600 University Street, Suite #610
Seattle, WA 98101

(206) 622-0222
www.moffattnichol.com

MEMORANDUM

To: Humboldt Bay Harbor, Recreation and Conservation

From: Kyle Landon, Moffatt & Nichol

Date: 3/27/2024

Subject: Redwood Marine Multipurpose Terminal - Shore Protection Design

M&N Job No.: 212991/03

Disclaimer: *This draft technical memorandum is a work-in-progress and is intended to be an internal document for use by the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project team as a part of the conceptual design process and the ongoing permitting process. This memorandum is meant to be read as a part of a comprehensive packet of technical analyses. It is not written to be a standalone document and it is assumed that the reader has substantial project knowledge and context to understand the memorandum's content. All aspects of this memorandum are subject to change and may become less accurate over time. To better understand the project, please review the more comprehensive and up to date documents posted to the Humboldt Bay Harbor District's website at https://humboldtbay.org/humboldt-bay-offshore-wind-heavy-lift-marine-terminal-project-3.*

1 Introduction

Site improvements to support the waterfront development of the Redwood Marine Multipurpose Terminal (RMMT) will include construction of shore protection. The approach to the design of the shoreline treatment varies based on the exposure to waves, slope stability and land use of the adjacent upland areas. Much of the existing nearshore areas within the project site can be characterized as low-gradient intertidal areas and shallow subtidal mudflats with the majority of eelgrass present between -3 feet NAVD88 and +1 feet NAVD88 (Merkel 2022[1]).

2 Shoreline Reaches

The shore protection design breaks the shoreline into three reaches to capture the unique existing condition present in each of these areas. These three reaches are shown in Figure 2-1. The shoreline at the two proposed wharfs (Wharf #1 and Wharf #2) will be protected by an armor stone slope. The design of the slope protection at the wharfs is described in a separate memo titled *Dredging and Rock Slope Protection*.

[1] *Memo "Re: Redwood Marine Multipurpose Terminal Preliminary Eelgrass Survey" by Merkle & Associates, Sept 2023*

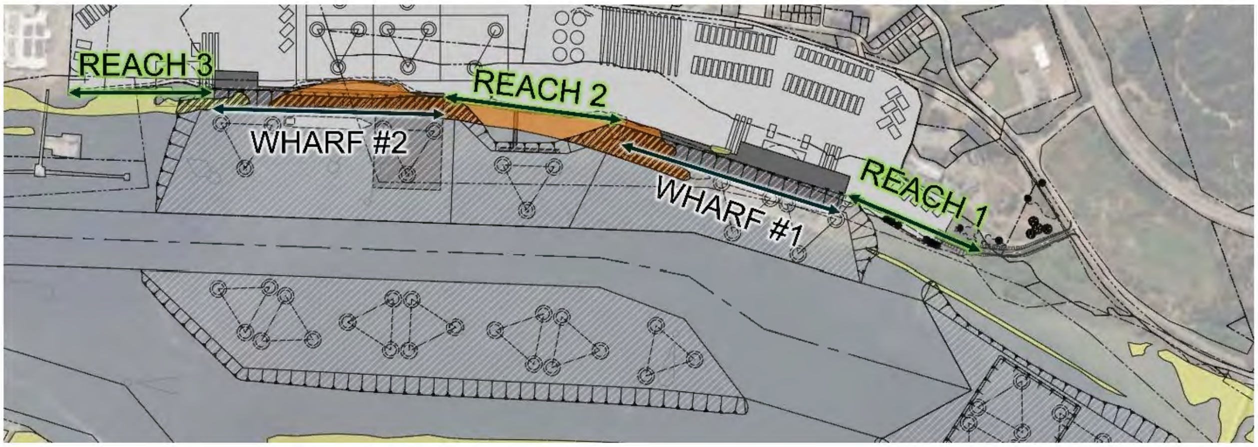


Figure 2-1. Site Plan. Patchy Eelgrass beds shown in Orange and dense eelgrass beds shown in Yellow. (Eelgrass data collected by NOAA Coastal Services in 2009).

2.1 Reach 1

Reach 1 is 1,050 feet long and is located north of Wharf #1 as shown in Figure 2-2. The shoreline is predominantly covered with rock and concrete debris. Offshore the bay rises into a large mudflat. Remnants of an approximately 190-foot-long steel bulkhead are located in the northern portion of Reach 1.

The site design proposes raising the top of bank grades from +10 feet NAVD88 to approximately +16 feet NAVD88. The shore protection must also take into consideration raising of grades and realignment of the north access road. Habitat features will be desirable in this area to blend into a mitigation area proposed for the shoreline north of Reach 1.

Figure 2-2. Existing Conditions - Reach 1

2.2 Reach 2

Reach 2 is 1,280 feet long and is located between Wharf #1 and Wharf #2 as shown in Figure 2-3. The southern section of the existing shoreline is covered by stone and concrete debris with slopes between 2H:1V and 3H:1V. Moving north the armoring becomes sparser and the shoreline transitions to a compound section with a gradual lower slope backed by a steep, and in some locations over steepened, upper slope. The lower slope is covered with scattered concrete debris. Large patches of eelgrass have been mapped offshore of the shoreline in Reach 2 (Merkel 2022). The site design proposes raising the top of bank grades from +10 feet NAVD88 to approximately +16 feet NAVD88. The north and south ends of the shoreline will need to tie into the armor stone slopes and cutoff walls under Wharf #1 and #2.

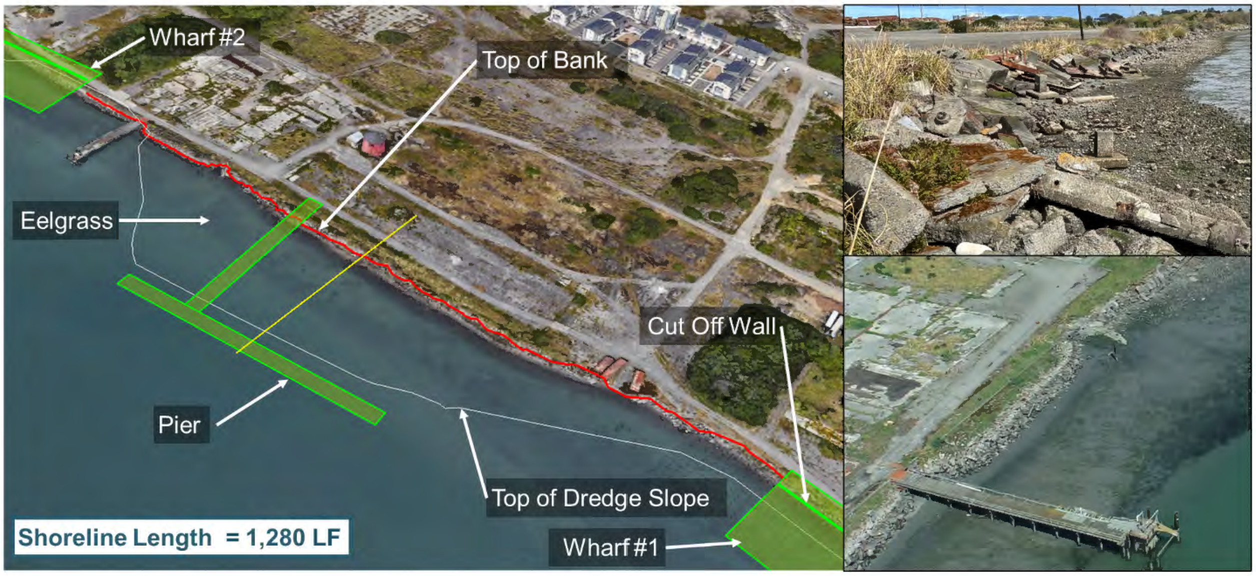


Figure 2-3. Existing Conditions - Reach 2

2.3 Reach 3

Reach 3 is located south of Wharf #2 and is 1,350 feet long, as shown in Figure 2-4. Most of the shoreline is covered by a heavily vegetated revetment composed of stone and concrete debris. The crest of the revetment is dominated by invasive Pampas grass. The slope of the existing revetment varies between 2H:1V and 3H:1V with small sections that are steeper. The grading of the south end of the site will in general be lower than much of the upland areas and will generally maintain existing top of bank elevations along the shore. The northern end of the reach will tie into the cutoff wall and armor stone slope under Wharf #2. The southern end of the reach will tie into the neighboring port property. When the RMMT is graded, the southern port property grade will be approximately 3ft higher.

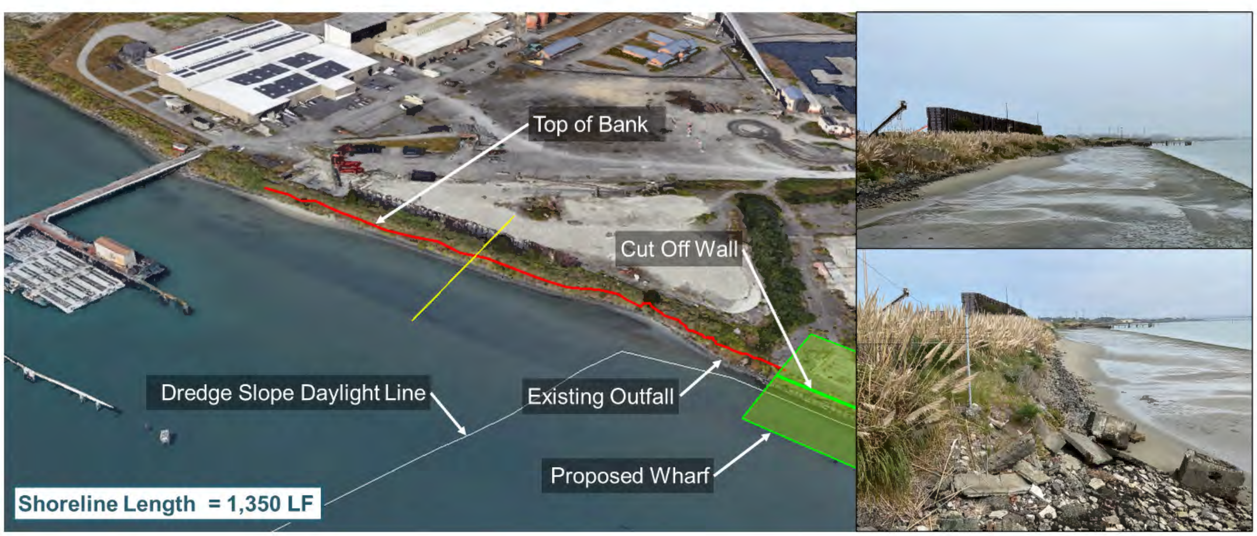


Figure 2-4. Existing Conditions - Reach 3

3 Basis of Design

The following section provides a summary of the design criteria relevant to the shore protection design. A more complete Basis of Design is provided in the Preliminary Basis of Design (M&N 2022). The shore protection is designed with a 25-year design life.

3.1 Design Water Levels

3.1.1 Tides

The tidal datums used for the shore protection design are provided in Table 1. The selection of the tidal datums is detailed in the Preliminary Basis of Design (M&N 2022). MHHW is used in conjunction with the 100-year wave run-up to establish the crest elevation of the shore protection.

Table 1. Tidal datums at Samoa

Tidal Parameter	**Elevation (ft MLLW)**	**Elevation (ft NAVD88)**
Highest Astronomical Tide (HAT)	+9.36	+8.64
Mean Higher High Water (MHHW)	+7.37	+6.65
Mean High Water (MHW)	+6.65	+5.93
Mean Sea Level (MSL)	+3.99	+3.27
Mean Low Water (MLW)	+1.30	+0.58
North American Vertical Datum of 1988 (NAVD88)	+0.72	0.00
Mean Lower Low Water (MLLW)	0.00	-0.72
Lowest Astronomical Tide (LAT)	-2.43	-3.15

3.1.2 Stillwater Levels

NHE (2022) provides an estimate for the 100-yr total water level (1% extreme high-water) for the current conditions (2022) and for 2070, which are listed in Table 2.

Table 2. Current and future total water levels

Year	**Stillwater Level (ft-NAVD88)**
2022	10.7
2070	14.5

3.1.3 Sea Level Rise Projections

OPC (2018) was used to obtain sea level rise projections for Humboldt Bay. The shore protection design uses a value of 2.3 feet for sea level rise (SLR), which corresponds to the Medium-high aversion probability (0.5% probability of exceedance) for 2050 under the high emissions scenario.

3.2 Waves

3.2.1 Wind Waves

The project site is sheltered from ocean swells and exposed to local wind waves. NHE (2022) completed a wind wave study and found the 100-yr design wave to have a peak wave height (Hmo) of 2.2 feet and period (Tp) of 2.7 seconds. This wave height is used to size the shore protection.

3.2.2 Vessel Wakes and Propwash

Vessel wakes and propwash will be assessed in future analysis.

3.2.3 Wave Runup

A wave runup of 3.8 feet was calculated using the Technical Advisory Committee for Water Retaining Structures (TAW) methodology assuming a 2H:1V rock slope and the design wave discussed in Section 3.2.1.

3.2.4 Propwash

Currents from propwash will be assessed in future analysis.

3.2.5 Tidal Currents

Design tidal currents are provided in Table 3 (M&N 2022).

Table 3. Design tidal current

Parameter	**Current Velocity (knots)**
Max. Ebb	3.4
Mean Ebb	0.9
Max. Flood	1.9
Mean Flood	0.7

3.3 Geotechnical Conditions

The following geological conditions were identified by reviewing historic data and conducting a new set of field investigations including both cone penetration test and soil borings (EMI 2022, SHN 2022).

3.3.1 Subsurface Soil Conditions

Figure 3-1 shows the preliminary soil profile developed for the shoreline. In general, the site is underlain by historic fill down to 0 ft NAVD88 and then by sand and clay/silt. The site is prone to liquefaction during earthquake conditions (EMI 2023).

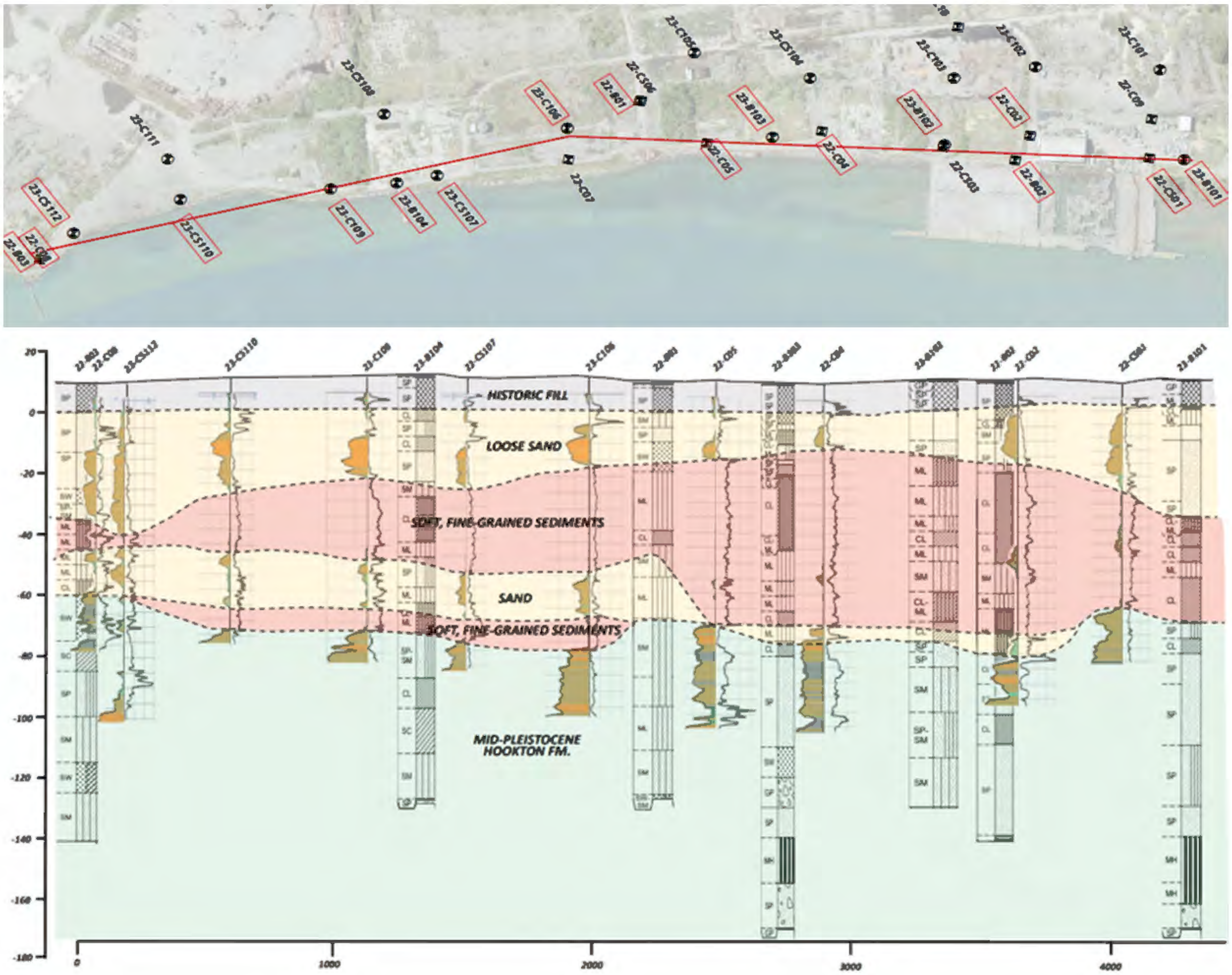


Figure 3-1. Preliminary geotechnical profile at the site shoreline. (SHN 2023[2])

3.3.2 Slope Stability

Slope stability analysis has been conducted for the wharf structures, but not other improvements along the shoreline. This section will be updated once that analysis has been complete. That said, the shore protection will likely not be designed to withstand extreme seismic events without some failure. In areas deemed to be critical enough to resist failure during seismic events, the shore protection design can be modified to accommodate the need.

3.4 Habitat Suitability

Based on ESA (2021), Figure 3-2 provides a conceptual summary of the relationship between water level and habitat. These habitat zones are used to inform the potential for integrating habitat enhancement features into the shore protection design.

[2] *"Geotechnical field investigations" Presentation by SHN, Dec 7, 2023*

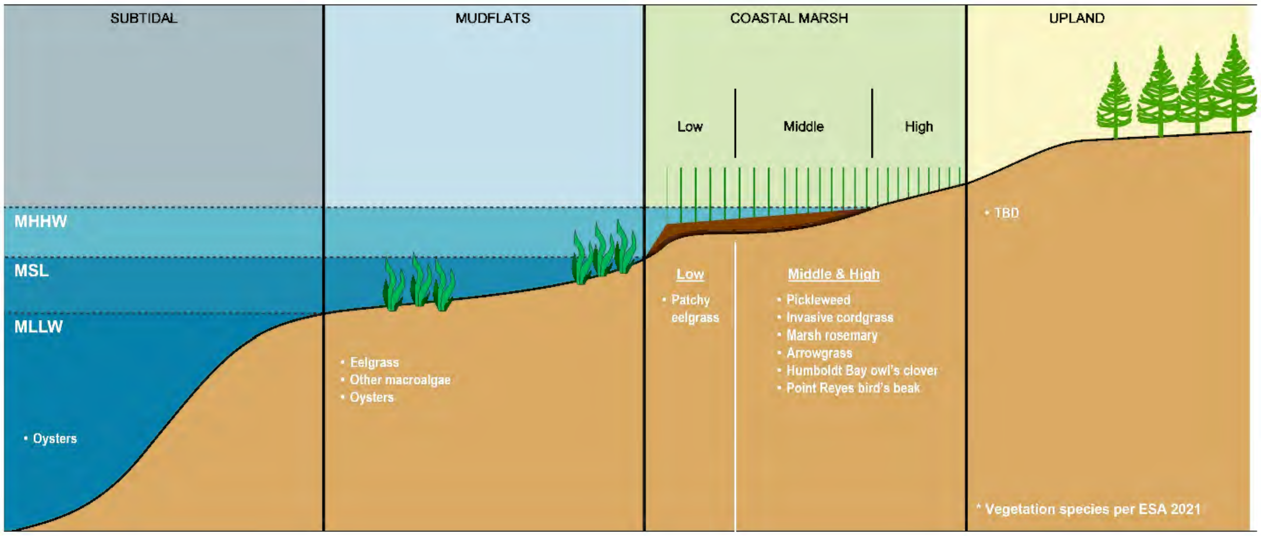


Figure 3-2.Conceptual habitat zonation

4 Shoreline Protection Design

The shore protection design is focused on three potential design sections that could be used to protect the shoreline from erosion. The three designs are a stone revetment, bulkhead, and a habitat revetment. The stone revetment is the simplest to construct but has a considerable footprint that will require mitigation. The bulkhead would reduce the footprint of the shore protection but is more complex to install and comes with a higher capital cost than the stone revetment. Finally, the habitat revetment would have a larger footprint than the stone revetment but may be partially self-mitigating due to the inclusion of habitat enhancements such as native plantings and ecology friendly building materials. For the conceptual level design, a new revetment is proposed for the entire shoreline (Figure 4-1). A revetment is the simplest, most cost effective solution, is currently used at the site, is easy to maintain and adapt to SLR, and is the most common shoreline treatment for working ports. Replacing the existing scattered rock and debris shore protection with clean rock in a more compact footprint would provide a benefit to the bay ecosystem.

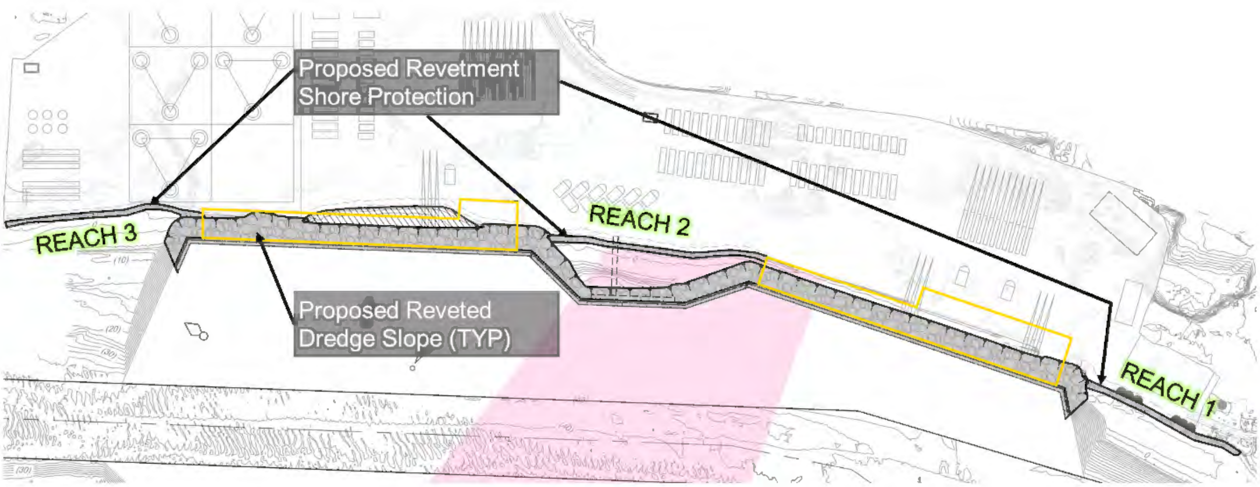


Figure 4-1. Proposed shoreline protection plan view

4.1 Design Considerations

4.1.1 Crest and Toe Elevations

The design crest elevation is the maximum elevation below which “hard” shore armoring is necessary to prevent erosion. Above the design crest elevation soft solutions such as plantings may be appropriate. The design crest elevation is set at an elevation of +13 feet NAVD88 based on the MHHW, SLR projections, and runup per Section 2.3. The bank slope above the design crest elevation can be stabilized by vegetation or other “soft” engineering approaches.

The design toe elevation marks the minimum elevation above which hard shore armoring is necessary to prevent erosion. The design toe elevation is set at 18 inches below the toe of the existing bank. The resulting design toe elevations vary between -0.5 to +2 feet NAVD88.

4.1.2 Initiatives

The Habor District and Crowley both have set forward initiatives to help guide the development of the site, Green Port and Envision, respectively. A primary component of these initiatives is a consideration of how the project will affect the natural environment and resilience. These initiatives may influence the selection of shoreline treatment in some areas. Incorporating adaptable designs, selecting material with greater benefit to the ecosystem (such as eco-concrete solutions), and creating shoreline cutbacks are some ways to help advance the initiative goals.

4.1.3 Upland Setbacks

The upland work area for RMMT is designed to accommodate a 3,000 pounds per square foot live load as defined by the surcharge areas and soil improvement areas. This live load must be setback a sufficient distance from the shoreline to prevent structural failure of the shore protection. Currently that set-back distance is estimated at 110ft for reveted slopes. In areas other areas, such as Reach 1, the slope treatments must be able to support truck traffic. The setback distances can be reduced for bulkheads, but will vary depending on the design.

4.1.4 Shoreline Cutbacks

Upland operations and shoreline designs are often laid out in long linear segments. A highly variable boundary does not often create additional usable space and makes for a more complex and potentially expensive shoreline treatment. With this fact in mind, there are opportunities to cutback and straighten the existing shoreline. Specifically, Reach 2 is an area that may be cut back and straightened to match the orientation of the wharves. Allowing for cutbacks may be one way to help meet goals of the Envision and Green Port initiatives.

4.1.5 SLR Adaptation

The proposed design for RMMT has a 50-year design life. However, it is likely that this area will be used for commercial marine operations far into the future. As a result, some consideration should be given to if and how the shore protection can be adapted as SLR rise continues within Humboldt Bay. Revetment designs have the potential to be adapted by extending the revetment slope upland as sea levels rise. Other options include building up a crest berm or running a small wall along the crest. The adaption of bulkheads are typically more complex and more expensive.

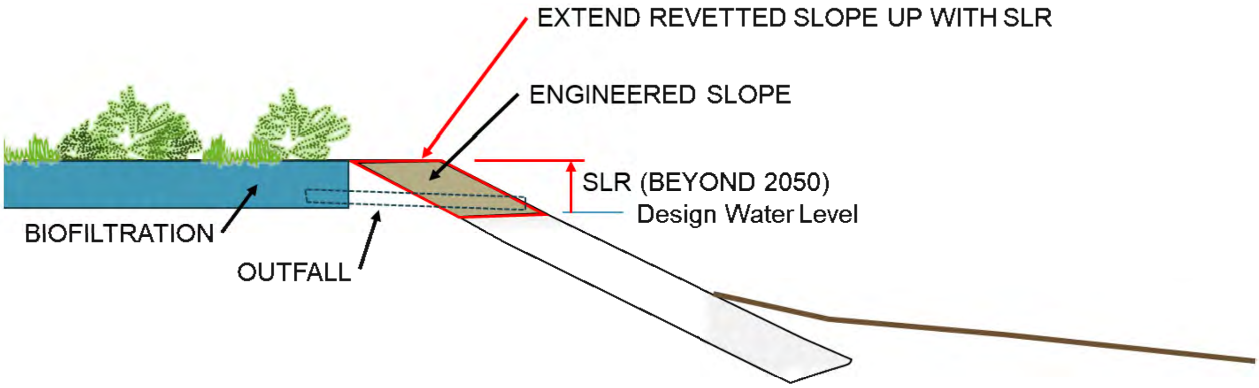


Figure 4-2. SLR adaptation concept

4.2 Design Concept and Additional Concepts

4.2.1 Stone Revetment

The stone revetment would require a four-foot-thick section with a 2.5 foot layer of 14 inch D50 riprap underlain by a 1.5 foot layer of 5" cobble. A 2H:1V slope was selected for the revetment given the design criteria summarized in Section 2.3. The stone revetment is the simplest structure to construct for slope protection. The sloped nature of the revetment requires placing rock below the High Tide Line (HTL) resulting in the need for mitigation. The stone armored slopes also provide a highly reflective surface for wave energy that may contribute to local scour and erosion, especially near the revetment toe. For this conceptual design stage, the revetment is being proposed for the whole of the shoreline. With further advancement of the design and coordination with permitting agencies and stakeholders, other shoreline treatments may be proposed. The stone revetment is estimated to cost **Error! Reference source not found.**. Concept level costs for the stone revetment are based on average costs for other rock projects in the region. The stone revetment concept can be modified to include modular precast eco-concrete tide pool units spaced throughout the revetment and placed near MHW. As a rule of thumb, the units are about 3 times more expensive than the rock they displace.

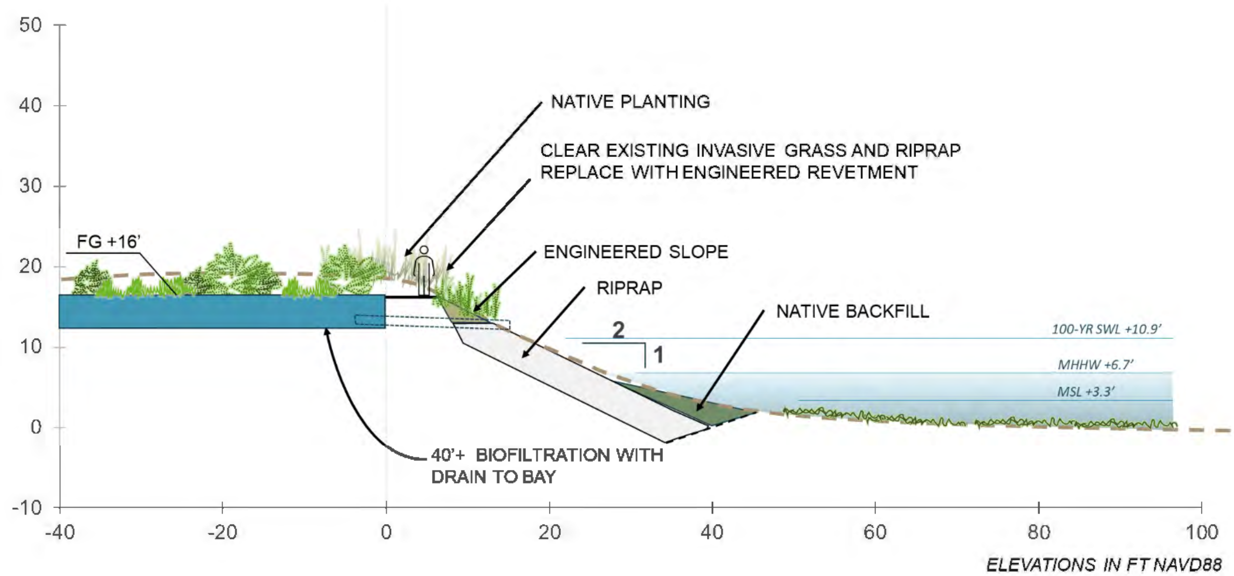


Figure 4-3. Rock revetment cross section

4.2.2 Tiered Habitat Revetment

The design of the tiered habitat revetment is similar to a rock revetment except that it includes a stepped design to allow for native plantings along the face of the revetment. The toe of the revetment can be stabilized with a combination of rock and precast Eco-concrete units which provide additional habitat benefit. The tiered design of the revetment does result in a larger footprint above and below the HTL. However, the habitat enhancing features (i.e., plantings and eco-concrete) should provide some level of self-mitigation for these additional impacts. The use of plantings will also reduce the wave reflective nature of the revetment leading to less local scour and erosion. The tiered habitat revetment will also help improve the aesthetics of the shoreline. The tiered habitat revetment is estimated to cost **Error! Reference source not found.**. Concept level construction costs for the tiered habitat revetment are higher than the stone revetment due to special placement required for the Eco-concrete units and integration of vegetated tiers for habitat enhancement.

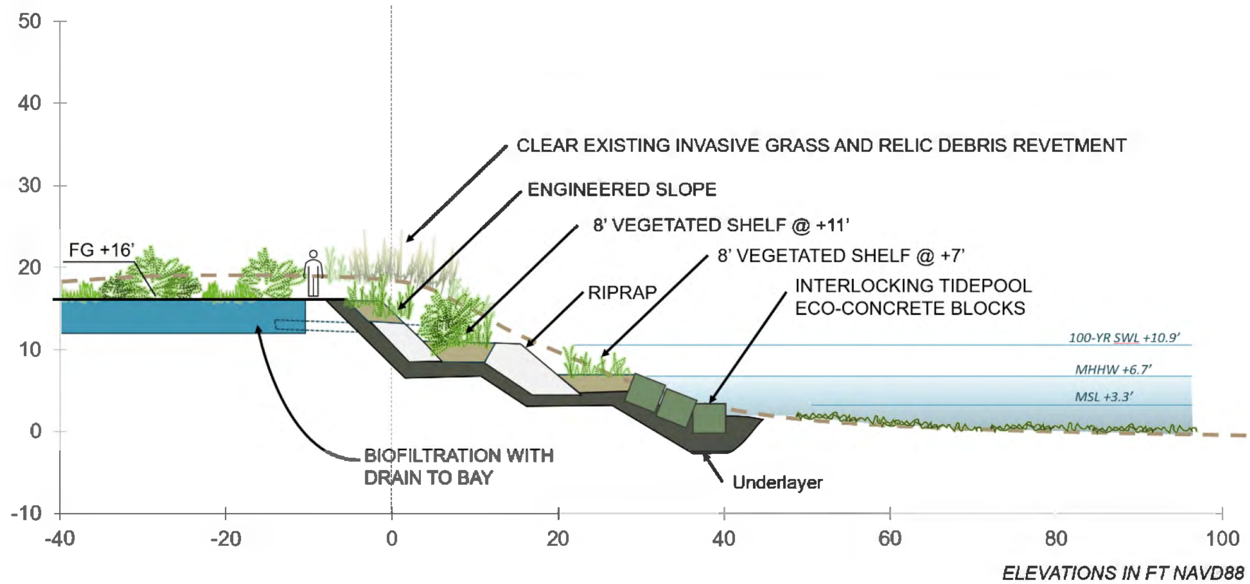


Figure 4-4. Tiered habitat revetment cross section

4.2.3 Bulkhead

The bulkhead would consist of a vertical sheet pile wall with riprap or eco-concrete scour protection at the bulkhead toe. The vertical nature of the bulkhead results in the smallest possible footprint but results in higher capital cost relative to a stone revetment. The vertical wall would present an even greater potential for wave reflection and resulting local scour and erosion compared to a stone revetment. However, for the bulkhead, the required set back distance for port vehicles loading will be less than the revetment or tiered revetment solution. In addition, the bulkhead may better protect from slope failures during and after a seismic event. The bulkhead concept may be applied where upland space is especially constrained, a bulkhead tie-in is required at either ends of the wharf, or a more stable shoreline solution is needed to address seismic concerns. For purposes of cost comparison of the bulkhead concept to the other rock slope treatments described above, it is assumed the bulkhead is a tied back structure retaining on the order of 15 ft of soil and includes rock toe protection. The bulkhead concept is estimated to cost **Error! Reference source not found.**. The wall design can be adapted to include eco-concrete treatment if the tidal exposure is appropriate. Additionally, the riprap toe may be replaced with a pre-cast eco-concrete mat. Incorporation of the eco-concrete measures will increase the cost, but will provide additional habitat benefits.

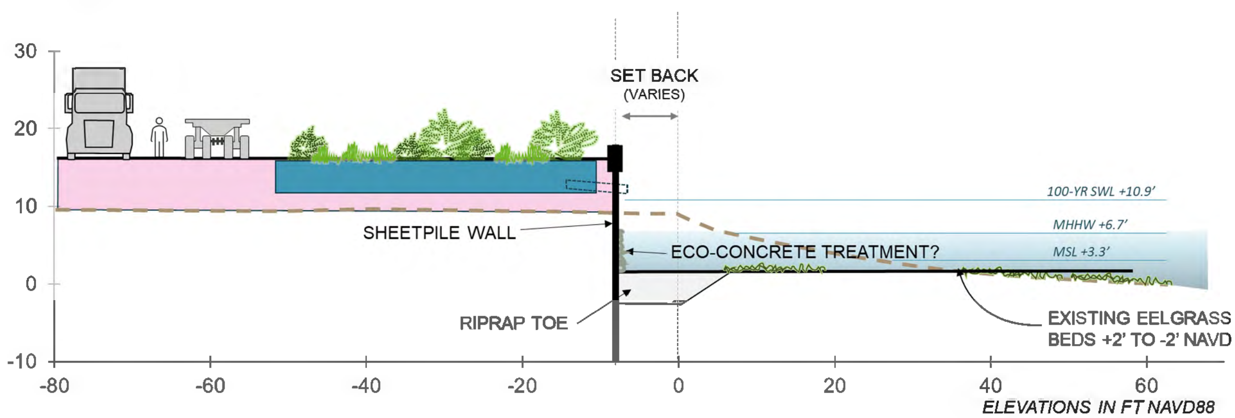


Figure 4-5. Bulkhead cross section

5. Next Phase Considerations

At the start of the next phase of work, the following are critical steps in the continuation of the planning, analysis, and design work.

The three suggested shoreline protection types described below should be reviewed and a preferred type for each of the three reaches should be selected. The following table provides key considerations for making the selection. These selections are critical to meet timelines for project description development and submittal of permit applications. A stone revetment may be the most suitable for all reaches due to small footprint, low maintenance cost, low adaptation cost, and because it provides some ecological value.

	Stone Revetment	**Tiered Habitat Revetment**	**Bulkhead**
Footprint	Less than Tiered Habitat Revetment	More than Stone Revetment	Smallest (nearly vertical wall)
Habitat Benefits	Displaces less native habitat than tiered habitat revetments, has some ecological value.	Displaces the most native habitat, has the highest ecological value.	Displaces the least native habitat, has no ecological value.
Relative Cost	$1,200 to $1,800/LF	$1,800 to $2,700/LF	$10,000 to $12,000/LF
Adaptability	High	Medium	Low

moffatt & nichol
600 University Street, Suite #610
Seattle, WA 98101

(206) 622-0222
www.moffattnichol.com

ATTACHMENT A:
ECONCRETE PRESENTATION MATERIAL

ECONCRETE

We Bring Concrete to Life

Humboldt – Shoreline stabilization

Preliminary proposal

December 2023

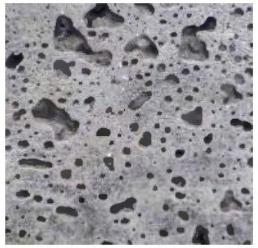
www.econcretetech.com

ECOncrete Technology

ECOncrete admixture

Encourages biological recruitment

+



Surface complexity

Supports marine life settlement

+

Nature inclusive Design

Supports growth and survival

Scientific Validation

2012-2022

E.g., Pilot Project at Port of Haifa, Israel

Perkol-Finkel, Shimrit, and SELLA, Ido (2014)
"Ecologically active concrete for coastal and marine infrastructure: innovative matrices and designs.“ ICE publishing, 2014.

Sella, Ido, and PERKOL-FINKEL, Shimrit (2015)
"Blue is the new green- Ecological enhancement of concrete based coastal and marine infrastructure." Ecological Engineering 84. 260-272. Elsevier, 2015.

Sella, Ido (2022), et al. *“Design, production, and validation of the biological and structural performance of an ecologically engineered concrete block mattress: A Nature-Inclusive Design for shoreline and offshore construction”. Integrated environmental assessment and management 18.1: 148-162. 2022.*

Structures built using ECOncrete technology have been proven to significantly increase biodiversity, species richness and abundance, reduce the dominance of invasive species, as well as increase the percent of live cover in comparison to standard Portland cement-based structures (over 10 peer-reviewed publications).

Patented Solution and Technology License

License of use of ECOncrete Technology to produce ECOncrete units and 3rd party design concrete elements includes:

Admixture + **Liners formworks** / **Mold Systems** + **Q/C &Technical Support**

= 10% cont. cement.

Compatible with any type of cement

3rd Party design

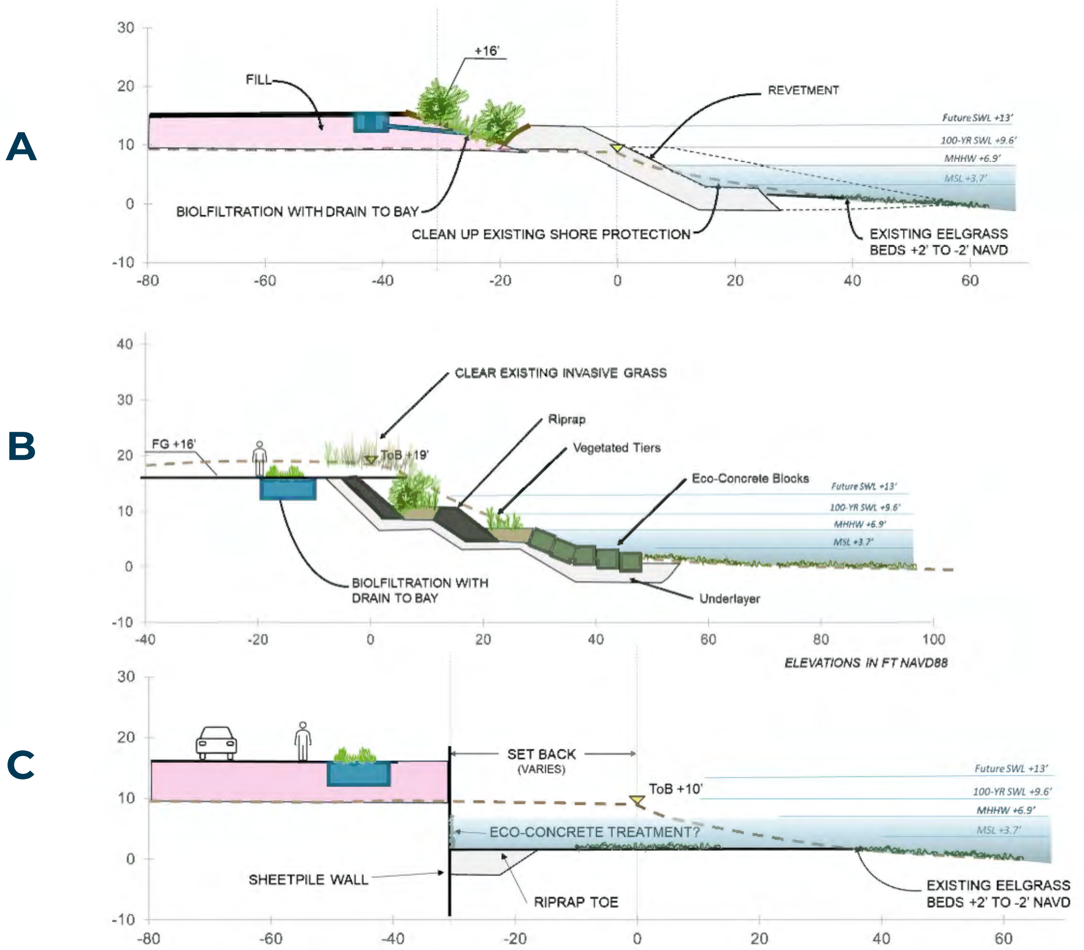
ECOncrete's propriety design

Design and execution phases

Shoreline Stabilization (Humboldt)

Scope of work

Location + SoW



Sample sections

ECONCRETE

Shoreline Stabilization (Humboldt)

‘Powered by ECOncrete’

A

Coastalock

B

Armor Block

Tide Pool

C

Seawall

Marine mattress

Shoreline Stabilization (Humboldt)

A – Revetment

Estimated length ≈ 850 ft (≈ 250m)

Project sample section (A)

ECONCRETE

Coastalock **Eco-engineered Solution for Resilient Coastlines**

Natural Tide Pool

ECOncrete Tide Pool
(2012/13)

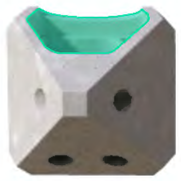
BIOMIMICRY
GLOBAL DESIGN
CHALLENGE

COASTALOCK
(2021)

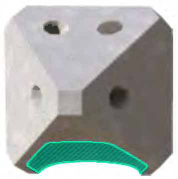
ECONCRETE

Coastalock

- **Eco-engineered single layer interlocking armor unit**
- Designed for **inter-tidal and submerged areas** of revetments and breakwaters
- **Multiple orientations** offer diverse habitats such as tide pools, caves and overhangs

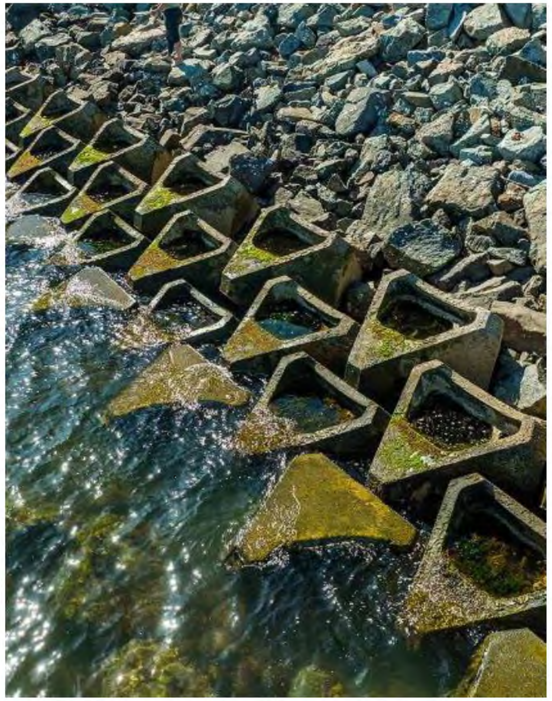

Tide pools

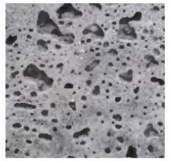

Caves


Overhangs

Volume (~1.86 yd³)
Weight (~7,515 lbs)

Standard unit
(dimensions can be fitted to specific project requirements)



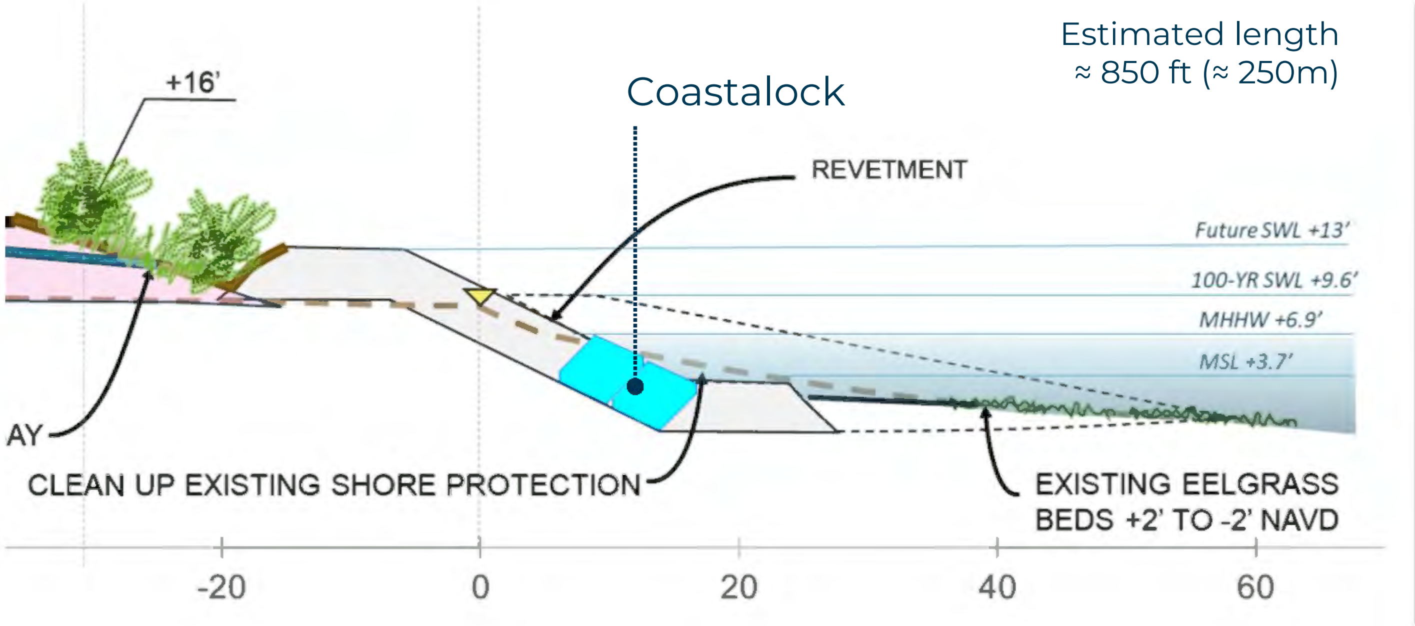


ECONCRETE

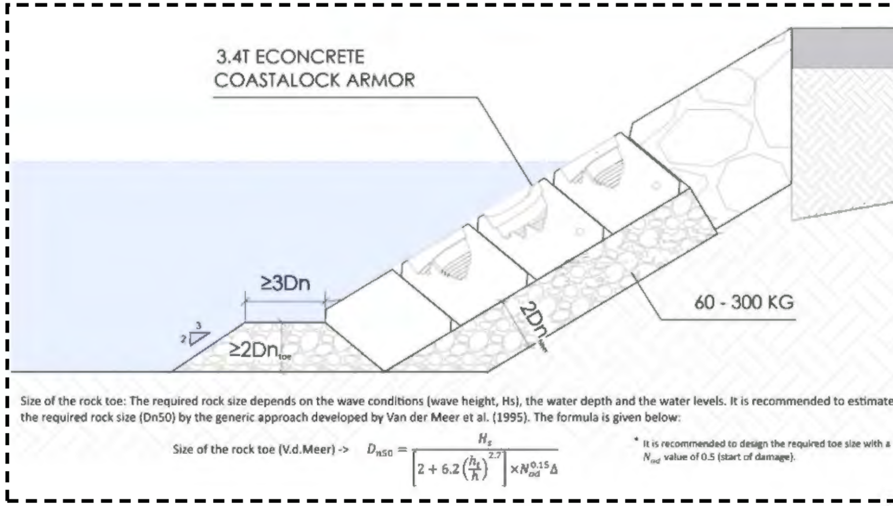
Shoreline Stabilization (Humboldt)

A – Revetment - Coastalock

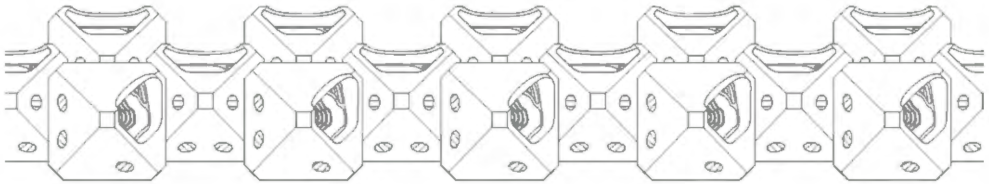
Estimated length
≈ 850 ft (≈ 250m)



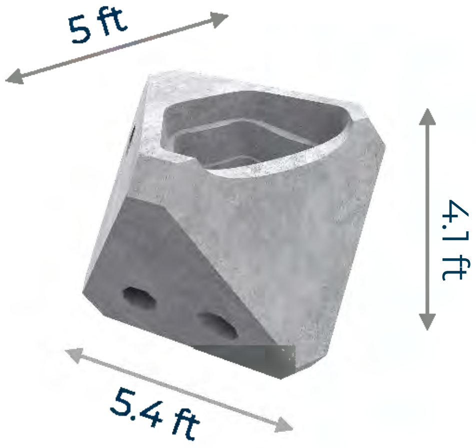
Project sample section (A), with 3 rows of Coastalocks



Coastalock integration in a revetment
(general concept)



Elevation, interlocking placement (3 rows of Coastalocks)



Volume (~1.86 yd³)
Weight (~7,515 lbs)

ECONCRETE

Shoreline Stabilization (Humboldt)

‘Powered by ECOncrete’

A

Coastalock

Length ≈ 850 ft (≈ 250m)

Technology License

+

+

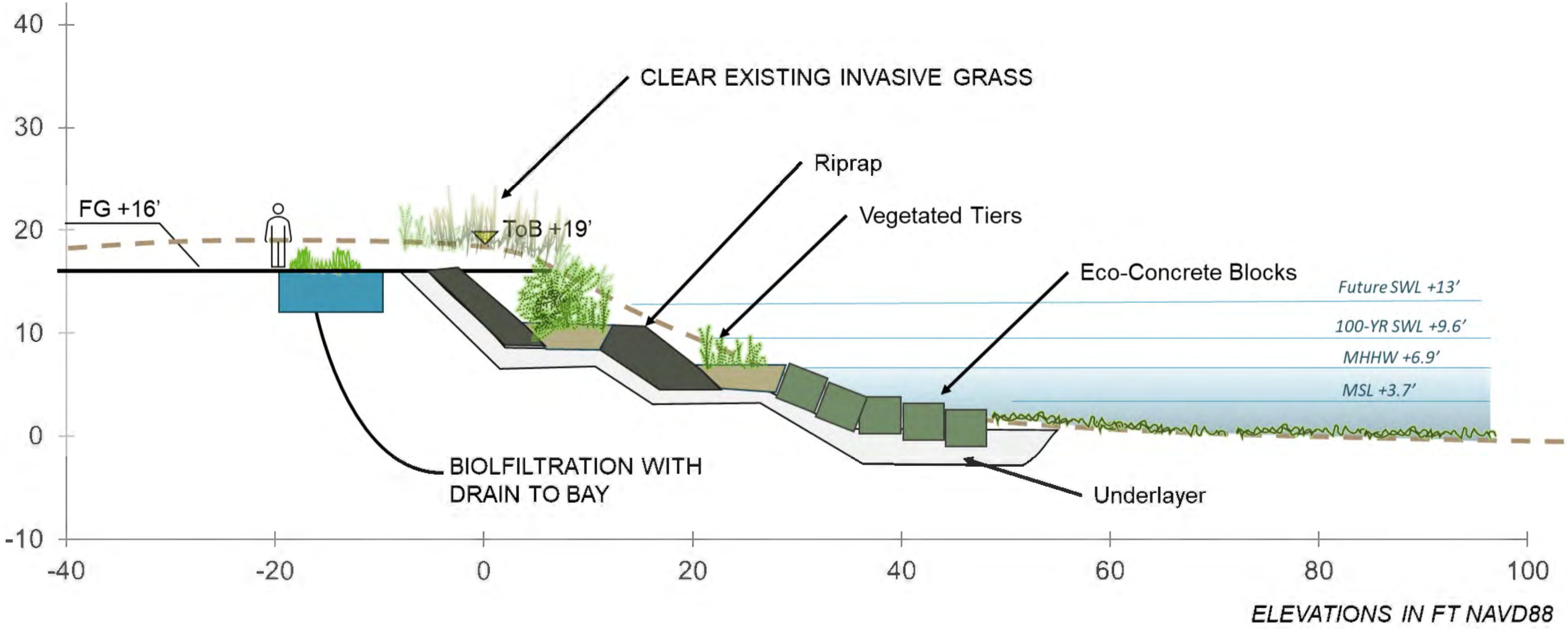
Quantity ≈ **300** Coastalock (1.86 yd³/unit)

Cost ≈ **XXX** $

Shoreline Stabilization (Humboldt)

B – Revetment toe

Estimated length ≈ 850 ft (≈ 250m)



Project sample section (B)

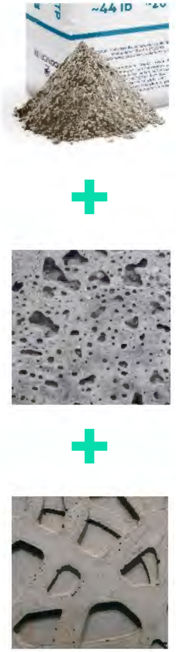
ECONCRETE

Tide Pool

Biomimicry Design Winner 2019

BIOMIMICRY
GLOBAL DESIGN
CHALLENGE

- Mimics rock pools at natural inter-tidal areas.
- Retains water at low tide to create an additional environment for a stable ecosystem.
- Performs best when placed in a continuous arrangement along a revetment, supporting larger, more biodiverse species communities



Tide Pool


Port of Monaco, 12 months post installation

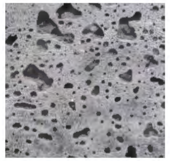
ECONCRETE

Tide Pool

Living Breakwaters Project, New York, US

Armor Block

- Armor blocks are modular infrastructure for toe protection, integration into breakwaters, ripraps, and revetments, or scour protection.
- They provide defense against hydrodynamic forces while facilitating biodiverse ecosystems and carbon storage.
- The placement and orientation of the unit gives the Armor Blocks indents multiple functions. Acting as a tide pool, a protective hub for fish and other fauna, and an overhang, the Armor Block supports a wide variety of marine life.



Armor Block

- The Armor Blocks' design allows incorporation of various add-on elements for conservation of targeted marine species:

Oyster Hatchery Units

Fish Hubs

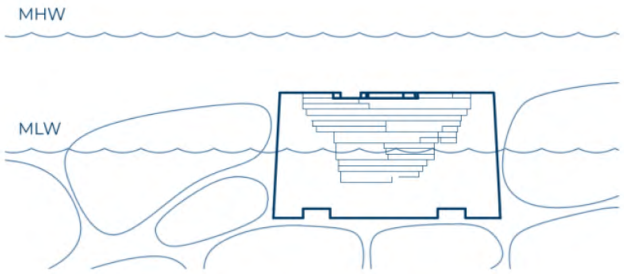
Oyster Disks

ECONCRETE

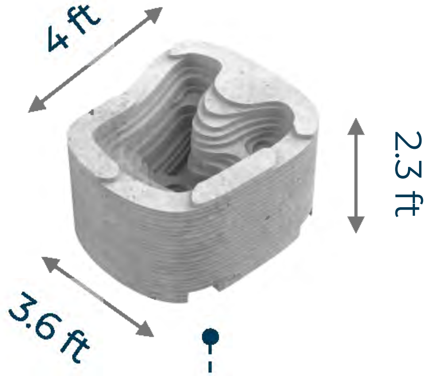
Shoreline Stabilization (Humboldt)

B – Revetment toe – Armor Block / Tide Pools

Estimated length ≈ 850 ft (≈ 250m)



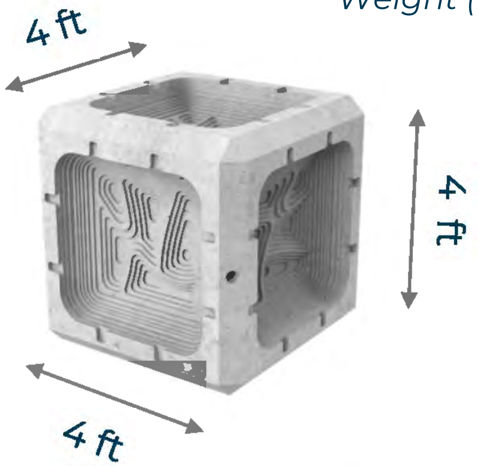
General Tide Pool integration in a revetment

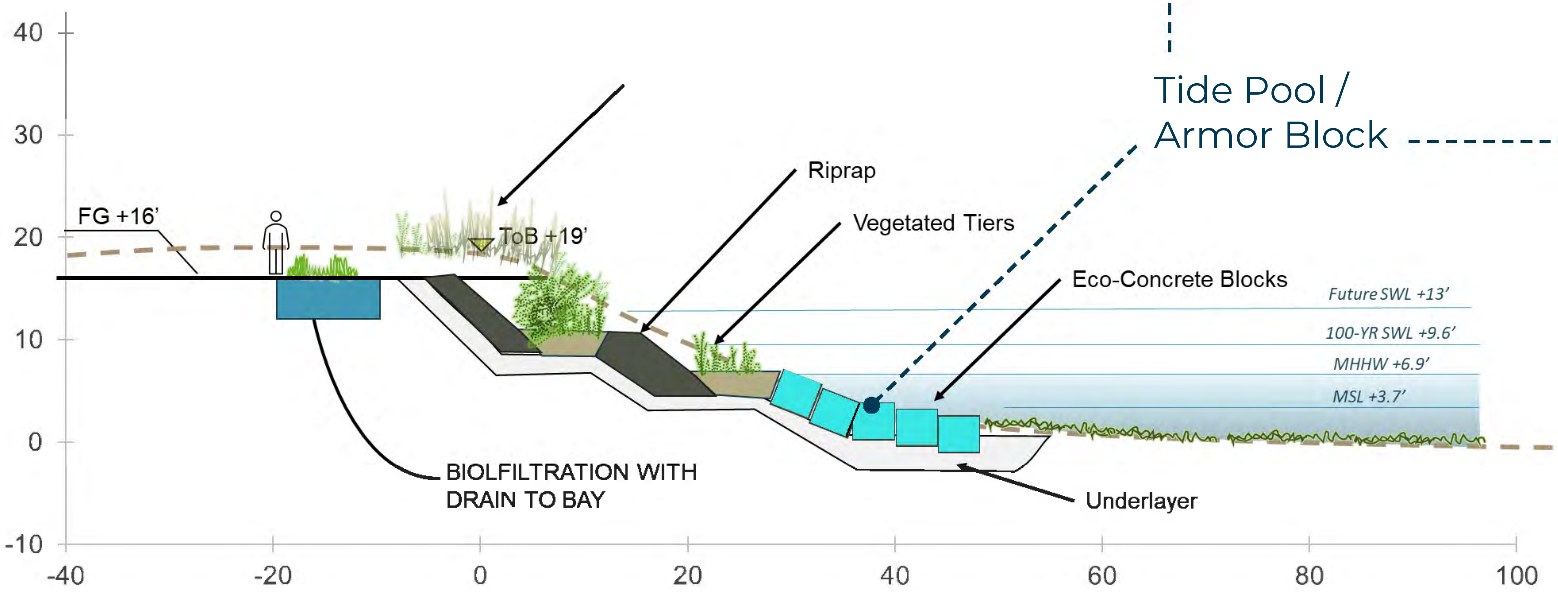


Volume (~0.75 yd³)
Weight (~3,020 lbs)

Tide Pool / Armor Block

Volume (~1.48 yd³)
Weight (~6,000 lbs)





Project sample section (B), with Armor block type solution represented

ECONCRETE

Shoreline Stabilization (Humboldt)

'Powered by ECOncrete'

B

Armor Block

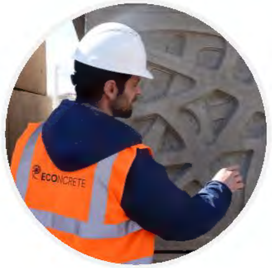
Tide Pool

Length ≈ 850 ft (≈ 250m)

Technology License

+

+



Quantity ≈ **XX** Armor Blocks (1.48 yd^3/unit)
Cost ≈ **XXX** $

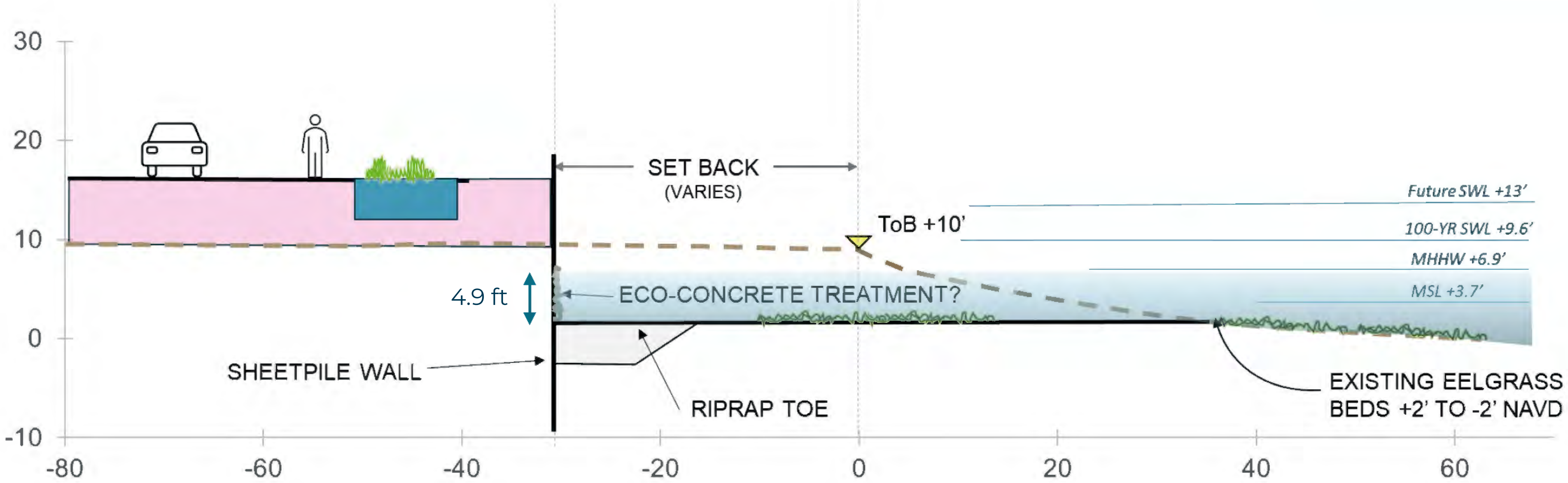
Quantity ≈ **XX** Tide Pools (0.75 yd^3/unit)
Cost ≈ **XXX** $

ECONCRETE

Shoreline Stabilization (Humboldt)

C – Quaywall

Estimated length ≈ 1500 ft (≈ 450m)



Project sample section (C)

Concrete Seawalls

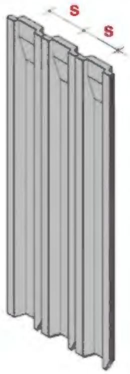
Prefab. sheet piles

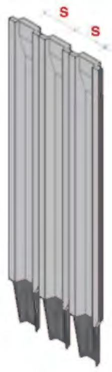
Sheet Pile

Sheet piles are widely used as temporary and permanent earth retaining systems for building platforms, stabilization of slopes, road embankments and riverbanks, and shoring walls of trenches. These embedded sheet pile walls are commonly employed for restricted site conditions, especially for wall alignment along the lot boundaries, and where open excavation is not permitted. They are also well suited to poor soil conditions, providing a cost effective alternative to replace other retaining wall systems supported on expensive piled foundations.

Read More about Sheet Pile

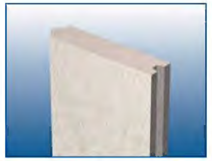
Download Brochure





Concrete Sheet Pile Press-in Method

Concrete sheet piles are prefabricated to eliminate the necessity for temporary wooden or metal form-work at site. This method can quickly and safely construct a strong high quality prefabricated structural wall. Additionally, this method does not disturb water flow in river and canal work. Construction planning does not need to be constrained by location and seasonal variations in weather.

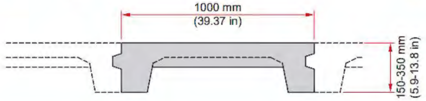


CP80

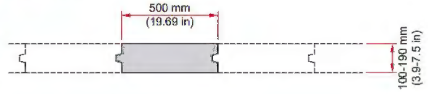
CP50

Pile Dimensions

Channel Type



Flat Type



Concrete Seawalls

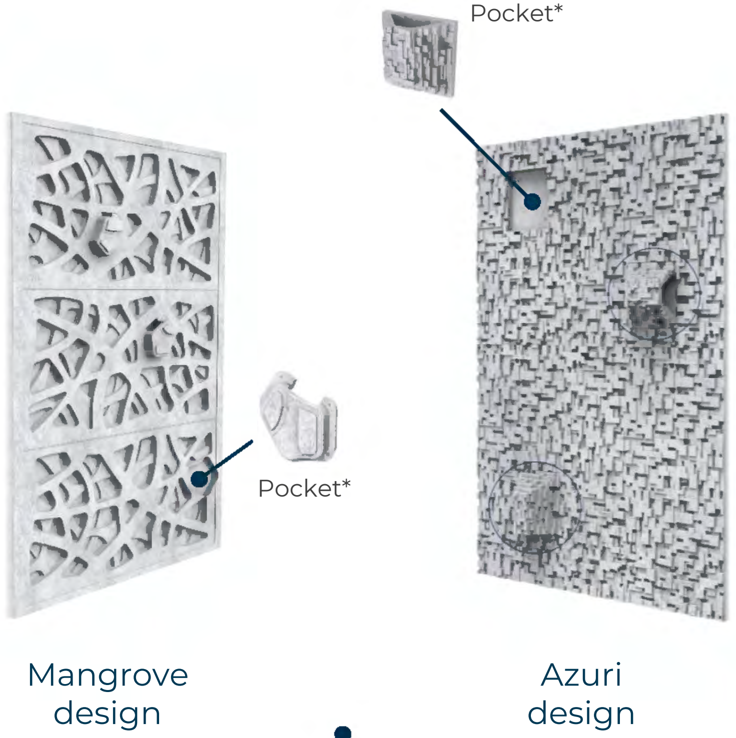
Integration of ECOncrete Technology in prefab. sheet piles

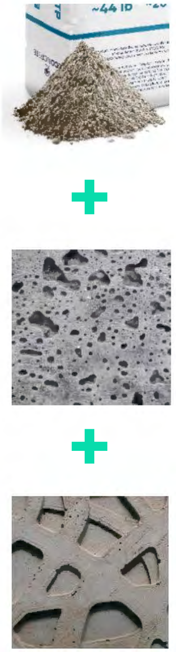
Integration of ECOncrete Technology

- Increase the biological performance of the element by improving its surface complexity and composition, enabling the recruitment of sessile species.

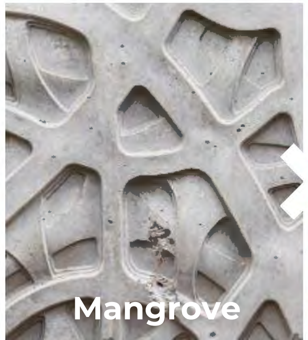
- Surface complexity patterns can be customized to any structural concrete solution adopted (sheet piles, quaywalls blocks, etc.).

Some examples of nature-inclusive design patterns.





***NOTE:** Integration of niches and cavities into the design (such as pockets) provide a diverse range of habitats for local target species . They can be installed into the design (with different orientations) in order to serve as hidden spots for the mobile species



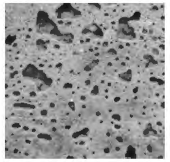
Prefab. Seawall Panels

For non-concrete seawalls or existing quaywalls

Marine Mattress

- Designed to provide shoreline stabilization and erosion control
- Prevents sediment accumulation on the units by incorporating inclined surfaces and corridor forms.
- The unique properties encourage the growth of marine flora and fauna, increase biodiversity, and reduce the dominance of invasive species

\+



\+

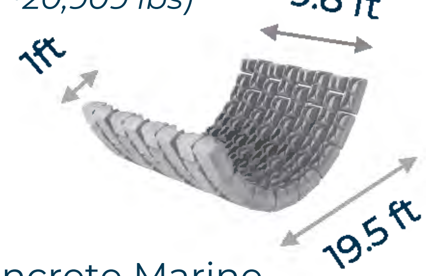
Shoreline Stabilization (Humboldt)

C – Quaywall – Seawall / Marine mattress

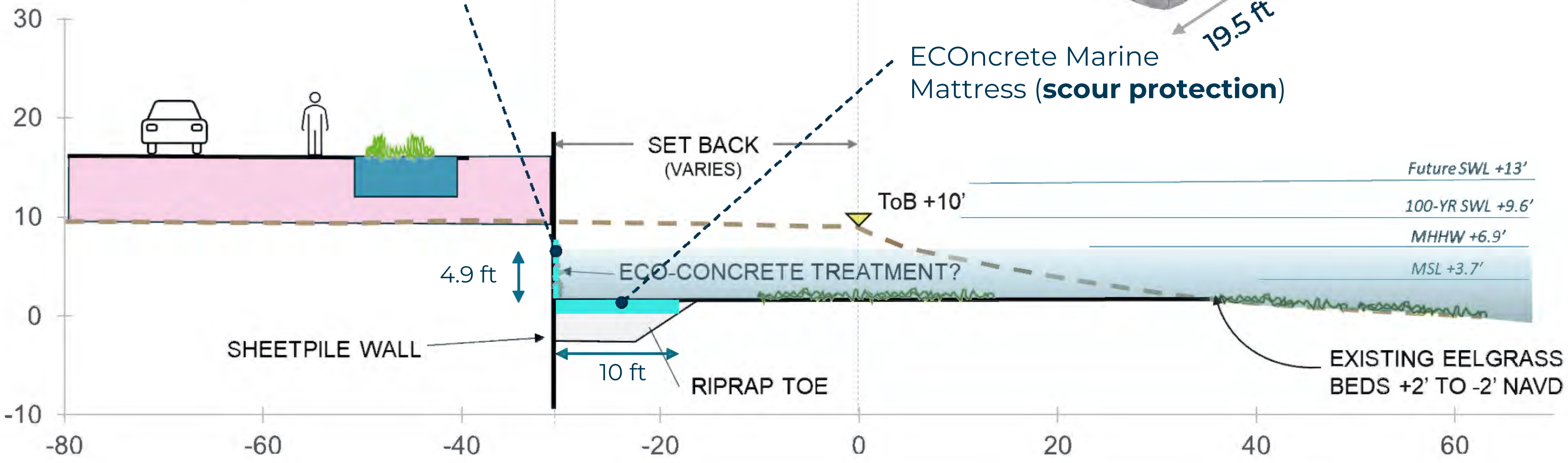
Estimated length ≈ 1500 ft (≈ 450m)

Concrete sheet pile wall / Seawall panels

Volume (~5.17 yd³)
Weight (~20,909 lbs)



ECOncrete Marine Mattress (**scour protection**)



Project sample section (C), with ECOncrete Seawall and Marine Mattresses

Shoreline Stabilization (Humboldt)

'Powered by ECOncrete'

c

Seawall

Marine mattress

Length ≈ 1500 ft (≈ 450m)

Technology License

+

+

Quantity ≈ **7350 ft²** of Seawall panels (0.46 ft thick)

Cost ≈ **XXX** $

Quantity ≈ **75** Marine Mattress (19.5x9.8x1 ft/unit)

Cost ≈ **XXX** $

ECONCRETE

We Bring Concrete to Life

Humboldt – Shoreline stabilization

Preliminary proposal

December 2023

www.econcretetech.com