

SO YOU WANT TO DESIGN A REEF?

*Master Plan for the
Redondo Beach Dive Site*

*University of Washington
Landscape Architecture 503 Studio, Spring 2018*

Edited by Jess Vetrano





ACKNOWLEDGMENTS

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CONTENTS

I.	INTRODUCTION	4	V.	REEF DESIGN	34
	<i>Project Origins</i>	1		<i>Developing Initial Concepts</i>	35
	<i>Project Process</i>	2		<i>Interim Charrette</i>	37
II.	BACKGROUND RESEARCH	4		<i>Reef Master Plan</i>	39
	<i>Gathering Information</i>	5		<i>Illustrative Perspective Images</i>	41
	<i>Visualizing Findings</i>	9		<i>Physical Model</i>	47
	<i>Analyzing Reef Precedents</i>	16	VI.	UPLAND OPPORTUNITIES	48
	<i>Establishing Goals</i>	19		<i>Considering Upland Impacts</i>	49
III.	SITE ANALYSIS	20		<i>Upland Precedent Analysis</i>	50
	<i>Site Context</i>	21		<i>Upland Phase One</i>	55
	<i>Site Analysis</i>	25		<i>Upland Phase Two</i>	57
IV.	MATERIALITY	28		<i>Upland Long Term Possibilities</i>	59
	<i>Digital Explorations</i>	29	VII.	IMPLEMENTATION	60
	<i>Physical Explorations</i>	32		<i>Budget</i>	61
				<i>Phasing</i>	62
				<i>Community Involvement</i>	62
				<i>Construction Documents</i>	64



PROJECT TEAM

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Brooke Sullivan

Studio Participants

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Fatema Maswood

Julia Brasch

Ellie Lange

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I. INTRODUCTION

PROJECT ORIGINS

Fifteen years after taking a landscape architecture studio Rus Higley, director of the Marine Science and Technology Center (MaST) at Redondo and a faculty member at Highline College, contacted us, the Department of Landscape Architecture at the University of Washington with a request: Would you be interested in developing a design for an artificial reef in Puget Sound? Yes, indeed! But why landscape architecture? Because, as Rus explained, in the design studio that he took with Associate Professor Iain Robertson all those years ago he learned that landscape architects know how to design facilities that use art and design to explain science and that, he believed, was a crucial ingredient to bring a potential artificial reef project to life.

As a research and recreational diver and manager of the MaST Center, Rus has developed deep knowledge of the marine conditions at Redondo Beach, a location considered to be one of the best recreation dive sites in Puget Sound. Through his pioneering work at MaST he has assembled a team of teachers and researchers and which enhances the Redondo Beach location's value as an educational as well as a recreational dive site.

Like many recreational divers in Puget Sound, Mike Racine, President of the Washington Scuba Alliance (WSA) was concerned about the loss of dive sites in the region as old pilings and debris were removed by DNR during Sound cleanup operations. Mike successfully spearheaded efforts by WSA divers and the City of Des Moines to obtain \$500,000 funding the Washington State Capitol Budget for construction of a new artificial reef which would be developed in conjunction with removal of old tires and other debris from the locale. Mike's efforts resulted in a win for divers, the city, Puget Sound marine life, and the Puyallup tribe who harvest geoduck in the area.

The city of Des Moines, recognizing the value of recreational diving has installed on-shore facilities for divers and fishers and repaired the storm-damaged beach boardwalk. The city, and Des Moines Art Commission led by Fred Andrews, was interested in making further improvements to diving and other facilities in the area.

PROJECT PROCESS

The success of these long and imaginative collaborations set the scene for seven talented graduate and undergraduate landscape architecture students and faculty Iain Robertson & Brooke Sullivan to work with the stakeholder groups on the project and so a UW Spring Quarter 2018 landscape architecture studio, The Octopus's Garden Reef Studio, began. UW Landscape Architecture has a long history of successful collaborations with community groups and has developed plans and designs for diverse facilities throughout the region and beyond, but never an underwater reef. We were excited, but were we out of our depth? The imaginative but practical design ideas and proposals produced by the students indicate that they have risen to the challenge and developed an excellent design for the Redondo Reef. As is typical of our landscape architecture studios this report--detailing how others might successfully develop artificial reefs--adds, with a flourish, far more than our clients had expected from our class.

This report and our design drawings are a testament to the effectiveness of the design process we use in landscape architecture studios to engage actively with our clients, to bring in research expertise from across the university, to imagine and test different approaches to the problem, and to create products that elegantly serve the community and stretch the imagination. But most of all this work is a testament to the talent and efforts of the seven students in this studio Julia Brasch, Ellie Lange, Fatema Maswood, Darin Rosellini, Jess Vetrano, Malin Weiss-Anderson and Rachel Wells.





II. BACKGROUND RESEARCH

GATHERING INFORMATION

As landscape architecture students, we were not particularly familiar with the workings of the sea having spent most of our time designing upland sites. Therefore, this project required quite a bit of initial information gathering to help us get up to speed with marine science. Beyond scouring the library and internet for books, journals, websites, and other resources, we also received conversational lectures from members of the MaST staff, professors from the University of Washington, and researchers from Friday Harbor, among others. We also attended several events that helped broaden our knowledge of marine systems.

MaST Center Kick Off Meeting

At the beginning of May, we traveled down to the Redondo site to meet Rus Higley and the rest of the MaST staff, tour the site, and get answers to some initial questions we had generated. They filled three, massive white boards with information in response to the fifty questions we sent to them, which offered a great starting point for us in moving our investigation forward. We also were able to gather hundreds of photos of the existing site conditions, which helped us greatly when performing much of our analysis and design in Seattle.

Nearshore Restoration in Puget Sound

On April 7th, 2018, Dr. Tish Conway-Cranos of the Estuary and Salmon Restoration Program in the Department of Fish and Wildlife spoke to a group at MaST on ongoing restoration projects in the Salish Sea watershed. The lecture provided case studies of coastal de-armoring, restoration projects, and the role of sediment movement between freshwater and saltwater systems. We left with a stronger understanding of connections between ecological systems, and looking at the link between the nearby Redondo Creek and Puget Sound with a new sense of possibility.

Climate Science on Tap: Climate Change Impacts in Puget Sound

In early April, a few of us attended an event hosted by Cascadia Climate Action regarding the future of Puget Sound in the face of changing climates. The event included three scientists who acted as panelists and provided overviews of their work combating the adverse ecological effects of climate change before fielding audience questions. These scientists included Christopher Krembs, Iris Kemp, and Lynne Barre.

Friday Harbor Visit

On Saturday, April 21st, 2018 we took the ferry from Anacortes to Friday Harbor, Washington in order to visit the University of Washington's Friday Harbor Laboratories. These labs host both faculty and researchers from across the globe to study marine ecosystems. This visit allowed us to test the knowledge we had gathered thus far against experts in oceanography, nearshore and deep-sea ecology, bull kelp ecosystems, and many others.

We also were able to observe how many different types of materials support marine life, which inspired many of the materiality decisions we made when designing the final reef and are displayed to the right.

Based on what we observed and learned at Friday Harbor Labs, our understanding that the best form for supporting maximum marine life includes complex, textured surfaces with many 'hidey holes' was confirmed. We also gained an understanding of how tidal flows might influence our reef site.



Images of Material Observations from Friday Harbor

Puyallup Tribe Meeting

We attended a meeting with WSA members, a Puyallup Tribe Shellfish Biologist, and a Water Quality Planner/Project Manager at King County's Land and Water Resources Division to discuss the Poverty Bay and Redondo Creek water quality concerns of these stakeholders. We learned that the tribe shellfish biologist was primarily concerned with impaired water quality at the site because shellfishing is often closed 6 months a year due to bacteria levels, and the water quality planner was concerned about both the level of sediment and bacteria being contributed by the creek. This meeting made clear to us the importance of addressing the stream and its contribution to the water quality of the area in our design proposal, and inspired us to think about ways of addressing water quality that could result in multiple benefits for all stakeholders.

American Construction Company Visit

After studying reef organisms and requirements and brainstorming, we visited American Construction Company in Tacoma, the contractor for Saltwater State Park, to better understand how underwater features were constructed and what types of things added cost. This trip helped us propose design strategies that are realistically within our budget. The budget available does not account for as much structure as would be ideal for diving and habitat maximization, so we are recommending augmenting rock with reclaimed, inert materials like precast concrete, shoreline riprap, and quarry discards, which also aid in wayfinding, making distinctive dive features, and is environmentally conscientious.

VISUALIZING FINDINGS

As designers, we understand things best visually. Therefore, to make sense of all of the background information, we decided to make a series of graphics that illustrate the complex biological and social systems we have been studying. These graphics are also intended to serve as educational materials for the MaST center, which will help explain these systems to the general public, making them part of the reef project as well.

Figure 1. *Diver Experience*

Diver Experience

Figure 1 is intended to summarize all of the information we have gathered about what affects a diver's underwater experience, as well as what policies are in place to dictate how and where reef structures can be placed.

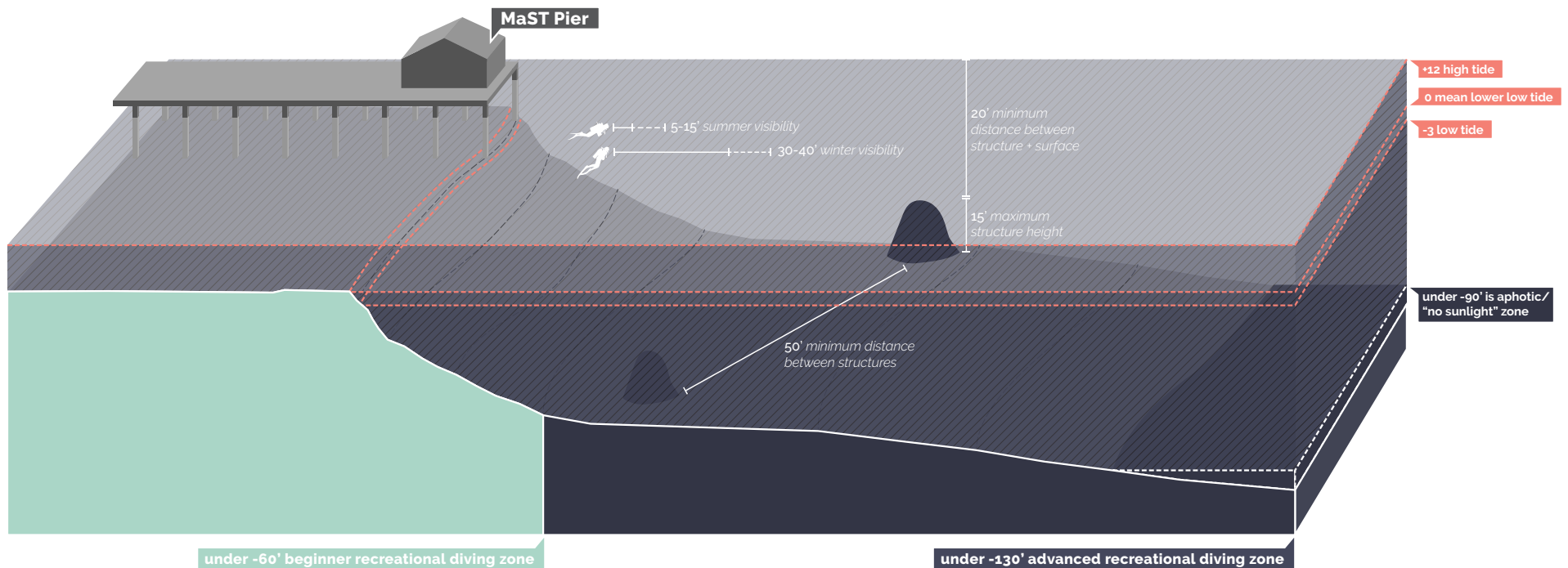
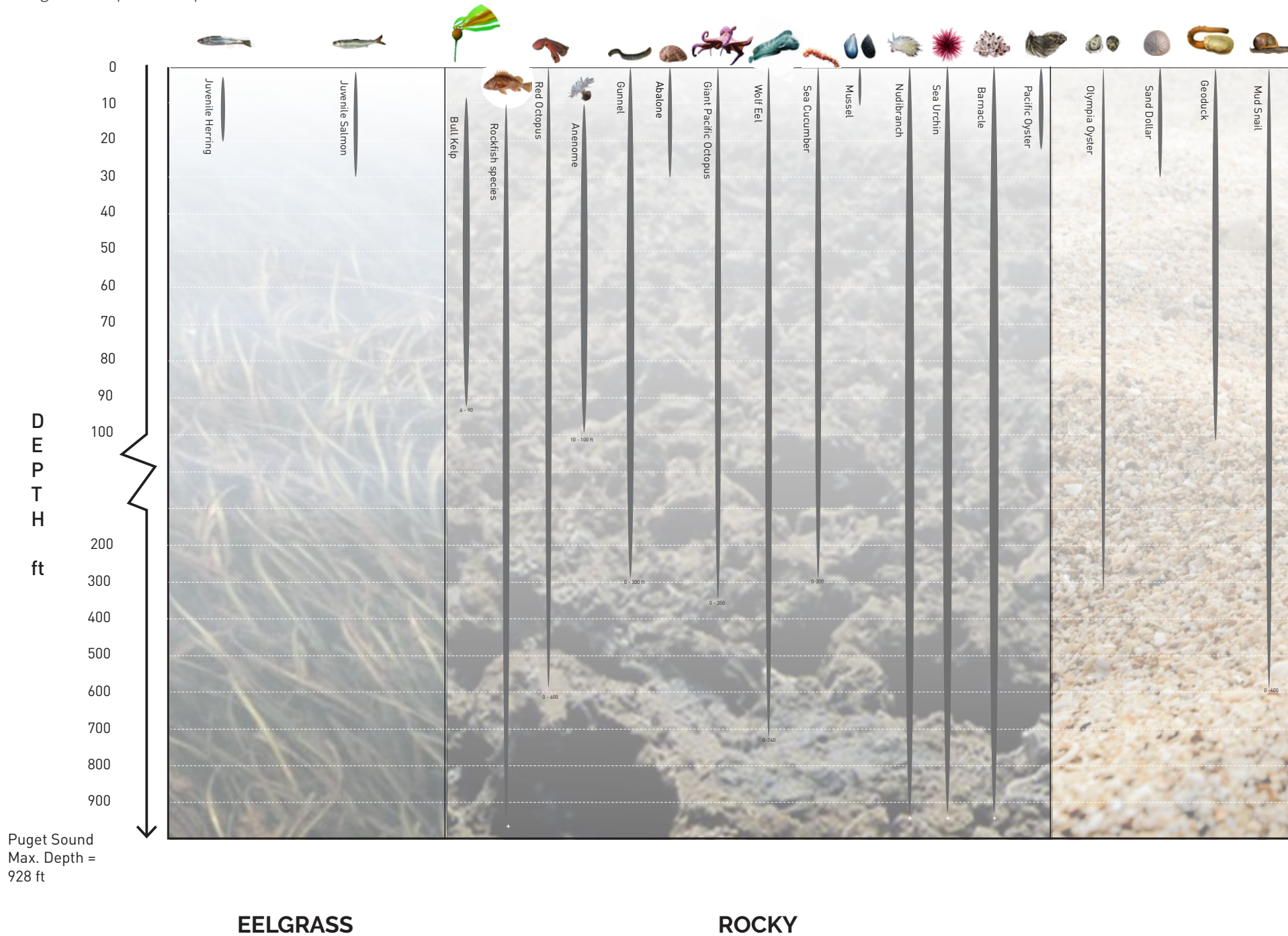
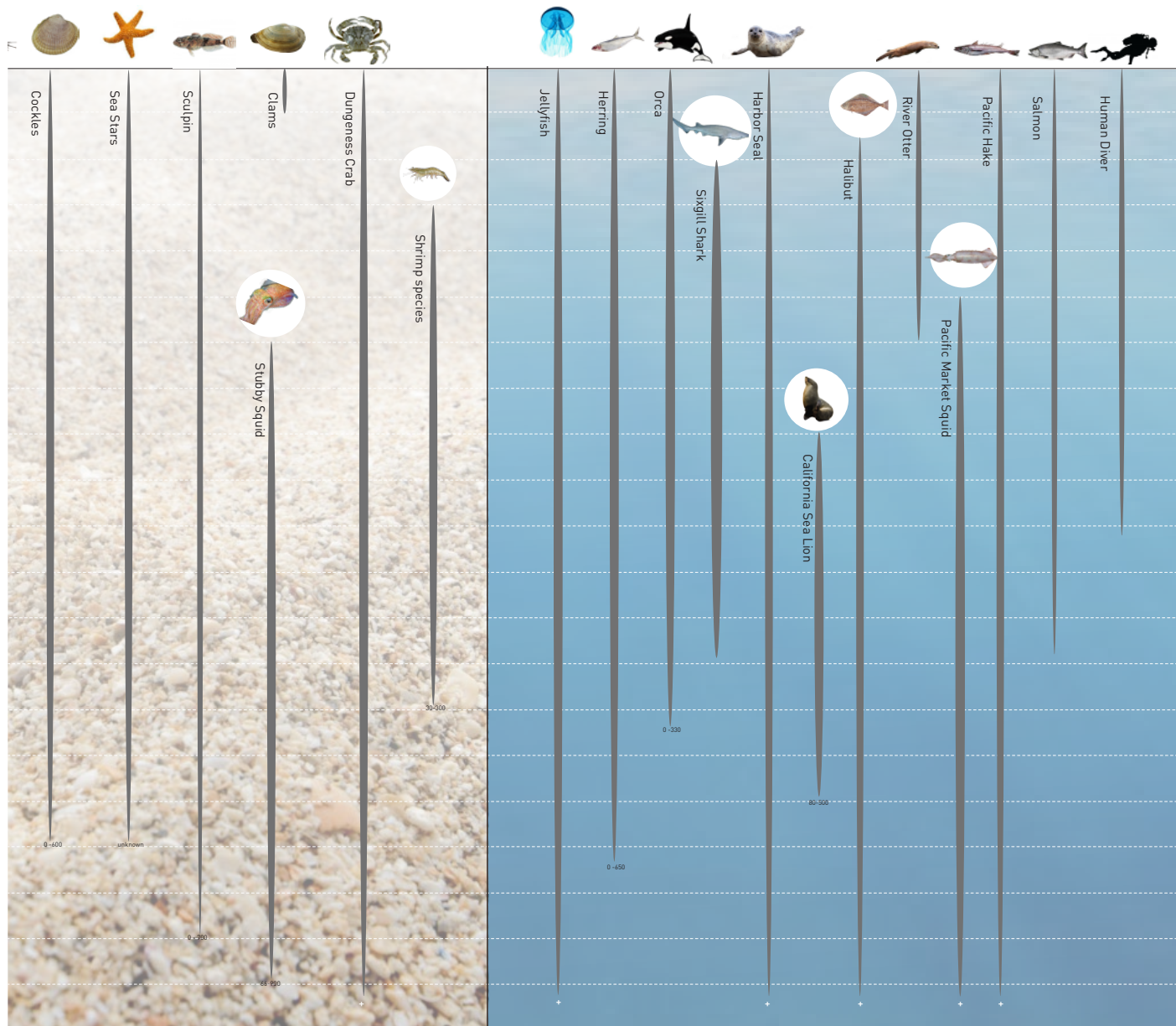


Figure 2. Species Depths + Substrates





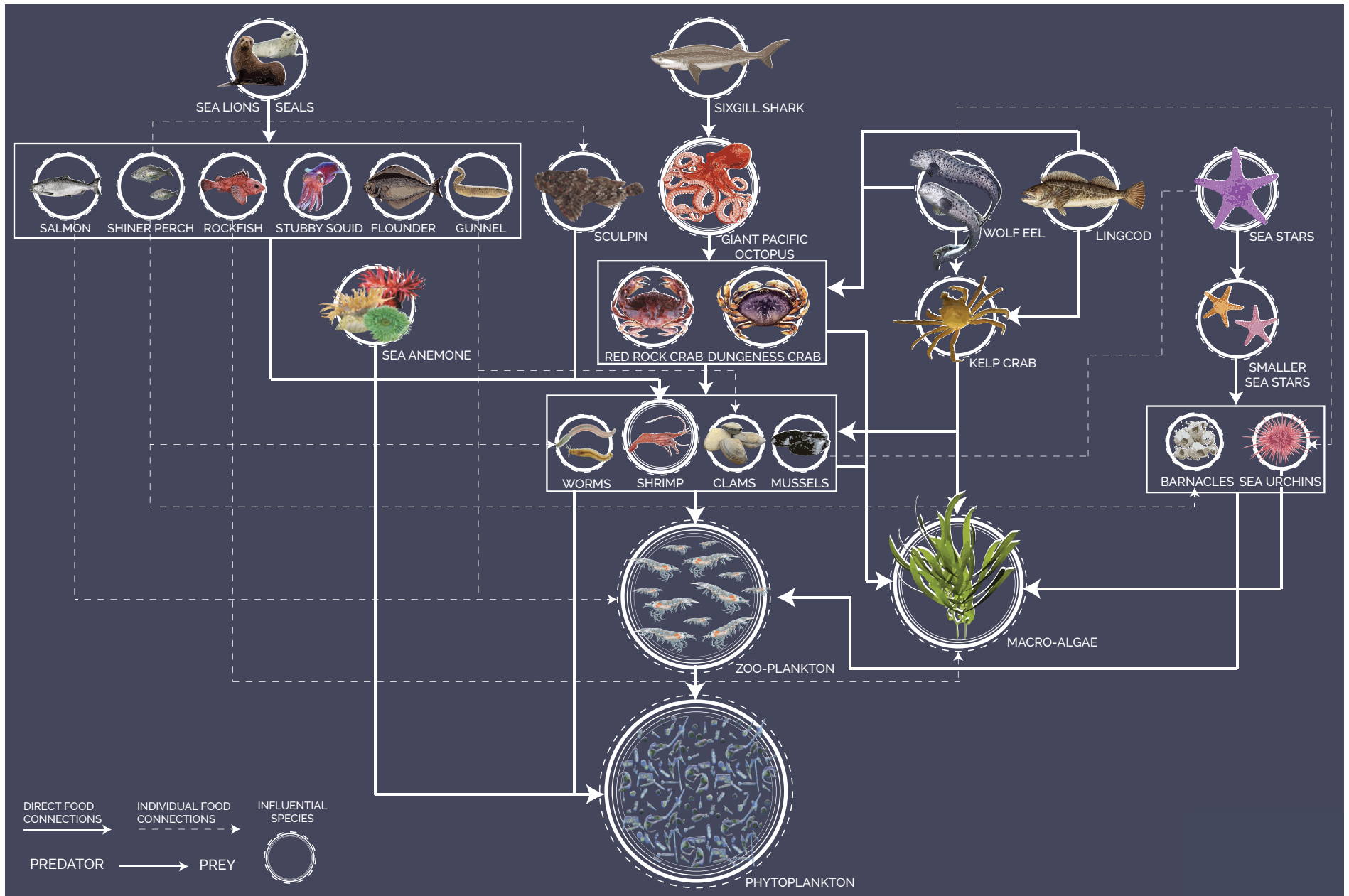
Species Depths + Substrates

Figure 2 visualizes key species of nearshore and marine ecosystems within Puget Sound. Length of line corresponds to the range of depths a given species may be found within, while its location along the x axis indicates the type of environment it is typically found in.

SANDY//MUDDY

OPEN WATER

Figure 3. Food Web of Common Redondo Species



Food Web

The food web displayed in Figure 3 illustrates the species that are currently in Redondo along with species that we want to emphasize in our reef design. Many of the listed species are diver favorites and divers want to see more of these species in the reef. This food web shows the feeding relationships within a community of Redondo species and how they relate to each other. If the circle is larger with more rings, it means that it is an influential species in the web and without it, the ecosystem would be extremely different. The solid lines are main food sources while the dotted lines are secondary food sources for those species. While this food web emphasizes important connections within the Redondo ecosystem, it only illustrates a small quantity of life in the area and it doesn't cover all connections throughout Redondo for reasons of clarity and complexity.

Habitat Renderings

Figure 4 and Figure 5 are illustrations of marine life, and indicate relationships between species living within four different habitats present in the area surrounding the artificial reef. Marine plant and animal life is interdependent and shaped by the edges and interactions of benthic and pelagic substrates and species. The goals of the reef are to support the rich life of Puget Sound's nearshore ecology with an emphasis on smaller organisms.

Megafauna Near Redondo

Kelp and sandy habitat in Redondo host a dynamic community of larger species. Kelp habitat provides places for species to live and a place for them to feed. The edge condition between sandy and kelp habitat offer diversity for species like fish, crab and eels to both live and feed.

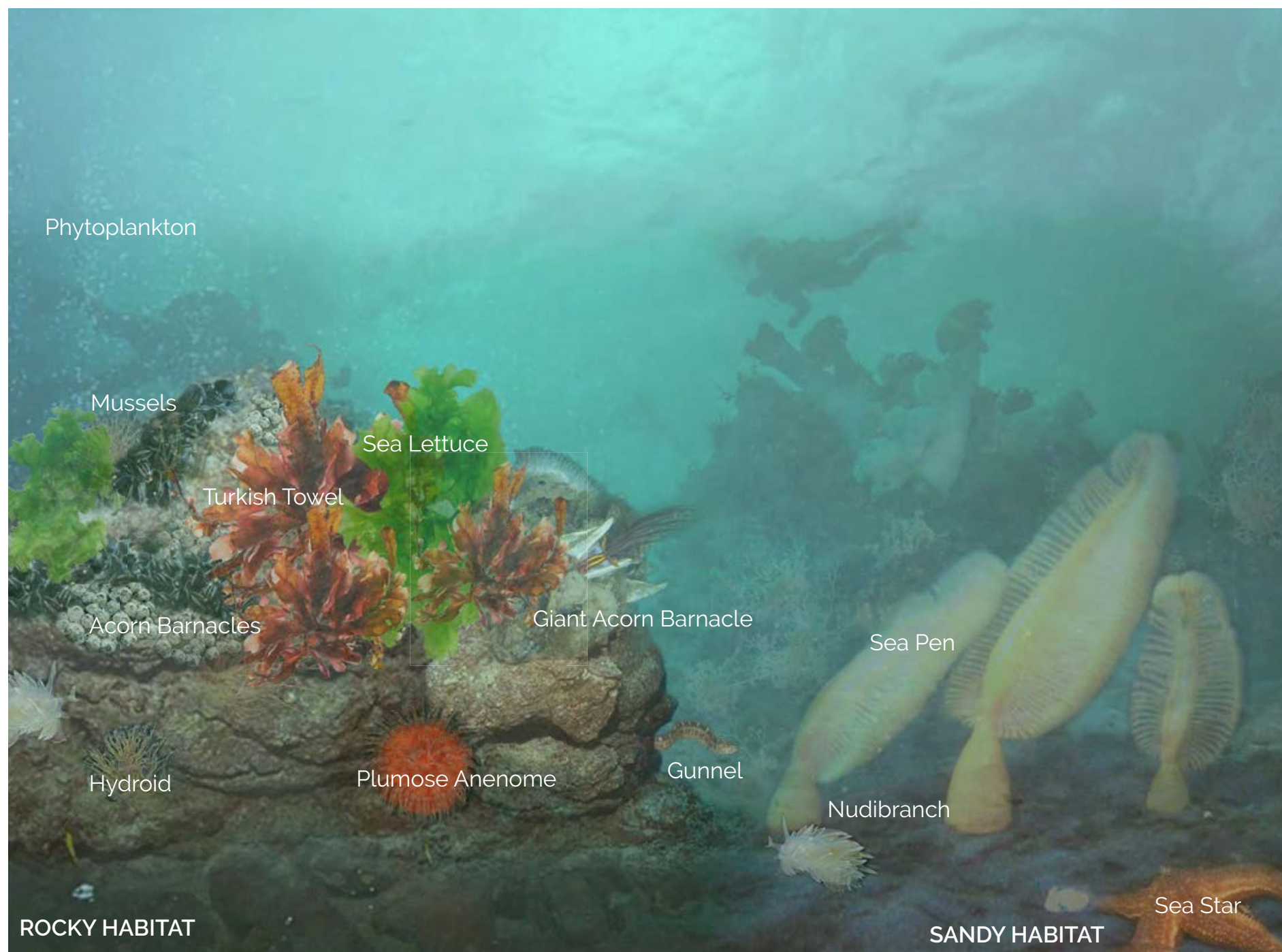
Smaller Life + Meiofauna Near Redondo

Larger rock, gravel, and sandy habitat host a variety of the smaller life that dive sites around Redondo are known for. An artificial rocky reef with a high degree of 3D complexity creates textured habitat, attracting meiofauna that then attract megafauna.

Figure 4. Megafauna Near Redondo Reef



Figure 5. Smaller Life + Meiofauna Near Redondo Reef

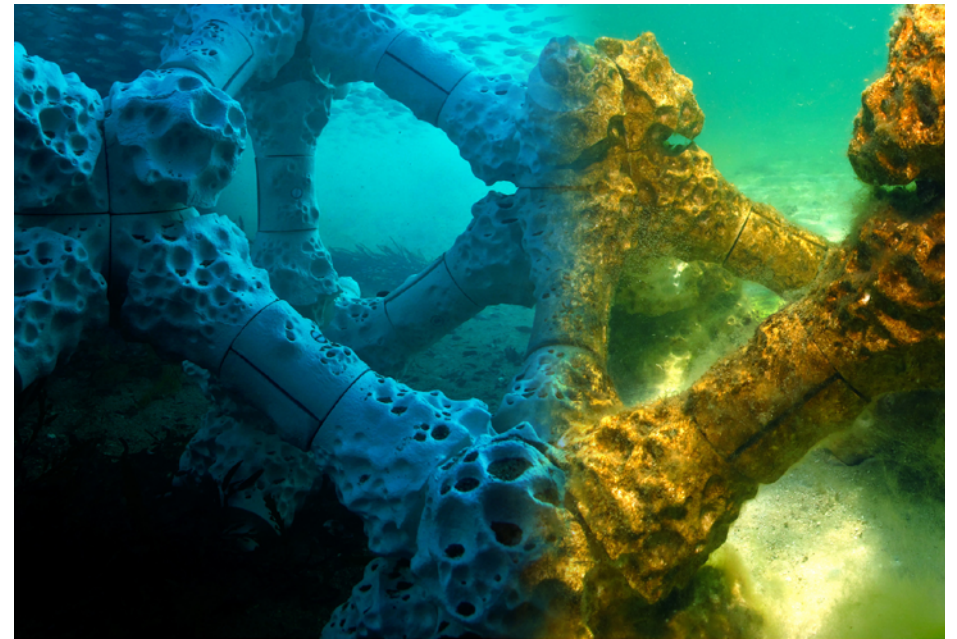


ANALYZING REEF PRECEDENTS

It is important to understand what has already been done and learn from other's successes and failures rather than starting from scratch. Therefore, we spent time at the beginning of this process researching and collecting examples of places where artificial reefs have been installed elsewhere throughout the world.

Notable things we discovered when researching these precedents were that there are few, if any, examples of artificial reefs being constructed from completely natural materials; many examples incorporate aspects of art, often using artist-designed pieces for the actual structures; and many of the reef designs exist in warmer climates.

The following precedents are representative of the projects that provided us with the most inspiration for our own reef design process.



Reef Design Lab

Melbourne, Australia, www.reefdesignlab.com

Modular Artificial Reef Structure: 3D printed reef structures designed for coral reef restoration.

Eco Engineering: Complex textured seawall tiles, digitally-designed, used in habitat restoration and wave attenuation.



Bull Kelp Restoration Project

Hornby Island, British Columbia

Nile Creek Enhancement Society in British Columbia is experimenting with recolonizing Bull Kelp (*Nereocystis luetkeana*) by collecting sori (reproductive structures) from wild kelp and growing them in their lab to gametophyte stage. Sporophytes are then grown on string, which divers wrap around an experimental pipe lattice. This method is still being developed, but shows great promise, as transplanted kelp have started to reproduce and recolonize the structure.

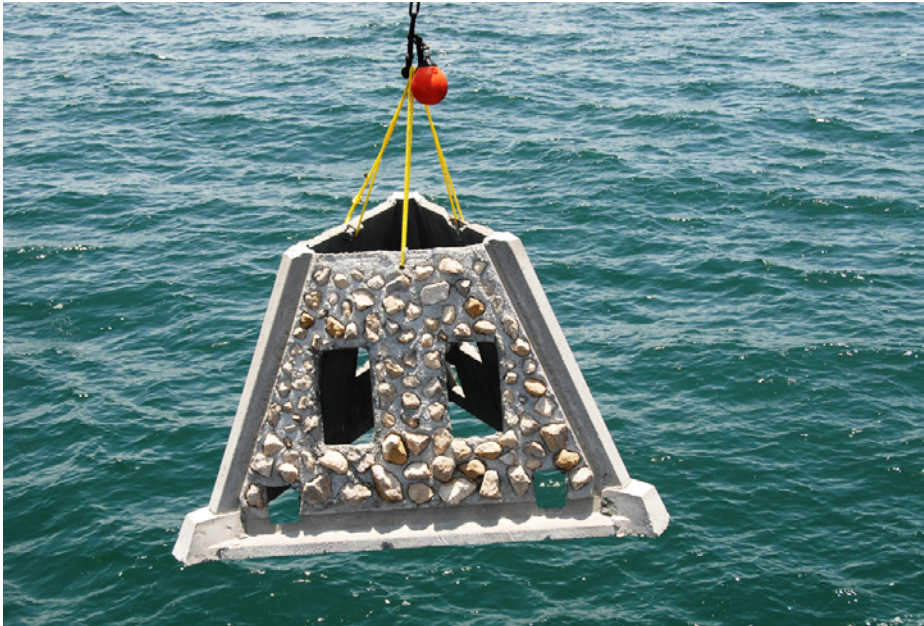


Isla Mujeres Underwater Museum

Isla Mujeres, Cancun, Mexico

This underwater museum was created by Jaime Gonzalez Cano, the director of the national Marine Park, to help the reef recover from the negative impacts of pollution, over-fishing, and global warming.

The project is composed of 500 permanent sculptures made from ocean-safe materials. These represent an interesting incorporation of art and artificial reef design.



Alabama Gulf Coast Artificial Reef Project

Alabama, U.S.A., AL Dept. of Conservation's Marine Resources Division, U.S. Army Corps of Engineers

Alabama has one of largest artificial reef programs in the world. While new structures are typically limestone aggregate or oyster shells, in the past, obsolete battle tanks, cars, culverts, and concrete bridge rubble among others were intentionally sunk to become artificial reef structure. There are a total of 30 inshore fishing reefs, five of which are experimental dual-purpose sites, providing excellent inshore fishing while improving oyster production on nonproductive relict oyster reefs. In addition, seven gas production platforms have been enhanced with limestone rock attracting fish pads.



Suan Olan Artificial Reef + Dive Site

Koh Tao, Thailand

This diver training site utilized pre-built concrete components to construct an interactive dive site including large rings for swim throughs, buoyancy rings, and structures to encourage diverse marine life.

The Island of Koh Tao received assistance from the Thai Department of Marine and Coastal Resources for funding and construction.

ESTABLISHING GOALS

We established the following Mission Statement, Goals, and Objectives in coordination in collaboration with our clients and other participants at the interim design charrette to help guide our design process.

Mission Statement

The Redondo Beach Dive Site will enhance permeability between upland and underwater environments by creating opportunities for public recreation, shoreline access, and environmental integrity while incorporating stakeholder needs and desires through the design of an artificial reef and associated upland improvements.

Goals

- » Goal 1: Maximize diver experience
 - » Objective 1: Designate as official dive site through DNR
 - » Objective 2: Provide on-shore amenities (bathrooms, showers, seating, staging area, access)
 - » Objective 3: Establish diving routes for beginner, intermediate, advanced divers
- » Goal 2: Maximize habitat diversity, particularly for targeted species
 - » Objective 1: Integrate complexity in reef materiality
 - » Objective 2: Create habitat for targeted species (wolf eel, octopus, chinook, rockfish, bull kelp, etc.)
 - » Objective 3: Improve water quality via targeted design interventions (e.g. rain gardens, stream daylighting, etc.)
- » Goal 3: Incorporate capacity for data collection and citizen science
 - » Objective 1: Establish transects
 - » Objective 2: Perform freshwater quality sampling design
 - » Objective 3: Test a variety of materials for viability in use of future reefs
- » Goal 4: Engage wider Des Moines community through arts, education, other socio-cultural enhancements
 - » Objective 1: Activate seawall through the incorporation of ADA accessibility, seating, other public uses
 - » Objective 2: Designate locations for community-designed art
- » Goal 5: Propose a cost-effective, implementable reef design
 - » Objective 1: Seek bids under \$250,000
 - » Objective 2: Utilize recycled materials over quarry rock where possible
 - » Objective 3: Encourage community participation in construction process where possible



III. SITE ANALYSIS

SITE CONTEXT

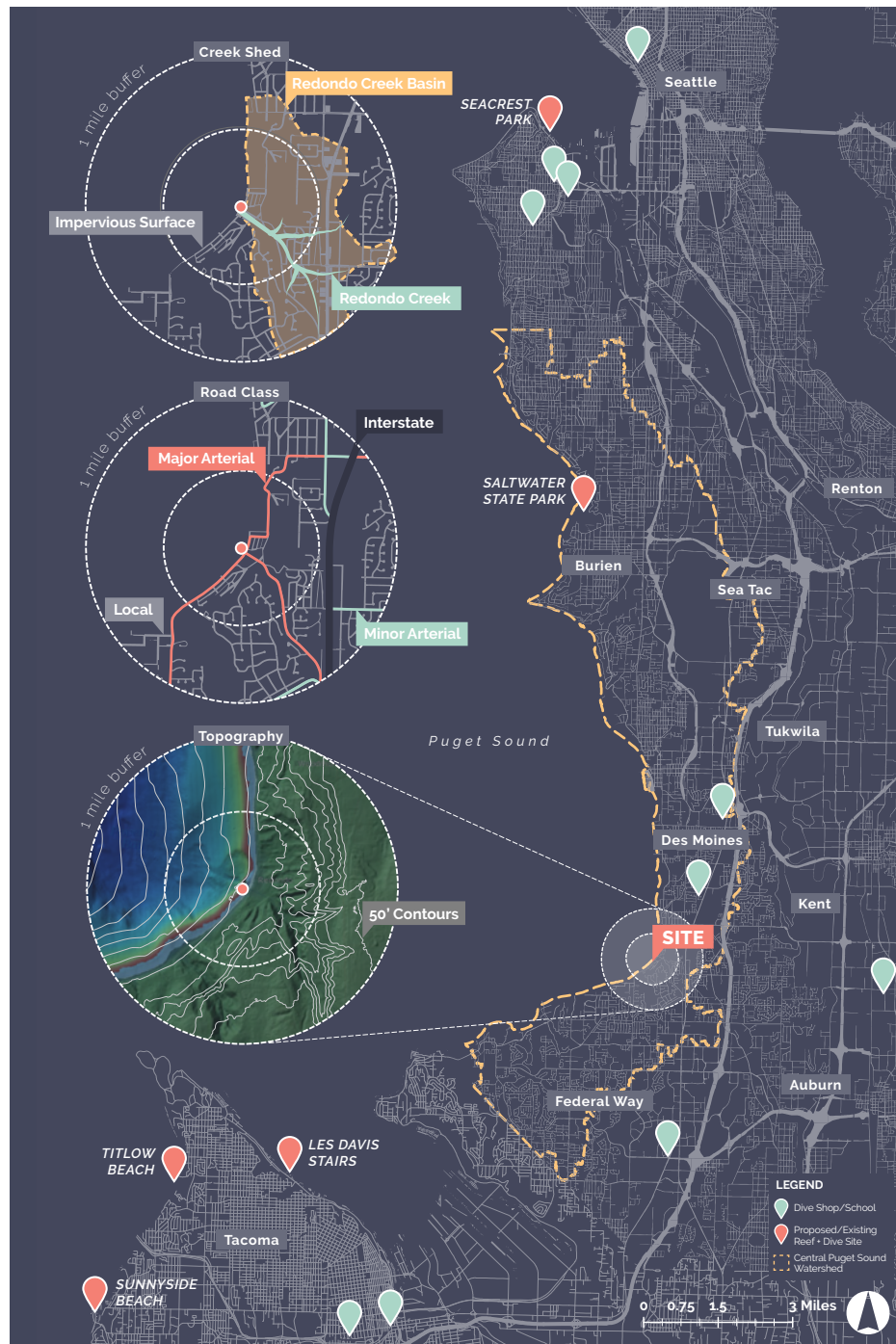
Salish Sea Context

The Salish Sea is an inland sea and network of coastal waterways including the southwestern edge of British Columbia in Canada and the northwestern corner of Washington in the U.S. A bi-national unified marine ecosystem, it is one of the largest and most biologically rich inland seas in the world. As human populations in the sea's drainage basin have increased, the health of this ecosystem has been impacted, especially marine water quality and marine species population health.

Figure 6. Salish Sea Context



Figure 7. South Puget Sound Context



South Puget Sound Context

Redondo Beach Dive Site is located in the southeastern corner of Puget Sound. It is in the City of Des Moines in King County, Washington. Figure 7 is meant to illustrate its proximity to other existing and proposed dive sites in the area, as well as where all of the nearby dive shops are. Three call out illustrations set to a one mile buffer provide context regarding the Redondo Creek-shed, the road classifications surrounding the site, and the topography and the bathymetry of the area.

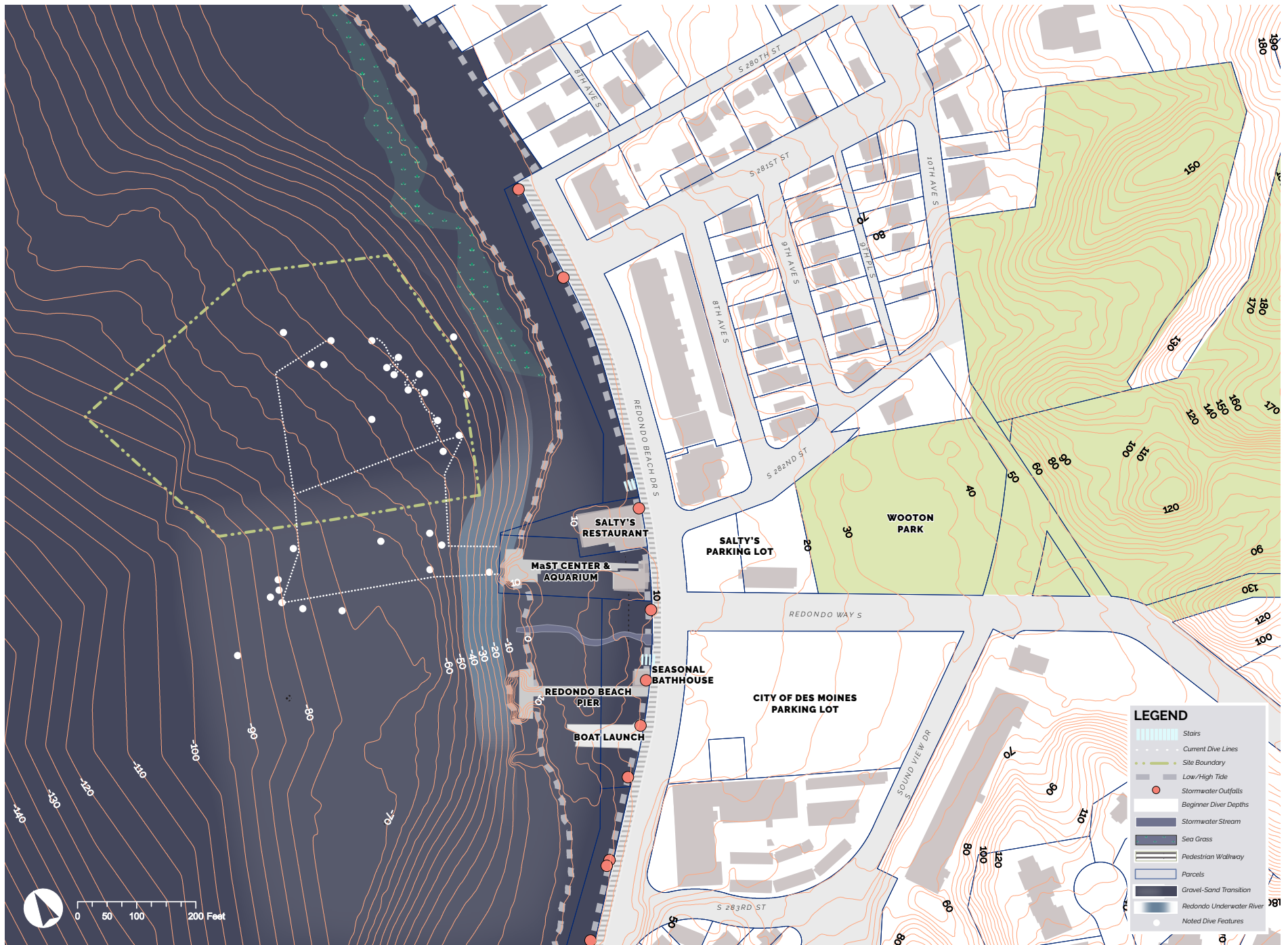
Watershed Context

Figure 8 depicts the existing conditions of the freshwater and estuarine environment around the dive site. Stormwater discharge outfalls, and points at which the creek is culverted, preventing fish passage, are identified with pink and red circles, respectively. According to the Washington Department of Fish and Wildlife, Redondo and Cold Creek have historically supported populations of coho salmon. The textured white overlay on Redondo Creek and Poverty Bay indicate its status as a Category 5 stream under the Washington Department of Ecology's Water Quality Assessment and 303(d) list. Category 5 indicates "polluted waters requiring a water quality improvement project." This listing is primarily for bacteria levels. Sea level rise projection data is courtesy of Climate Central, an independent organization of leading scientists and journalists researching and reporting the facts about climate change and its impact on the public.

Figure 8. Watershed Context



Figure 9. Site Analysis

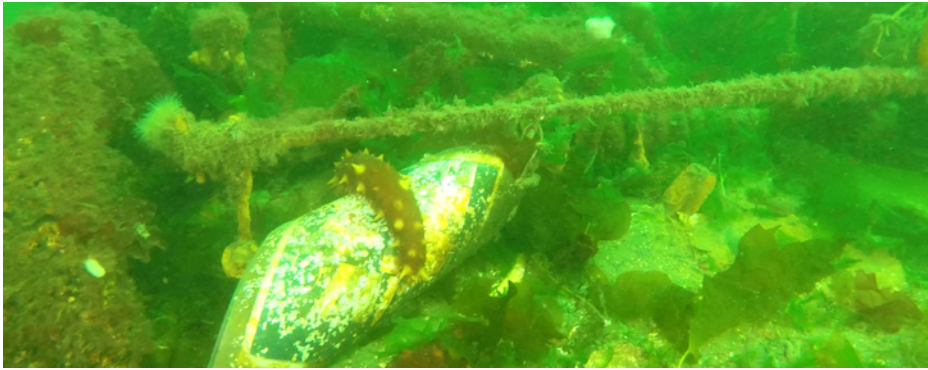


SITE ANALYSIS

Figure 9 illustrates existing conditions and features both on land and in the water related to diving. The map also shows the existing dive lines that connect to the many existing dive features identified by the local dive community. Existing upland dive amenities currently only includes parking and a seasonal bathroom and shower facility. As indicated by the red circles, there are also many stormwater outfalls that feed into Puget Sound in this location, which highlights how connected the aquatic systems are with those happening upland.

This information is overlayed with the proposed boundary of the new rocky reef to illustrate what portions of the existing site will be altered moving forward. In addition to the creation of rocky reef material, key areas of interest in creating a new dive site are water access, diver amenities, protection of eelgrass (*Zostera marina* L.) and nearshore vegetation, and the improvement of water quality.

The following pages include imagery of the existing conditions at Redondo Beach, both underwater and on shore.



Sunken, disintegrated VW Beetle frame (top left), dashboard (bottom left), and axle (right) (Images courtesy of Randy Williams)



Sunken Pipe Boat (Image courtesy of Randy Williams)



Sunken Tires (Image courtesy of Randy Williams)



Existing Access Point Over Sea Wall



MaST Center and Aquarium



Existing Staircase Used To Access Reef



Existing Buried Redondo Creek Outfall



Existing Buried Redondo Creek Drain



Existing Gazebo at Wooton Park



Existing Boat Launch and Fishing Pier



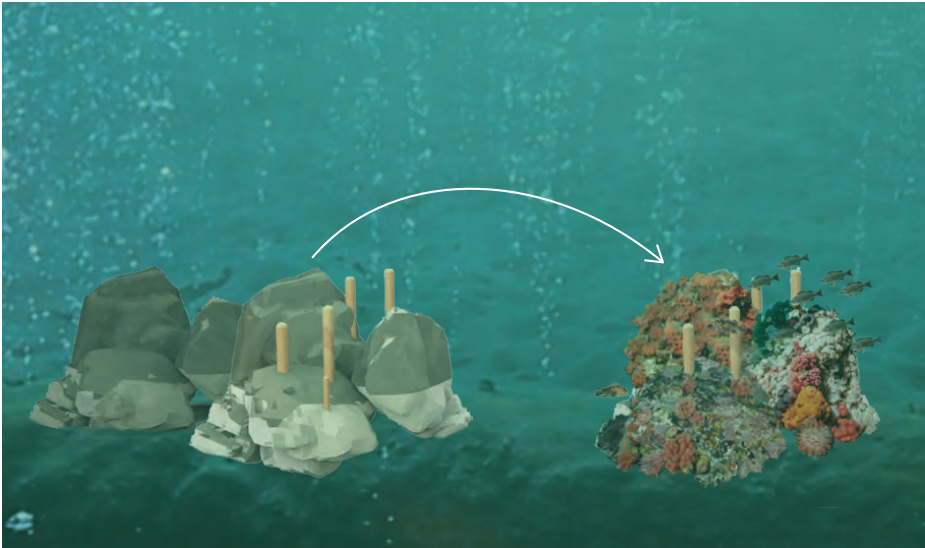
Existing Crosswalks leading to MaST Center From Parking Lot



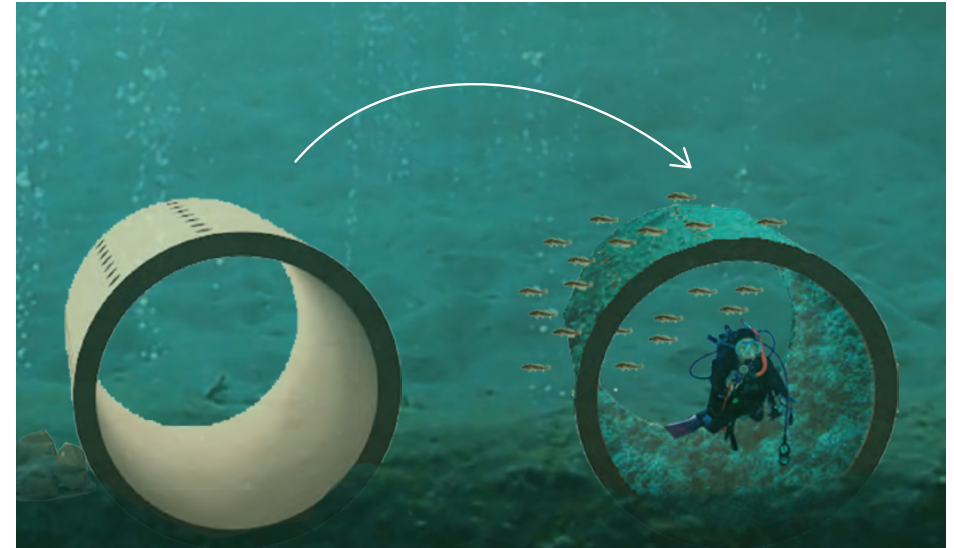
Existing Gazebo at Wooton Park



IV. MATERIALITY



Reclaimed Rip Rap



Culverts

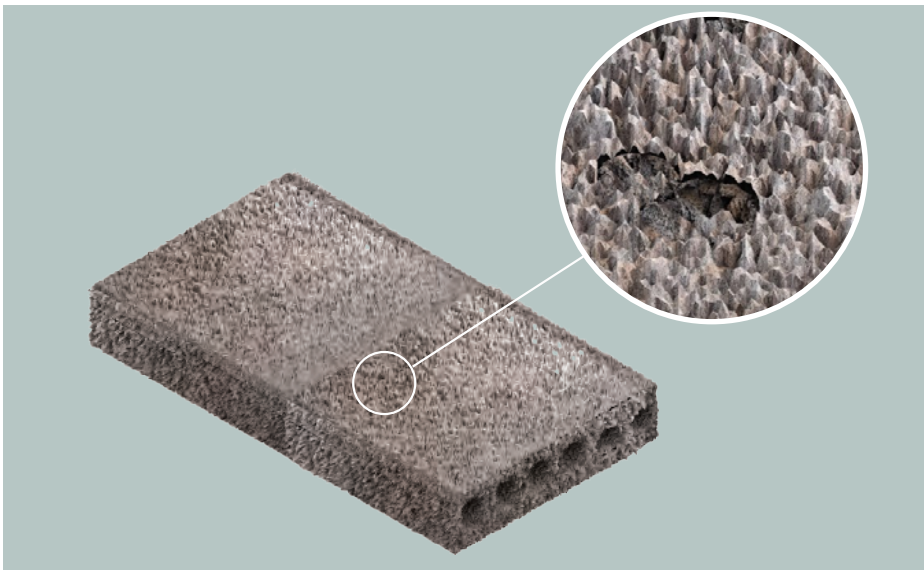
DIGITAL EXPLORATIONS

Recycled, Re-purposed, Reclaimed, + Amended

We propose diverting waste stream stone and concrete to construct the majority of the structure. The reef will primarily utilize rip-rap from seawall de-armoring, discarded cast concrete structures, and temporary materials. Budget that would have gone towards purchasing mined quarry stone can be redirected to some purpose-built cast structures made with ocean-safe, eco-friendly concrete. Examples of how reclaimed rip rap and culverts, both at the time of implementation and once life has established are displayed above.



Textured Concrete



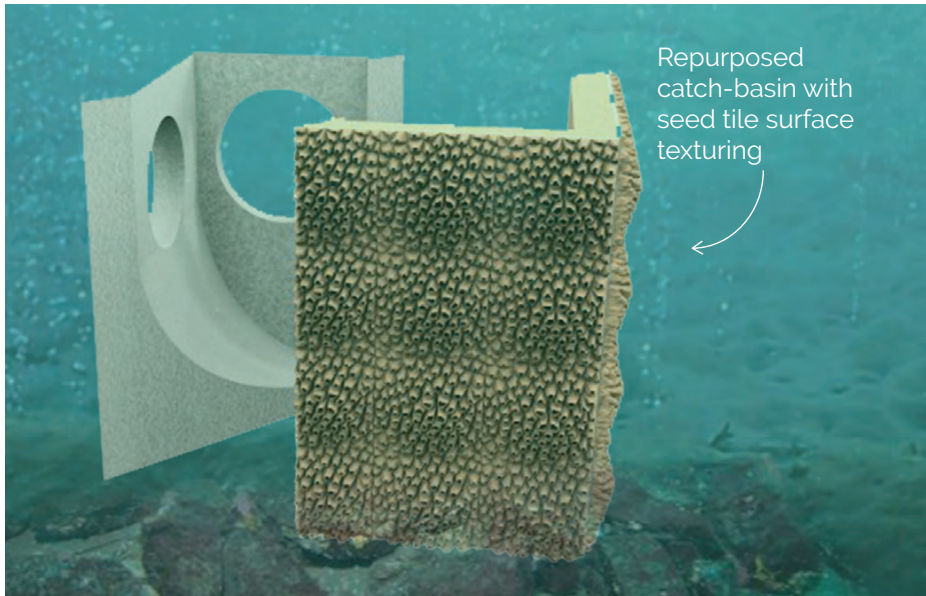
Textured Concrete Detail

Re-purposed concrete, as displayed to the left, can be manipulated for 3-dimensional complexity, as it can be too smooth for successful habitat formation without additional texturing. Possibilities are breaking, drilling holes, and surface amendments to expose aggregate. Materials from seawall de-armoring include a mix of granite, basalt and concrete. Stone surfaces can also be amended by texturing, drilling holes, and inserting temporary materials, such as wood, that will create habitat as they decay.

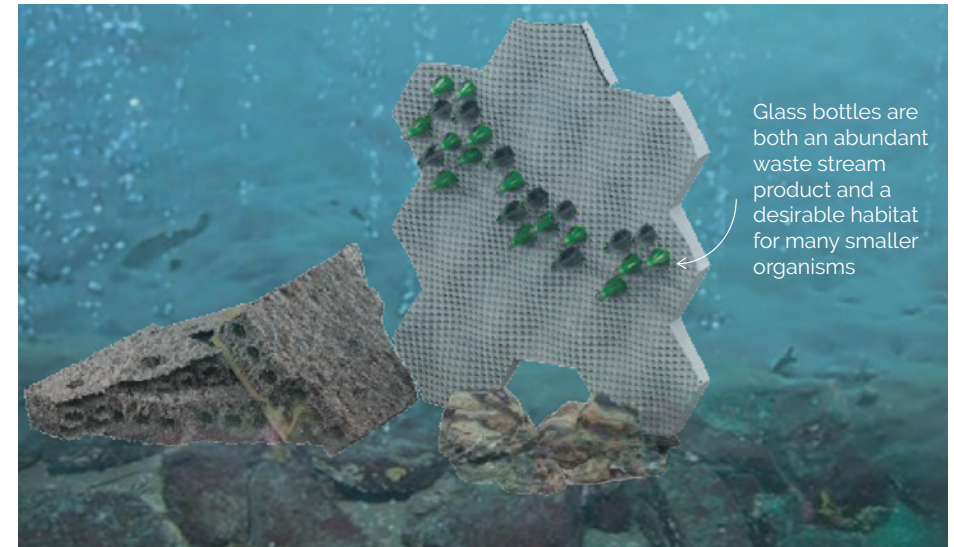
Amended + Purpose Built

The images to the right display what amended or purpose built materials could look like, both broadly and in detail. Inexpensive reclaimed concrete can become more viable habitat with surface texturing.

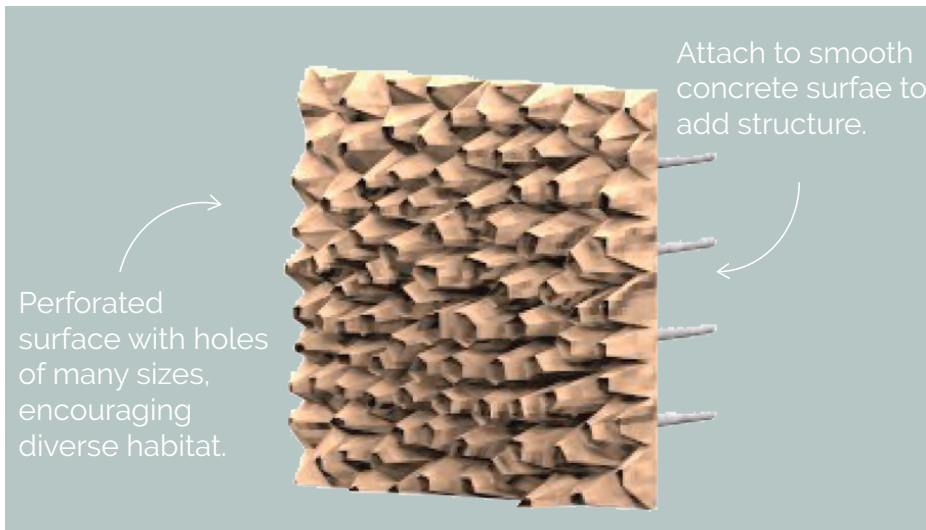
Magnesium Oxide Concrete, while more expensive than Portland Concrete is an order of magnitude stronger, more light-weight, and carbon-sequestering, to list only a few of its benefits. The material is ocean-safe and does not leach lime. Materials like glass can be cast in place in the material with a lower likelihood of shrinkage during the curing process, inexpensively adding textural richness.



Cast 3D Seed Tiles Detail



Ocean-Safe MagOx Concrete



Mixed Materials: Concrete + Seed Tile

PHYSICAL EXPLORATIONS

In order to explore the potential for casting as a way to generate complex forms, we created three small casts using plaster and a selection of natural materials. Our intention in using natural materials is that they will inevitably decompose when placed underwater. While they remain, they will provide habitat and nutrients to marine species, and once they decompose the marine habitat will expand due to the crevices that once surrounded each natural feature.

While the models we created were of a very small scale, there are meant to just be representative of the forms this type of fabrication can create. We imagine that the actual installations would be much larger, and that they could be tiled to cover unused manholes or other recycled forms. The natural content of all of these materials would conform with the strict guidelines set forth by the DNR, and pose no danger to the marine life that would inhabit each form.





V. REEF DESIGN

DEVELOPING INITIAL CONCEPTS

Following a period of background research, including site analyses, material studies and expert interviews, we proposed individual concepts for reef improvements. A selection of these design concepts are provided to the right.

In general, the conceptual designs we presented explored how structural and material complexity create desired habitat for a range of biological life and improved the diver experiences. More specifically, several proposed options explored the provision of natural and artificial forms, and diver circulation patterns. Additionally, several designs explored mixing rigid rock with found, reclaimed, reused or recycled materials.

These initial concepts were free flowing, and did not find themselves bound by the parameters of budget. We were free to explore broad sweeping changes that would enhance the reef in both the near and longer term. Thus, explorations into the role of runoff from Redondo Creek, and the potential for the reef to serve as a source of biological life and to mitigate impacts of global change began to appear in the discussions. From several of these big ideas came three more refined proposals that were explored more fully for the mid-term charrette.

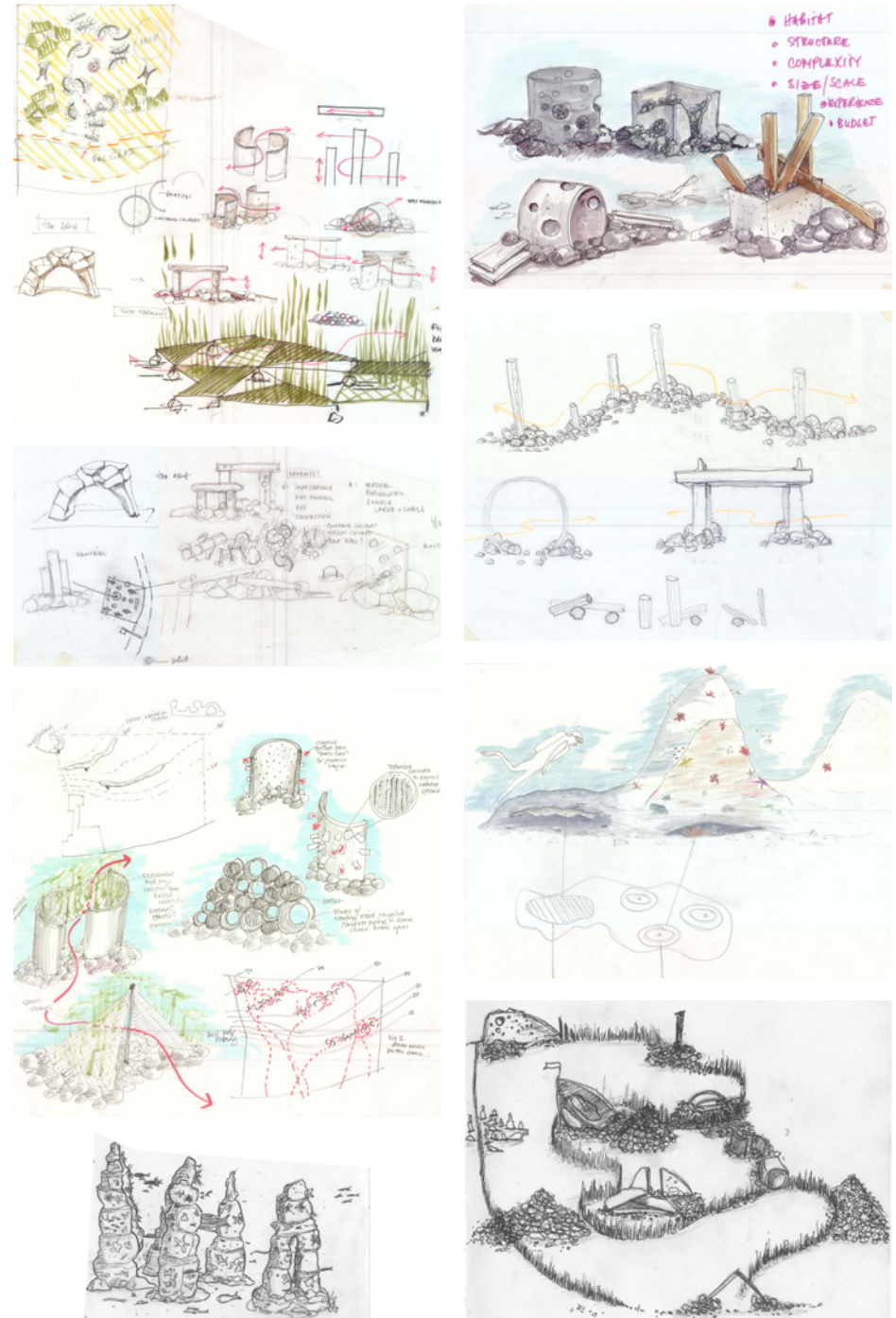


Figure 10. Alternative 1: Twelve Piles

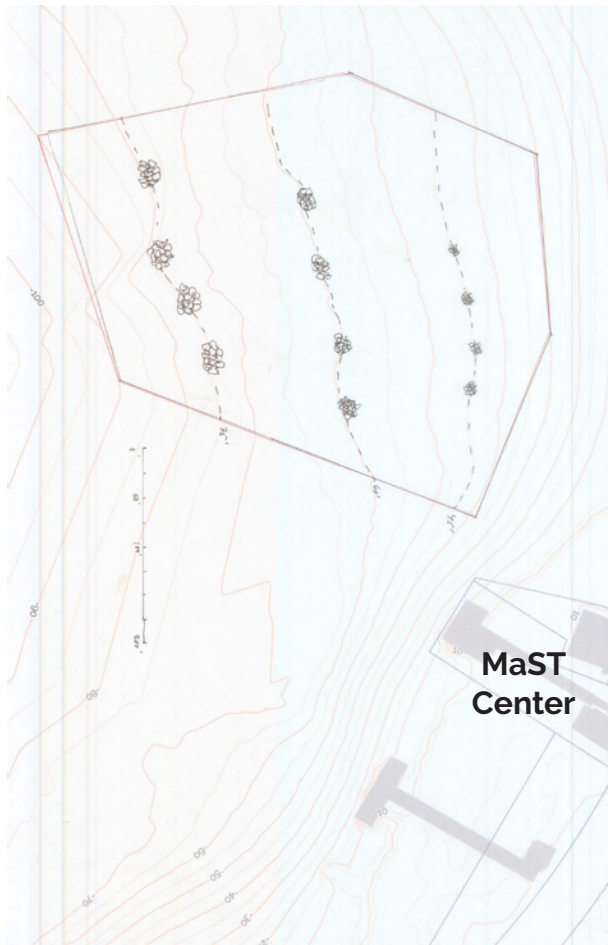
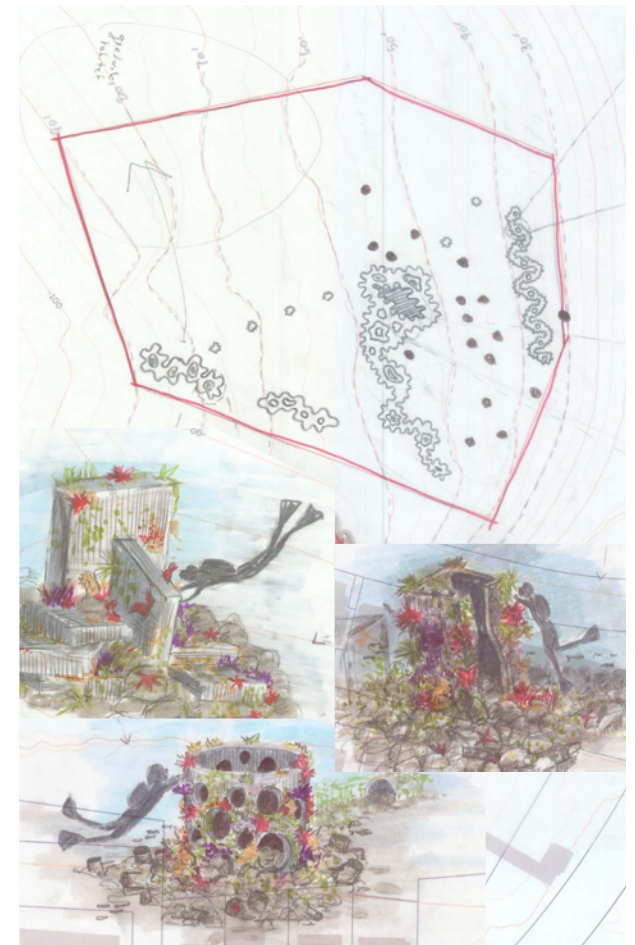


Figure 11. Alternative 2: Circular Arrangement



Figure 12. Alternative 3: Linear Arrangement



INTERIM CHARRETTE

For the charrette we presented three design schemes. One represented the initial plans for the reef that involved the placement of twelve rock piles (Figure 10), and two alternatives that we developed which introduced a circular scheme (Figure 11) and a linear scheme (Figure 12). The schemes we created were formed separately in two teams of three people. The intent of presenting three alternatives to the associated stakeholders was to establish a hybridized version to push forward that was based in the goals of those who would actually be implementing and using the reef.

For the design charrette we asked people from the diver community, city of Des Moines, Scuba Alliance, art commission and many others to attend to help narrow down our plans to move forward. We decided to combine parts of both schemes to have circular diving paths with linear piles. The conversation moved towards materiality and what materials we were looking at utilizing in our designs instead of just using rock for our structures. Our charrette team proposed recycled and ceramic materials which were well received and highly considered with our visitors. We were left with good ideas to move forward with to inform our final design. Everyone left the design charrette enthusiastic, excited about our work and wanting more.



Images of the Design Charrette Team

Figure 13. Proposed Master Plan

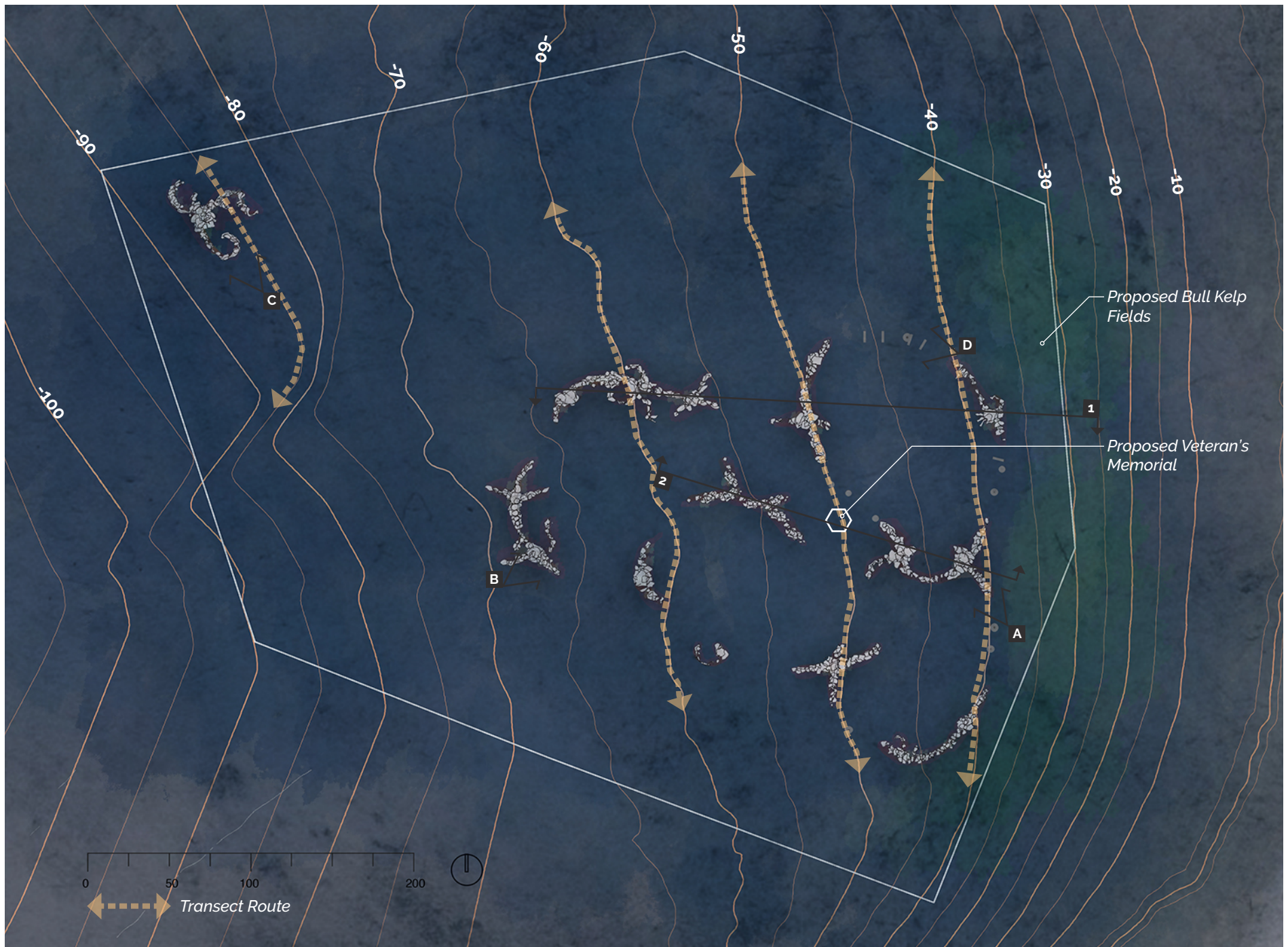


Figure 14. Sections of Proposed Master Plan

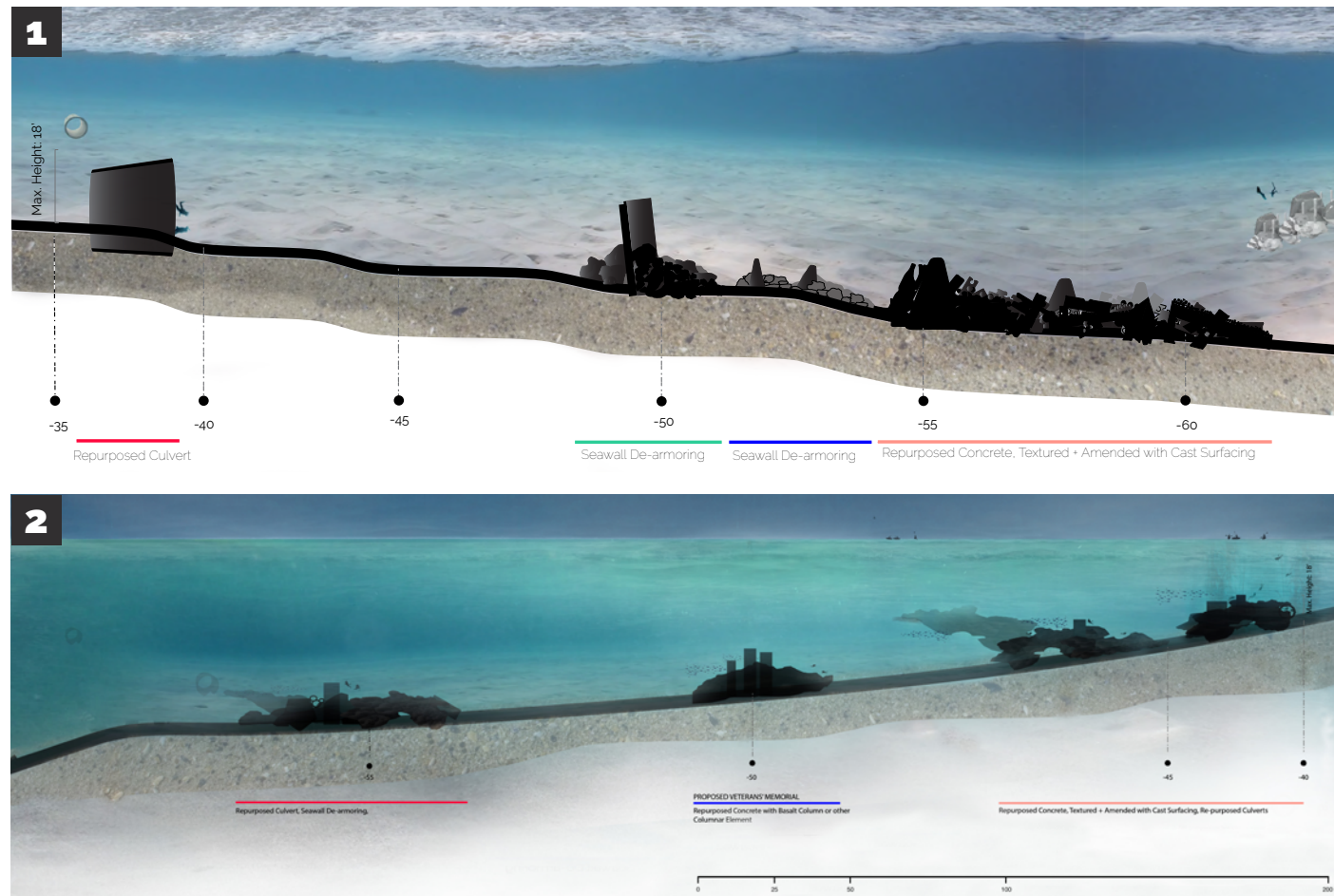
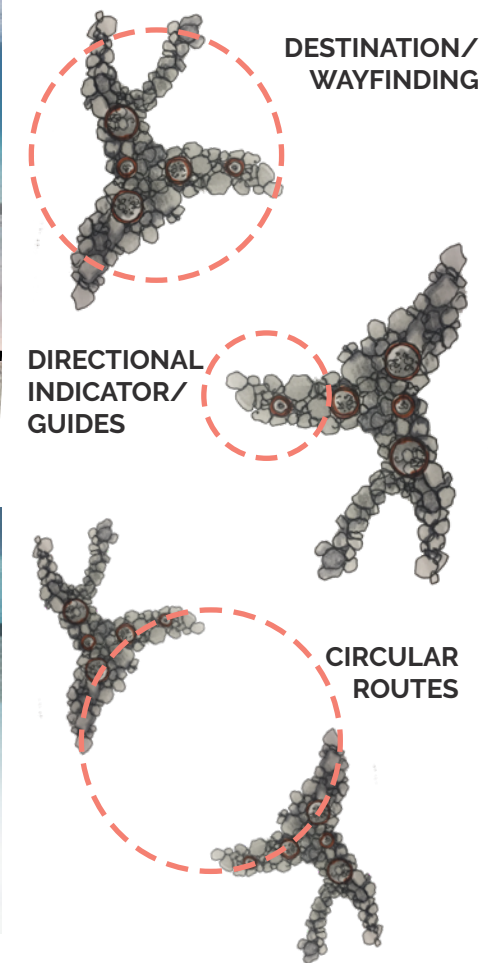


Figure 15. Reef Structural Features



REEF MASTER PLAN

This reef master plan was derived from what was developed in the initial stages and then tested at the interim charrette. It represents a hybridized version of the alternatives we presented at the charrette, carrying forward the most successful ideas to create our preferred master plan. Our main idea with this plan is the creation of complex, linear structures that support a diversity of marine species while creating an exciting diver experience. These linear structures are placed in a circular arrangement

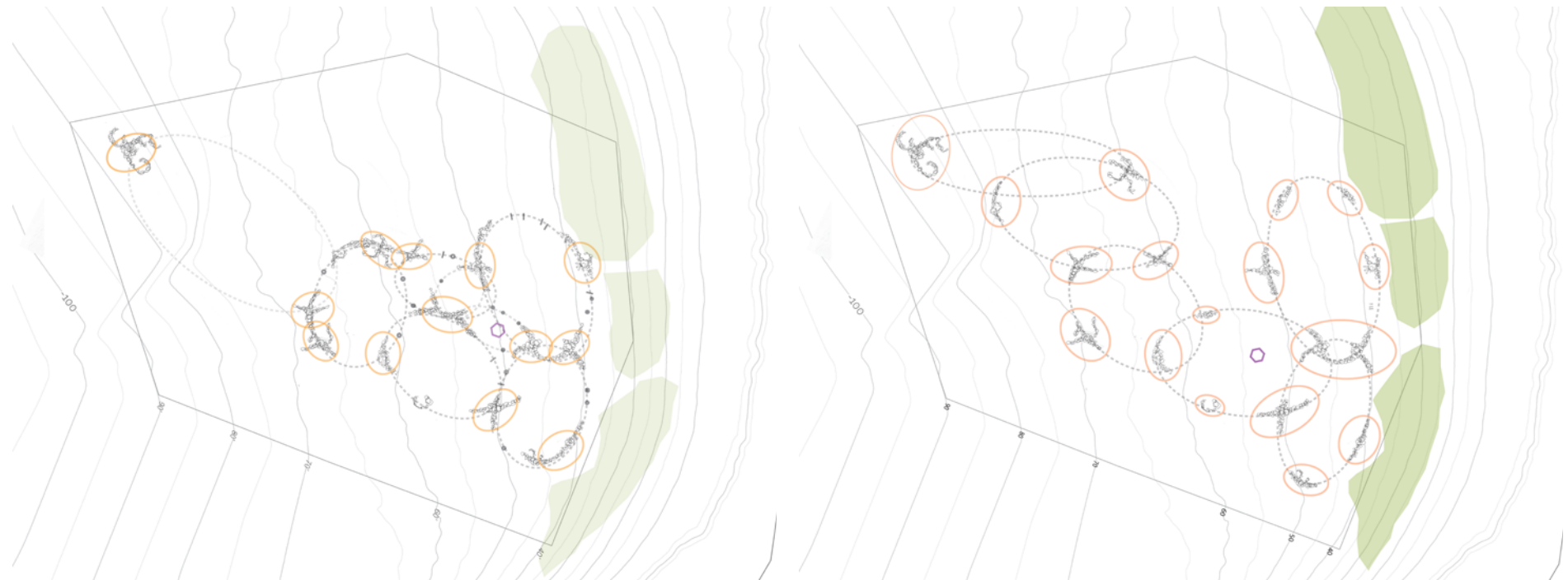
to aid in wayfinding while creating a variety of route opportunities. At shallower depths, materials are smaller to support a larger array of marine life but the structures themselves are of larger footprints. As you move deeper and construction costs increase, structures are made of larger materials and the structures compose smaller footprints.

As shown in Figure 15, the structures are composed to assist with

wayfinding. Each destination is intended to have a distinct theme and/or scale so each reef area is unique and identifiable. The “arms” of each structure work as directional indicators, guiding divers to the next structure along the designated route. The structures are arranged in overlapping circular routes, which together form a system of clear routes that provide safe and directive guidelines for a rich and varied diving experience.

Depending on how materials are procured and when adequate funding is available, these structures can be laid out in a variety of ways to accommodate client desires. Two of these arrangements can be seen in Figure 16.

Figure 16. Route Alternatives



Bull kelp restoration is also a proposed component of this master plan. There are several methods to consider with bull kelp restoration, which include:

- » Seeding ropes in an area known to have bull kelp - San Juan Islands, among others
- » Collaboration with Puget Sound Restoration Fund or other restoration organizations and experts
- » Student/citizen designed and monitored restoration efforts on which studies and papers might be published.

ILLUSTRATIVE PERSPECTIVE IMAGES

To help visualize what the future reef might look like, we developed a series of perspective images that illustrate reef conditions at a variety of depths. The included views are displayed on the site plan in Figure 13, and represent what structures might look like at shallow (Figure 17), intermediate (Figure 18), and deep (Figure 19) depths, as well as how one of the connections might be formed (Figure 20).

It is important to remember that the exact materials for these reef structures have yet to be procured. Therefore, the views displayed in the following graphics will not look exactly the same as the future dive site. They do, however, display the reuse of many recycled forms, an aspect we do hope is retained when the site plans are implemented.

Shallow Perspective

This vision of the reef (Figure 17) shows what a diving experience might look like in 5-10 years with bull kelp restoration. It is also a chance to imagine how reclaimed materials can be used for wayfinding and naturalistic design features. This scenario uses a reclaimed manhole, rip rap, and basalt scraps to create a unique diving feature that still utilizes a majority of natural rock.

Intermediate Perspective

This view imagines what a reef structure composed of a combination of reuse concrete rubble, concrete catch basins, and basalt columns may look like after several years underwater. A variety of sizes of recycled

Figure 17. View of Potential Shallow Depth Reef Structures



Figure 18. View of Potential Intermediate Depth Reef Structures



Figure 19. View of Potential Deep Reef Structures



Figure 20. View of Potential Connector Reef Structures



concrete material serve to create interstitial spaces of various sizes, establishing habitat for a wide range of Puget Sound marine life. Basalt columns are an example of a distinctive structural component that could serve as wayfinding to divers of the site.

Deep Perspective

Figure 19 displays how the reef structure might look in the deepest portion of the site. This view incorporates recycled bottles from the existing bottle field, which is currently at a very similar depth, as part of a vertical structure which could be created from a reclaimed man hole or other similar structure. Materials used at this depth are larger to support larger marine life while the footprint of the structure is smaller.

Connector Structure Perspective

Figure 20 displays a view of the reef is a transition point between reef structures using reclaimed manholes that have a texture applied to the surface to create different habitat spaces. This transition piece acts as wayfinding for divers to locate the next reef structure while also supplying habitat for divers to enjoy.





PHYSICAL MODEL

We developed a physical, three dimensional model of the Redondo Beach Dive Site and our proposed reef structures to help people understand how the site feels without having to be a registered diver. As a result, this model will serve as an excellent educational tool for the MaST Center to use to describe marine life and diver experiences. Some images of this model are included above.



VI. UPLAND OPPORTUNITIES

CONSIDERING UPLAND IMPACTS

As designers, we are attuned to the connections between systems. At the Redondo reef site, we found that a strong design integrating diver experience, ecological health, and habitat restoration necessitated exploring how waterfront and freshwater creeks meet Poverty Bay to create a complex, interdependent ecosystem. We expanded our study area beyond the reef site to assess water quality issues and the ongoing effects of climate change as important factors in the site's future. Based on our observations, we arrived at three scales of interventions, from a low-impact option that integrates a variety of green stormwater infrastructure into the existing waterfront, to an intensive approach that takes climate modeling for sea level rise into account, identifying areas of concern and proposing a framework plan.

While these proposals are suggestions for a later phase of the project, we believe that seriously considering environmental impacts and the effects of climate change along the waterfront and upland area surrounding Redondo Beach are significant aspects of designing a reef and caring for the marine life in Poverty Bay.

Watershed Connections

Redondo Creek emerges as a trickle (top right) or a roar (bottom right) from a culvert beneath the boardwalk at Redondo Beach. The stream, piped for a short length beneath paved streets, parking lots, and the boardwalk, is only one suggestion of the larger watershed and complex systems that Poverty Bay and the dive site at Redondo are embedded in.



Redondo Creek Spilling into Puget Sound as a Trickle (top) or a Roar (bottom)



UPLAND PRECEDENT ANALYSIS

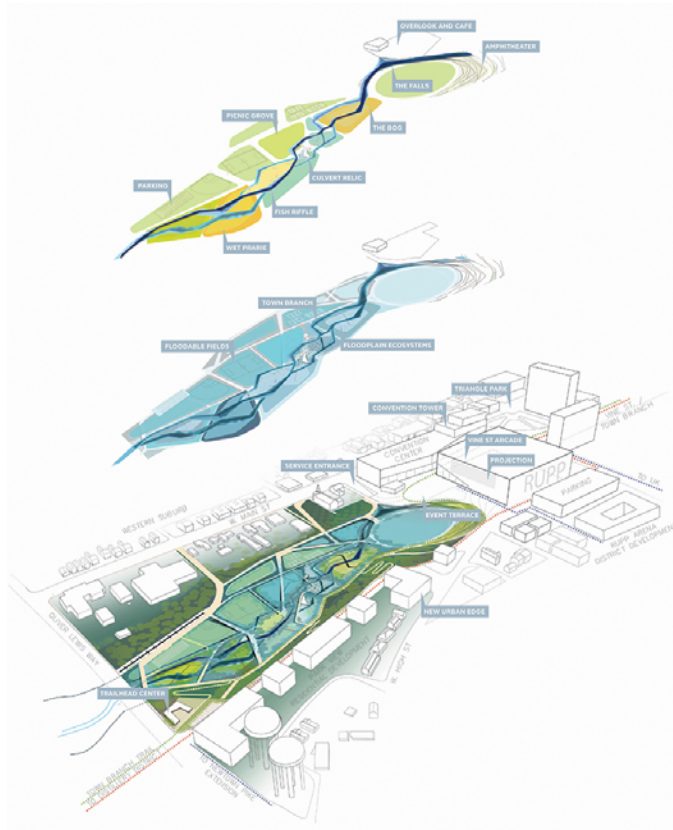
To understand how Redondo Beach might respond to future potential issues, such as increased pressures from human development and sea level rise, we looked at the following precedents to guide our proposed upland opportunities. The first two precedents are long-range planning initiatives implemented by other cities that are dealing with the same future issues as Des Moines.

Town Branch Commons, Lexington, Kentucky

Town Branch Commons is a daylighting project for Town Branch Creek that:

- » Will be a multi-functional public space
- » Brings public awareness to local waterways
- » Simulates natural function to restore creek function, but protect city infrastructure

Lexington is using a public-private partnership model to fund, construct, and maintain this future town asset.



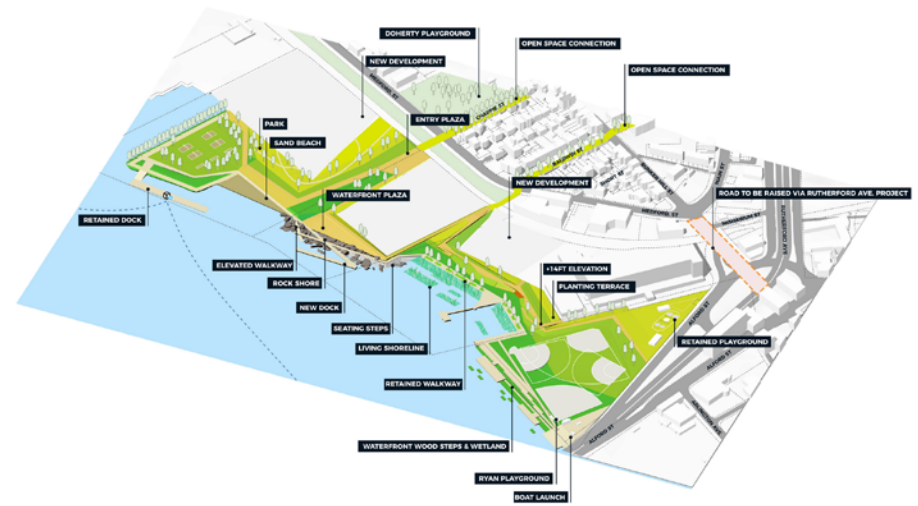
Images and design by SCAPE

Coastal Resilience Solutions For Boston

Boston is implementing a sea level rise strategy that includes:

- » Phased construction to address financial and functional constraints
- » Raised, but floodable public spaces to preserve real estate and add public resources
- » Some areas with naturalized coastlines and some with sea walls to direct water to prepared spaces

The East Boston Resilience strategy is part of several wider Boston initiatives to make the city more climate ready including Imagine Boston 2030 and Go Boston 2030



Images From: Coastal Resilience Solutions For East Boston And Charlestown Report

Individual Site Strategies

The following five precedents represent individual site strategies for cost effective, multi-functional solutions in response to sea level rise. Incorporating aspects of these precedents in the upland of Redondo Beach are essential in preparing the area for the unimaginable.

Figure 21 displays the consequences of projected sea level rise intervals on the Redondo Beach area. The current Redondo seawall is indicated for reference.

Intertidal Zone



Nisqually National Wildlife Refuge, South Puget Sound

Restored intertidal ecologies

- Provide many opportunities for quality public recreation
- Absorb large amounts of water and provide a cushion against storm surges
- Improve water quality
- Provide important habitat for nearshore organisms including salmon, eelgrass, and orcas
- Both partial and full coastline restoration provide extensive benefits and may cost less than traditional sea walls

For more information see:

Coastal Hazards Resilience Network
Puget Sound Nearshore Ecosystem Recovery Project
Shore Friendly
King County's Strategic Climate Action Plan

Figure 21. Projected Sea Level Rise

Mean Tides

**2018
rise: 0'**

Current

Shoreline



Curl Curl Beach Boardwalk, Greater Sydney, Australia

Shorelines are the most visible indicators in changing sea levels and are often the most damaged infrastructures

- Gradual infrastructural changes protect property and spread investment over time
- Can still be valued public resources
- Contamination and infrastructure damage is preventable with planning
- Larger, thicker sea walls are not always the most beneficial or cost effective approach

Extended boardwalks give the residents access to the Puget Sound and serve as a community attraction

For more information see:

State of Knowledge: Climate Change in Puget Sound
Preparing for a Changing Climate: Washington State's Integrated Climate Response Strategy
Puget Sound Nearshore Partnership

Nearshore Spaces



Hans Tavsens Park, Copenhagen, Denmark

Consider floodable nearshore spaces

- Serve as flexible or public spaces
- Protect property and infrastructure by directing floodwaters
- Enable healthier waterways alongside human habitation
- Give sewers and other infrastructures time to process large amounts of water
- Work independently or in concert with other infrastructure

For more information see:

Coastal Resilience: Puget Sound
Floodplains by Design
Denmark's floodable public spaces

Coastal Terracing



Trinity River Park Design, Dallas, Texas

Urban terracing protects buildings and infrastructure from flooding

- Provides community recreation space
- Helps water quality by filtering pollutants
- Can be done in stages
- Necessary urban infrastructure can be interwoven with coastal and riparian assets
- Emphasizes connections between Sound and upland

For more information see:

Floodplains by Design
Puget Sound Partnership
Washington Department of Ecology
The Nature Conservancy

Watershed



Thornton Creek Water Quality Channel, Seattle

Urban salmon populations can be recovered by daylighting urban streams and

- Improve water quality in the community and the Puget Sound
- Provide flood control
- Enable scientific study
- Decrease nitrogen pollution
- Need initial investment, but generally require less maintenance than gray infrastructure
- Can be done in stages

For more information see:

American Rivers: Daylighting Streams
Naturally Resilient Communities
Washington Water Trust

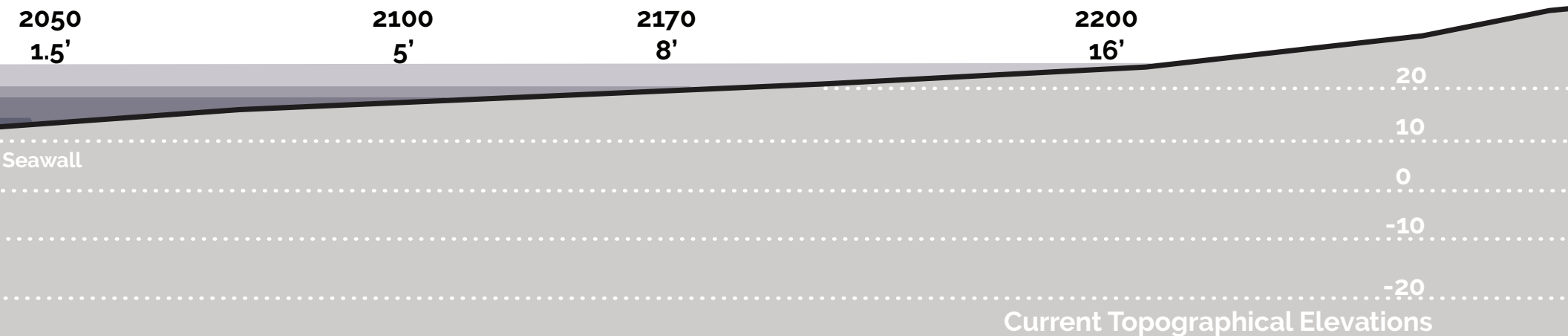
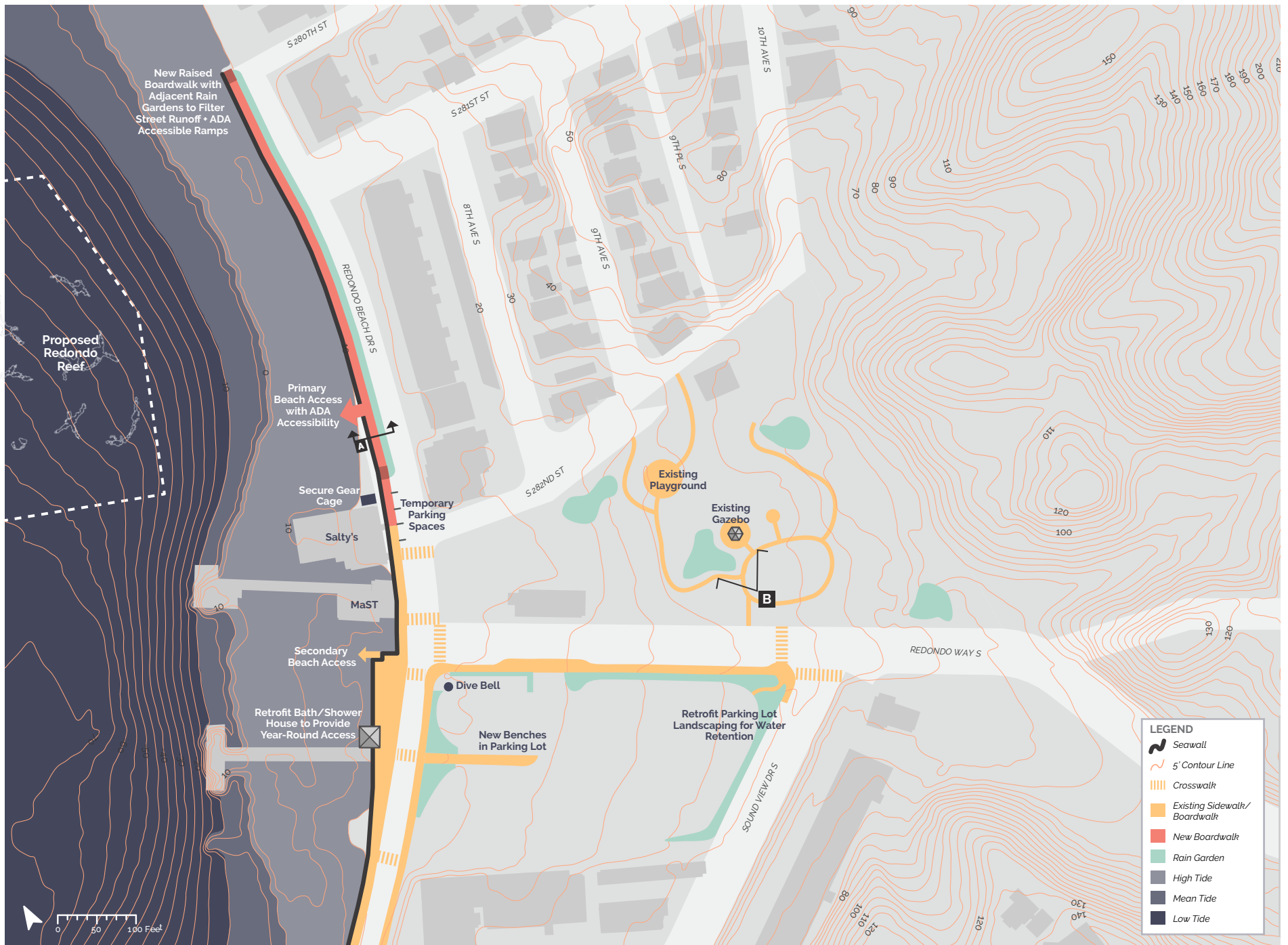


Figure 22. Upland Concept Phase One



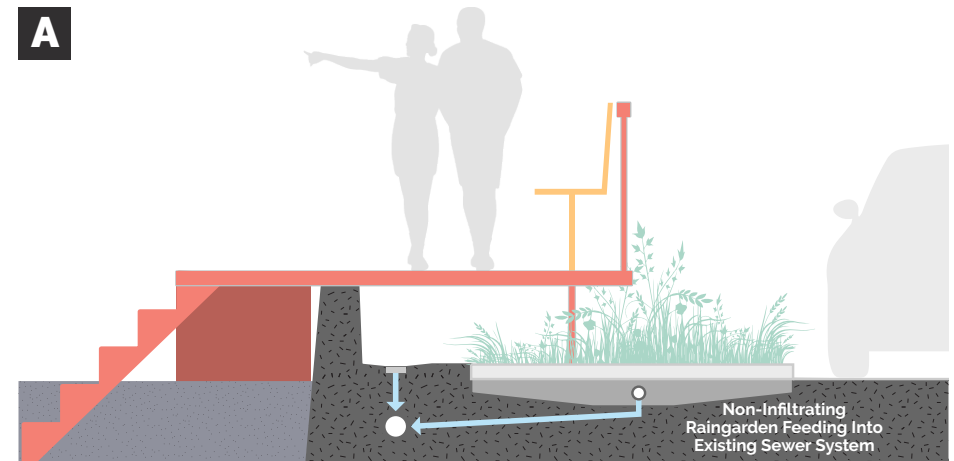
UPLAND PHASE ONE

The first phase of the upland redevelopment responds to the lack of walkability, the high traffic speeds, and the aging and insufficient diver amenities, while also setting up the basis of a system aimed at improving water quality feeding into Puget Sound.

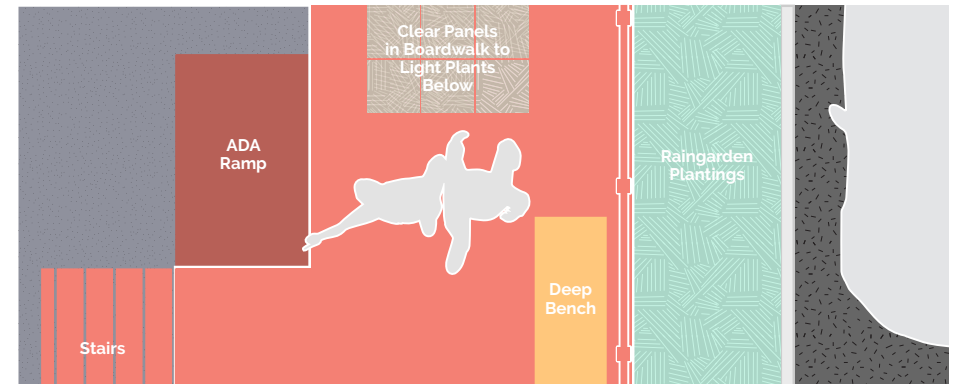
We are proposing a new, raised boardwalk be installed north of the MaST Center and Salty's to enhance the pedestrian environment and slow traffic speeds, while introducing ADA access across the seawall. An important feature is the creation of a bioretention buffer between the traffic lanes and the stormwater drains. This buffer would act to clean stormwater runoff prior to feeding into the existing sewer system. It would also enhance the aesthetics of the area and create further separation between vehicle and pedestrian traffic. This intervention would not alter the seawall in any way, and simply builds around it.

Other proposed interventions of this phase include:

- » Bioretention areas installed within the existing park and parking lot without altering existing amenities
- » Year-round shower and bathroom facilities at the existing bathhouse
- » Benches installed within the parking lot
- » Historic dive bell installed within the parking lot
- » Secure gear cage installed on beach



Section of Proposed Boardwalk

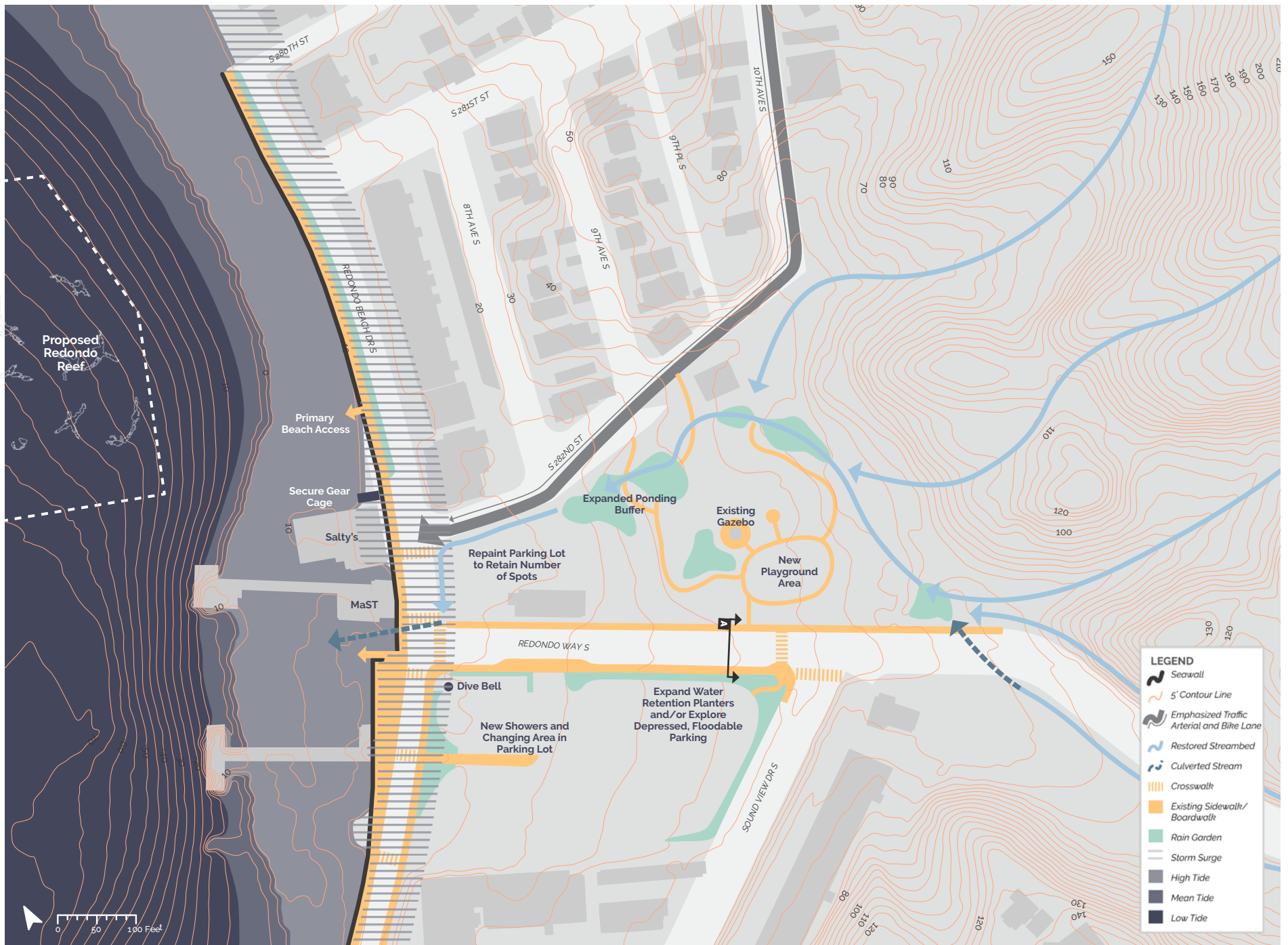


Plan of Proposed Boardwalk



Rain Garden in Wooton Park by Gazebo

Figure 23. Upland Concept Phase Two



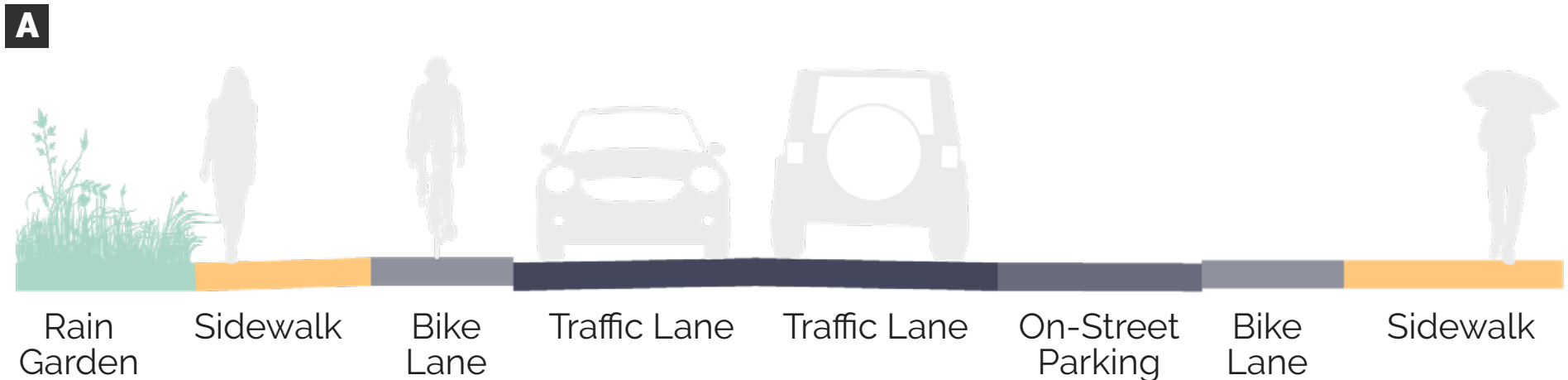
UPLAND PHASE TWO

The long term phase for Redondo Beach redesign offer future constraints and opportunities for the City of Des Moines. Our goals in this longer term phase are to enable a healthier water ecology for people and other life to enjoy both under and above water, while preserving infrastructure capital and property to the extent possible using current scientific projections of the future environment.

Notable design features and intentions:

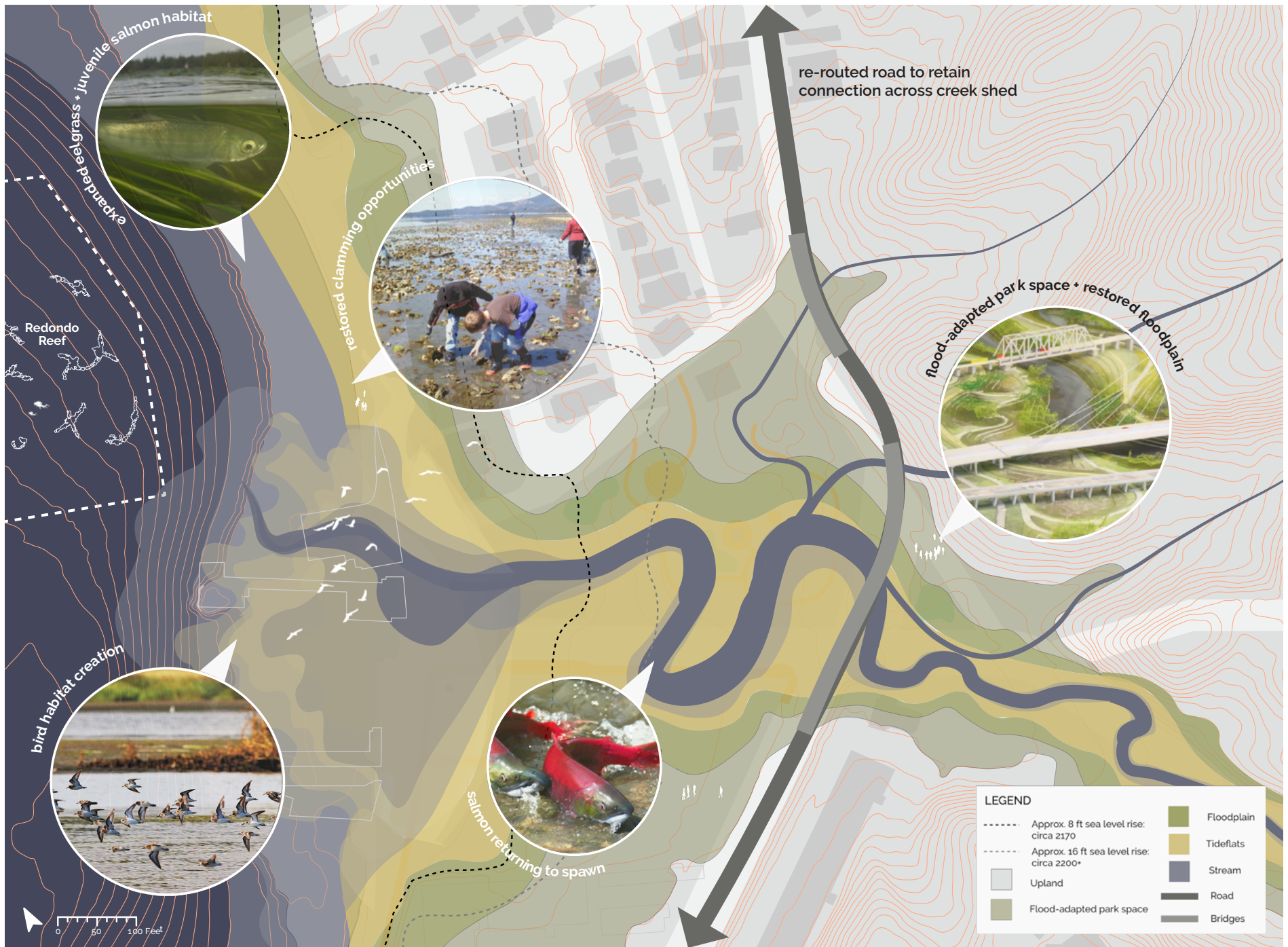
- » Install diver showers in the parking area
- » Create a more natural and less damaging sea wall using vegetation, terracing, berms, and wave breaks to allow water into areas that can be flooded to protect areas where flooding would cause damage

- » Connect the rain gardens installed in Phase 1 as a method of stream daylighting for Redondo Creek
- » Assist in restoration of salmon in Redondo Creek to the extent possible
- » Repaint the parking lot at Salty's to preserve the number of spaces, despite some stream daylighting there
- » Connect natural spaces along the water and in the park to be a more cohesive and desirable recreation space for Des Moines



Section of Proposed Streetscape on Redondo Way

Figure 24. Upland Long Term Possibilities



UPLAND LONG TERM POSSIBILITIES

This concept, which engages long-term sea level rise projections for what the Poverty Bay coast can expect to see within 200 years, responds to the inevitable threat of land and property encroachment by the sea. The black dotted line indicates projections for where the shoreline may be given 8 feet of sea level rise, currently projected for around 2170, while the gray dotted line indicates projections for where the shoreline could be given 16 feet of sea level rise, currently projected for sometime after 2200. While a heightened seawall to keep the water away represents a short-term solution, it is one that will become impossible to maintain in the long term as storm surges increase in size, quantity, and intensity.

This concept imagines a way to alleviate such impacts and costs by engaging the ongoing and inevitable inward march of the sea by restoring the stream and its surroundings to a more natural form. In this illustration, the stream is completely day-lit, its floodplain restored, and it is allowed to contribute sediment to surrounding mudflats and a natural, de-armored shoreline. In allowing the stream to function more naturally, low-lying areas form, such as the mudflats and floodplains

depicted in tan and green. These help to attenuate and absorb incoming fluxes of water from the bay, in addition to cleaning freshwater runoff draining into Poverty Bay via the stream. This vision also includes the concept of flood-adapted park spaces, a solution that has been proposed by innovative landscape architects for various scenarios and locations. Flood-adapted park spaces could take the form of terraces at a higher elevation, overlooking the floodplain and stream, that allow for recreational use as parkland while also functioning as a flood buffer for higher-elevation development. In very large storm or flood events, the floodplain could become inundated, and the park space would act as an additional buffer to prevent flooding of property. This concept allows for the built-in flexibility to respond to changing and accelerating natural phenomena at the land-sea interface while also supporting stronger ecological health and imagining greater opportunities for public recreation and ecological education.

Sources: Climate Central, Michael Van Valkenburg Associates



VII.IMPLEMENTATION

BUDGET

To ensure this project could be successfully implemented, we considered budget, phasing, community involvement and construction documentation. An important consideration for this project was mitigation, and opportunities to reduce negative impacts were explored involving the chosen materiality and construction methods.

Contractor Estimate

Overall, it is important to see this reef succeed, and to do so we need to make the budget stretch as far as possible. Meeting with the contractors helped us be more realistic with our design recommendations. Table 1 was developed based on our conversations with the contractors and illustrates an estimate for costs associated with constructing the reef entirely of new rock, and includes transportation, environmental, and labor costs as well as material costs.

Our earlier designs were much more elaborate, but understanding how costs were generated now allows us to plan for maximization of reef habitat and budget. We were able to estimate the amount of new rock we could buy based on our meeting with the construction company, and are now able to suggest some creative ways to stretch the budget further, which include the following:

- » Phasing
- » Reclaimed and recycled materials
- » Community involvement

Table 1. Estimated Contractor Construction Budget

	Quantity	Unit Measure	Unit Price (Labor and Materials)	Total Price
Mobilization and Demobilization	1	Labor	\$ 30,000.00	\$ 30,000.00
Turbidity, Debris Boom, & Environmental Controls	1	Labor	\$ 20,000.00	\$ 20,000.00
Furnish & Install Cobble Ramp (>2' boulders)	50	Tons	\$ 140.00	\$ 6,500.00
Furnish & Install Quarry Rock Mounds (> one man rock)	30	Tons	\$ 230.00	\$ 6,500.00
Furnish & Install 1-2' boulders in mounds	350	Tons	\$ 100.00	\$ 35,000.00
Furnish & Install 2-4' boulders in mounds	1400	Tons	\$ 90.00	\$ 130,000.00
				\$ 228,000.00

Reclaimed + Alternative Materials

Our meeting with contractors allowed us to conclude that new rock of any size is more expensive than using reclaimed rocks. This led to our recommendation to purchase less of the new, full-priced materials and prioritize reclaimed and re-purposed materials along with other nontraditional options like reef safe concrete. As a strategy for stretching the budget further, we recommend using large pieces, including non-focal point concrete features, to add volume to piles by placing these features under smaller, more habitat friendly rocks.

We also determined that reclaimed and modified materials, in addition to expanding the budget and being more environmentally friendly, would ease diver navigation through the incorporation of unique features that assist in wayfinding. Examples of what this might look like were explored in the “Materiality” Chapter. Sources of reclaimed rock could include, but are not limited to:

- » Quarry waste
- » Reclaimed rip rap (sea wall, river, riparian dearmoring projects, or other shorelines structural deconstruction)

Reclaimed or rejected concrete structures (culverts, manholes, catch basins, pipes, vaults, junction boxes, grade rings, etc.) could also serve as an excellent source of more affordable material. These materials could be sourced from:

- » Municipal utilities upgrading systems (non wastewater, non highway)
- » Precast concrete companies (many pieces are rejected for minor defects and can often be purchased at a discount or may be donated)

- » Contractors or construction companies working on large projects who may have acquired excess material over time
- » Reef safe concrete is another option that could be explored as a way to incorporate custom or artistic components to the reef structures.

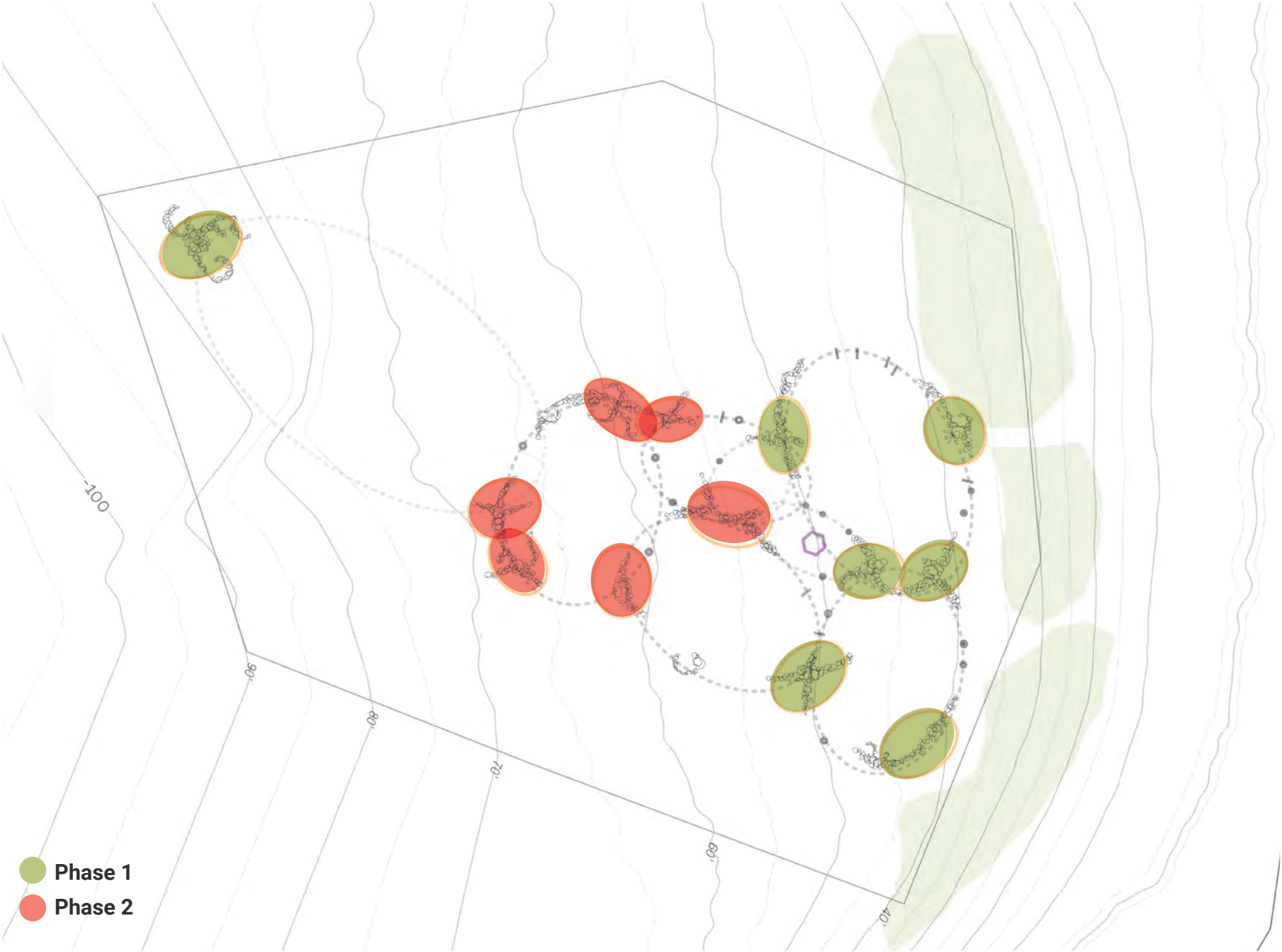
PHASING

While obtaining recycled and reclaimed materials is extremely cost effective, it makes the creation of a construction schedule more difficult as you can not pinpoint when appropriate materials might become available. Therefore, we have incorporated flexibility in our reef design to allow portions to be built out under differing time frames. This will allow time for existing reef structures to be phased out gradually, and for the new reef to be built out gracefully in their place based on when funds and materials are available. We have created a phasing plan to identify which reef structures should be prioritized for the initial construction. This plan is illustrated to the right in Figure 25.

COMMUNITY INVOLVEMENT

The community has been an important stakeholder throughout this process, and their contributions to this project should be expressed through its built form. As we did not have sufficient time to adequately engage the various associated communities in the creation of detailed components within the reef, we aimed to create a design that would serve as a base to be built upon in the coming years. We hope that

Figure 25. Phasing Plan



future engagement efforts will help design and place the following amenities throughout the dive site and associated upland area:

- » Community art (e.g. schools, tribes, etc.)
- » Memorial art or installation (e.g. veterans, tribes, or other identified communities)

Beyond serving as a recreational amenity for divers, we hope the reef's utility can extend upland to many other user groups. The dive site's proximity to the MaST center makes it an excellent opportunity to incorporate community data collection and research. Overall, we hope the reef will serve as an educational tool for the entire Redondo community, starting with the donation of the physical model created for this project to the MaST center.

CONSTRUCTION DOCUMENTS

The following construction documents were developed to assist with the DNR permitting process and act as a first step in identifying pile locations, sizing, and materiality. Due to our recommended inclusion of recycled materials, the exact specifications of what will be constructed cannot be predicted at this point. Therefore, these construction documents are intended to identify the general location and layout of our reef design, while incorporating flexibility to account for material variability.

REDONDO BEACH DIVE SITE

OCTOPUS'S GARDEN

PROJECT ADDRESS

28203 REDONDO BEACH DR S., DES MOINES, WA. 98198

PROJECT TEAM

UNIVERSITY OF WASHINGTON - DEPARTMENT OF LANDSCAPE ARCHITECTURE
6/16/2018
PREPARED IN LA DESIGN STUDIO SPRING QUARTER 2018
LARCH 503 STUDIO - IAIN ROBERTSON & BROOKE SULLIVAN
DARIN ROSELLINI, FATEMA MASWOOD, JESS VETRANO, RACHEL WELLS,
ANNA- MALIN WEISS ANDERSON, ELIZABETH LANGE
FOR FURTHER INFORMATION CONTACT IAIN ROBERTSON AT IAINMR@UW.EDU

OWNER

WASHINGTON SCUBA ALLIANCE
31811 PACIFIC HWY S #B307
FEDERAL WAY, WA 98003

PROJECT DESCRIPTION

WSA DIVING REEF IS A DESIGN BY LARCH 503 STUDENTS TO SERVE THE DIVING COMMUNITY. IN WASHINGTON SCUBA ASSOCIATION (WSA), THE DESIGN IS A DIVING REEF OFF OF REDONDO BEACH IN DES MOINES, WA. THERE ARE SEVERAL PHASES THAT ARE BEING RECOMMENDED UPLAND AND FOR THE REEF. THE REEF IS OFF THE SHORE OF REDONDO BEACH, THERE IS A PARKING LOT AND UPLAND PARK.

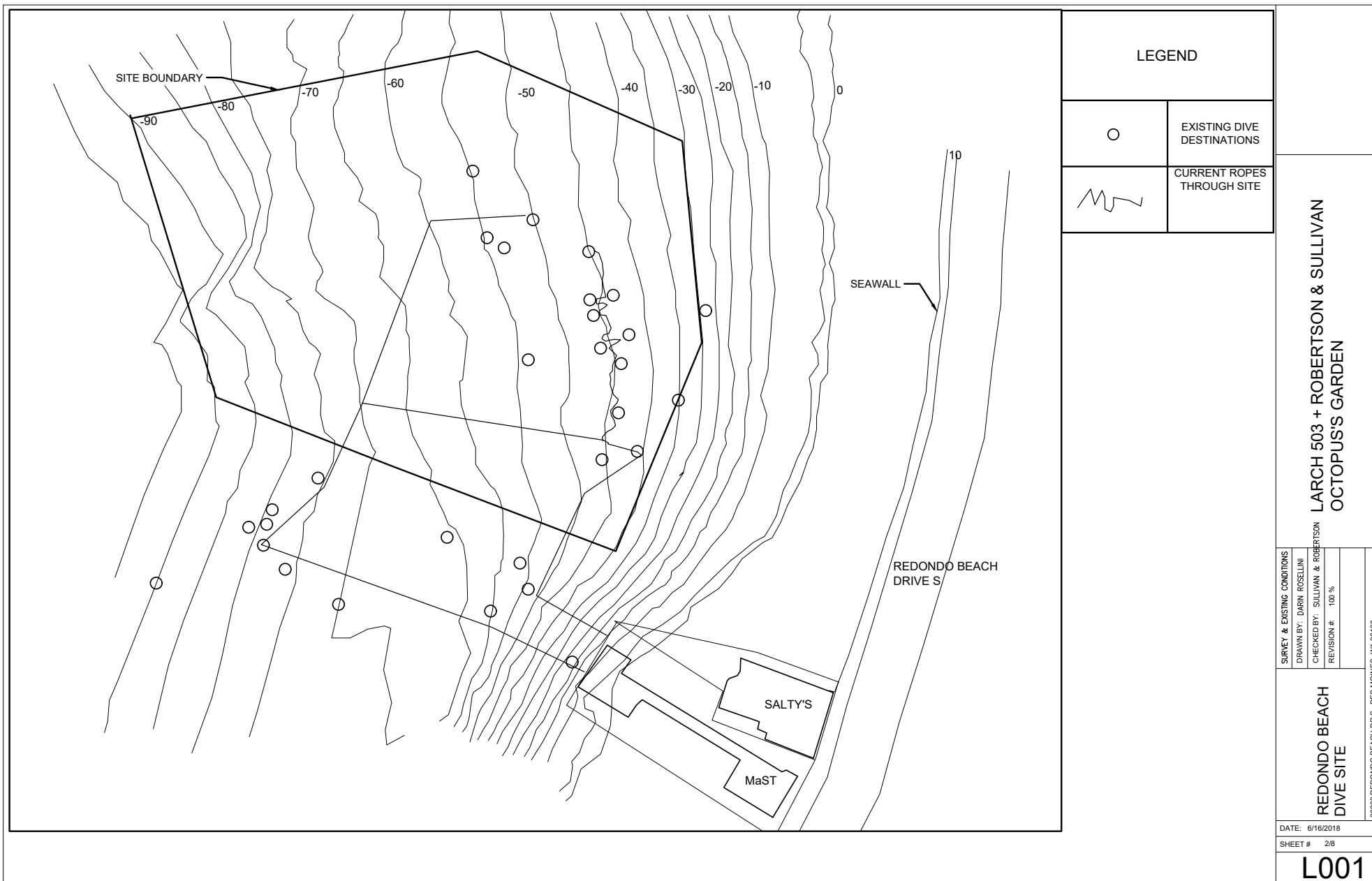
TABLE OF CONTENTS

- 1 - L000 - COVER SHEET
- 2 - L002 - EXISTING CONDITIONS
- 3 - L100 - REEF CONSTRUCTION PLAN
- 4 - L200 - COORDINATE LAYOUT PLAN
- 5 - L201 - SECTION & DETAILS
- 6 - L202 - LARGE SECTIONS
- 7 - L300 - VEGETATION PLAN
- 8 - L400 - TRANSECTS & MITIGATION PLAN



LARCH 503 + ROBERTSON & SULLIVAN
OCTOPUS'S GARDEN

COVER SHEET		REDONDO BEACH DIVE SITE	28203 REDONDO BEACH DR. S., DES MOINES, WA 98198
DRAWN BY: DARIN ROSELLINI			
CHECKED BY: SULLIVAN AND ROBERTSON			
REVISION #:		90%	
DATE: 6/16/18			
SHEET #		1/8	
L000			

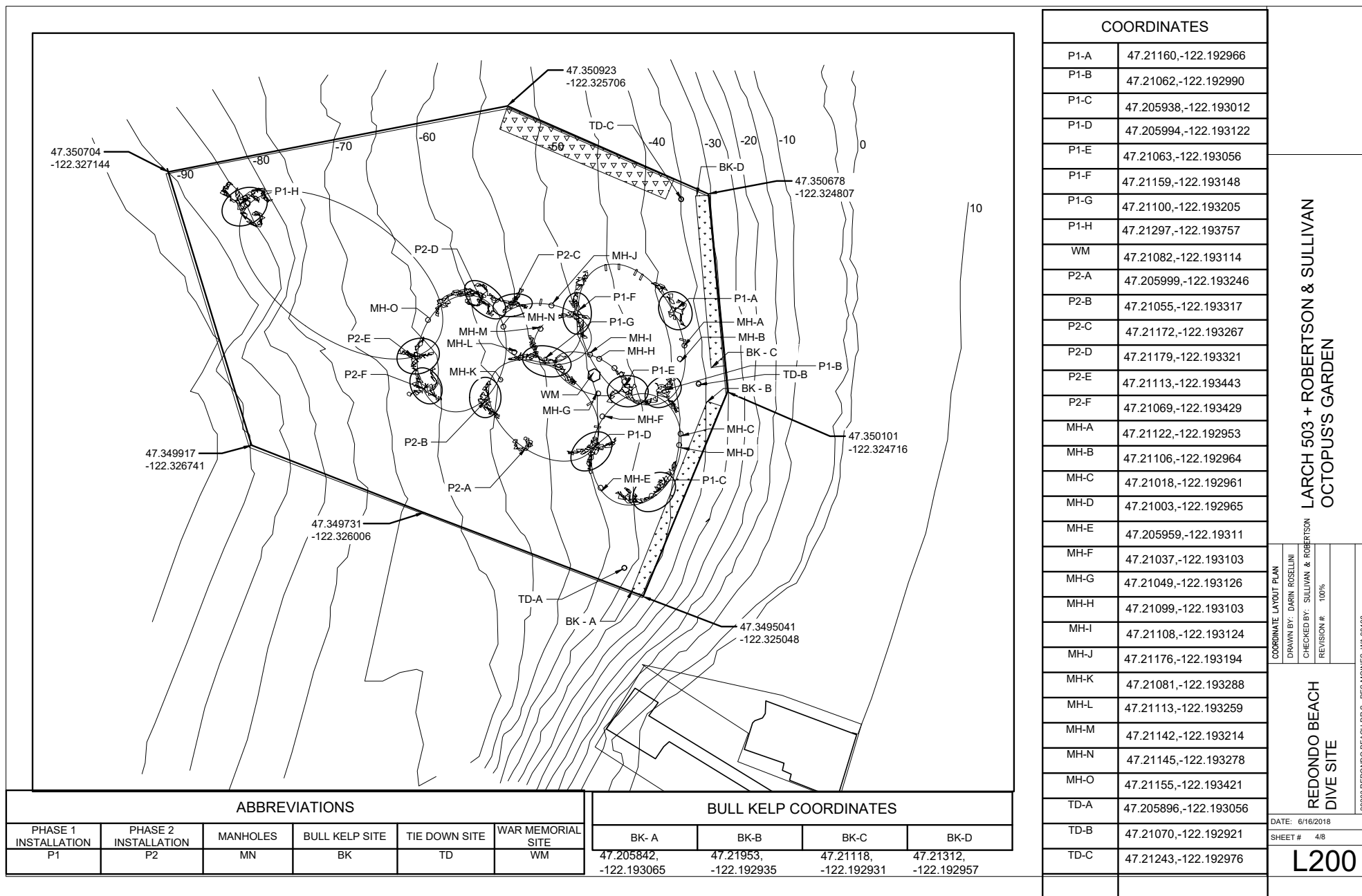




LEGEND	
PHASE I ROCK	
PHASE II ROCK	
MANHOLE	
TIE DOWN	
DIVING ROUTES (NOT A BUILT ITEM)	
DESTINATIONS	
RECYCLED PROCESSED CONCRETE	
MEMORIAL SITE	

REF PLAN DRAWN BY: DARIN ROSELLINI CHECKED BY: SULLIVAN & ROBERTSON REVISION #: 100%		REDONDO BEACH DIVE SITE 28203 REDONDO BEACH DR S., DES MOINES, WA 98198	
LARCH 503 + ROBERTSON & SULLIVAN OCTOPUS'S GARDEN		DATE: 6/16/2018 SHEET # 3/8	

L100

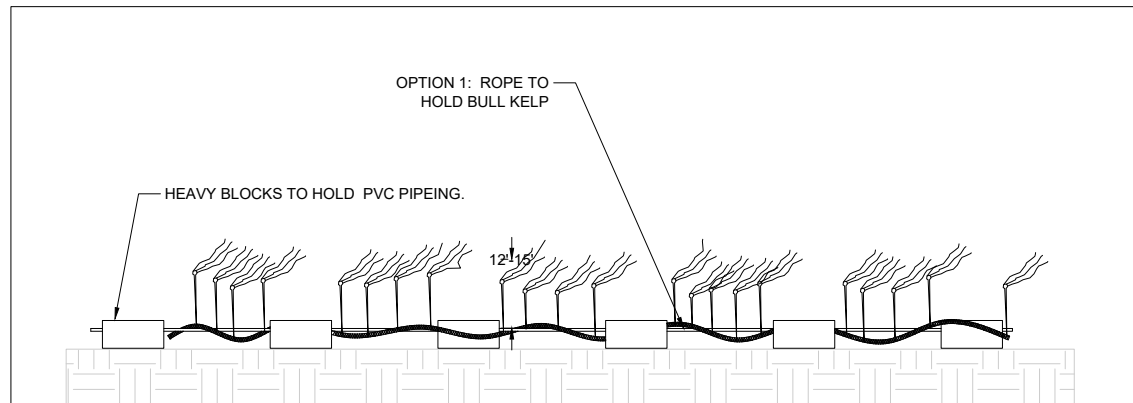
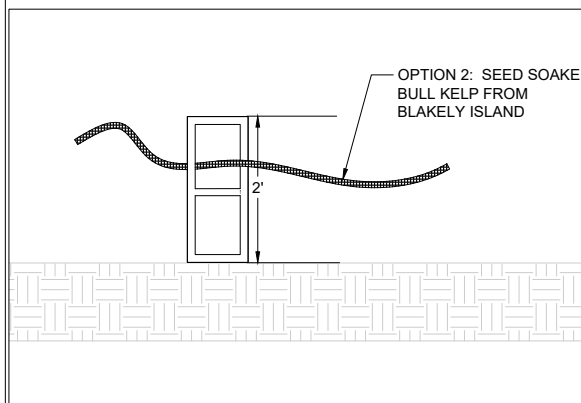
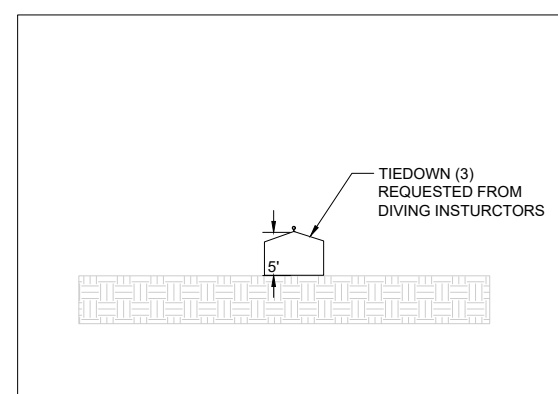
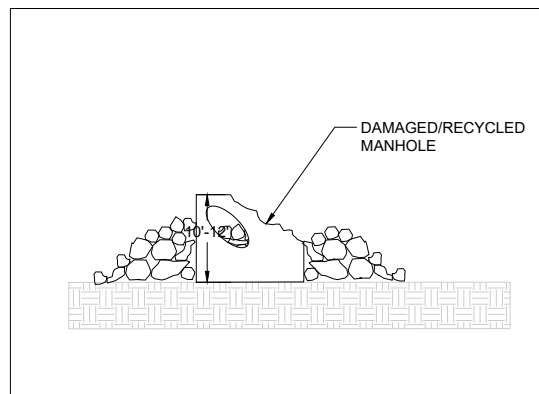
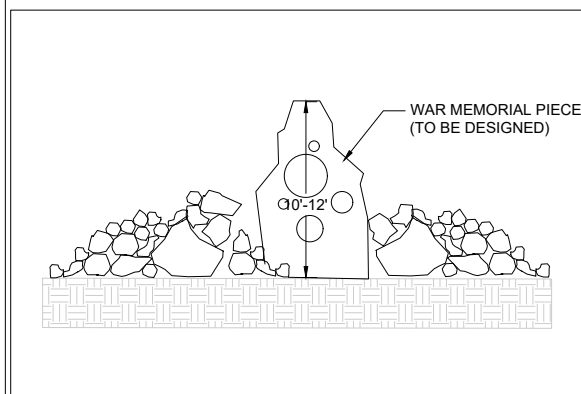
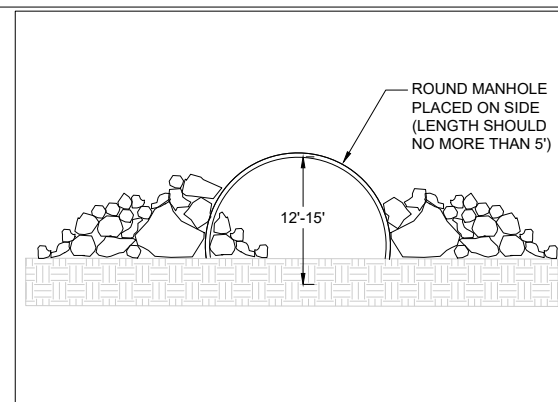
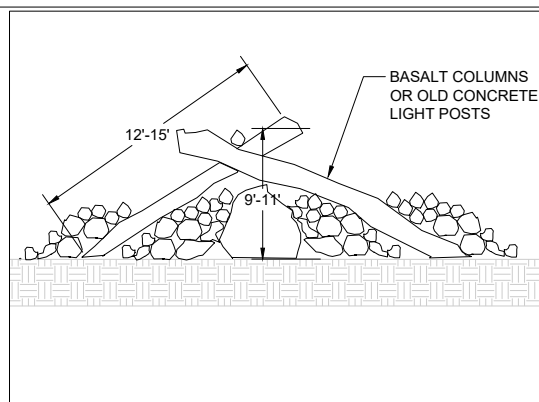
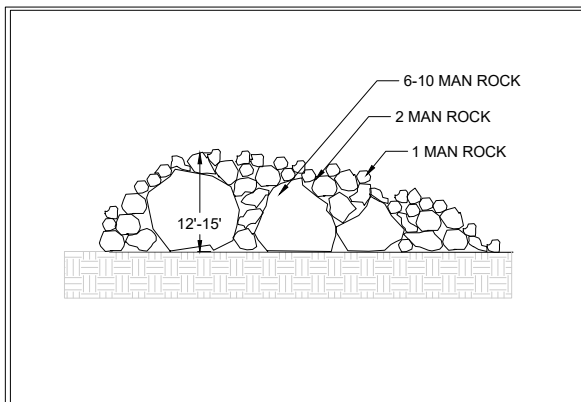


ABBREVIATIONS					
PHASE 1 INSTALLATION	PHASE 2 INSTALLATION	MANHOLES	BULL KELP SITE	TIE DOWN SITE	WAR MEMORIAL SITE
P1	P2	MN	BK	TD	WM

BULL KELP COORDINATES			
BK-A	BK-B	BK-C	BK-D
47.205842, -122.193065	47.21953, -122.192935	47.21118, -122.192931	47.21312, -122.192957

COORDINATES	
P1-A	47.21160,-122.192966
P1-B	47.21062,-122.192990
P1-C	47.205938,-122.193012
P1-D	47.205994,-122.193122
P1-E	47.21063,-122.193056
P1-F	47.21159,-122.193148
P1-G	47.21100,-122.193205
P1-H	47.21297,-122.193757
WM	47.21082,-122.193114
P2-A	47.205999,-122.193246
P2-B	47.21055,-122.193317
P2-C	47.21172,-122.193267
P2-D	47.21179,-122.193321
P2-E	47.21113,-122.193443
P2-F	47.21069,-122.193429
MH-A	47.21122,-122.192953
MH-B	47.21106,-122.192964
MH-C	47.21018,-122.192961
MH-D	47.21003,-122.192965
MH-E	47.205959,-122.19311
MH-F	47.21037,-122.193103
MH-G	47.21049,-122.193126
MH-H	47.21099,-122.193103
MH-I	47.21108,-122.193124
MH-J	47.21176,-122.193194
MH-K	47.21081,-122.193288
MH-L	47.21113,-122.193259
MH-M	47.21142,-122.193214
MH-N	47.21145,-122.193278
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TD-C	47.21243,-122.192976

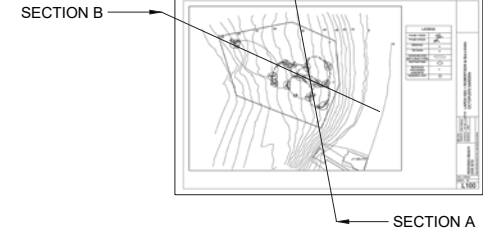
COORDINATE LAYOUT PLAN		DRAWN BY: DARRIN ROSELLINI CHECKED BY: SULLIVAN & ROBERTSON REVISION # 100%		LARCH 503 + ROBERTSON & SULLIVAN OCTOPUS'S GARDEN	
REDONDO BEACH DIVE SITE		DATE: 6/16/2018 SHEET # 4/8		L200	



LARCH 503 + ROBERTSON & SULLIVAN
OCTOPUS GARDEN

SECTION & DETAILS	DRAWN BY: DARRIN ROSELLINI
	CHECKED BY: SULLIVAN & ROBERTSON
	REVISION #: 100%
REDONDO BEACH DIVE SITE	28203 REDONDO BEACH DR S., DES MOINES, WA 98108
DATE: 6/16/2018	
SHEET # 5/8	
L201	

*Placeholder -- This graphic is still
being completed*



REDONDO BEACH DIVE SITE		LARGE SECTIONS		LARCH 503 + ROBERTSON & SULLIVAN OCTOPUS'S GARDEN
		DRAWN BY: DARN ROSELLINI CHECKED BY: SULLIVAN & ROBERTSON REVISION #: 10%	DATE: 6/16/2018 SHEET # 6/8	
L202		28203 REDONDO BEACH DR S., DES MOINES, WA 98198		

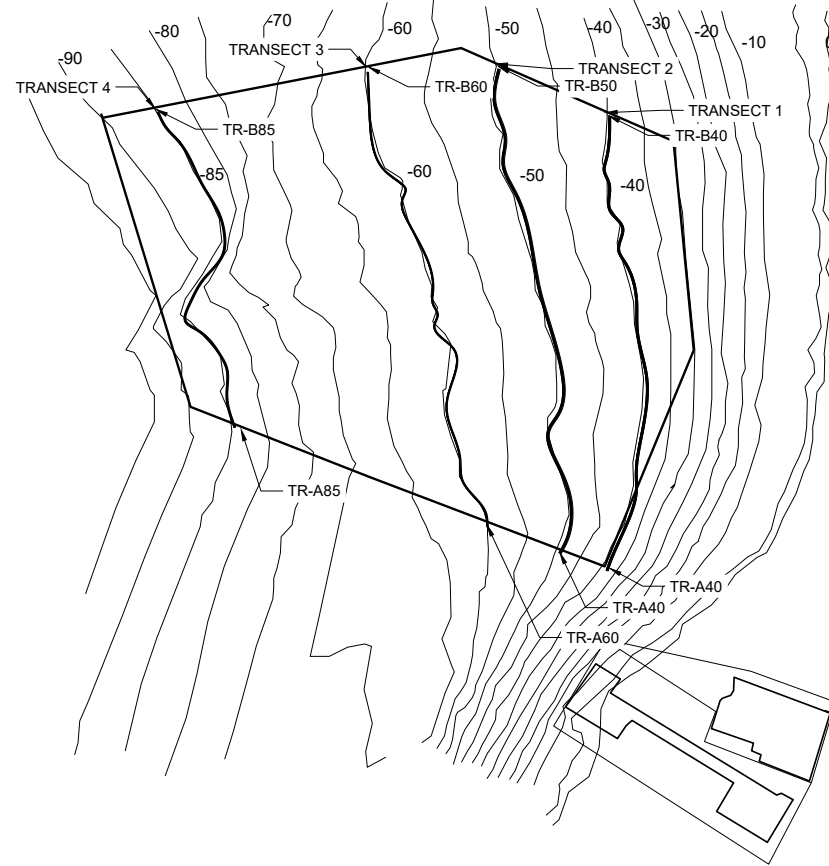


2 OPTIONS FOR INSTALLATION OF BULL KELP:

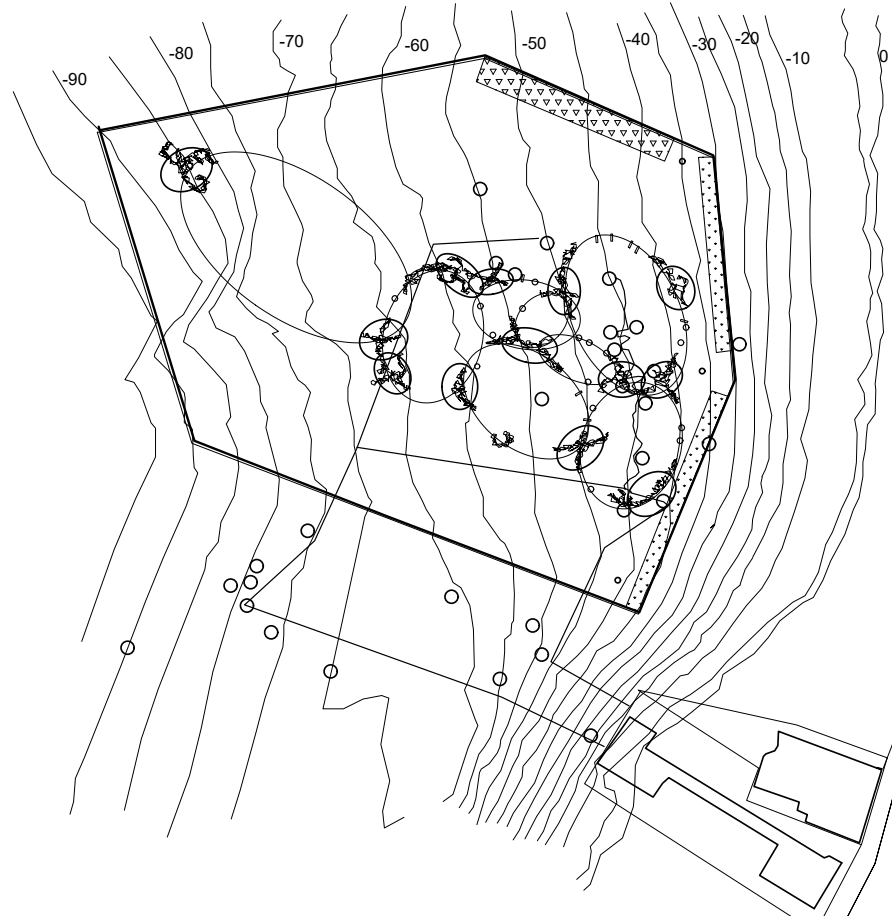
- 1) RESTORATION PROCESS
 -SORI (REPRODUCTIVE STRUCTURES) ARE COLLECTED FROM WILD KELP
 -GROWN TO GAMTOPHYTE STAGE
 -SPOROPHYTES RE GROWN ON STRING WHICH GETS WRAPPED AROUND A PIPE
 -MONITORED TO OBTAIN
- 2) 'SEED ROPE' BY SINKING A KELP RICH AREA, BLAKELY ISLAND IN SAN JUAN AND TRANSPORT FOR INSTALLATION. (METHOD TO BE APPROVED BY PROJECT BIOLOGIST.)

VEGETATION PLAN		LARCH 503 + ROBERTSON & SULLIVAN OCTOPUS'S GARDEN	
DRAWN BY: DARIN ROSELLINI	CHECKED BY: SULLIVAN & ROBERTSON	REDONDO BEACH DIVE SITE	
REVISION # 100%		28203 REDONDO BEACH DR S., DES MOINES, WA 98198	
DATE: 6/16/2018		SHEET # 7/8	
		L300	

TRANSECTS



MITIGATION



TRANSECTS

	TRANSECT 1		TRANSECT 2		TRANSECT 3		TRANSECT 4
TR-A40	47.205844 -122.193046	TR-A50	47.205863 -122.193109	TR-A60	47.205889 -122.193229	TR-A85	47.205998 -122.193640
TR-B40	47.21347 -122.193027	TR-B50	47.21400 -122.193224	TR-B60	47.21401 -122.193438	TR-B85	47.21347 -122.193775

MITIGATION OF SITE TO BE
APPROVED BY DNR AND
CLIENT.

REQUIREMENTS DETERMINED
BY PERMIT.

TRANSECTS & MITIGATION

DRAWN BY: DARRIN ROSELINE

CHECKED BY: SULLIVAN & ROBERTSON

REVISION #: 100%

REDONDO BEACH DIVE SITE

28203 REDONDO BEACH DR S., DES MOINES, WA 98198

DATE: 4/13/18

SHEET # 8/8

L400