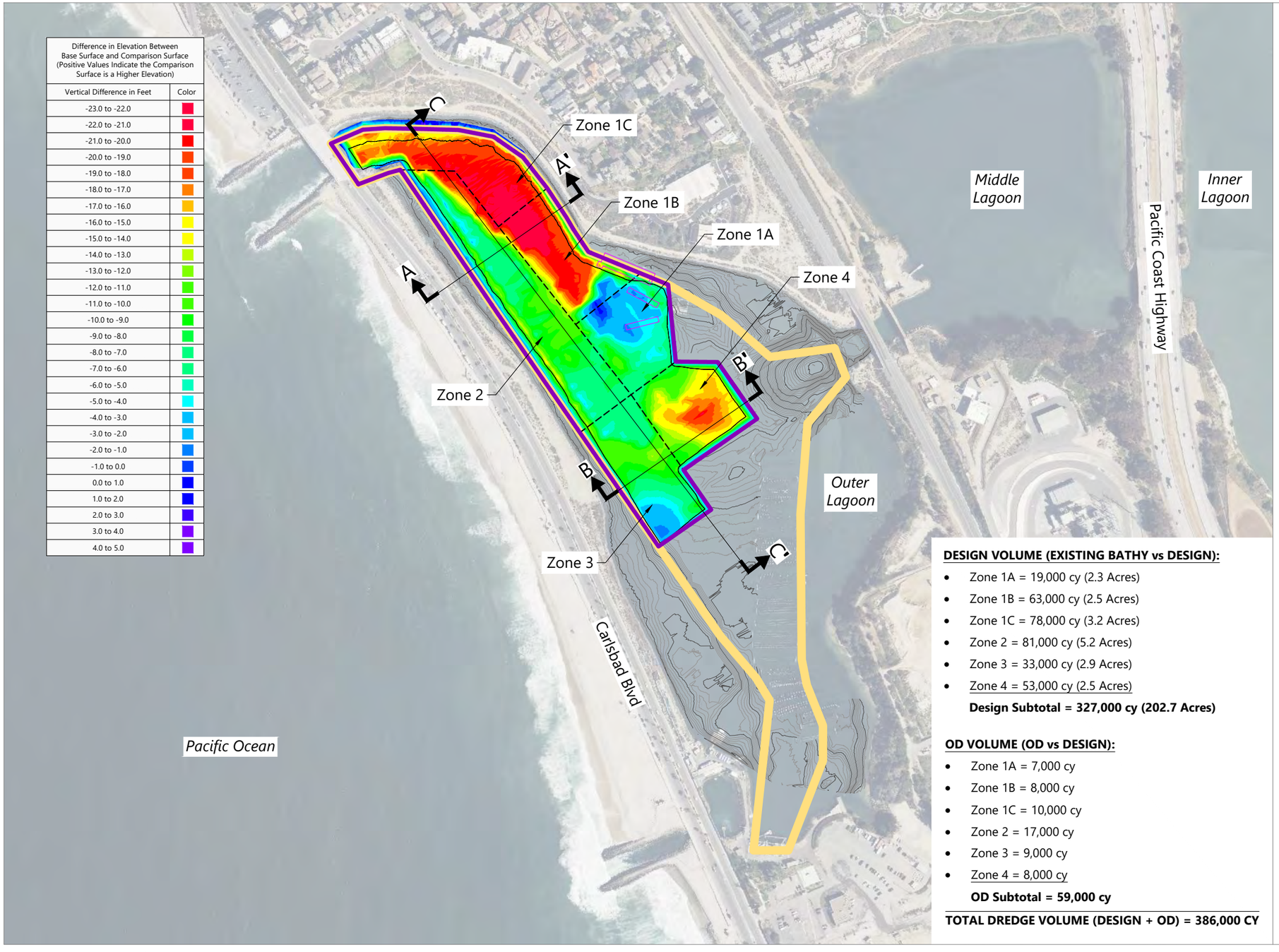
| Difference in Elevation Between Base Surface and Comparison Surface (Positive Values Indicate the Comparison Surface is a Higher Elevation) | |
|---|---|
| Vertical Difference in Feet | Color |
| -23.0 to -22.0 | |
| -22.0 to -21.0 | |
| -21.0 to -20.0 | |
| -20.0 to -19.0 | |
| -19.0 to -18.0 | |
| -18.0 to -17.0 | |
| -17.0 to -16.0 | |
| -16.0 to -15.0 | |
| -15.0 to -14.0 | |
| -14.0 to -13.0 | |
| -13.0 to -12.0 | |
| -12.0 to -11.0 | |
| -11.0 to -10.0 | |
| -10.0 to -9.0 | |
| -9.0 to -8.0 | |
| -8.0 to -7.0 | |
| -7.0 to -6.0 | |
| -6.0 to -5.0 | |
| -5.0 to -4.0 | |
| -4.0 to -3.0 | |
| -3.0 to -2.0 | |
| -2.0 to -1.0 | |
| -1.0 to 0.0 | |
| 0.0 to 1.0 | |
| 1.0 to 2.0 | |
| 2.0 to 3.0 | |
| 3.0 to 4.0 | |
| 4.0 to 5.0 | |




**LEGEND:**

- Existing Contours (1' & 5' Intervals)
- Proposed Dredge Extents
- Zone Boundary
- Previously Permitted Dredge Limits
- Dredge Obstacle

**DESIGN VOLUME (EXISTING BATHY vs DESIGN):**

- Zone 1A = 19,000 cy (2.3 Acres)
- Zone 1B = 63,000 cy (2.5 Acres)
- Zone 1C = 78,000 cy (3.2 Acres)
- Zone 2 = 81,000 cy (5.2 Acres)
- Zone 3 = 33,000 cy (2.9 Acres)
- Zone 4 = 53,000 cy (2.5 Acres)

**Design Subtotal = 327,000 cy (202.7 Acres)**

**OD VOLUME (OD vs DESIGN):**

- Zone 1A = 7,000 cy
- Zone 1B = 8,000 cy
- Zone 1C = 10,000 cy
- Zone 2 = 17,000 cy
- Zone 3 = 9,000 cy
- Zone 4 = 8,000 cy

**OD Subtotal = 59,000 cy**

**TOTAL DREDGE VOLUME (DESIGN + OD) = 386,000 CY**

**NOTES:**

1. Existing bathymetry based on survey conducted January 12, 2024 by Coastal Frontiers Corp.
2. Preliminary dredge volumes assume a dredge depth elevation of -22 ft MLLW, with two feet of overdredge (OD) and 2 horizontal to 1 vertical (2H:1V) side slopes to existing grade.

0 400
Feet

**SOURCE:** Aerial ©2024 Microsoft Corporation ©2024 Maxar ©CNES (2024) Distribution Airbus DS
**HORIZONTAL DATUM:** California State Plane, Zone VI, NAD83, U.S. Survey Feet
**VERTICAL DATUM:** MLLW

Publish Date: 2024/04/04 9:43 AM | User: jbigsby
Filepath: K:\Projects\0648-Poseidon\Agua Hedionda Lagoon Maintenance Dredging\0648-RP-002 (Site Plan & Sections).dwg Figure 3

ANCHOR QEA

**Figure 3**
**Isopach**

Preliminary Dredge Design
Agua Hedionda Lagoon Maintenance Dredging

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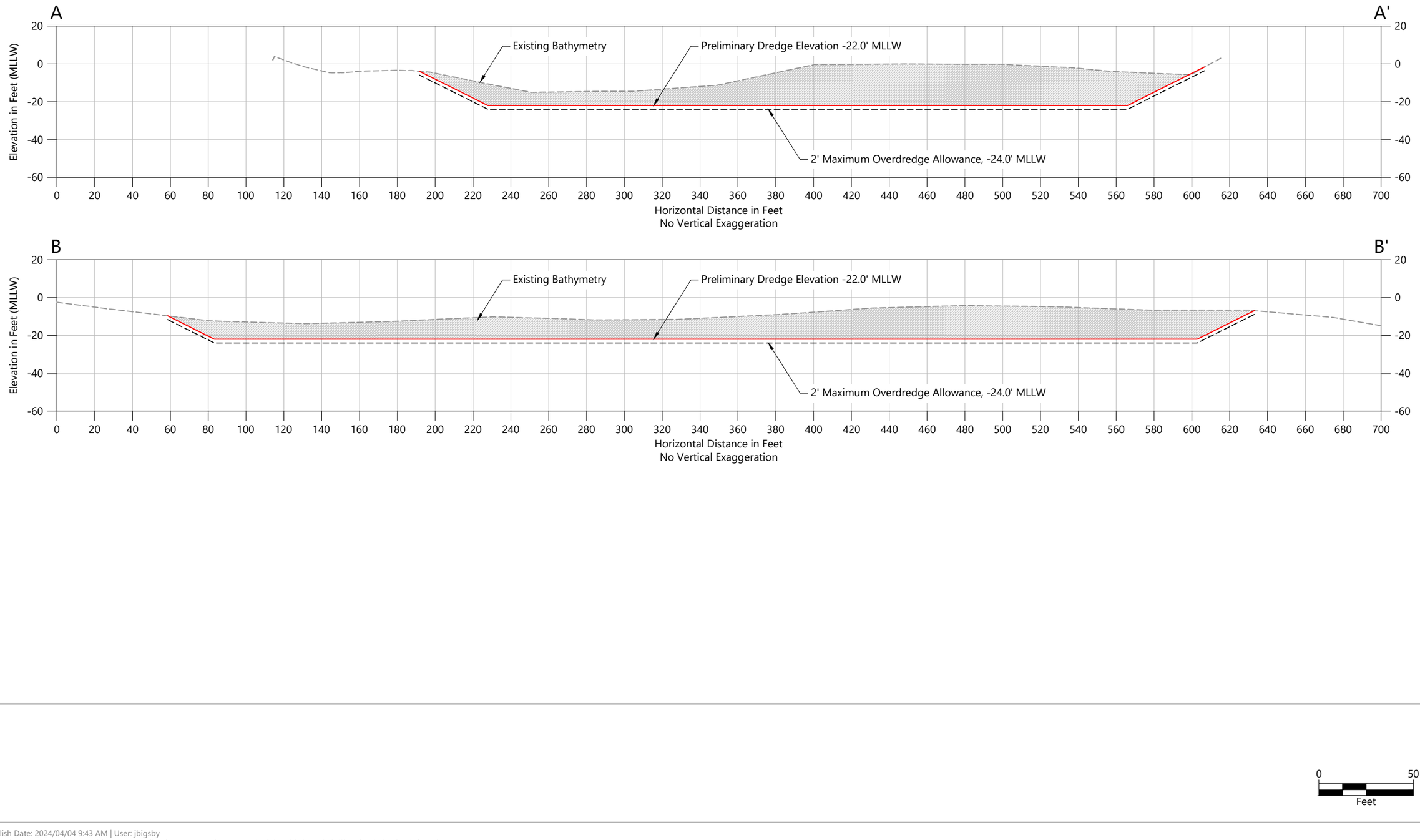


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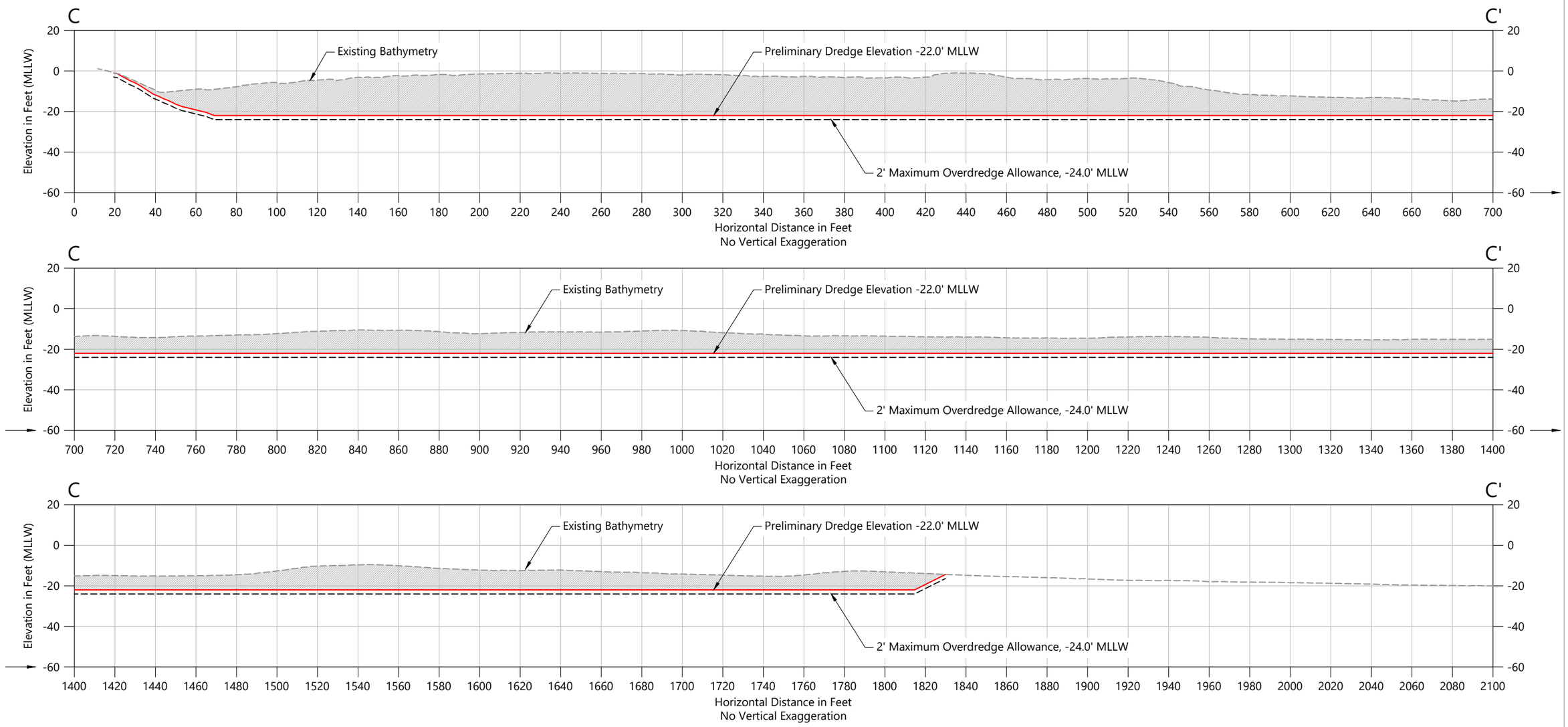
Filepath: K:\Projects\0648-Poseidon\Agua Hedionda Lagoon Maintenance Dredging\0648-RP-002 (Site Plan & Sections).dwg Figure 4

ANCHOR QEA

**Figure 4**
**Cross Sections**

Preliminary Dredge Design
Agua Hedionda Lagoon Maintenance Dredging

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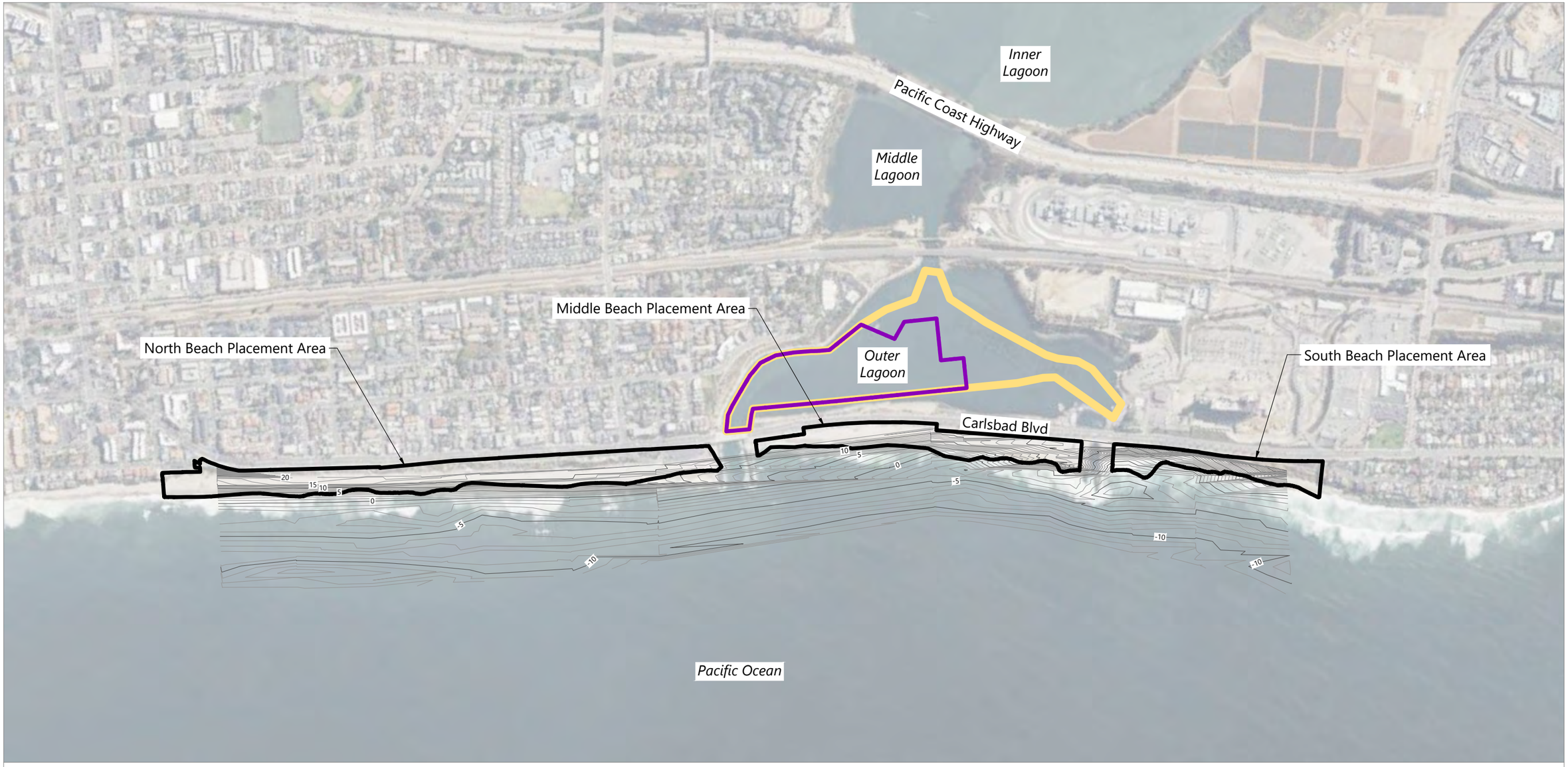
Filepath: K:\Projects\0648-Poseidon\Agua Hedionda Lagoon Maintenance Dredging\0648-RP-002 (Site Plan & Sections).dwg Figure 5

ANCHOR QEA

**Figure 5**
**Cross Sections**

Preliminary Dredge Design
Agua Hedionda Lagoon Maintenance Dredging




**SOURCE:** Aerial ©2024 Microsoft Corporation ©2024 Maxar ©CNES (2024) Distribution Airbus DS
**HORIZONTAL DATUM:** California State Plane, Zone VI, NAD83, U.S. Survey Feet
**VERTICAL DATUM:** MLLW

**NOTES:**

1. Existing beach topography based on survey conducted April 26, 2023 by Coastal Frontiers Corp.

**LEGEND:**

- Proposed Dredge Extents
- Previously Permitted Dredge Limits
- Beach Placement Areas
- 5 — Existing Contours (1' & 5' Intervals)

0 800
Feet

Publish Date: 2024/04/04 9:43 AM | User: jbigsby
Filepath: K:\Projects\0648-Poseidon\Agua Hedionda Lagoon Maintenance Dredging\0648-RP-003 (Beach Sampling).dwg Figure 6

ANCHOR QEA

**Figure 6**
**Beach Sampling Plan**
Preliminary Dredge Design
Agua Hedionda Lagoon Maintenance Dredging