

LAND AND WATER

An Ecological Education Center
at the Seattle Waterfront

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ABSTRACT

Land and Water: An Ecological Education
Center at the Seattle Waterfront

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Since the mid-21st century, the urban waterfronts have become a fertile land for mixed-use development. Being the front porch of the city, these waterfronts are often sites of urban spectacles that have sought to reactivate the shorelines, both culturally and economically. But the original nature of these fringe spaces as an ecological system has often been neglected due to human settlements. With today's concerns about climate change and rise in the sea levels, the waterfront has become one of the most vulnerable sites in the city. This thesis will explore a way of proposing an architecture that will not only support the diverse habitat of Puget Sound but also create a scenario where man can co-exist with nature. The focus will be towards re-establishing of the Elliot Bay shoreline's ecological process while creating natural waterways that can once again feed the Elliot bay as it used to, a century ago. All with the city's life existing side by side.

LAND AND WATER

Ecological Education Center at Seattle Waterfront





Figure A - Seattle city profile

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1. INTRODUCTION

Urban Waterfronts are time machines—portals to other worlds past and present. On the one hand, they are trading frontiers laced with nostalgia and countless human emotions and memories. On the other, they are a universal connection to our global environment and a litmus test of the health of the world. They have the potential to inspire a profound awareness of the connected world and as such they are important touchstones in urban planning.¹

Over the past century, urban waterfronts in the United States have undergone a major transformation, from their origins as wetlands to ports and sites of industrial production to areas of mixed use development in the last fifty years. Acting as both edge and threshold between land and sea, waterfronts were the foundation of trade and transportation connecting the urban population with the world. With the advent of technology and the globalization of financial markets, many of these areas were emptied of their industrial functions and often became urban deserts filled with waste and pollution. By the mid-21st century, city waterfronts began to be re-evaluated and converted into “fertile areas for urban planning and redevelopment.”² In the effort to rebuild healthy cities these developments have often focused on the reconnection of the cultural and economic life on land with the water. Seen as the “front porch of the city”³, urban waterfronts have become sites for iconic works of architecture that seek to embody the image of the city. (Figure 01 & 02)

In the past years, major waterfront projects are often treated as urban spectacles that are intended to attract public towards the water edge. Whether museums or convention centers or other public amenities, these architectural works have sought to reactivate the urban shorelines both culturally and socially. But the original nature of the waterfront as an ecological system has often been neglected. These fringe spaces, where both land and marine life meet, have long been affected by human. Altered by trade and contaminated by industry, these activities have threatened the area's natural ecosystem and deteriorated its delicate biodiversity. With today's concerns about climate change, depletion of natural resources and rise in the sea levels, the waterfront has become one of the most vulnerable sites in the city. Therefore, it is essential to consider the waterfront as a place where both human and natural systems converge and are both dependent on each other. (Figure 03 & 04)

The architecture of the urban waterfront needs to better respond to the unique ecology of its shoreline. This thesis explores a nature sensitive intervention at the Seattle's Central Waterfront that acts as a resilient urban filter supporting the marine and terrestrial habitat while responding to the unique characteristics of Elliot Bay shore. The design consists of an Ecological Education Center on Pier 48 that provides an interactive learning environment for the public to experience the natural systems seashore. Additionally, the building will be an energy efficient structure that utilizes the site's natural resources for its operations. (Figure 05)



Figure 03 - Diesel powered ships being loaded with cargo

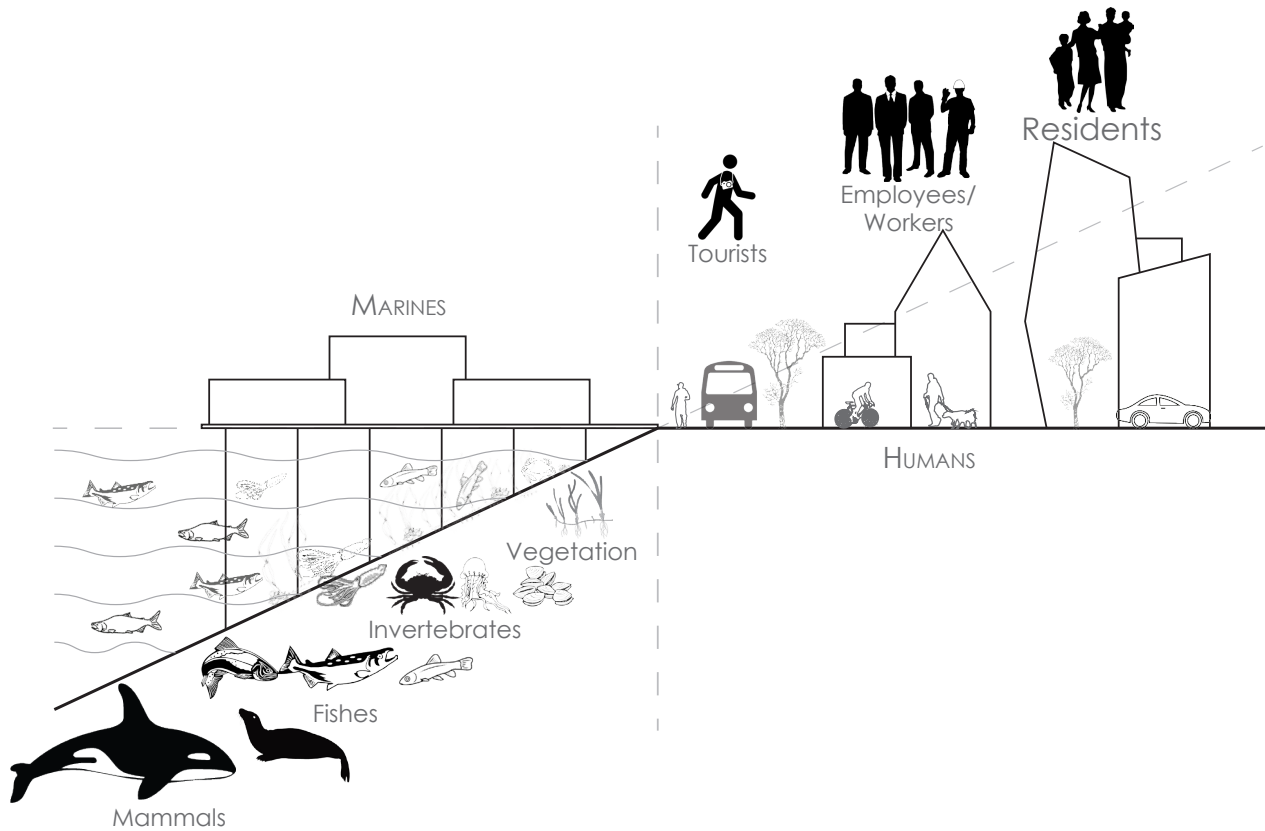


Figure 04 - Convergence of Land and Marine life



Figure C - Nisqually National Wildlife Refuge, WA





Figure 01 - A night view of Seattle showing the development at the waterfront.

2. THE WATER EDGE

Water, also known as the “Blue Oil”¹ due to its life-supporting characteristics, is one of the most valuable resources present on this planet. It is considered as “a public asset”² that makes earth habitable and is an essential nutrient in the functioning of all living beings. The attraction towards water has played an important role in the formation of human settlements through history in the transition from nomadic cultures into settlers. Ancient civilizations the Indus Valley, ancient Egypt and Mesopotamian were all founded along the fertile edge of rivers. The constant supply of food with opportunities for trade made the water’s edge a catalyst for growth from small scale villages into large dense cities. As Zoe Ryan observes, the waterfront has continued to play a major role in defining the character of the city: (Figure 06)

Used for defense, trade, transportation, industry and recreation, these bodies of water often provide a reason for founding a city in the first place and have come to define these cities and play a major role in their lively and unique character.³

THE TRANSFORMATION OF URBAN WATERFRONTS

Urban waterfronts are an important point of contact between the wilderness of the open sea and the order of the city. These serve as the linking platforms of exchange providing opportunities for city dwellers to re-connect with the ecology of marine life. As a gateway to the city, the waterfront in U.S. cities has undergone numerous transformations dating back to the earliest settlement. To fully understand their evolution, the development of the waterfront can be classified in four different stages:

1) Nascent Stage: Until approximately the mid-19th century, urban waterfronts were used primarily for the basic trade of foods and goods. Early settlers located along the shoreline that played a major role in the survival of the society. Architect and planner Peter Hendee Brown observes that the primitive city port served as the physical, social and economic nerve center of the city.⁴ Shipping vessels initially were small and mostly made from natural materials like wood and bamboo, thus restricting the conveyance of goods to a small scale. He notes that the absence of industrial processes allowed the ecology of these areas to flourish alongside the port operations. (Figure 07)

2) Industrial Stage: From the mid-19th till the mid-20th century, rapid commercialization and industrialization forced these primitive ports to expand to support an increase in the trade volume. This was either done through draining the wetlands to gain more dry space or, where deep water was available, constructing artificial islands. As centers for global trade, multiple warehouses, industries and docks were constructed along the water's edge near the port. In his article, *The Nature of Cities*, Andre Grant notes: "Here the prime value was in the efficiency of storing and processing trading goods alongside the easiest moorings and best-connected waterfronts."⁵ This sudden growth in trade and industry transformed the waterfront into a crowded and busy hub of human activity, cutting off the social and environmental life of the city from the water. While evidence of the growth of the city, these industrial waterfronts represented an "era of environmental degradation"⁶ where high levels of pollution started deteriorating the site's ecology. (Figure 08)



Figure 02 - A historic harbor with the wooden ships seen in the background.



Figure 03 - Diesel powered ships docked at the ports for loading and unloading



Figure 04 - An aerial view of the most busiest ports of USA, Los Angeles and Long Beach port.



Figure 05 - Guggenheim Museum located in Bilbao, Spain.

3) Expansion and Relocation Stage: Around the mid twentieth century, the operation of industrial waterfronts altered significantly. Starting with the development of new specialized industries, particularly for crude oil and ore extraction, and the advent of containerization, ports had to be relocated further downstream with access to larger water bodies to accommodate the larger shipping vessels. Similarly, with larger containerized cargo, more vast areas of land were required to store increased volumes of goods. With the introduction of commercial air travel and development of road infrastructure, water based transportation began to decline. As heavy industry moved to cheaper land on the outskirts of the city, the urban waterfront often become abandoned. As described by Zoe Ryan in his book, *Building with water*, "Marred by the toxic waste, these areas quickly fell into disuse and were left abandoned."⁷ (Figure 09)

4) Renewal Stage: As the ports moved out and industries relocated to the suburbs, waterfronts in major cities often deteriorated into vast wastelands. In the last quarter of the 20th century, civic authorities began working to recover these prime, but isolated, lands rediscovered for their significant cultural and economic value. The shoreline of major US cities was revived for non-maritime functions that focused on bringing back the public to the water edge. Large scale urban renewal projects were commissioned, promoting mixed-use real estate and lively public destinations. These new recreational and commercial amenities provided opportunities to live, work and play. By the end of the 1990s, the city's edge became home to the "Signature Architecture"⁸ like the Guggenheim Museum in Bilbao, Spain and the Tate Modern in London. As Zoe Ryan argues that architecturally distinctive landmarks and civic icons to honor interactions with their natural resource, water.⁹ Whether adaptive re-use of former industrial buildings or the innovative insertion of a contemporary design, these projects were the effort of cities to reshape their public image. The prime value of most of the development was typically driven by economy but typically ignored the natural ecosystems of the shoreline. (Figure 10)

URBAN WATERFRONT AS A FUNCTIONING ECO-SYSTEM

As sites of heavy development, urban waterfronts have been affected by the by-products of human activity. Being the “most economically convenient dustbin of industry,”¹⁰ through history these industrial sites have been carrier agents of diseases poisoning the city's edge. While cities have made a greater effort in recent years to regenerate their shorelines, the emphasis on “prestigious projects”¹¹ that attract investors and the public continues to undermine the ecology of the region. As Zoe Ryan states,

As memorable destinations, waterfront cities are the convergence point for two intensely complex ecosystems, the natural ecosystem of the water's edge and the built ecosystem of concentrated human settlement.¹²

Waterfronts, an interface of land and water, are sites in which habitats for all living creatures exist. These are distinctive areas of negotiation between natural and artificial life, as the latter cannot exist in its most sustainable form without respecting the former. Throughout history, settlements relied on the natural resources provided by the water's edge. These shorelines are ecosystems that sustain life; supporting plants that in turn support the fish which further support human existence. This is especially true for the ecosystem of an estuary or a partially enclosed body of water that meets the sea. In this transition zone between river and maritime environments exists what ecologists call “most productive natural habitats in the world.”¹³

The estuary ecosystem is a natural system that has been greatly affected by the impact of human society. With over 60% of the world's population living along its shoreline, these areas have gone through a great deal of degradation. Mostly due to soil erosion and filling of the wetlands. Similarly, the amount of pollutants present in water due to excessive industrial waste and land run-off has resulted in the deterioration of water quality. The construction of sea walls and piers has further negatively impacted aquatic life along the water's edge. (Figure 11 & 12)

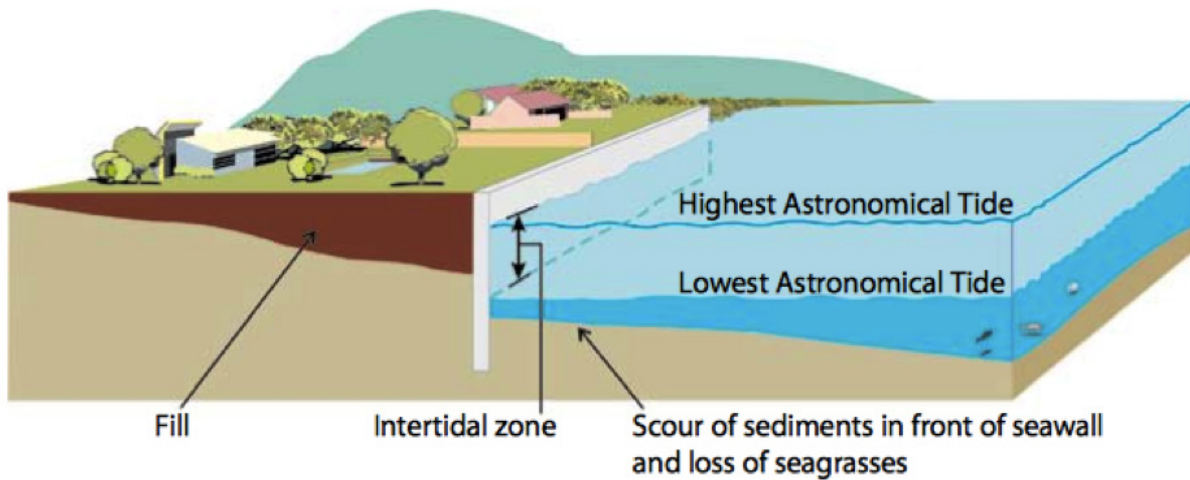
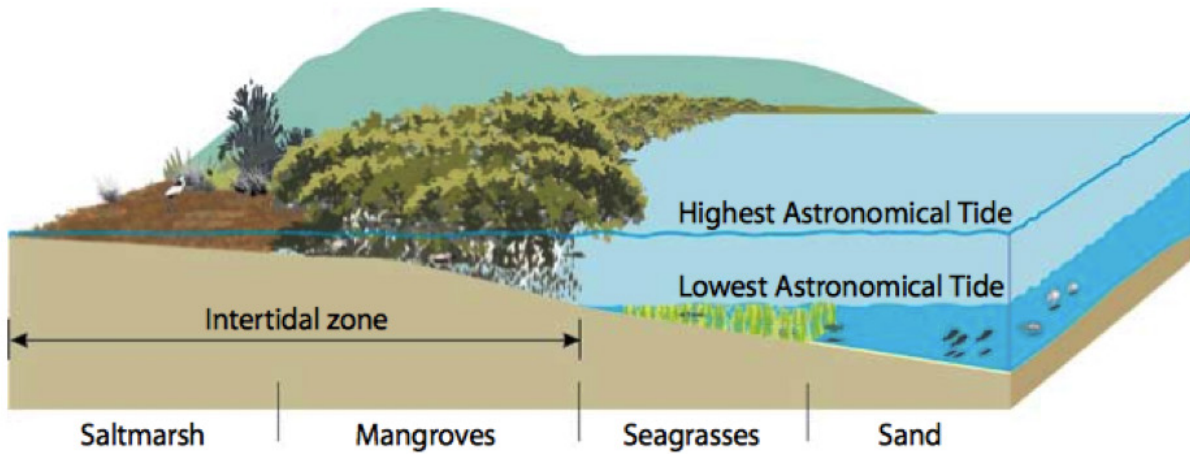


Figure 06 - A sketch taken from an article on Ecological Engineering depicting a loss of biodiversity due to the construction of sea-wall. The Elimination of the near shore and the soft green edge deteriorates the marine habitat as small fishes need shallow waters for their survival. Additionally, due to the absence of vegetation, the land is more vulnerable to storm surges as there are no dense barriers present on the seashore.

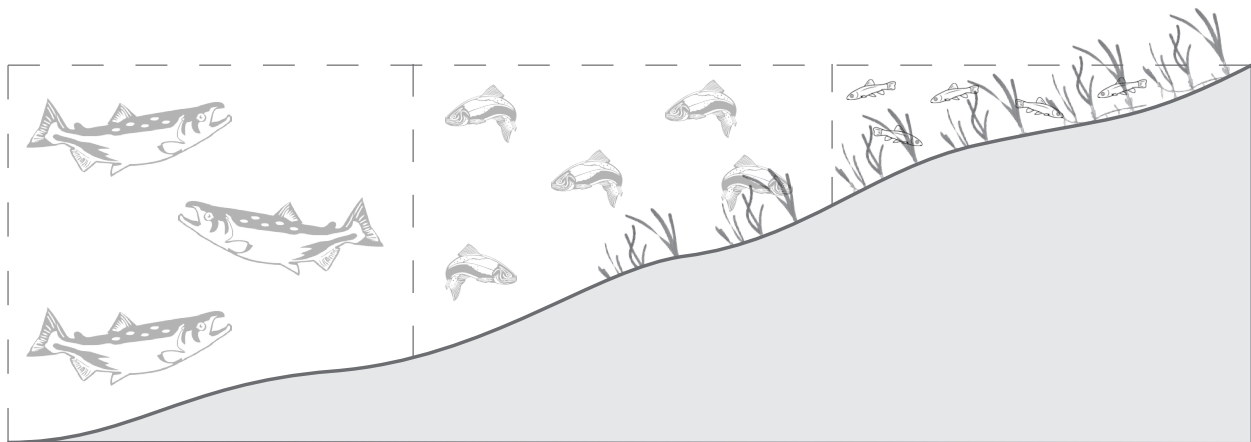


Figure 07 - A diagram depicting the relationship of water depth to the fish sizes.



Figure 08 - Shoreline's natural process that plays a major role in supporting an ecosystem.

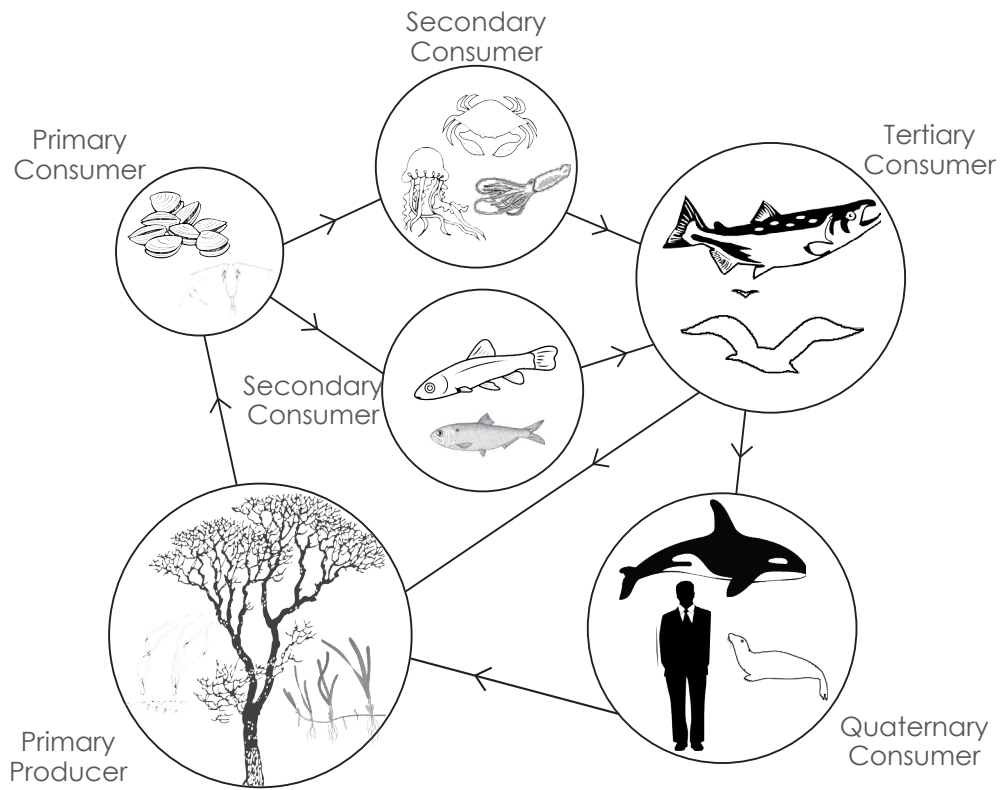


Figure 09 - A food web depicting the dependency of multiple organisms on one another.

ECOLOGY - AN AGENT OF INTEGRATION

According to Dimitra Babalis ecology can be defined as the relationship organisms have with one another and their surroundings. It is a process divided into two concepts, 1) adaptation¹⁴ – when living beings adjust to their surroundings for survival and 2) Interaction¹⁵ – communicate with the surrounding, to be able to engage the society's culture with nature. As Babalis argues, “ecology can become an instrument of interaction, adaption and process.” She argues that the design of public spaces can act as an interface, “creating a synergy between land and water.”¹⁶ While landscape architect have taken up this challenge, too often the built environment has lagged behind. But this thesis will argue that architecture too has the potential to restore the ecology of the water's edge and reactivate the connection between human and marine life. (Figure 13 &14)

The following case studies of recent waterfront projects will seek to demonstrate the potential of buildings to reconnect cities to their edge condition.

VANCOUVER CONVENTION CENTER WEST

Location: Vancouver, British Columbia, Canada
Architect: LMN, DA Architects & Planners, Musson Cattell, Mackey Partnership (MCM)
Size: 1,200,000 Square Feet
Year: 2009

Located on the north shore of Vancouver's downtown peninsula, the Vancouver Convention Center West integrates the life of the city with the natural ecosystem of the Vancouver Harbor in its form and layout. The folded planes and tilted facade in its massing helps to maintain the view corridors established by the downtown grid. This encourages the extension of the public realm through the site by providing continuous access to the water's edge. Similarly, the transparent skin of the exterior reinforces the integration of the natural context by reflecting the distant natural setting – mountains, sea and parks. (Figure 15 & Figure 16)

The design approach encompasses at once a single building and a new urban district, creating an ecologically connected experience that embodies all the diverse elements that define its local and regional location.¹⁷

Described as a “habitat stepping stone”¹⁸ by its designers, LMN Architects, the Convention Center seeks to provide life sustaining features for both marine and bird life. The expansive “living”¹⁹ green roof is a home to the region's migratory birds and bee colonies, allowing nature into the heart of the downtown core. The non-accessible portion of the roof allows native plants to grow freely, thus bringing back the vegetation that was formerly lost to the city's urbanization. The sloped surface with skylights and voids allows the user and public to visually connect with the activity taking place on the green roof making them part of the ecosystem. Simultaneously, below ground, the removal of the contaminated soil, left by the industry, and the addition of a habitat skirt with rough, rocky surfaces has allowed the restoration of the aquatic life. Additionally, the help of glass panels inlaid in the promenade, allows natural light to reach the water below, supports the growth of a diversity of native flora and fauna. This presence of this allows small fishes and invertebrates to see clearly and hide from predators by swimming into in the newly grown dense vegetation. (Figure 17)



Figure 10 - An aerial view of the Convention Center with the reconstructed landscape parks.



Figure 11 - Visual connections created through clear glazing with the green roof in the background.

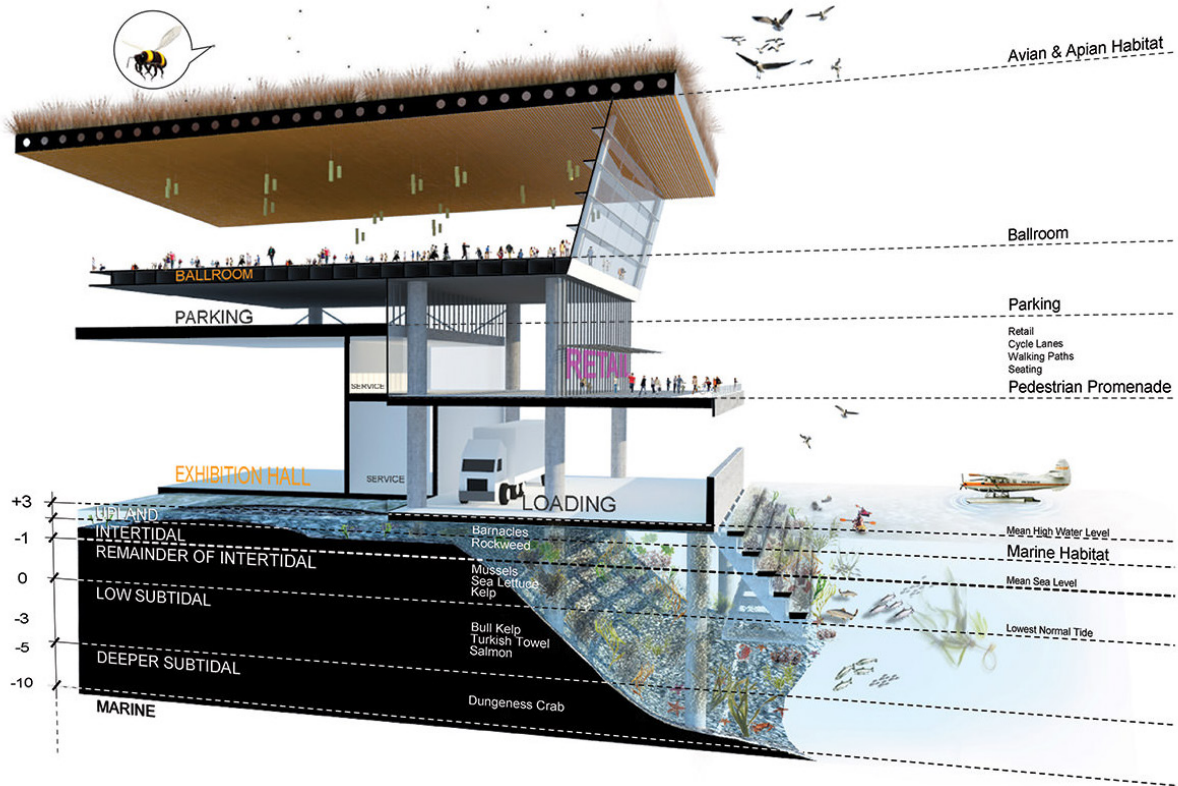


Figure 12 - The two ecological design elements, green roof and marine bench, allows the terrestrial and aquatic habitat to exist with the human settlement.

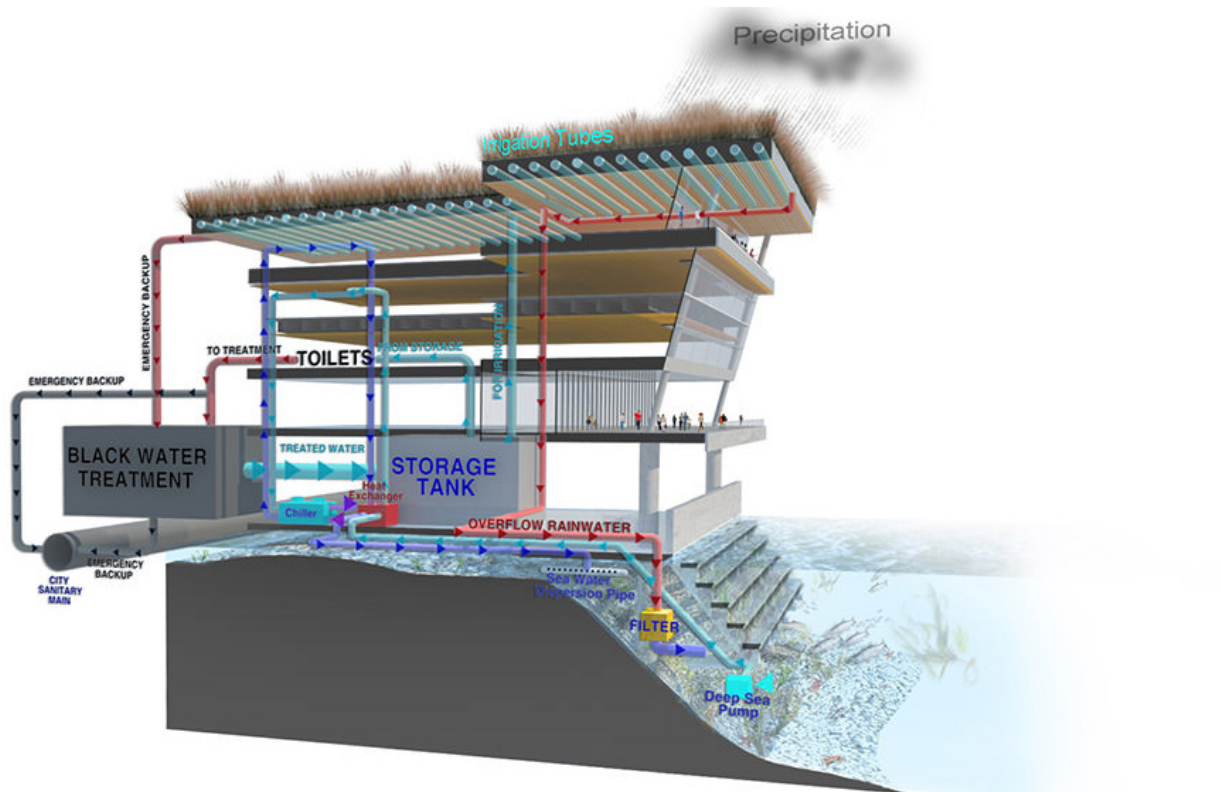


Figure 13 - The highly efficient mechanical systems incorporated into the building design utilize the site's renewable resources to reduce load on the city's system.

The Convention Center is a certified LEED Platinum building, as it makes use of the site's renewable sources in its operation. The high-performance glass facade with automated panels allow air to naturally circulate within the space without the use of active mechanical systems. The illumination of the interior of the main spaces is maintained naturally with sunlight through the help of transparent glazing and skylights. The interior spaces that are prone to direct sunlight, especially towards the south and west, are protected with the help of overhanging roofs and sunshades without blocking the views. In case of mechanical ventilation, the project has taken the advantage of the deep-water currents which supply a constant temperature to the sea water based heat pumps, thus reducing the electrical load on the city systems. (Figure 18)

DU PONT ENVIRONMENTAL EDUCATION CENTER

Location: Wilmington, Delaware, United States
Architect: GWWO Architects
Size: 149,620 Square Feet
Year: 2009

Located south of Wilmington's downtown, the Du Pont Environmental Education Center enhances the relationship between the city and the natural environment in its program and siting. The building completed in 2009 supports activities like teaching, community meetings and recreation that allow the users to interact with the surrounding marshlands along Christina River. The siting of the Education Center in a wildlife refuge but elevated on pilots sets up a dialogue between the structure and the "natural systems" of tidal rivers and wetlands. An open-air boardwalk at the lower level allows the user to experience the wetlands first hand when entering or leaving the structure, emphasizing a physical interaction between human and nature. (Figure 19 & Figure 20)

As noted by the designer, GWWP Architects, the Environmental Education Center seeks to "create a symbiotic relationship between urban development along the waterfront and the natural environment."²⁰ The detailing of the building refers to the adjacent railroad and industry. The building's form visible from the distance, makes it stand out from the natural surroundings, allowing it to act as a "beacon,"²¹ that marks the edge between the artificial or urban realm, and the natural marshlands. The use of Cedar wood on the exterior gives the structure a warm, natural look and allows it to weather in response to the natural surroundings, making it the best choice for the longevity of the project. The circulation tower is constructed with red-stained vertical slats creating a contrast with the v-groove siding of the main structure. These vertical slats allow the tower to be naturally ventilated so the visitor moving up the stairs can connect to the natural surroundings. The bridge in between the tower and the building also allows the user to enjoy framed views of the nature before entering the structure, "highlighting the tenuous connection between man and nature."²² (Figure 21)



Figure 14 - The transparent facade and the project balconies of the Education Center creates a strong connection with the Christina River marshlands.



Figure 15 - The open-air boardwalk provides an opportunity to the visitor to physically interact with the nature before approaching the building.



Figure 16 - The naturally ventilated staircase tower stands out from the rest of the structure, while encouraging a spatial connection with the exterior.



Figure 17 - The full height glazing allows an opportunity to the visitor to experience framed views of river and city.

The Education Center's east – west orientation reinforces the visual connection between the building and the city to the north and the wetlands to the south. The floor to ceiling glass visually reinforces the integration of context into the user's experience and at the same time allows ample daylight, naturally illuminating the space. The usage of overhangs, in the form of balconies, prevents sunlight from entering the structure making the space visually comfortable. The operable nature of the glazing allows natural ventilation to take place, passively cooling the space without increasing the load on the city. (Figure 22)

COPENHAGEN STRATEGIC FLOOD MASTER PLAN

Location: Copenhagen, Denmark
Landscape Architect: Ramboll Studio Dreiseitl
Size: 34 Square Kilo Meter
Year: 2014 (Proposal)

Climate change has adversely affected the lifestyle of the citizens of Copenhagen, especially after the cloudburst of 2011²³. Since the recent years, heavy rainfall with extreme flooding has become a commonly faced problem that puts a halt to the city's daily life. Presently the city is in pursuit of developing a strategic flood master plan "The Copenhagen Cloudburst Formula"²⁴ that not only mitigates the extreme flooding but also improves the existing conditions of the city. The traditional underground pipe drainage solutions have become less feasible as increase in rainfall requires more utility space. Thus resulting in the decision of going for a "surface-first approach"²⁵ that involves the redesigning of the urban fabric through "Blue-Green street"²⁶ interventions. (Figure 23)

As Blue-Green solutions are considered to be "low-tech,"²⁷ the landscape architects at Ramboll studios had come up with a proposal of changing the profile of the street by incorporating series of bioswales and vegetation. Though the main water discharge will be through the underground pipes but the change in the drainage location with the addition of bioretention vegetation reduces the volume of water flow over time. By doing so, not only the life expectancy of the existing infrastructure has increased but opportunities of recreation, health and human wellbeing are also created. Simultaneously, the surface water is naturally filtered through vegetation preventing the urban pollution from seeping into the ground thus maintaining an adequate water quality of the area. According to the architects, this new blue-green infrastructure provides a feasible approach ensuring a long-term resilience and economic buoyancy, while creating a possible synergy with the urban environment.²⁸ (Figure 24, 25 & 26)

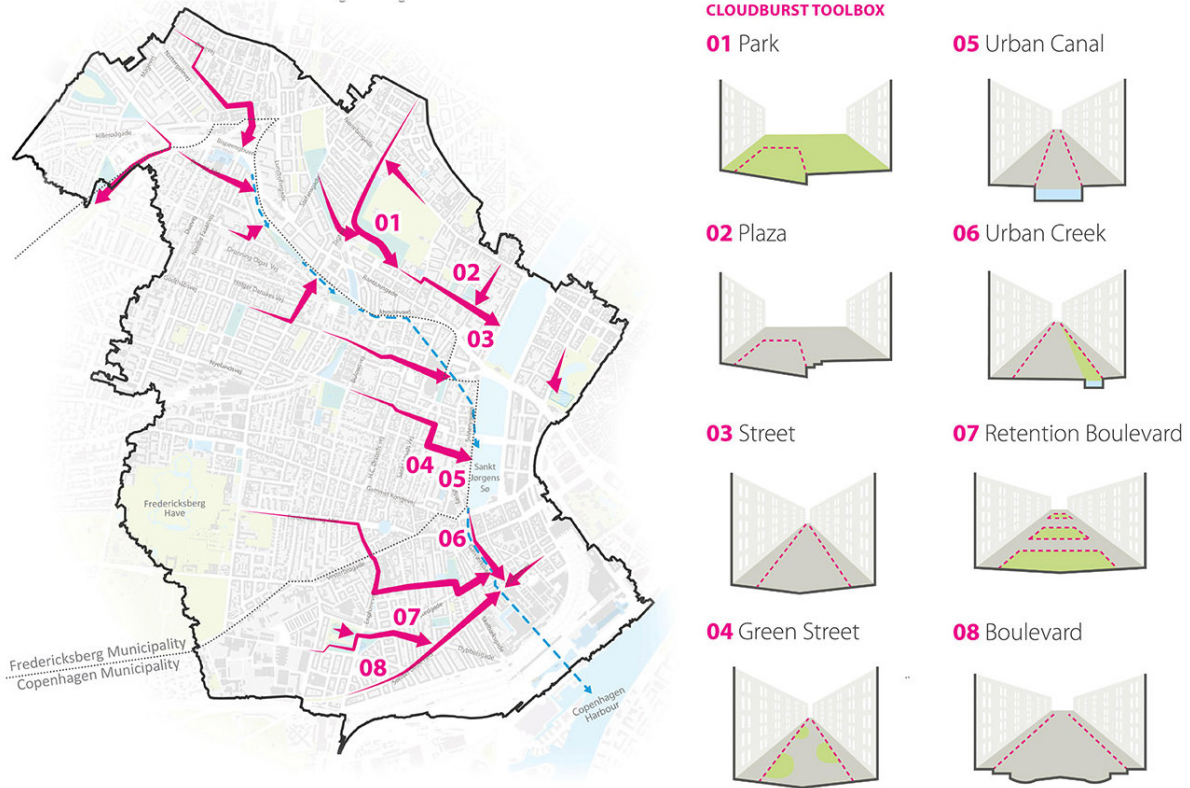


Figure 18 - A masterplan depicting the locations of the proposed strategies to mitigate the adverse effects of heavy rain and flooding.

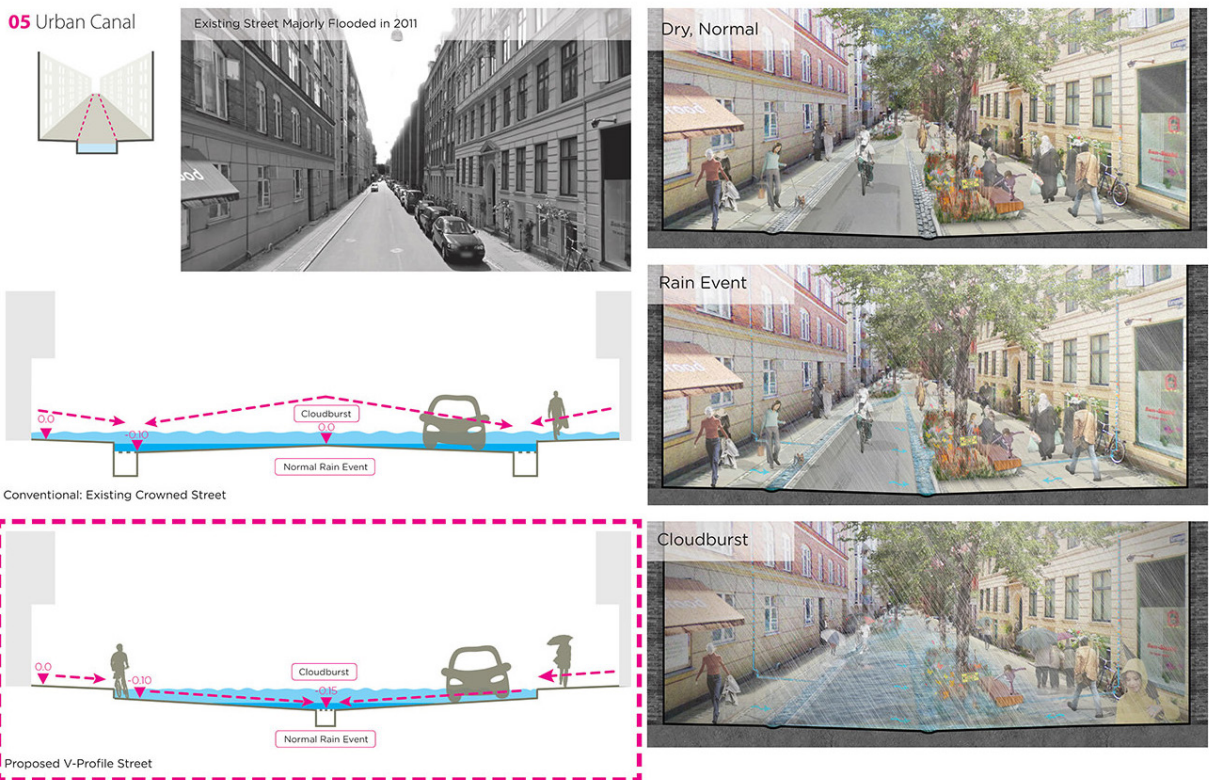


Figure 19 - A conceptual diagram of the green-blue street proposal depicting of a change in the street slope and addition of vegetation.



Figure 20 - Habitat recovering at the Oslo Opera House

The urban waterfront is currently in a critical stage of its development, forever altered by its former use for industry and trade. Recent commercial developments have sought to recover the water's edge as an important site in the city. But these projects have often focused on commercial uses, causing damage to the fragile natural ecosystems. This thesis argues that urban waterfront projects should shift their attention to consider marine ecology to reconnect cities with their shorelines. Architecture can play a role in helping to extend the public realm to the water. Like with the Vancouver Convention Center, this large-scale building makes use of design strategies to facilitate a connection between the users and the natural environment. But in the case of the Du Pont Education Center, the focus of the program with exhibits, classrooms and offices for nature education is on enforcing the connection between humans and nature. The intent is to provide greater access to the recovering marine ecology in a way that was prohibited by former industrial uses. Whereas, in the Copenhagen Strategic Flood Master Plan, the proposed Blue-Green Streets depict how the city's infrastructure can be used for filtering and retaining the rain water, thus maintaining an adequate quality of water in the area. Such ecologically minded projects that address the needs of both human and marine life can play a major role in the betterment of natural habitats. By considering landscape and climatic conditions and incorporating energy efficient systems, long lasting structures can be designed that are self-sustaining and are less of a burden on city systems.



Figure D - Eelgrass in Puget Sound





Figure 01 - Survey of Puget Sound, 1867

3. THE SITE

This thesis uses methods that emphasize how an understanding of natural ecology of the water's edge can be incorporated into its architecture. The site analysis will study the Puget Sound ecosystem in its historical and environmental layers. At the same time, I shall investigate the impact of human settlement on marine life and the Elliot bay's shoreline. The purpose of this examination is to help in understanding the physical fabric of the area in relation to the movement of aquatic life. This analysis is crucial to the development of the general design concept and program.

PUGET SOUND - EARLY PHYSICAL AND BIOLOGICAL SETTING

The Puget Sound ecosystem corresponds to the southern portion of the Strait of Georgia.¹ These areas are also called the "Salish Sea ecosystem,"² a fjord classified as a large estuary. The topography and bathymetry of the Puget Sound ecosystem has been shaped mostly by the geologic forces of the region, including "plate tectonics, volcanism and glaciation."³ The average depth of Puget Sound and Elliot Bay at mean low water is approximately 205 feet with a maximum of 930 feet. Per the USGS's report on "Puget Sound Shorelines and the Impacts of Armoring", it is believed that mammals, like humans, migrated to North America from Siberia across the Bering Land Bridge during the Wisconsin Glacial period, some 10,000 years ago. This was the period, when the deposits left behind by the glaciation and tectonic activities, in which the near shore character of the Puget Sound Ecosystem was defined. (Figure 23)

The Puget Sound ecosystem has a “maritime climate”⁴ based upon its setting and land forms. Having the Pacific Ocean on the west allows the wind to bring in mild-moisture-laden air throughout the year. Simultaneously, the mountainous ranges on the west and east block the low-level air coming from the ocean and the cold breezes from the interior of the country. This usually results in “wet, mild winters and cool, dry summers.”⁵ The location and orientation of the mountain ranges, Olympic and Cascade, allow them to receive a great deal of rain and snow throughout the year, which becomes the main source of fresh water supply in the region. (Figure 23)

The combination of unique topography with diverse soil type allows the Puget Sound ecosystem to have a variety of environmental conditions. These conditions in return support a wide variety of biodiversity within the region. This ranges from the highly productive coniferous forests of Douglas-Fir, hemlock and true fir along the coasts and the mountain slopes, to the richness of salmon species. According to the Center of Biological Diversity, the Puget Sound Basin is a “hot spot”⁶ for biodiversity nationally, making Washington state one of the most productive areas for salmon, oyster and clam fishery. (Figure 24)

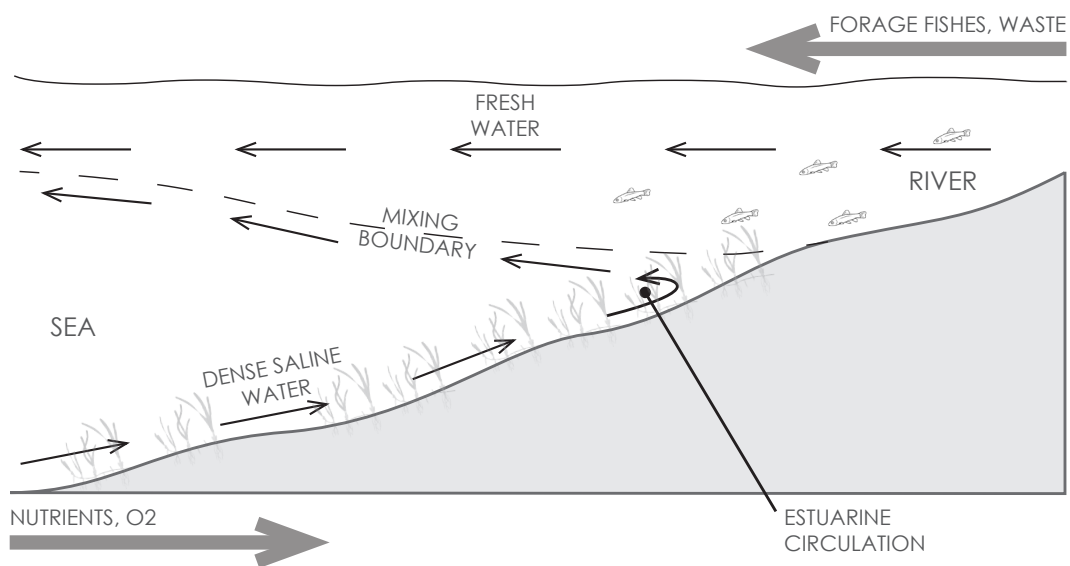


Figure 02 - An Estuary formation diagram



Douglas Fir

Clams



Oysters

Pacific Salmon



Figure 03 - Hot spot of Biodiversity



Figure 04 - A sketch depicting the Elliot Bay edge in its natural condition while the Coast Salish People⁷ hunt and gather during rainy winters.



Figure 05 - Coast Salish People's cedar canoes seen along the coast of Puget Sound with coniferous forest in the background.

HUMAN SETTLEMENT - THE CHANGING LANDSCAPE

The attraction towards Puget Sound ecosystem has played an important role in the formation of human settlements. In their book "Aquitecture, Buildings and cities designed to live and work with water", Robert Baker and Richard Coutts observe that, "Access to water was fundamental to the transition from nomadic cultures to settlers."⁸ The constant supply of food with opportunities of trade made the coastline the catalyst for growth and development.

Coast Salish Settlement: Until approximately the mid-19th century, Coast Salish Indians had settled along the Puget Sound's coast. They lived in permanent villages, spending most of their time hunting, fishing and gathering. The end of the glacial period allowed the expansion of the Puget Sound estuary that resulted in the increase of a wide variety of food resources. Timothy Quinn states that, "Their existence was supported by the region's abundant natural resources, primarily salmon, smelt, eulachon, herring and shellfish. Western Red Cedar was used as a building material for longhouses and canoes and as a source of material for clothing."⁹ (Figure 25 & Figure 26)

Early European Settlement and US Statehood: By the 1850s after the first European settlement in Seattle at “Piner’s Point”¹⁰, the Puget Sound ecosystem had been discovered as a beneficial economic venture. The area’s “high-productivity resources”¹¹ were utilized to fuel the local economy to shape the town site into a “premier city.”¹² Logging was the “focal point of the economic activity”¹³ as forests were being cut down to support the Hawaiian and the California Gold Rush market. The deforestation along the shoreline gave way to the construction of piers and steam powered saw mills supporting the timber industry.

By the end of the 19th century, railroad was introduced to support the increase volumes of export of Puget Sound’s natural assets, connecting the distant coal mines with shoreline. In 1889, after achieving statehood, the state sold intertidal land to private investors leading to the construction of new industries that drastically changed the appearance of the shoreline. The industrial revolution brought in “a mechanized era of natural resource extraction”¹⁴ making Washington State one of the “top five producers of timber in the United States”¹⁵ along with an increase in Salmon fishing of more than 2000 percent. With the arrival of the Klondike Gold Rush in the late 1890s Seattle became the “Gateway to Alaska,”¹⁶ supplying food, goods and labor through the “mosquito fleet”¹⁷ of local ferries up north. By the turn of the century, Seattle became the major port on the West Coast for trade with the world. (Figure 27 & Figure 28)

In the early 1900’s The Elliot Bay sea wall was built to support the railway and road access to the piers. It was built landward of the piers to block the water, thus eliminating the shallow water habitat for the marine life. The space between the sea wall and natural shoreline was then filled with earth that was taken by razing down Denny Hill, providing more land for maritime functions for trade, commerce and industry. According to Timothy Quinn, this was the “era of unmitigated ecosystem provisioning”¹⁸ meaning that the shoreline was drastically altered for human use while ignoring the presence of marine life along the coast.



Figure 06 - A sketch depicting the start of the impacts of human interventions after the European settlement settled in Seattle around 1860's.



Figure 07 - A bird's eye view of the old Seattle as it was in 1878, showing the formation of the city grids and the construction of Piers along the Elliot Bay.

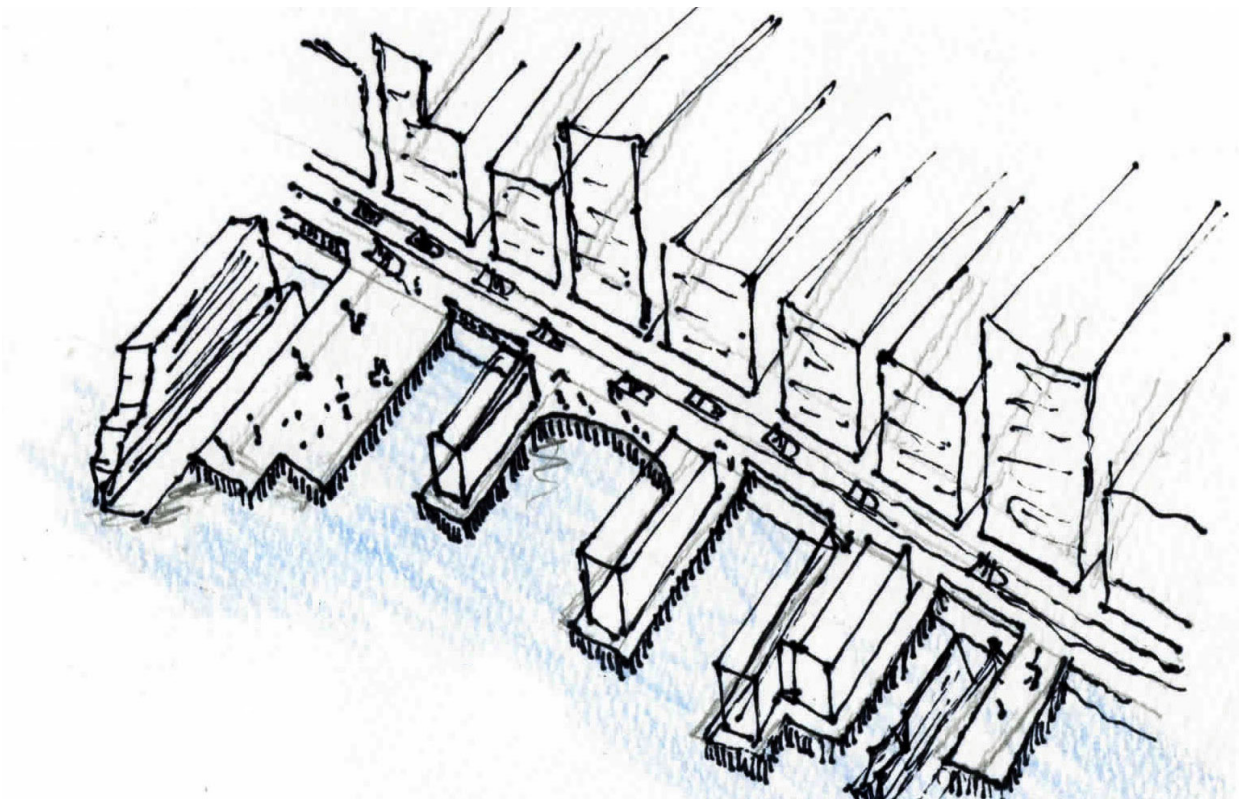


Figure 08 - A sketch depicting the present day Elliot Bay edge condition, with wide piers and a developed city infrastructure.



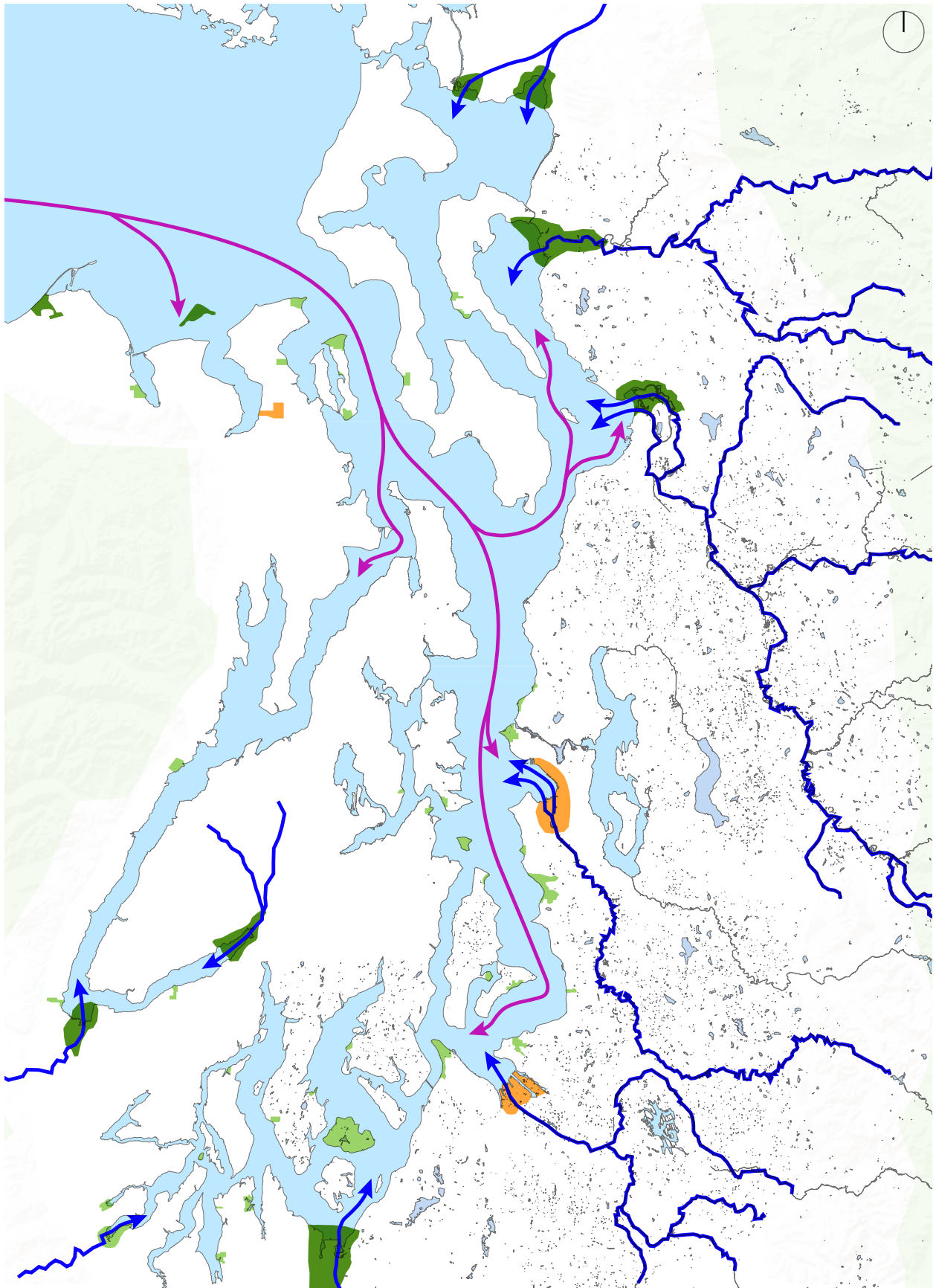
Figure 09 - An aerial view of the present day waterfront with commercial, social and residential functions taking place, while the tall downtown buildings overlooking into the Bay.

Post World War Settlement: In the early 1950s, since deep water was available near the coast, the shipping industry boomed and the density of the area increased. At the same time the ferry services also began connecting people daily to the different shores of the Puget Sound, like the Colman Docks (Pier 50 & 51) by the Washington state ferries and Pier 48 for ferries to Alaska. To avoid congestion, the city constructed the Alaskan Way Viaduct along the coast, diverting the Highway 99 traffic from downtown. While this eased up the traffic from the city center, it created a spatial and visual barrier between the shoreline and city. By the early 1960's the advent of containerization forced the Port of Seattle to build a larger pier, Pier 46, at the mouth of the Duwamish river with improved facilities, including Harbor Island. The old industrial piers and warehouses north of the Port became vacant and by the 1970's were being converted into function supporting recreational activities, like restaurants, shops, waterfront park and amenities. At the same time mixed-use development was being implemented with the construction of condominiums and waterfront hotels. This was done in the effort to reconnect the city with its shoreline by attracting social life to the water edge. Though the activities brought the public to the shore, the industrial character of the revitalized structures didn't encourage a strong connection with the shoreline. Many of the reused industrial buildings created an inward-looking environment with no connections to the exterior. (Figure 29 & Figure 30)

Metropolitan King County, where a few thousand Salish once hunted and fished, is now home to more than 1.6 million citizens. Like the community it serves, Seattle's central waterfront has undergone a profound transition from frontier anchorage to international port in a mere century and a half, and the pace of change seems only to accelerate.¹⁹

Figure 10 - The scale of transformation from a soft coastal edge into a hard city edge is shown by superimposing the present day Seattle city's limit over the earlier condition, prior to the European settlement of the 1850's.





AN ECOSYSTEM IN DECLINE

The commercialization and industrial revolution exploited the natural resource extraction on which the Seattle's economy earlier relied. These activities had caused a steep decline in the region's "ecological capital (large salmon runs, mature forest, coastal wetlands, clean water)"²⁰ leaving behind "treeless ground"²¹ and polluted water shores. Over the last 100 years, more than 60 percent of the State's old-growth forest has been harvested. Approximately 23 percent of Puget Sound Basin forestland has been converted to human-dominated uses, including agriculture and urban lands.²² Additionally, the sale of the intertidal zone to fulfill the demand of land for commerce has further deteriorated the ecology of the region. (Figure 32)

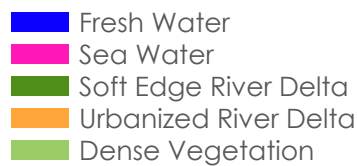
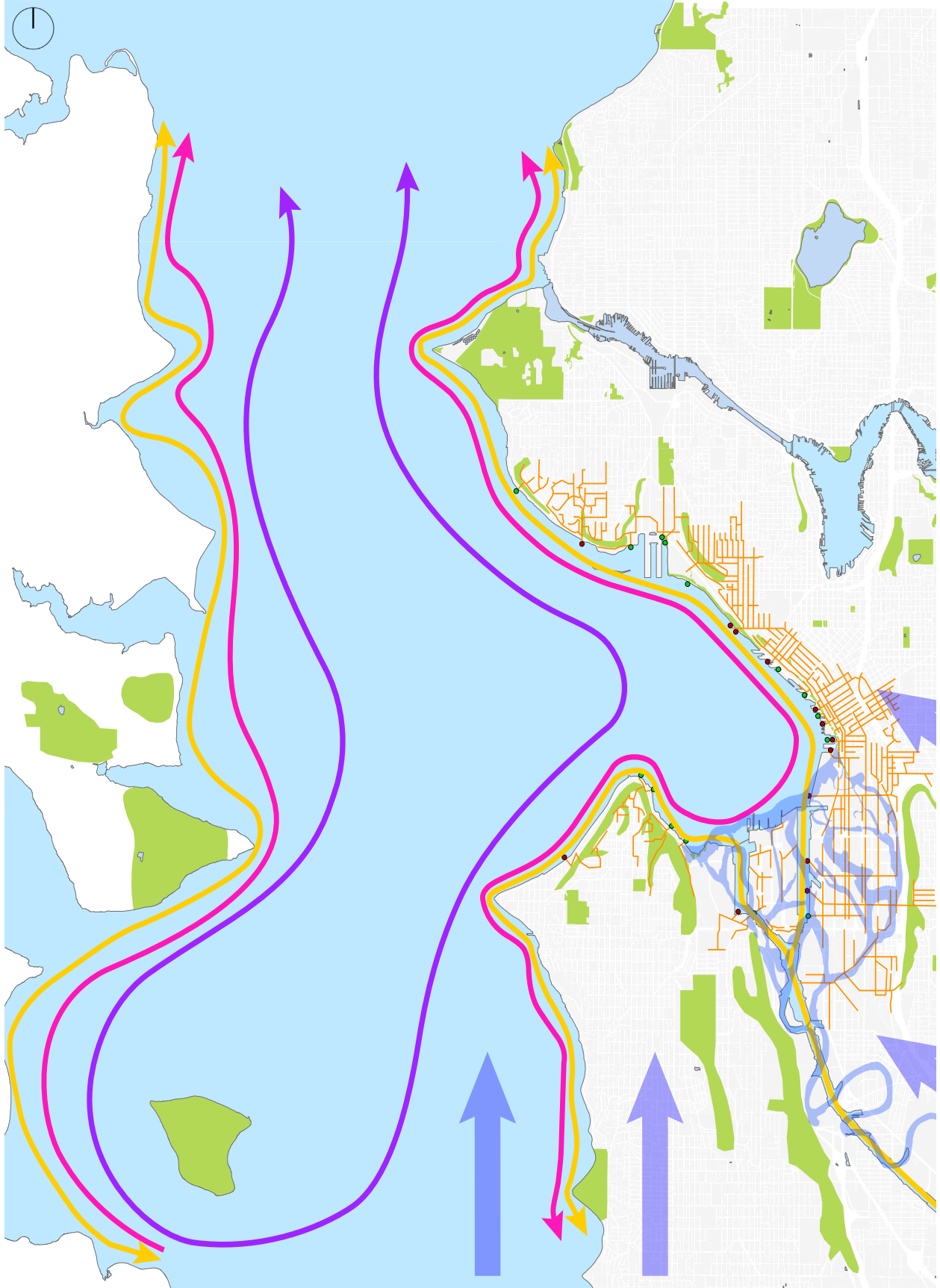


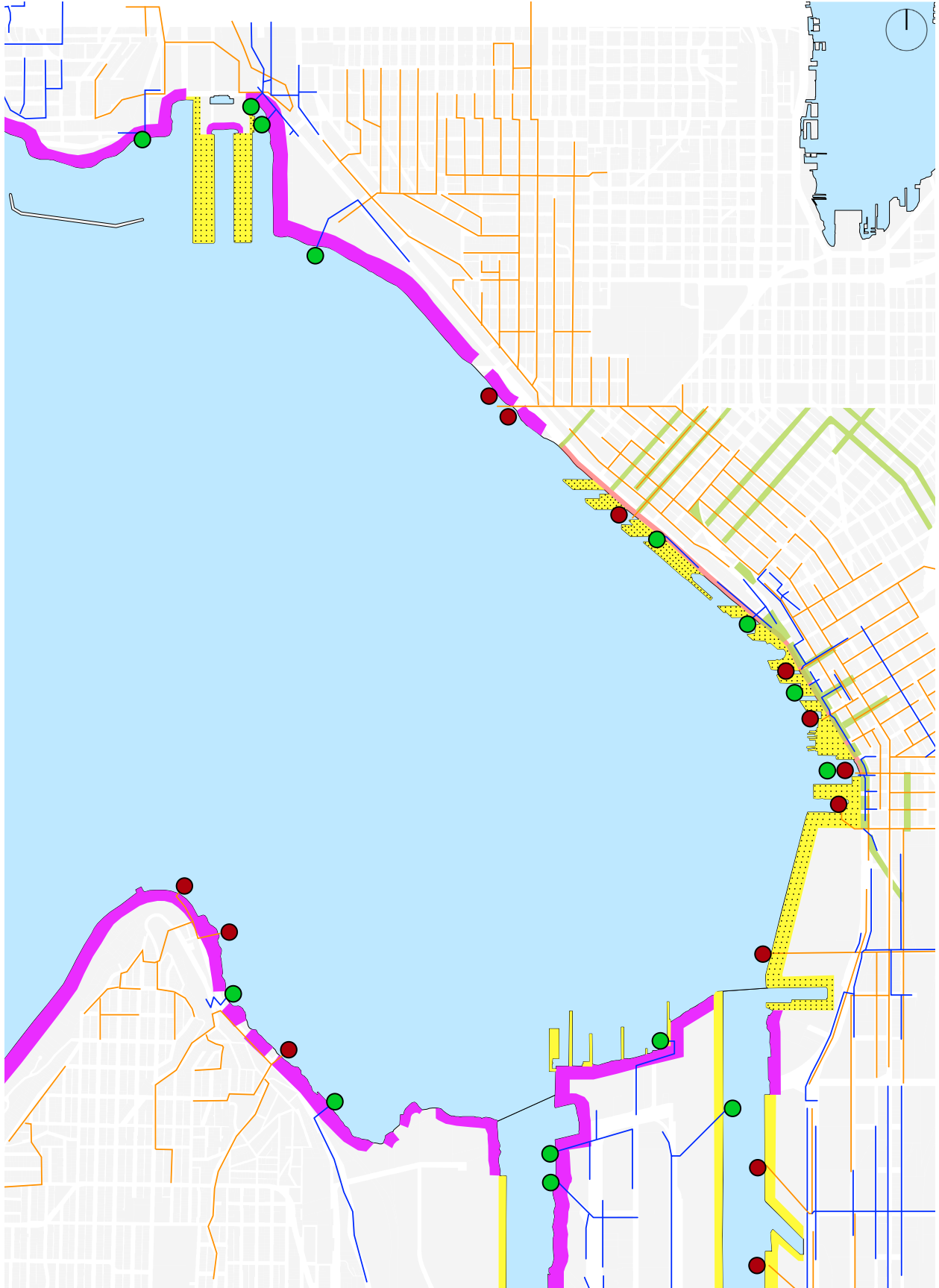
Figure 11 - THE URBANIZED WATEREDGE: A regional level analysis of the Puget Sound ecosystem showing the various habitat zones left today at locations where the river meets the sea. Tidal marsh and other river estuarine ecosystem types have declined by 80 percent in the last 150 years through a process of diking and draining.²³ What's left is shown in green, like the Nisqually River Delta towards the south and is preserved as a habitat zone by the state of Washington. The ones in orange, near Tacoma and Seattle, have been totally urbanized with very little soft edge. According to the ecologists, the Duwamish river delta has deteriorated the most.

One of the most heavily urbanized and polluted areas in Puget Sound,²⁴ Elliot Bay has the world's largest and deepest estuary.²⁵ The contaminants left behind by the past activities of the industry and port, with the present-day city discharge has stripped off the region of its marine and land biodiversity of 150 years ago. Before the human settlement the Elliot Bay coast was an "extensive intertidal mud flat"²⁶ with vegetation and steep bluffs, home to a variety of juvenile salmon species, invertebrates like squids, and eel grass. But due to urbanization and the construction of the Elliot Bay seawall and docks, the natural shallow water near the shore has vanished. The newly deep shore makes it difficult for vegetation, like algae, to grow, as they lack needed rocky soil and natural light. Similarly, the presence of large overwater structures along the Elliot Bay, which covers more than 65% of the edge, also prevent natural light from reaching the water below. This absence of light creates a hostile environment for the native juvenile fish and invertebrates as they become bait for the large fishes who tend to hide in these dark areas. (Figure 33)



Figure 12 - HABITAT CIRCULATION: A city level analysis depicts the major circulation patterns of the marine and terrestrial habitats next to the present day city, along with the natural vegetation that exists in its pre-european settlement state. Simultaneously, the present day Seattle port's requirement has completely modified the old Duwamish river delta by replacing the tideflats with piers and a sea wall. At the same time the rainwater drainage is combined with the underground sewerage pipes taking the discharge towards treatment center, thus reducing the water inflow in the Elliot Bay.





In addition, the near shore bathymetry along the Elliot Bay seawall has variable depths with sudden troughs and crests. Caused by dredging for easy mooring of large sailing vessels, this results in a condition where the areas surrounding the pier are deeper than those beneath it. This sudden change in water depths allows limited fresh water circulation near the shores, thus decreasing the level of oxygen that is needed for a habitat to survive. Additionally, the noise produced by the overhead vessels can be harmful to the fishes as sound travels more quickly and for a longer period in the water. However in the Elliot Bay for example, the growth of vegetation can play a major role in providing shelter against noise and at the same time from predator fish, while supporting micro-organism to feed the small fish. (Figure 34)








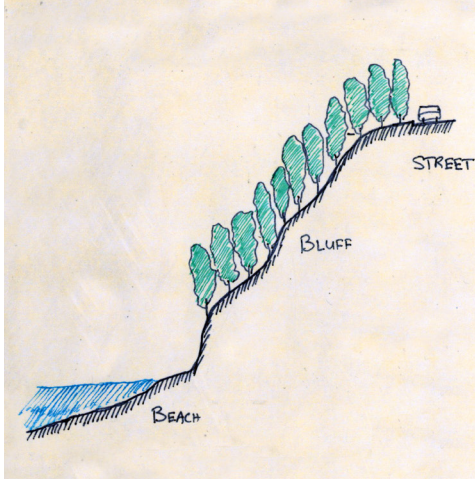
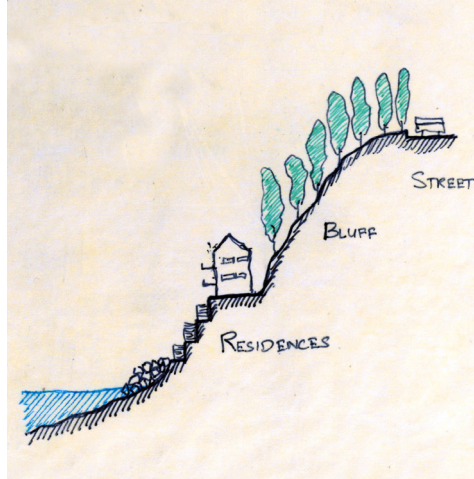
-  Overhead Structures (Piers)
-  Sea Wall
-  Soft Edge
-  Riprap Edge
-  CSO Pipes
-  Drainage Pipes
-  Green Streets

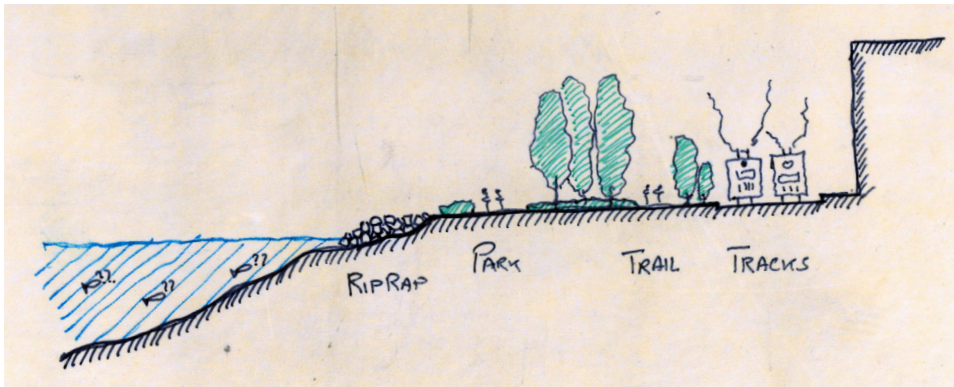
Figure 13 - PHYSICAL FABRIC: A more neighborhood level analysis depicts the present day man made city edge constructed in multiple ways, ranging from soft, rip-rap and sea wall (harsh) edge. These edge conditions are further explored in the forthcoming sections understanding the impact of human settlement along the seashore. Furthermore, the City of Seattle has started converting some of downtown residential streets into green streets which are also present along the water.



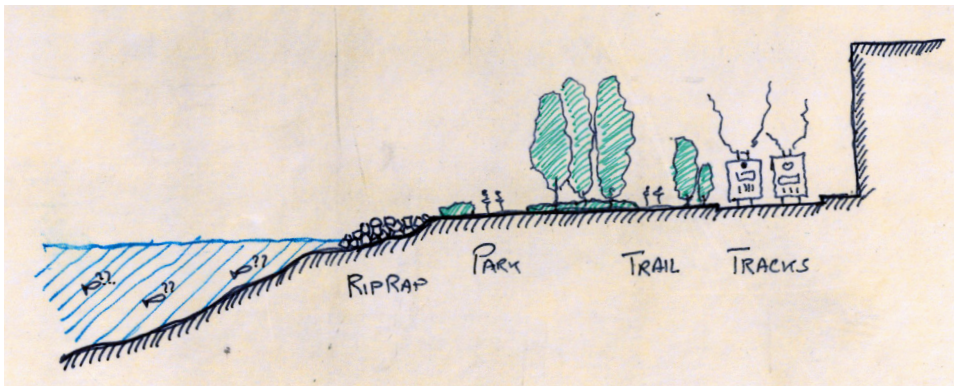
Section 01 - Magnolia Bluff



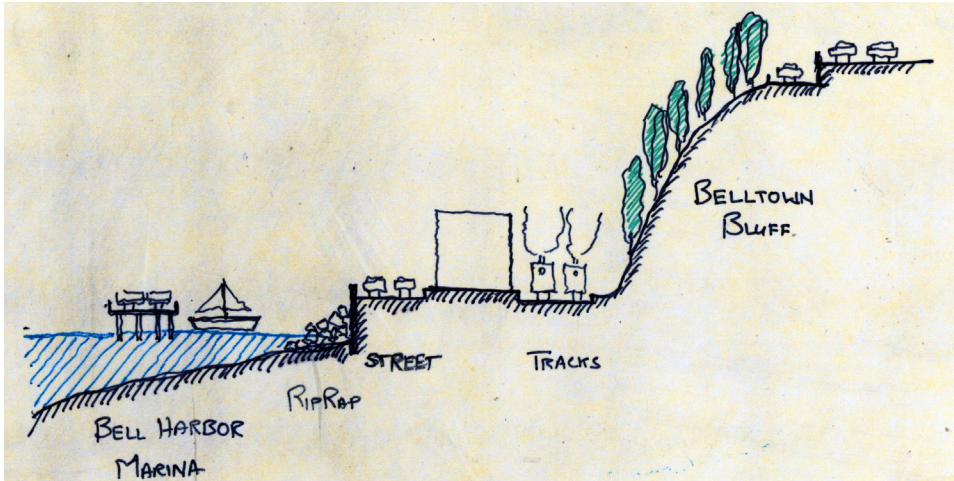
Section 01 - Smith Cove



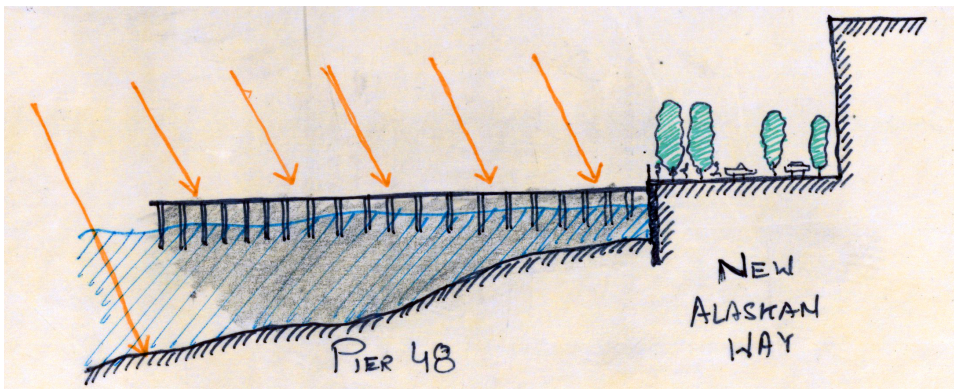
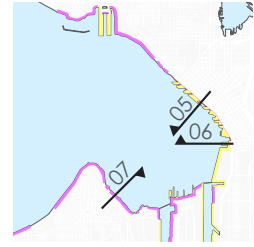
Section 03 - Centennial Park



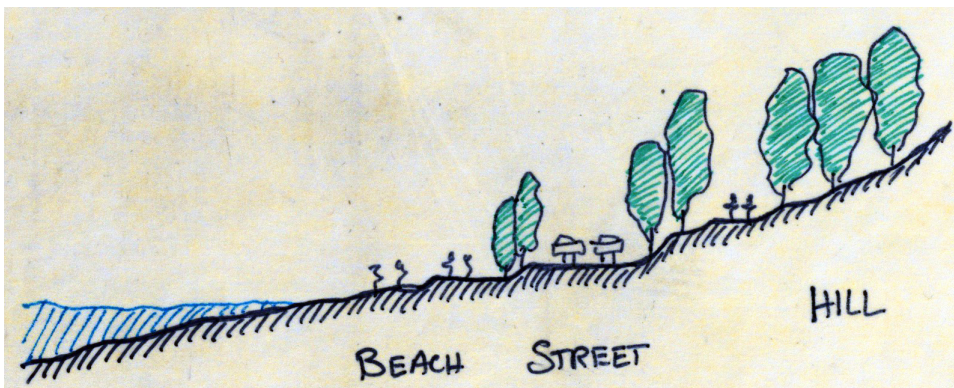
Section 04 - Myrtle Edward Cove



Section 05 - Bell Town Bluff



Section 06 - Pier 48



Section 07 - Seacrest Park Cove

Figure 14 - Cross sections through the various types of edge conditions in Elliot Bay.

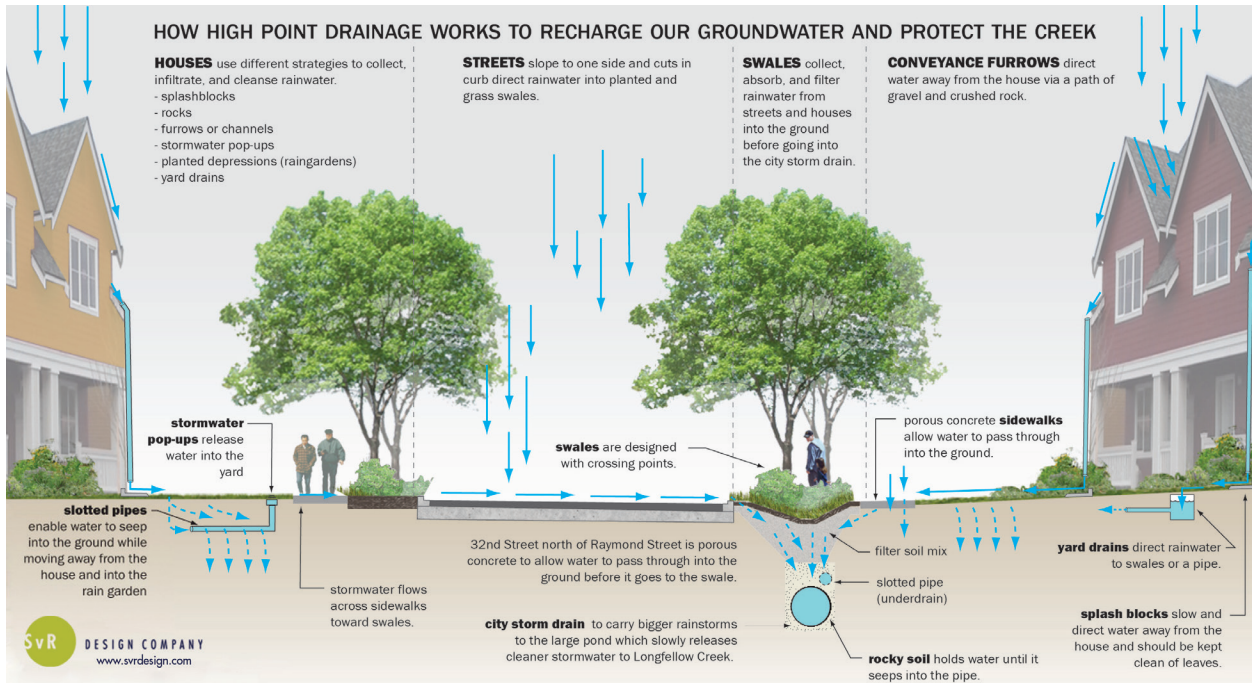


Figure 15 - A conceptual sketch by SvR showing a green street with wide sidewalks and landscape with an efficient rain water collection and drainage capabilities.



Figure 16 - Occidental Ave S in downtown Seattle, a green street, having no vehicular traffic and wide open spaces protected by the dense foliage.

SEATTLE GREEN STREETS

An approach by the city of Seattle towards improving the pedestrian experience by minimizing the traffic presence and increasing vegetation. As per the Seattle right-of-way improvement manual, "Green Streets are designated on a number of non-arterial streets within Downtown Seattle. Landscaping, historic character elements, traffic calming, and other unique features distinguish Green Streets from other Street Types. Green Streets are designed to emphasize pedestrian amenities and landscaping in areas that have dense, residential land uses. Each Green Street has its own unique character and design. The street right-of-way dimensions can vary significantly from street to street and from segment to segment."²⁷

Such an intervention allows the conversion of a utilitarian function of a street into a more communal gathering space. The incorporation of street furnitures, like benches and bike stands, and landscape would reduce the magnitude of traffic while lowering their speed, allowing more open space and attracting more pedestrians. Simultaneously, adding more planters and green sidewalks would direct the collection of rainwater into these soft pits which would filter the water before discharge. In the long run, it can be believed that such an approach towards traffic reduction and human friendliness would decrease the amount of traffic in the non-major streets encouraging the public to use more transit and car-sharing opportunities.

SALMON MIGRATION

The Puget Sound ecosystem also plays a major role in the life cycle of local salmon population. The areas near the shore are especially important for young fish, used for migration, shelter and food. Juvenile salmon experience the highest growth rates of their lives while in estuaries and nearshore waters.²⁸ These spaces allow the Salmon to adapt to the change in the water composition as they move from the river's fresh water to the ocean's salt water. These fishes spend weeks or months²⁹ in the estuary, transforming from a smolt to an adult before leaving the shelter. This migration usually takes place in spring and fall. The shallower shore habitat allows salmon to escape from the large predator fish that swim the deep sea. Ample daylight supports the growth of "marsh plants, seaweeds, eelgrass, epiphytes, and sediment microalgae,"³⁰ providing food for the young fish. Similarly when the adult salmon come back for breeding in the fall and winter, they use the estuary, as a transition space, before going upstream. (Figure 43)

Human activities along the coast have resulted in a significant loss³¹ in the number of salmon entering the ocean. The two major reasons for this decline are the construction of the seawall and overwater structures. The seawall wall creates a deep water shoreline, eradicating the natural systems that provide food and shelter for young fish. Additionally, this also causes lack of fresh water circulation, which results in water temperature rising further reducing the life expectancy of the juvenile fish. The construction of piers and docks over the water blocks light from entering the water below, increasing the probability of the fish to be preys for big dark sea fish.

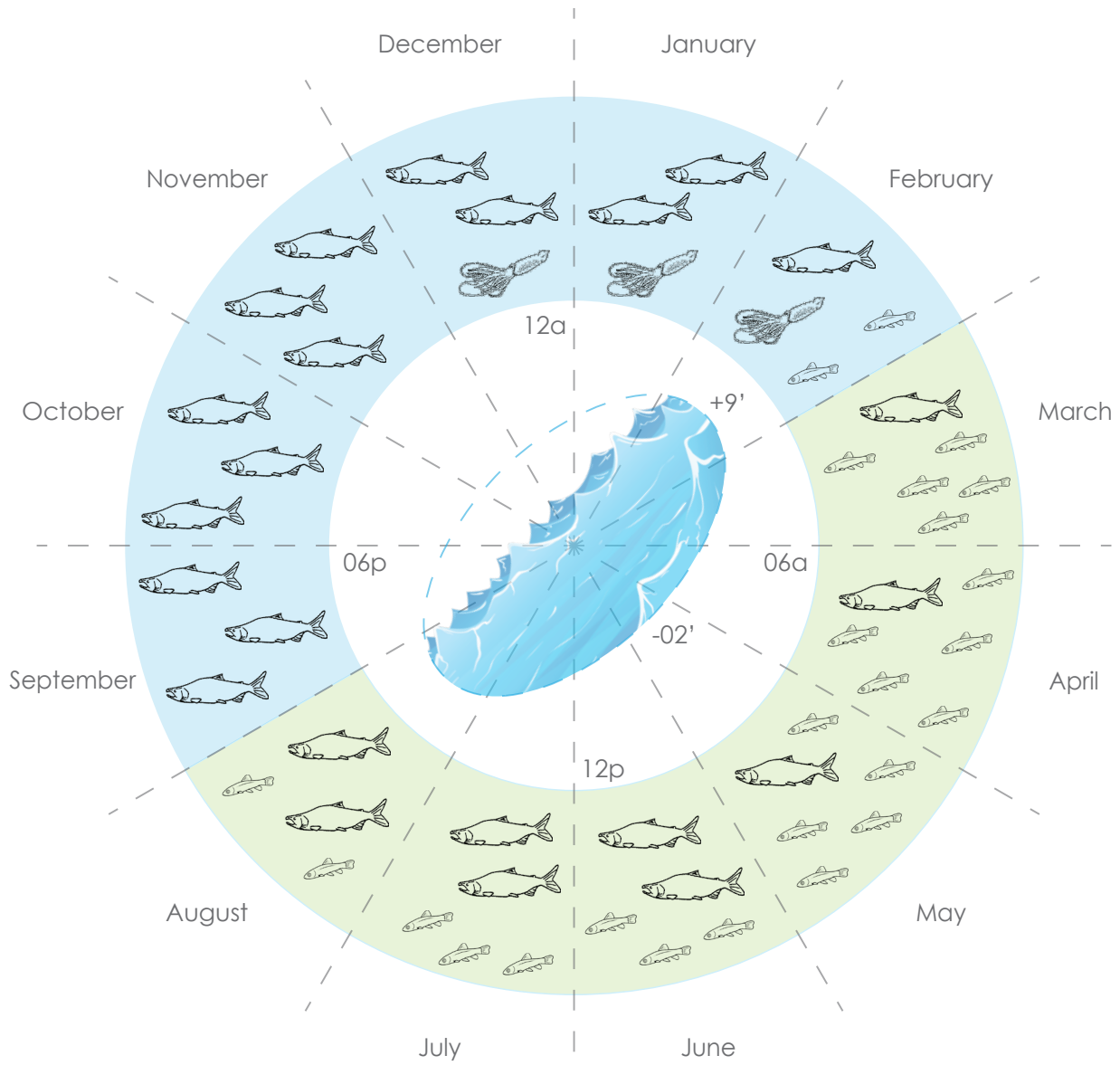


Figure 17 - A cyclical pattern of the various types of Salmonid and Adult Salmons present in the Waters of Elliott Bay.

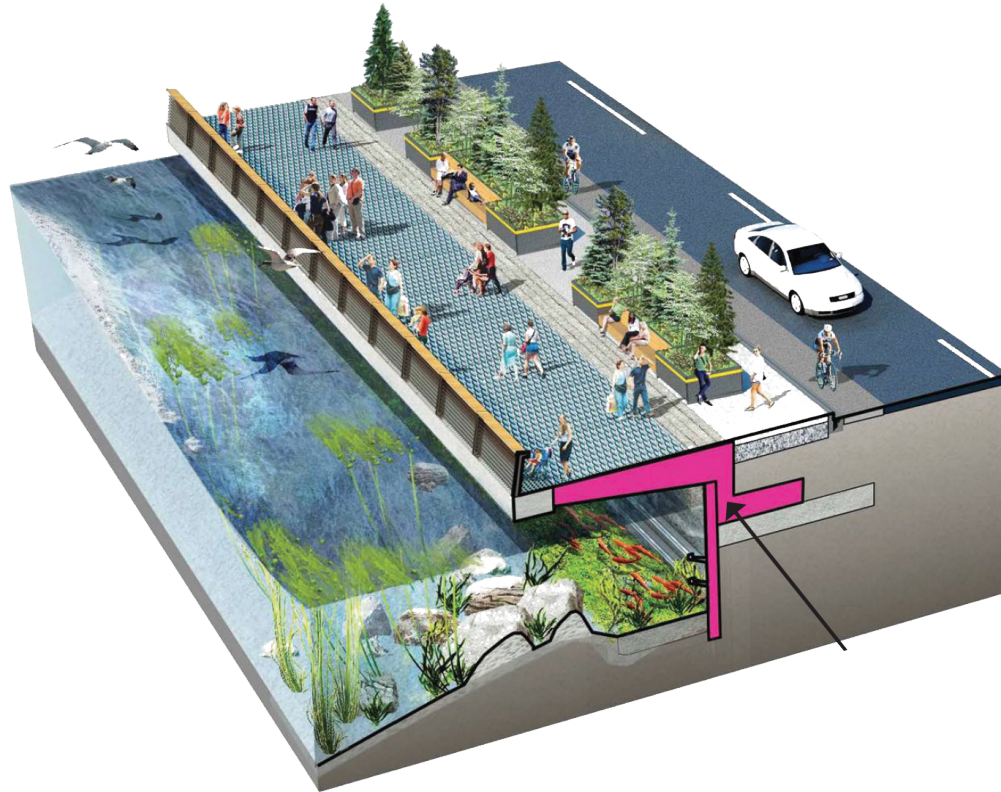


Figure 18 - A new habitat bench being proposed alongside the new Elliot Bay sea wall. The design also includes the glass inlaid sidewalk, allowing natural light to reach the sea floor below.

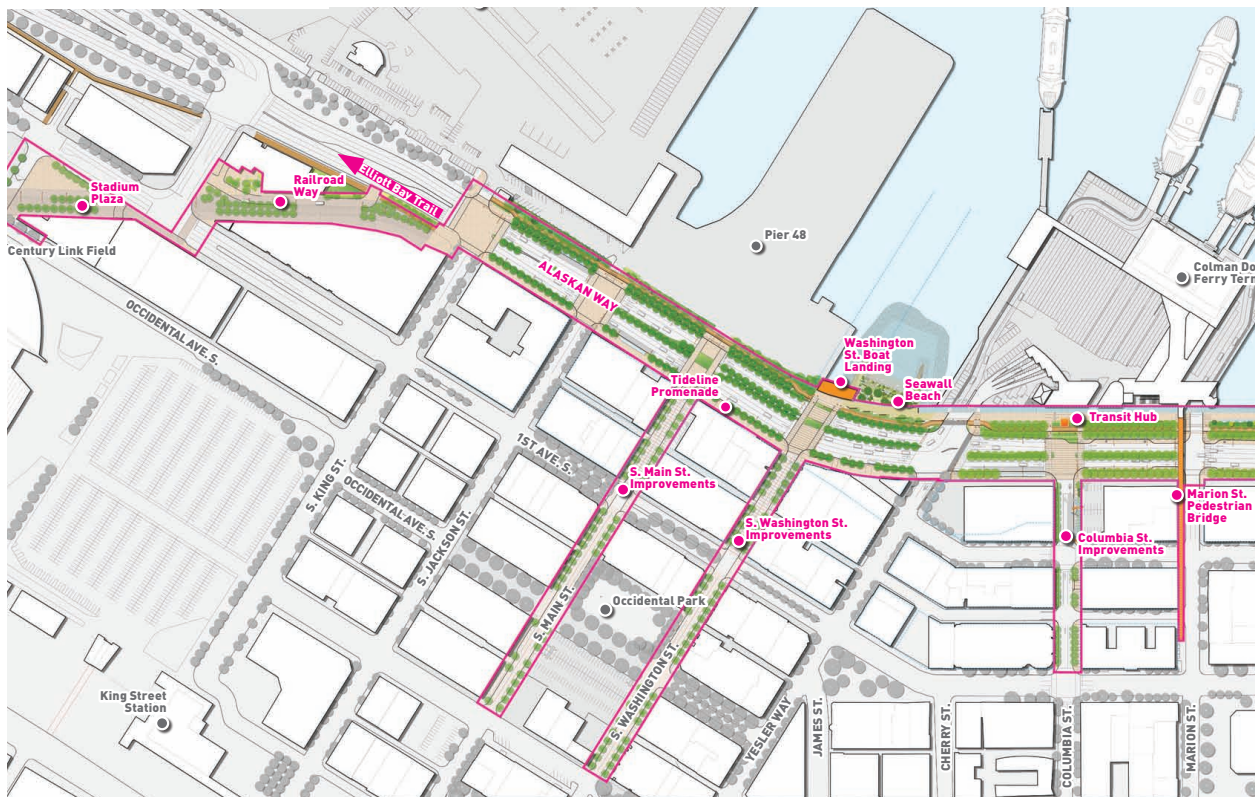


Figure 19 - The southern portion of Seattle Central Waterfront newly proposed plan by James Corner Field Operations.

THE NEW SEA WALL AND SEATTLE WATERFRONT PROJECT

The existing Elliott Bay sea wall was constructed during the mid-1930s. It was built from approximately “20,000 old growth trees”³² many of which are hidden behind a concrete facade. The construction changed the soil composition of the Elliot Bay and with the increased water depth and smooth concrete texture, has made it difficult for the marine life to grow. As per the Waterfront Seattle's new proposal, the new sea wall is being built more towards the land to restore the natural habitat, while providing rough surfaces for vegetation to attach to. The accommodation of the glass panels on the overhanging sidewalk is intended to allow natural light to reach the water below making it easy for juvenile fishes to see. (Figure 31)

Simultaneously, with the forthcoming removal of the Alaskan viaduct, the city of Seattle is in process of re-imagining the waterfront. According to the Field of Operation's conceptual layout, a series of public recreational street spaces are being proposed along the water edge, that seek to “create a vibrant public realm,”³³ reconnecting the city with its water. The core project, the continuous waterfront promenade, will act as a walkable spine connecting the various amenities and events at specific destinations. These destinations will be places providing opportunities of gathering, viewing and other social activities. The efficient layout of traffic, both vehicular and bicycles, is also part of the overall design to create a safe human friendly space for the public. (Figure 32)

PROGRAM

In response to the deteriorating conditions of marine and land ecology of Elliot Bay and the potential of new construction, this thesis proposes the design of an Ecological Educational Center at the downtown waterfront of Seattle. The project focuses on creating a physical environment where the public physically interacts with the region's biodiversity. The overall program of the ecological center will be divided into three categories,

- 1) The Arrival: To create a shoreline that is sensitive to the marine and terrestrial ecosystem, one has to start from the city. This portion of the project will consist of green streets that focus on improvement of the water quality before discharging into the sea. Additionally, opportunities of visual and spatial connectivity with the open spaces shall be explored allowing the city to operate while experiencing the green intervention.
- 2) The Edge: To develop a soft edge with opportunities for public to experience the tidal change, it is essential that this portion of the project shall be the point that states the transition between land and water. This space being in the center shall cater to both man and marine while providing opportunities for research of the near shore Puget Sound habitat.
- 3) The Culmination: To respect the habitat's existence while bringing the public out into the sea, this portion of the project will consist of an exhibition space visually connecting with the Puget Sound landscape. Consisting of underwater boardwalk and seminar rooms, this space exposes the public to the functioning marine habitat while providing opportunities for students to learn more about the area's natural ecosystem.

For an education based program to be situated, it is essential to have a site which is near to the entrypoint of salmon into the Puget Sound estuary, so that the public can visually engage with them throughout the year. Simultaneously, considering the present day condition of the Elliot Bay shoreline and the limits of the new sea wall, which ends at Colman Dock, the site should be towards the south. Learning from the past, constructing the port at the mouth of Duwamish and the filling of tideflats, that affected the terrestrial and marine habitat, would be most beneficial. Therefore, pier 48 appears to be the most favorable site for Ecological Education Center.

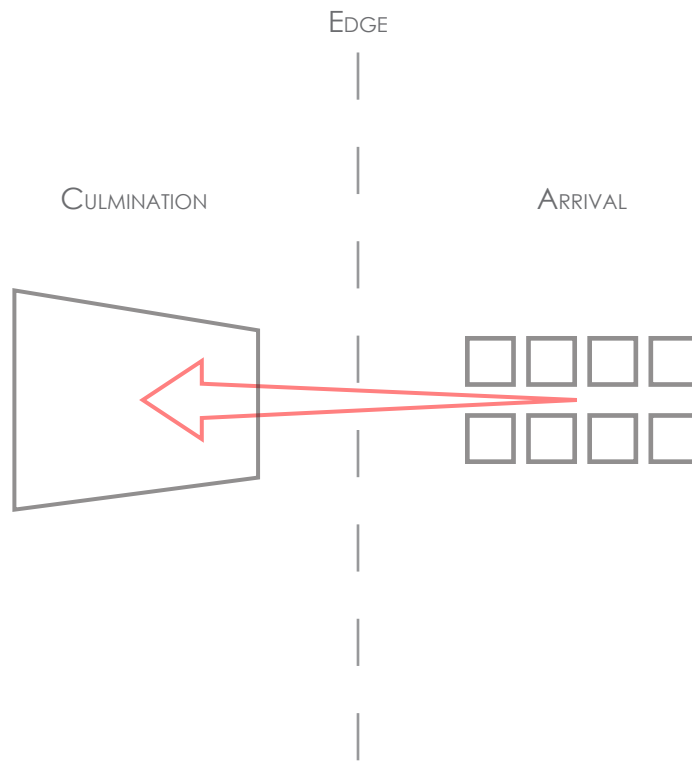


Figure 20 - A programmatic diagram explaining the relationship between city and water through a soft edge.



Figure 21 - Thesis project's site, Pier 48, looking into Elliot Bay while having Seattle port towards the South, Ferry terminal (Colman Dock) to the north, a bustling city in the south.

PIER 48

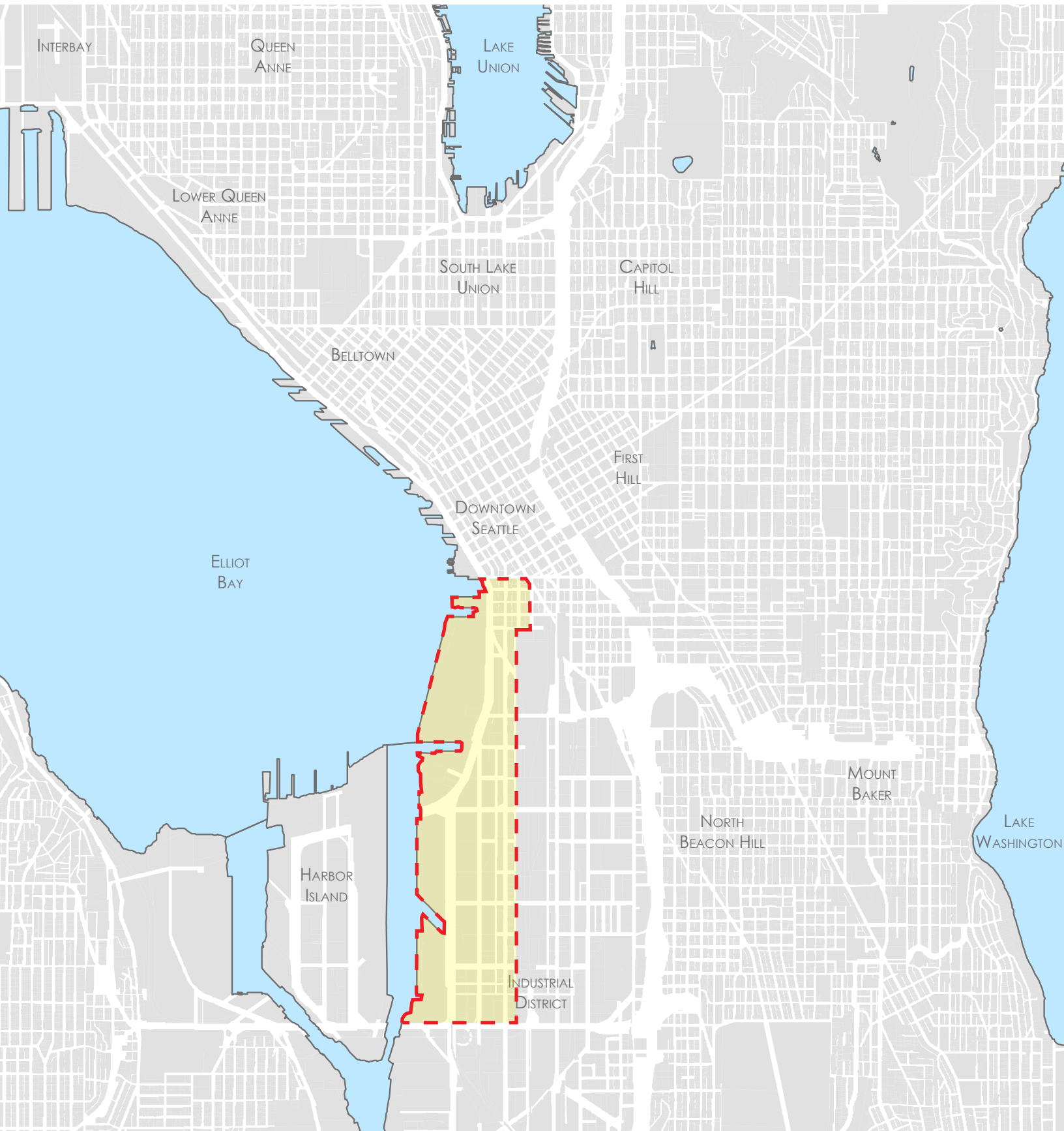
Situated at the mouth of the Duwamish river, Pier 48 provides an appropriate site for the exploration of this program. As per the Seattle Seawall Environment report, the sea bed level below and north of the pier is shallow providing a space for creating a natural habitat zone of the juvenile fish. This provides an opportunity to explore the aquatic life below the water, while creating spaces of interaction submerged beneath the surface. Since it is a vacant pier with no structure, provisions for creating voids and open decks will be manageable without affecting the surroundings.

Pier 48, constructed in the mid-1930s, was first used by the port of Seattle to support the mooring of various cargo ships. As the containerization took place, due to its inability to accommodate the new technology, the pier was used as the Seattle terminal for ferries to the Alaska from 1967 till 1989. Presently, it is used as a berthing place for large vessels but the Seattle State Ferry tends to use the space for a new ferry terminal which has been stalled due to lack of funds.

Additionally the site is easily accessible, being strategically located west to Pioneer Square and closer to multiple bus routes. The South Main street, meeting the front entrance of the pier, provides a clear line of access from the city to the water. Flanked on either side by port and utilitarian functions, the site has a potential to stand out and act as a living part of Elliot bay, sustaining both marine and land life. Eventually, after becoming an urban filter, providing safeguard to both and marine and terrestrial life the project shall be able to expand towards the south, taking over the port. This intervention would allow an improvement of the region's ecological condition while bringing back the shallow nearshore and a soft green edge.



Figure 22 - Elliott Bay with the study area highlighted in yellow



The site of Pier 48 on the downtown Seattle waterfront provides an opportunity to create an experiential project that links land and water. This space can act as an announcement to the user that they are transitioning from one medium to the other. The design for an Ecological Education Center will make use of a strategic approach to engage with the existing urban and natural context. The building will incorporate the landscape and water's edge through visual and spatial means. The project will consider the site as a the marine and bird habitat, alongside its primary function as a human one.

The thesis will explore the sustainability of the project in terms of its design and water treatment. Focus will be on the Elliot Bay's renewable resources for the operation and the aesthetics of the project. The design of this Ecological Education Center will demonstrate how to create an ecologically responsive structure on the Seattle waterfront that does not harm the natural ecosystem. With sustainability as it focuses, with respect to both usage and systems, the project seeks to stand as a model for future developments that allow human and marine life to co-exist in a mutually beneficial relationship.

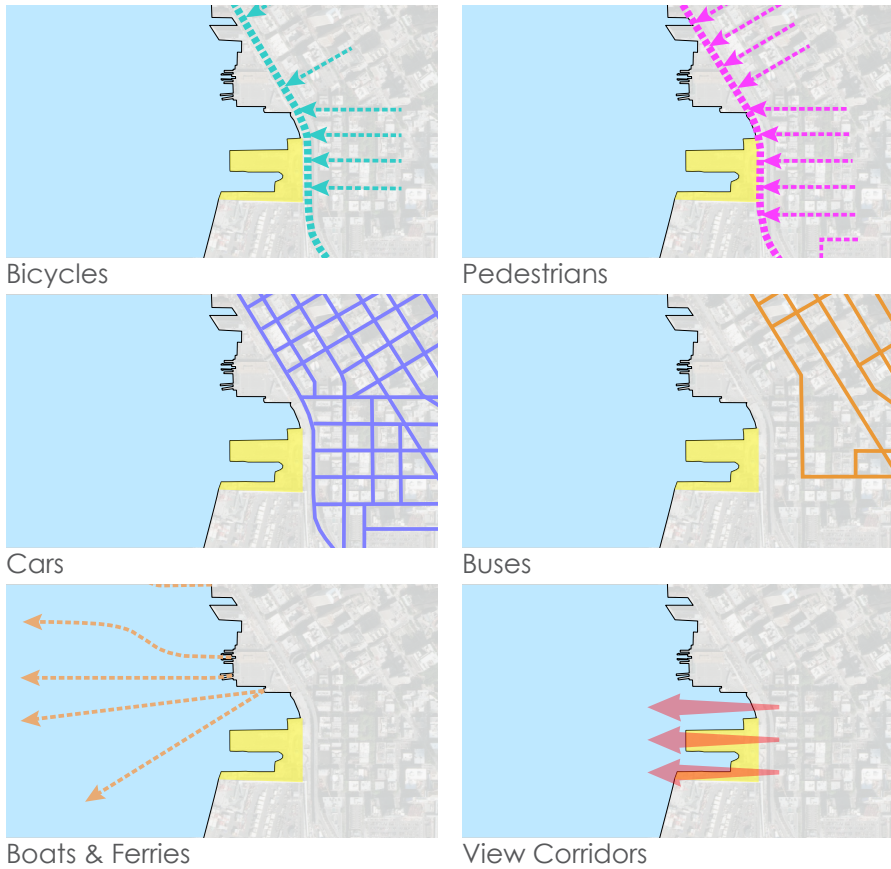


Figure 23 - City's daily activities around Pier 48.

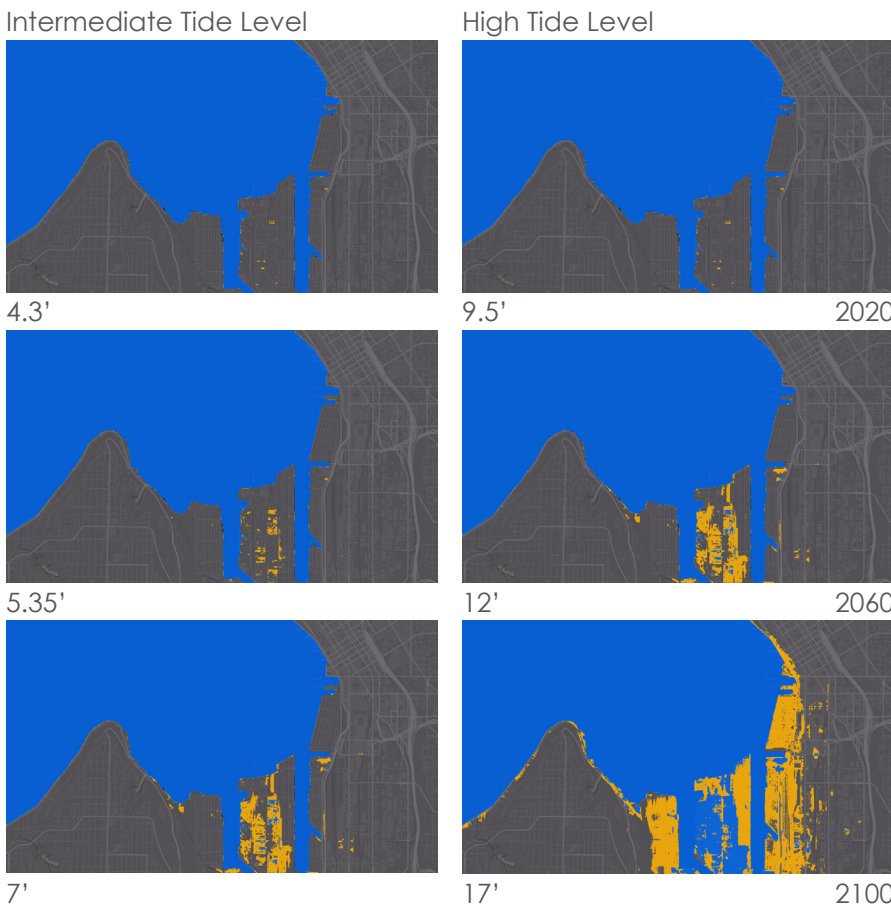


Figure 24 - Sea level rise predictions around Pier 48 as per the National Oceanic and Atmospheric Administration

Mean Level: +4.0'
 Avg. Low Lev.: -2.3'
 Avg. High LEv.: +9.0'



Figure E - Whidbey Island, WA.



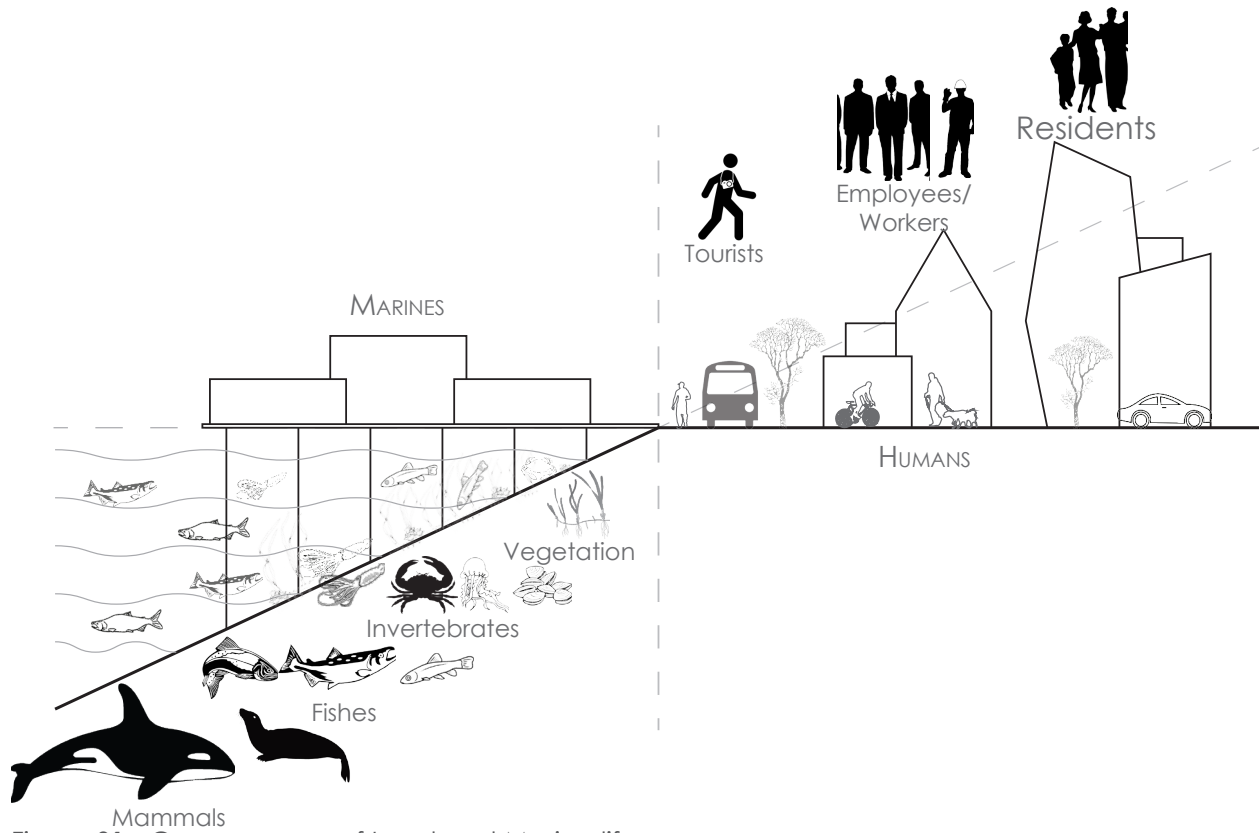


Figure 01 - Convergence of Land and Marine life

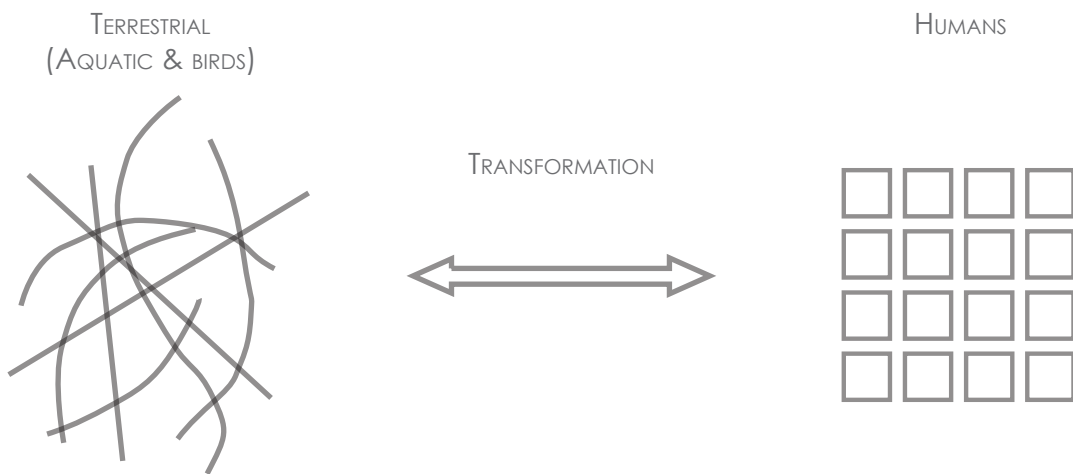


Figure 02 - The transformation from a rigid grid system towards a more flexible irregular system

4. DESIGN PROPOSAL

Since ecologists consider Puget Sound as a “Hot Spot” of biodiversity, with numerous terrestrial habitats residing within its realm, it is an important asset for the region in providing both food and economy to its public. Based upon the historical and ecological analysis of the area, the edge conditions of Elliot Bay play a crucial role in the livability of both marine and human life. Learning from the past and realizing that constructing harsh edges along the water and superimposing human settlements over aquatic habitat not only diminishes life from the near shore but also creates gap between the humans and wilderness of the seas. As the main point of contact between land and sea, the Seattle Waterfront should be designed in a way that creates a sense of harmony between the living beings. A sense of transformation from the artificial to the natural should be expressed, thus creating a flexible and regionally adaptable design improving the ecology of the site.

CONCEPT

To propose such an intervention that shows sensitivity towards the site's ecology, the design starts with a idea of establishing a shallow nearshore with no overhead structures. This approach would not only allow natural light to reach the seabed but also increase opportunities of photosynthesis which will result in the formation of dense vegetation underwater. The green seabed would provide young aquatic habitat with food and shelter while preventing erosion. Overhead structures are being proposed at the deep end of the site with skylights and perforated floor slab allowing natural light to illuminate the interior and water below. These structures are being covered with dense vegetation allowing the bird habitat zone to be developed away from the bustling city. This green roof also acts as a sponge absorbing rain water and dissipating it slowly into the sea. The forms of structures create a direct contact with the context allowing the user to have a visual connection with their surroundings. The proposal consists of the removal of the Pier 48 top slab while leaving behind its piles, which can act as perching stations for the birds.

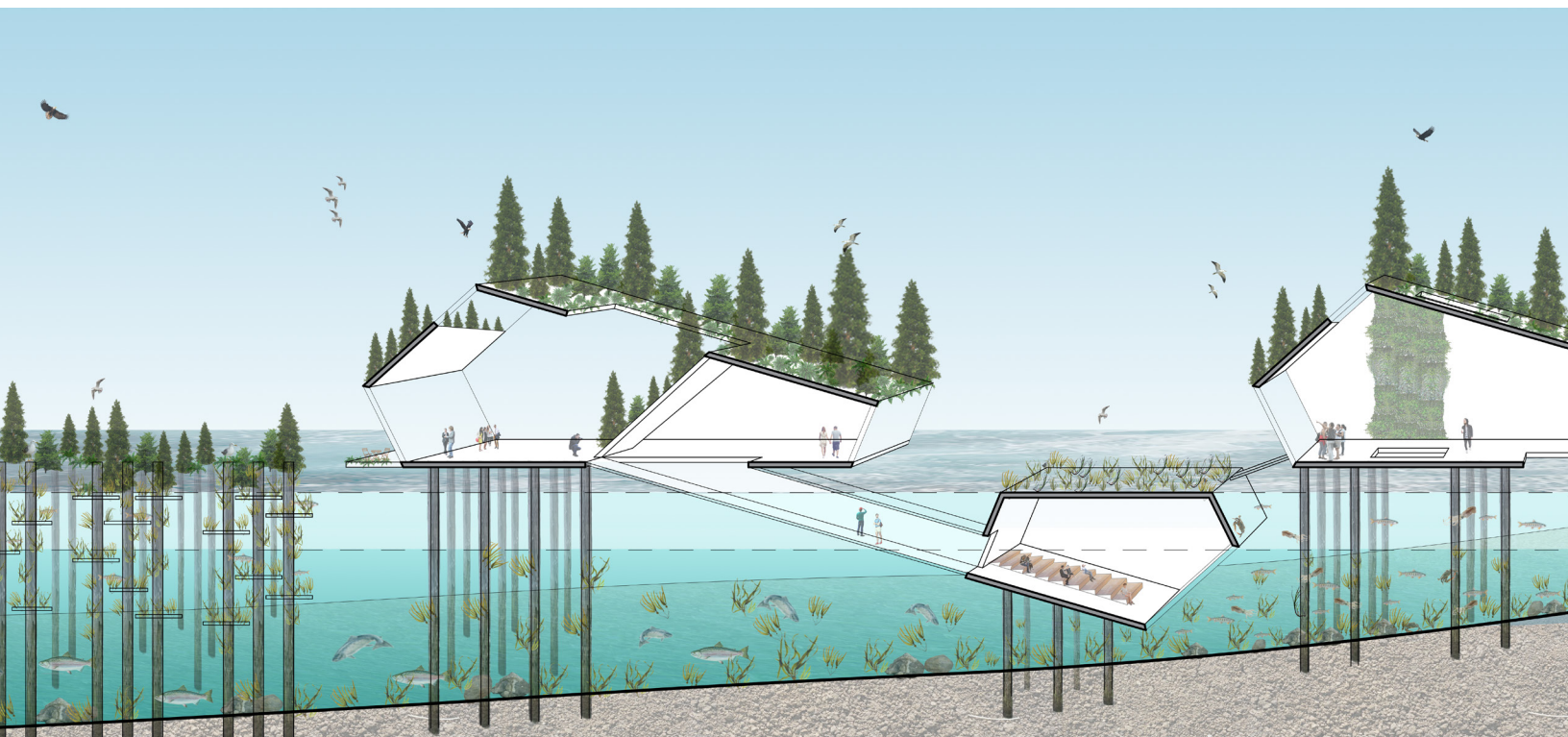
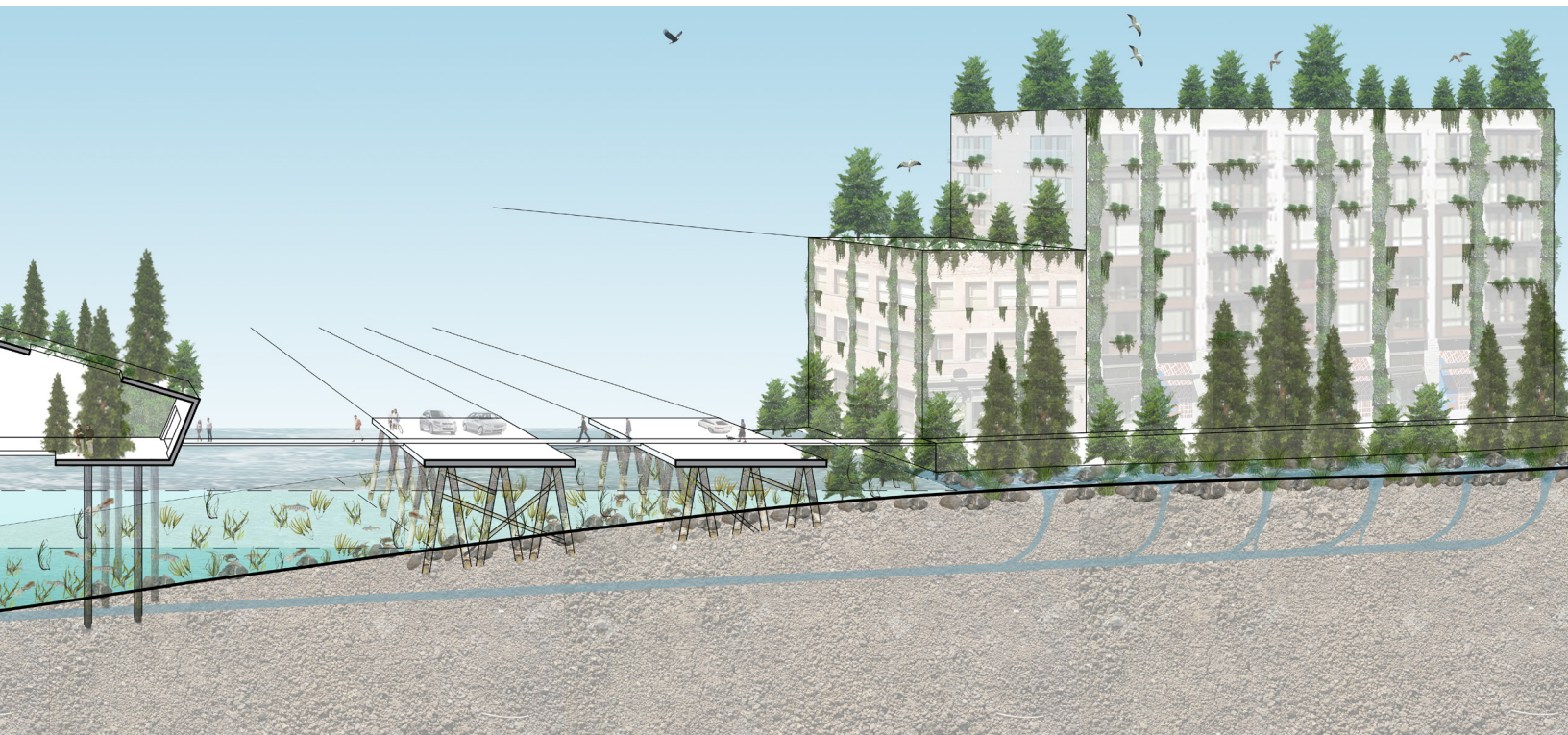


Figure 03 - Conceptual Section depicting the proposed shallow nearshore with the green streets towards the east and overhead structures towards the west over deep waters with visual connection with the surroundings..

On the other hand, rain water runoffs along with filtered grey water are being diverted directly into the Sound, reducing load from the underground city utilities. To manage an efficient water discharge into the Sound, without polluting the newly developed natural habitat, green streets with bioretention and biofiltration swales are being proposed. The plants species selected for such purposes will allow rain and grey water to seep into the ground than running off. Furthermore, roof gardens are also being proposed on existing structures for water retention and filtration at higher levels. Regarding the transportation infrastructure to exist with the ecological intervention, the Alaskan Way is being proposed on trestles which will allow the flow of water from the city into the sound. Therefore, these interventions will create a variety of learning environments for the public encouraging them to learn and explore about the natural ecosystem of Puget Sound and the way it operates while performing their daily routine.



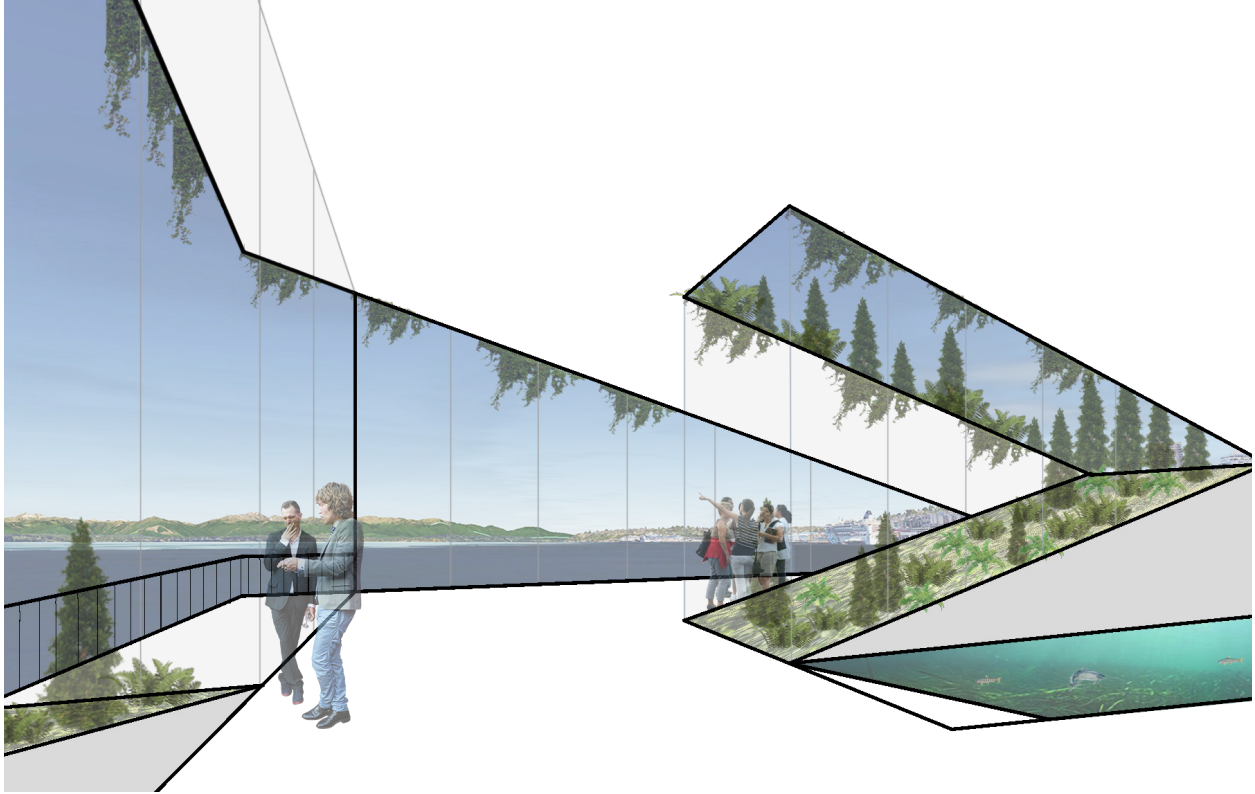


Figure 04 - A conceptual representation of the above surface structures with visual connection with the surrounding landscape.

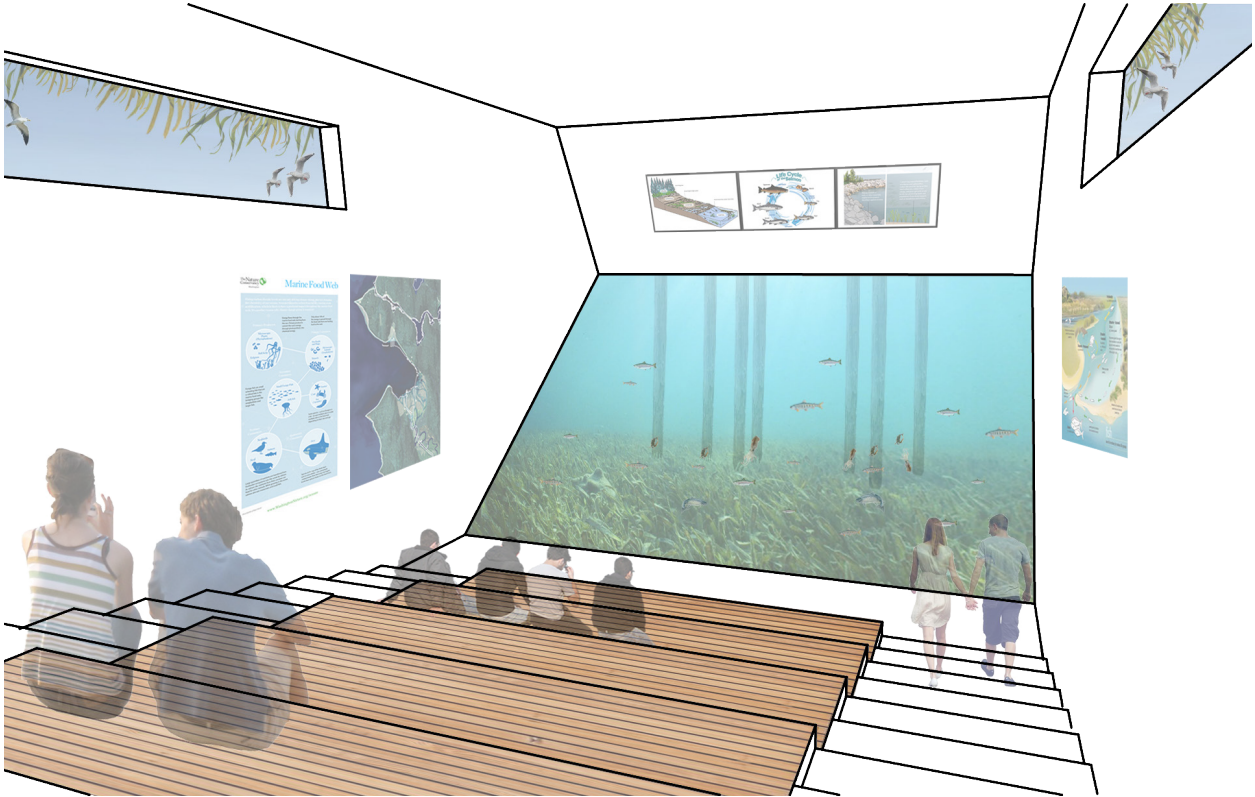


Figure 05 - A conceptual representation of the underwater structure depicting a visual connection with the aquatic habitat.

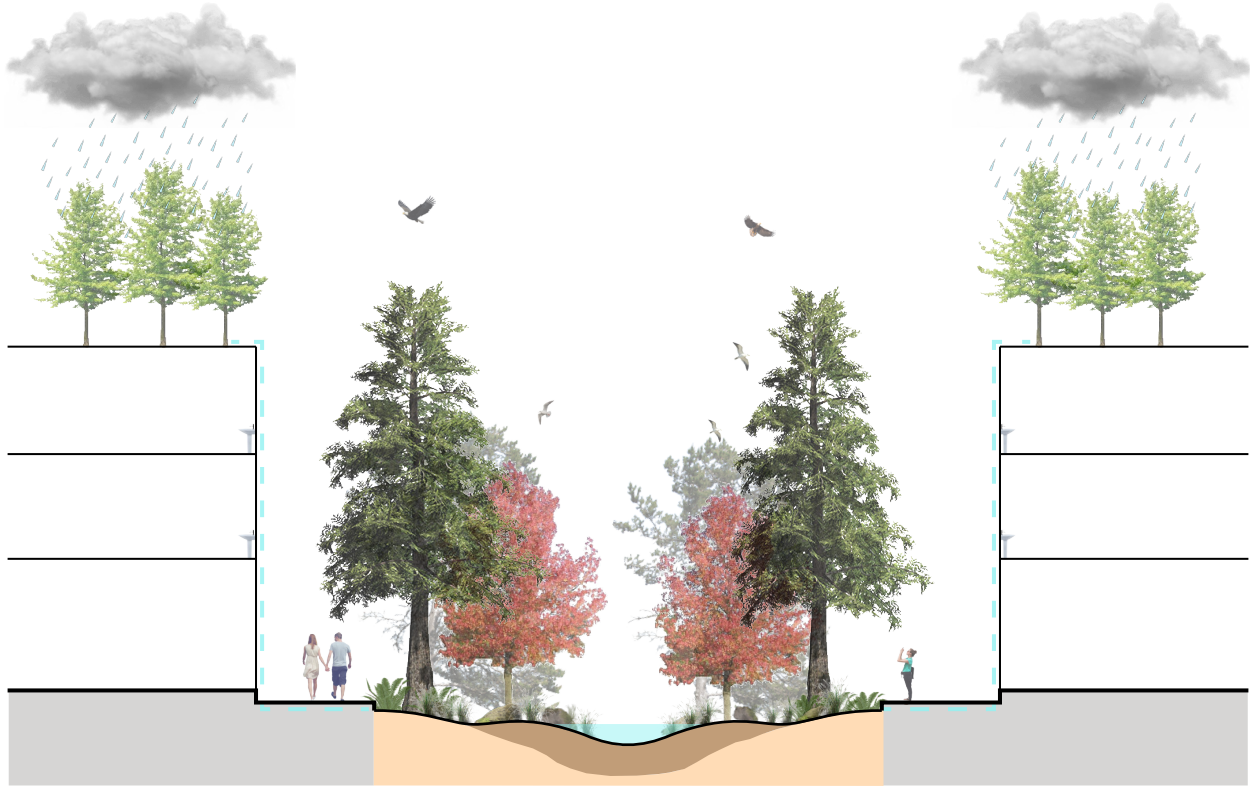


Figure 06 - A diagrammatic section of a green street that prevents water from running off quickly into the Sound.

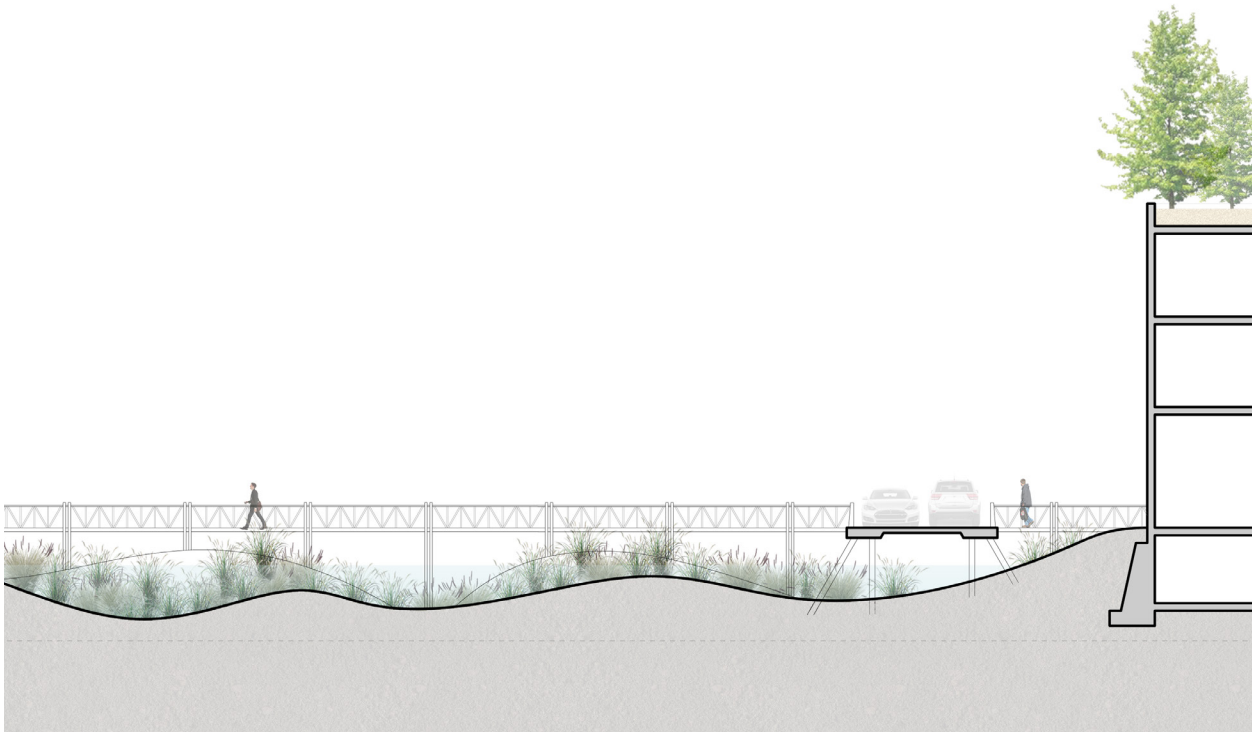


Figure 07 - A conceptual representation of the intertidal zone with dense vegetation preventing erosion and opportunities for habitat to exist.





Figure 08 - The project's SITE PLAN depicts the proposal of a soft edge where the sea water can come up to the city. The mixing of the fresh/filtered water from the green streets with the salt water creates an intertidal zone of brackish water allowing land and marine habitat to exist along a busy urban center. The portion of pier 48 that was built over sand and earth filled land has been converted into bluff 48, taking the name from the pier. The bluff acts as a container preventing the brackish water to drain into the Sound at low tide. Such behavior can create small intertidal pools which can improve the livability of the intertidal habitat. There shall be dense vegetation over bluff 48, with mostly shady trees and strong roots that can prevent soil erosion. Opportunities of spacial interaction between the public and nature has been developed. Especially through the interactive studio, where one can experience the tidal change at first hand. Similarly, the landscape studio and the subtidal studio, which are at the deep end of project, allows a more visual connection with the nature. As one can go beyond the city limits both above and below water to experience the beautiful landscape and biodiversity of Puget Sound. The structures are connected with the help of narrow bridge that occupies less space and does not obstructs the natural light from reaching the sea below. It provides the only access to the project at high tide while protecting the delicate habitat on the ground that are sensitive to human presence. On the other hand, at low tide there are opportunities for the public to approach the ground through staircases and stepping stones allowing a more close up interaction with the nature. Furthermore, a portion of the old pier has been retained and being transformed into a bird sanctuary with fruit trees and no human access. This approach will allow the terrestrial habitat to develop more significantly, while being observed by the public from cafe.



SERVICEBERRY



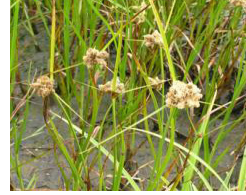
BULL KELP



EELGRASS



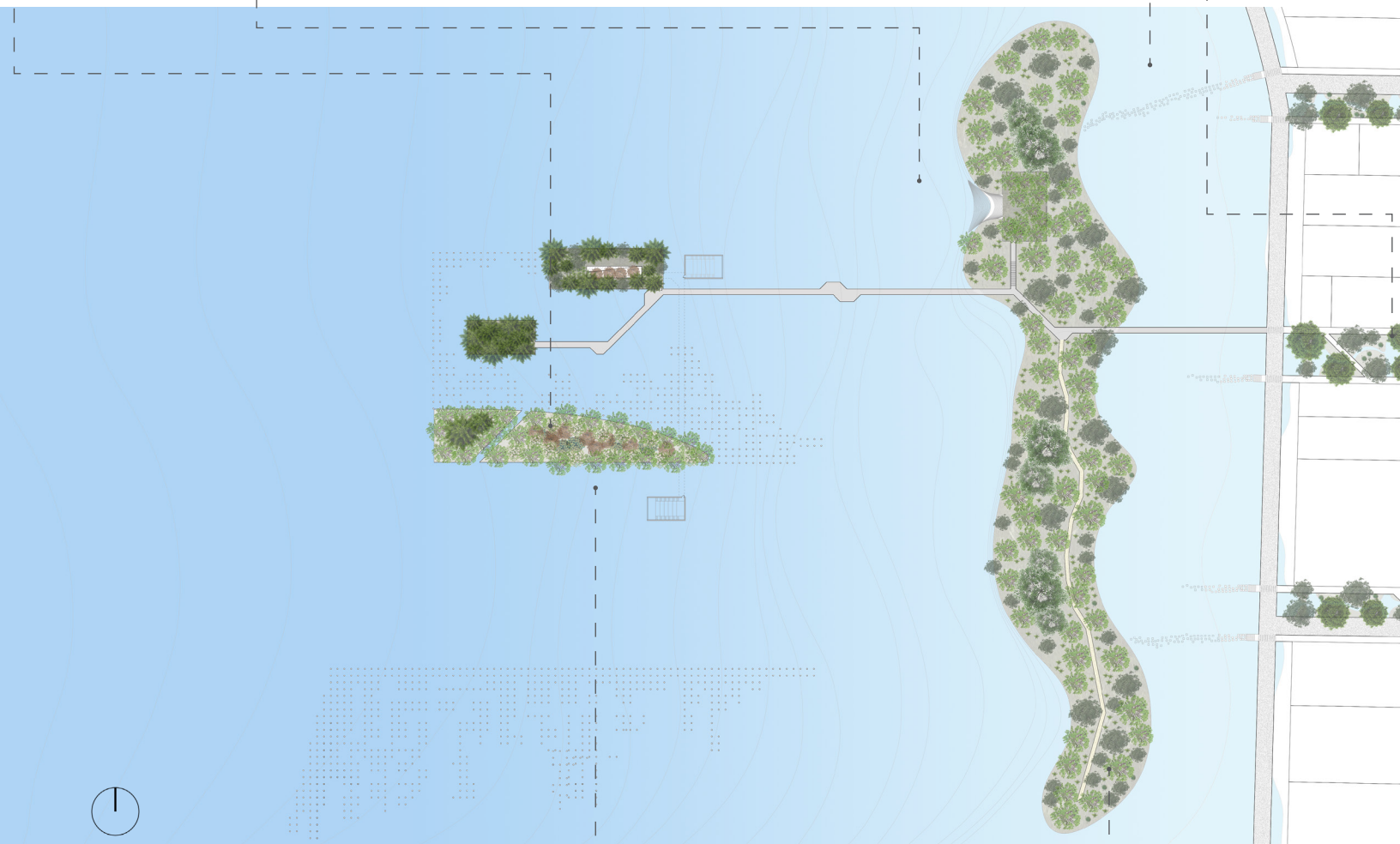
DUNE GRASS



SEACOAST
BULRUSH



KINNIKINNICK



DOUGLAS FIR



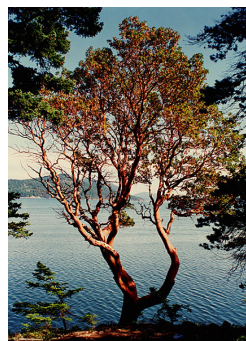
PACIFIC
DOGWOOD



BEAKED HAZELNUT



BIG LEAF MAPLE



MADRONE



SITKA SPRUCE



WESTERN
SWORDFERN

TUFTED
HAIRGRASS

SLOUGH SEDGE

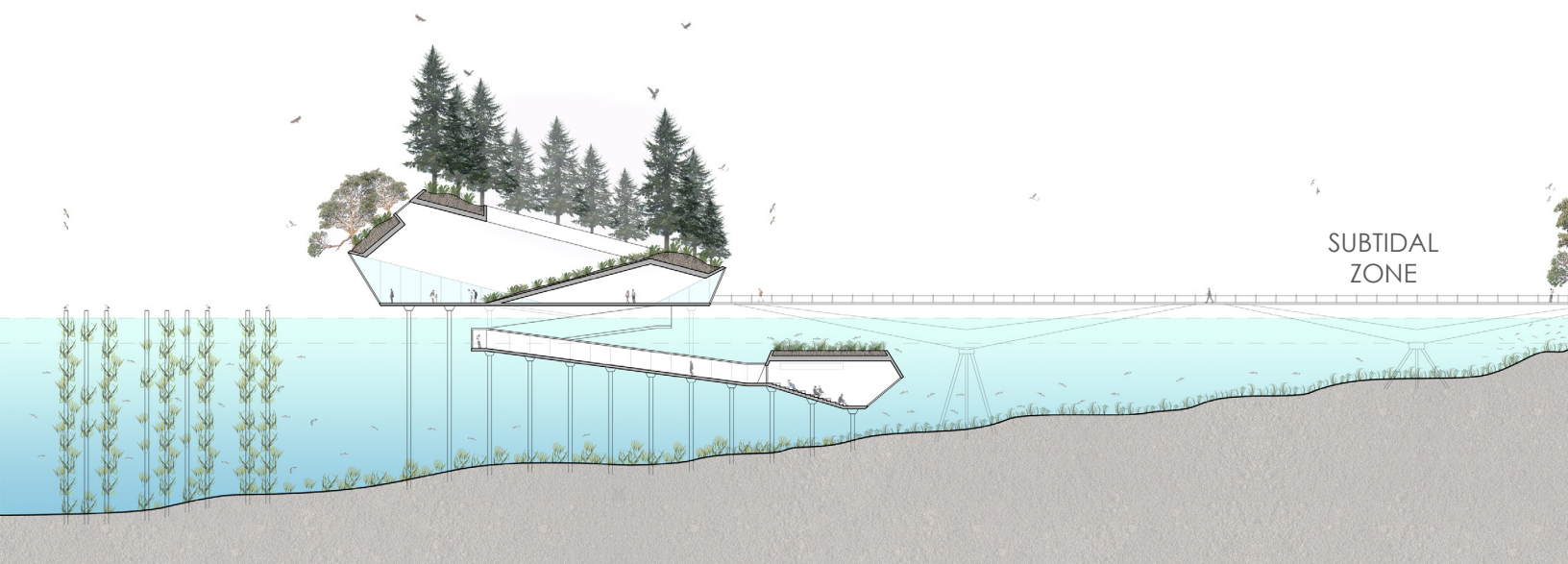


SHORE PINE

WESTERN RED
CEDAR

LIQUID AMBER

Figure 09 - Landscape played a major role in the development of the project, as it was used as a tool for proposing a sustainable approach. The VEGETATION PLAN depicts that mostly native vegetation had been considered for supporting the various functions proposed at the site. As part of the concept, the native plants play a crucial role for fostering the unique habitats of Puget Sound while creating the vernacular landscape. The selection of the plant species, like Tufted Hairgrass and Kinnikinnick, for the city streets would help in retaining and filtering the rain water as well as the grey water from the nearby structures before discharging it into the Sound. Due to their dense foliage, the pollutants are stopped from entering the Sound. Similarly, species like Dune grass and Seacoast Bulrush due to their ability to exist in brackish waters and provide shelter to the fragile habitat are being proposed within the intertidal zone and the Bluff 48. Their ability to prevent soil erosion creates a firm ground for the nearby structures that can be vulnerable to land slides. For the shallow subtidal zone, Eel grass can be grown. Since the sea bed of Elliot Bay consists of sand and small rocks, they can prevent soil erosion while providing food for the zoo planktons which are essential for the growth of young Salmonids. At the same time, their long and dense foliage can protect the young fishes from being the food of the large fishes. On the other hand, trees like Shore Pine, Western Red Cedar, Stika Spruce and Madrone not only hold the soil from drifting but also are a great source of food for both birds and fishes. Fruit and flowering trees like Serviceberry and Beaked Hazelnut attracts an array of native and migratory birds while their fallen leaves are a good source of nutritions for the fishes. Furthermore, trees like Douglas Fir and Big Leaf Maple on top of the structures and the bluff are mainly proposed as landmarks, portraying their magnificence that they once used to do when covering the whole of Seattle area before the western settlement.



EXISTING
PILES

LANDSCAPE
STUDIO

SUBTIDAL
STUDIO

SUBTIDAL
ZONE

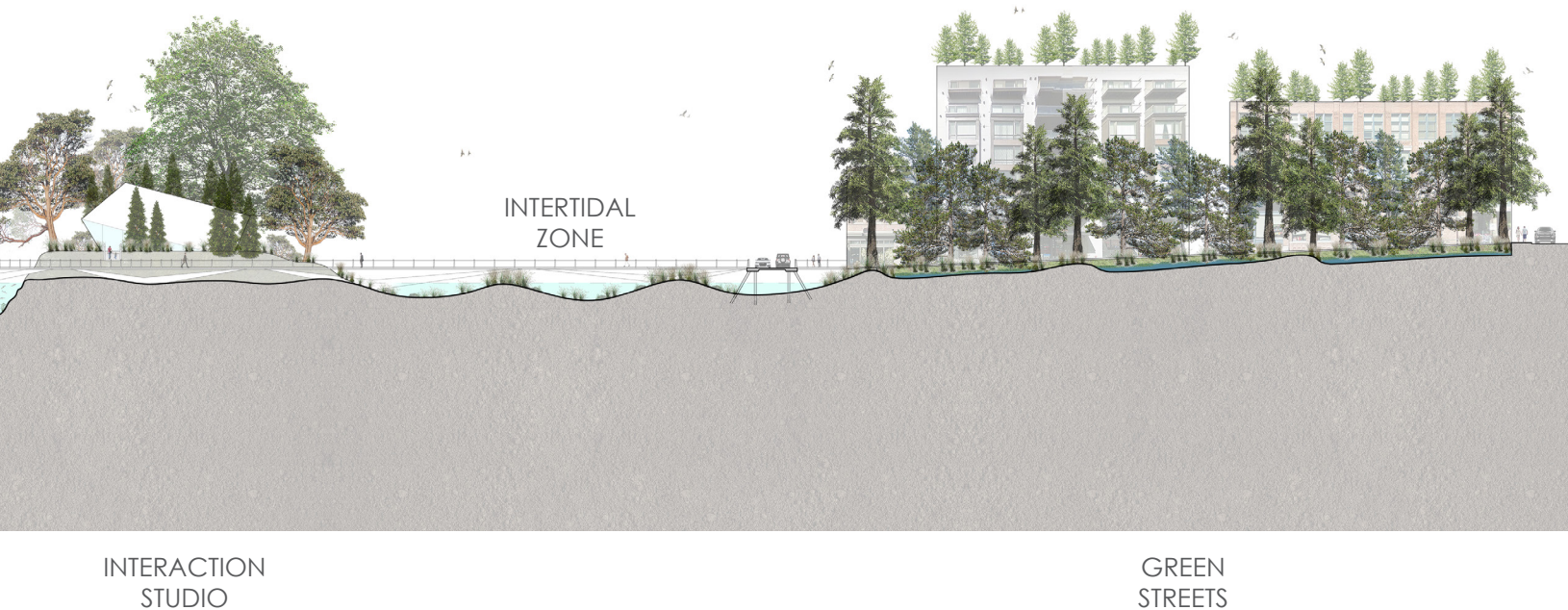


Figure 10 - The SITE SECTION depicts a series of interventions that starts by focusing at the existing city and transforming it into an urban forest, then creating an undulating intertidal zone having a variety of tidal pools which are protected by the Bluff. Moving further away from the city, the regraded shallow sea bed with the pedestrian bridge in the background provides adequate light and space for the fishes to develop. This regrade, having a combination of flat and slope beds, provide a flexibility for the fishes to exist with respect to their size. And finally, ending at the deeper end of the site with a structures that allows direct visual contact with the wilderness of the sea and the landscape beyond.

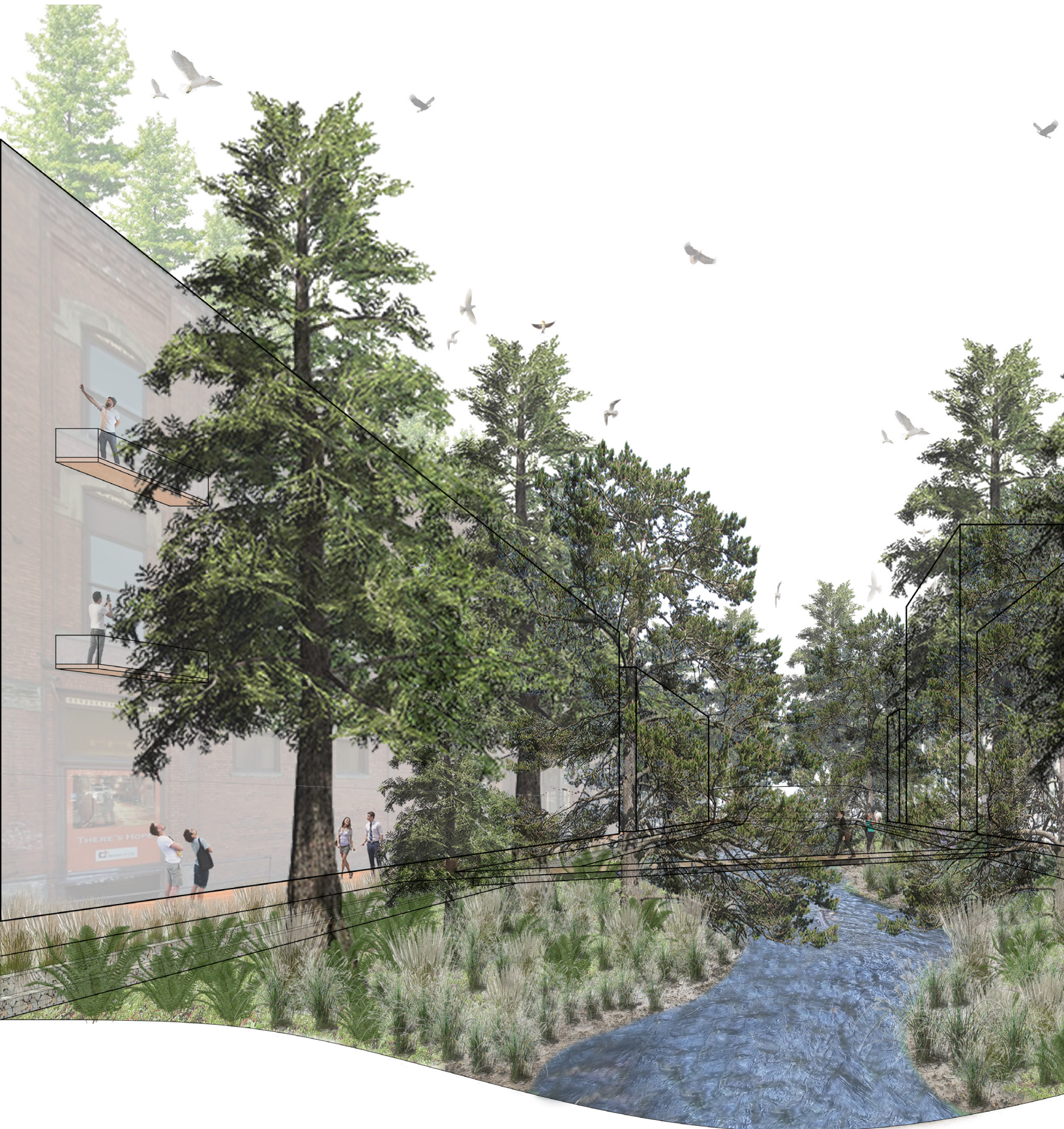




Figure 11 - S MAIN STREET, one of the least busy streets at the site, is proposed as a complete green street. Opportunities of spatial and visual connectivity are created through a crossing bridge in the center with balconies protruding out at higher level of existing buildings.

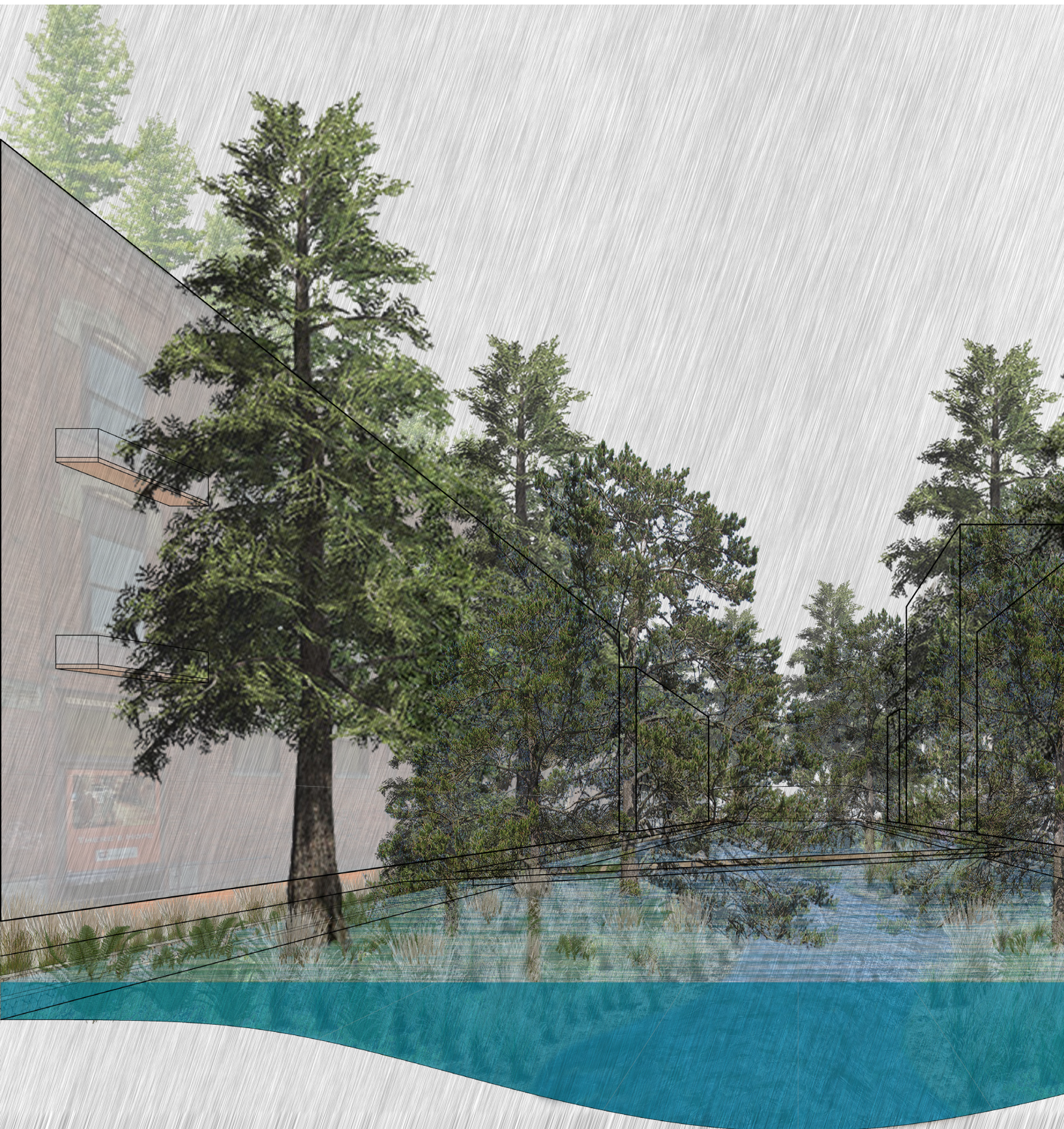




Figure 12 - Inspired by the Copenhagen Cloudburst Master plan, S MAIN STREET is allowed to flood during heavy rains. This approach will allow the city to operate while rain water discharge takes place through natural interventions without disrupting the city utilities network.





Figure 13 - S JACKSON STREET, also having a drainage pipe underneath but a slightly more active street than S Main Street, is proposed as a partial green street. The previous concrete portion of the street is wide enough to accommodate one lane of traffic and one lane of parking. This permeable surface allows water to seep into the ground where pollutants will be filtered naturally by the earth below. On the other hand, since the sidewalks will only have foot traffic, meaning less pollutants, their surface will have an impervious finish forcing the water to flow towards the vegetated areas.



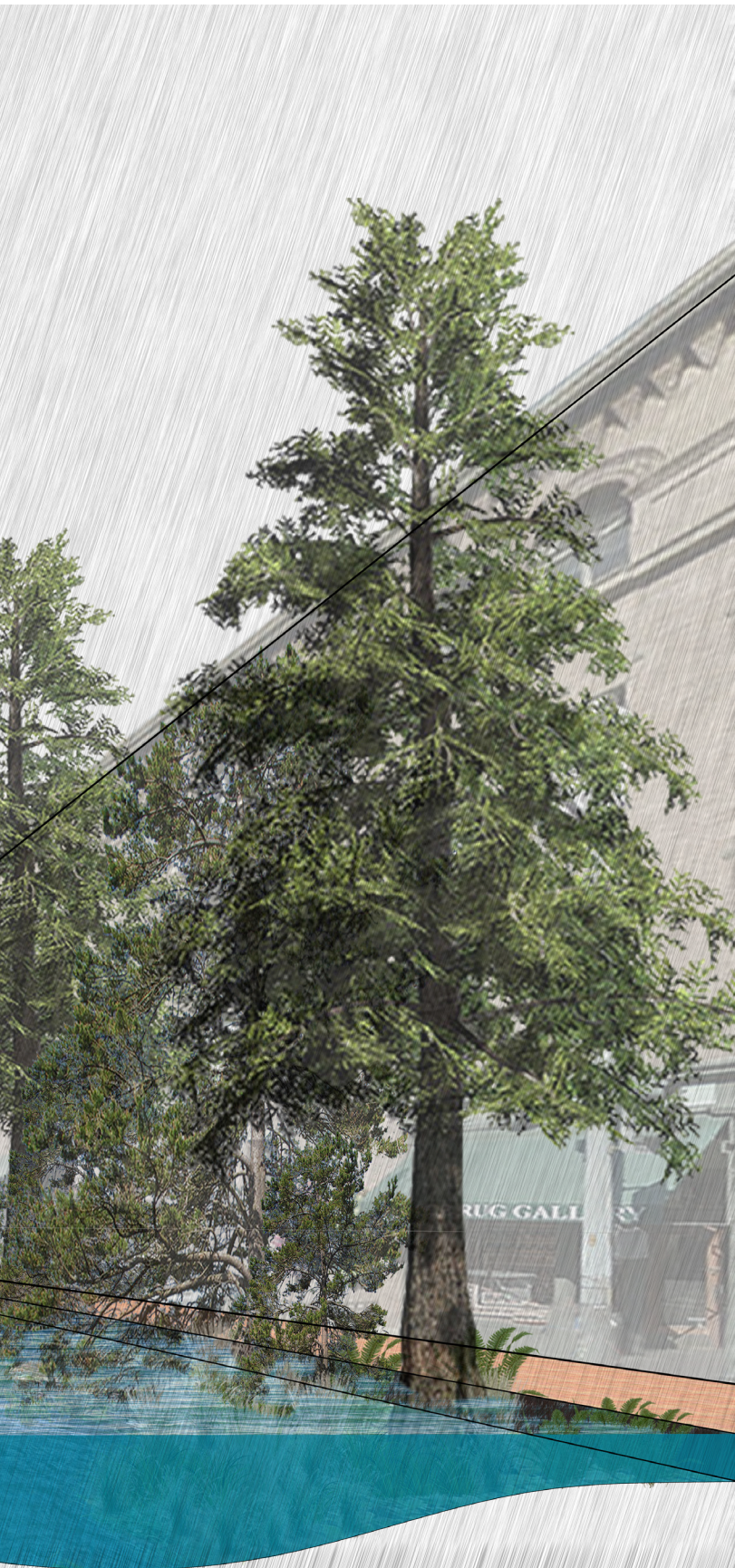
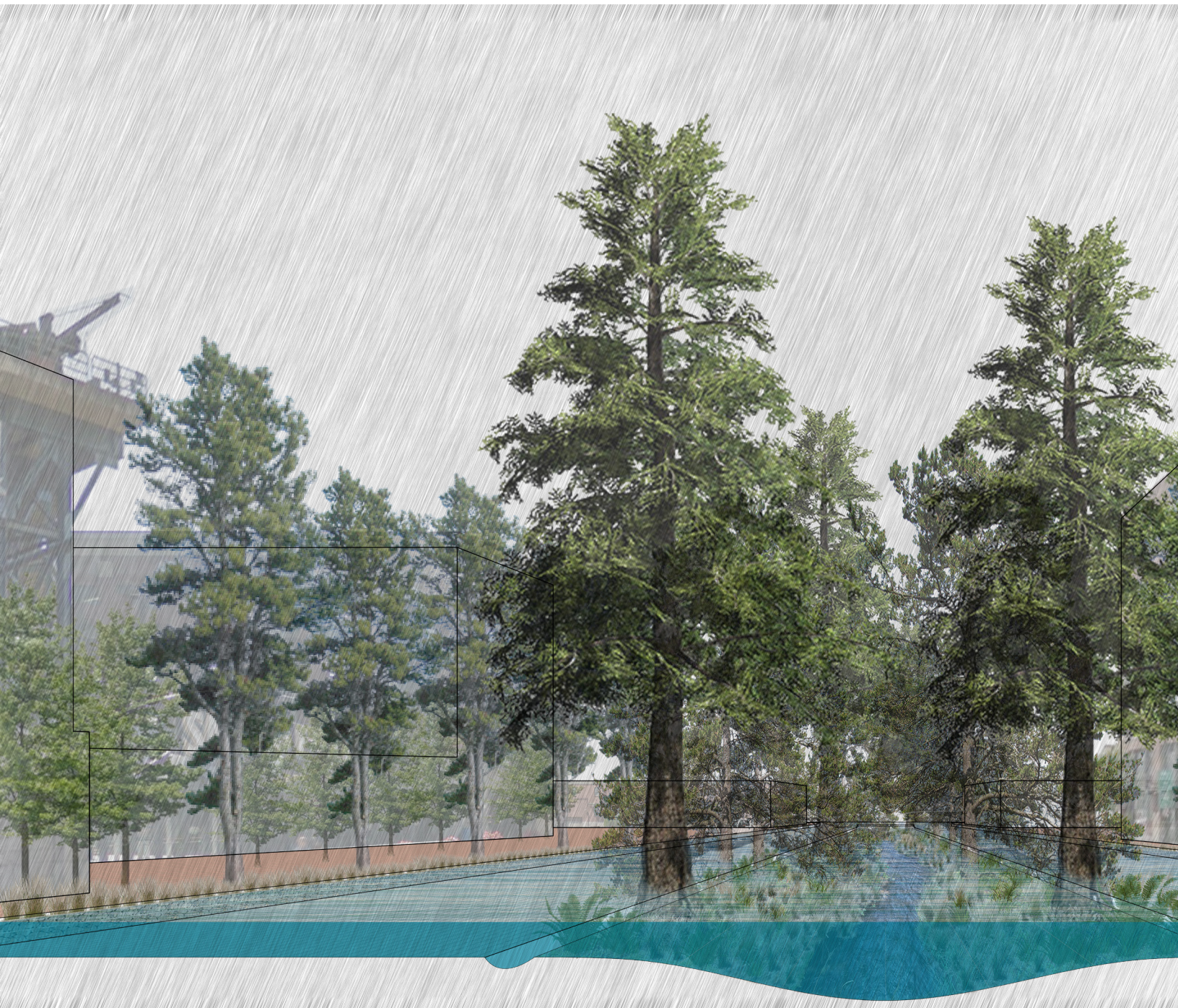


Figure 14 - S JACKSON STREET, during heavy rain is also allowed to flood. The Tufted grass and Slough sedge at the edges have the ability to absorb rain water and releases them over time giving less opportunity to runoffs and more for the ground to absorb.





Figure 15 - S ROYAL BROUGHAM WAY is a semi-partial green street accommodating both the heavy traffic and vegetation. The central green median acts as a water filtration zone with dense vegetation while the city operates as usual.



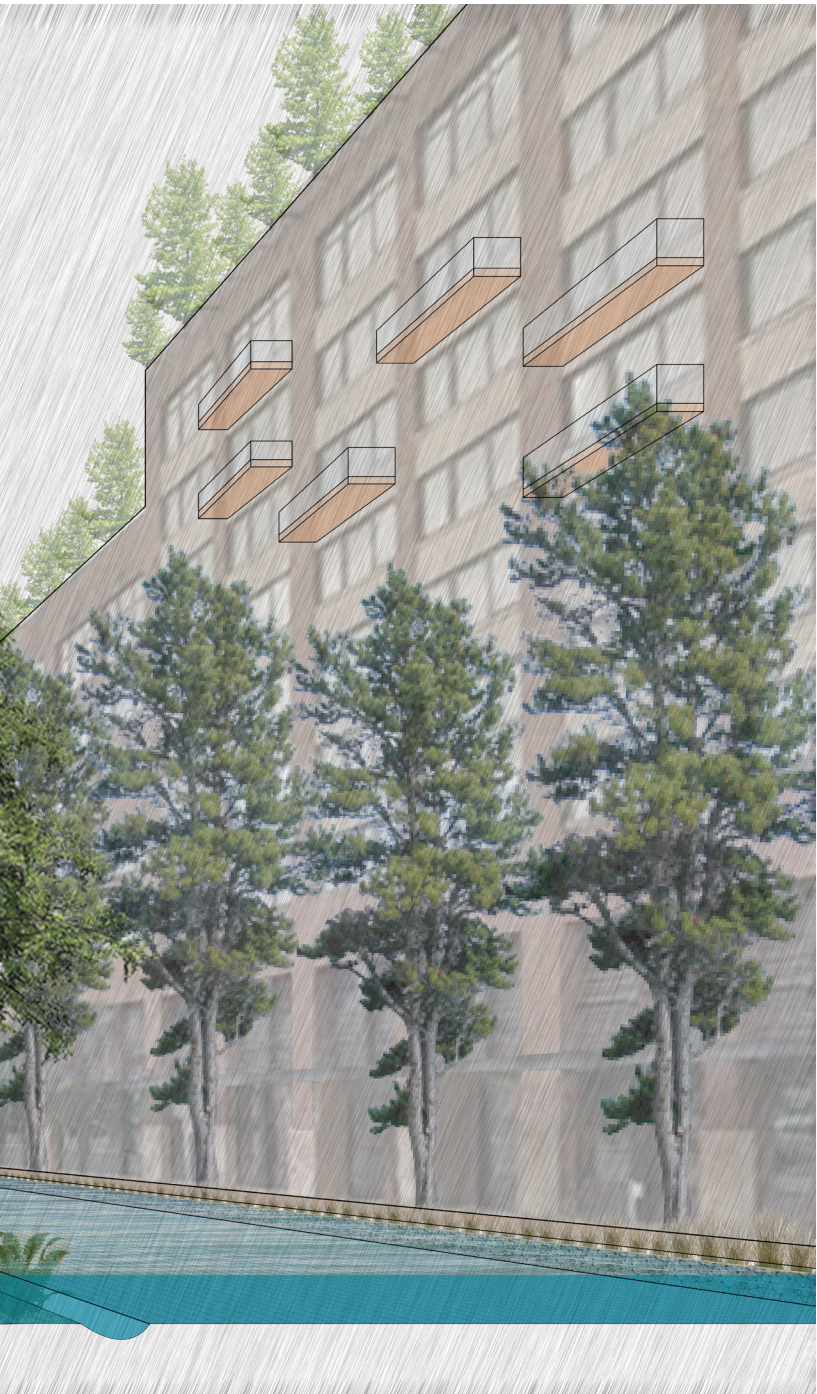


Figure 16 - S ROYAL BROUGHAM WAY, similar to its other neighboring street, is also allowed to flood during heavy rain.

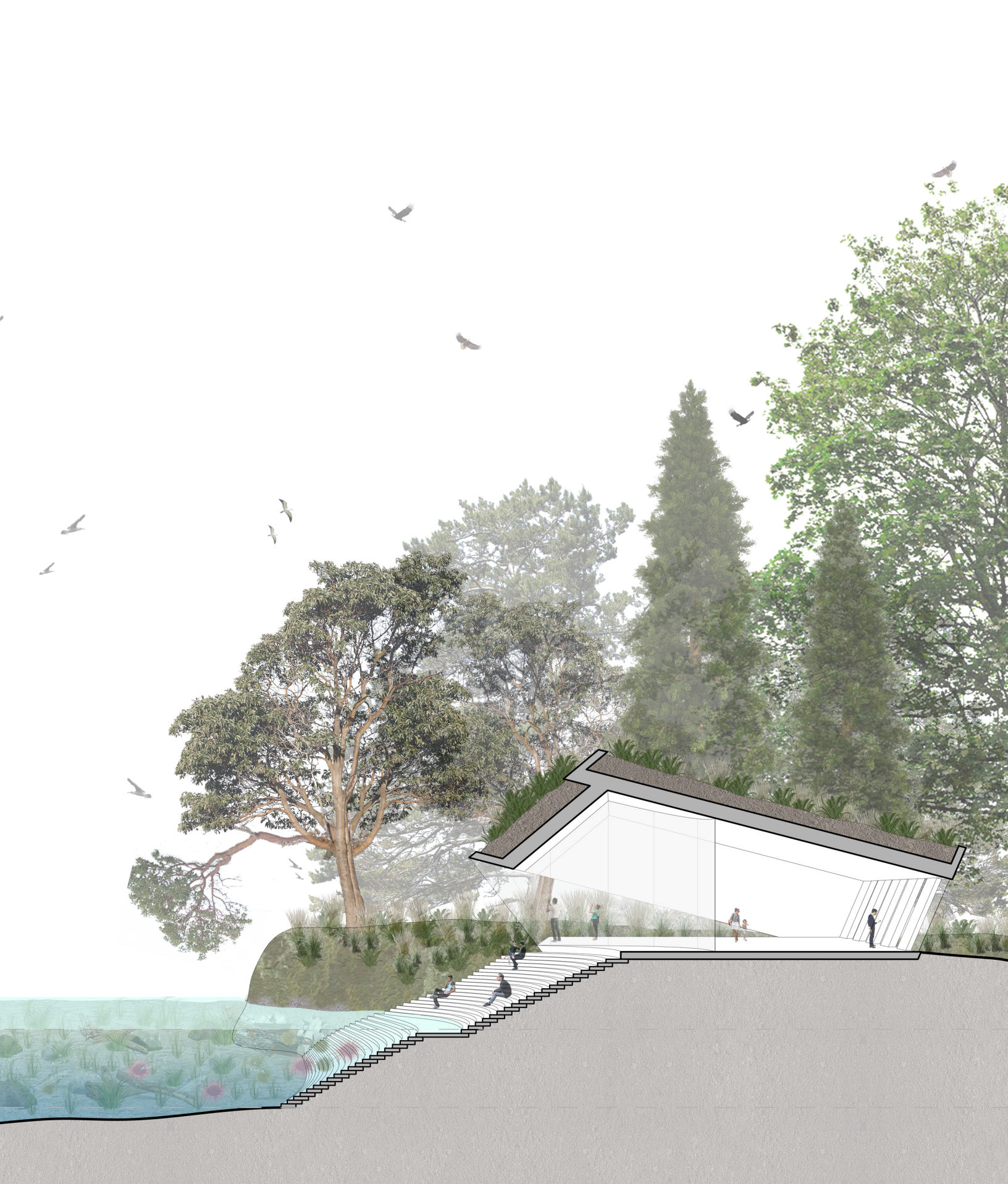
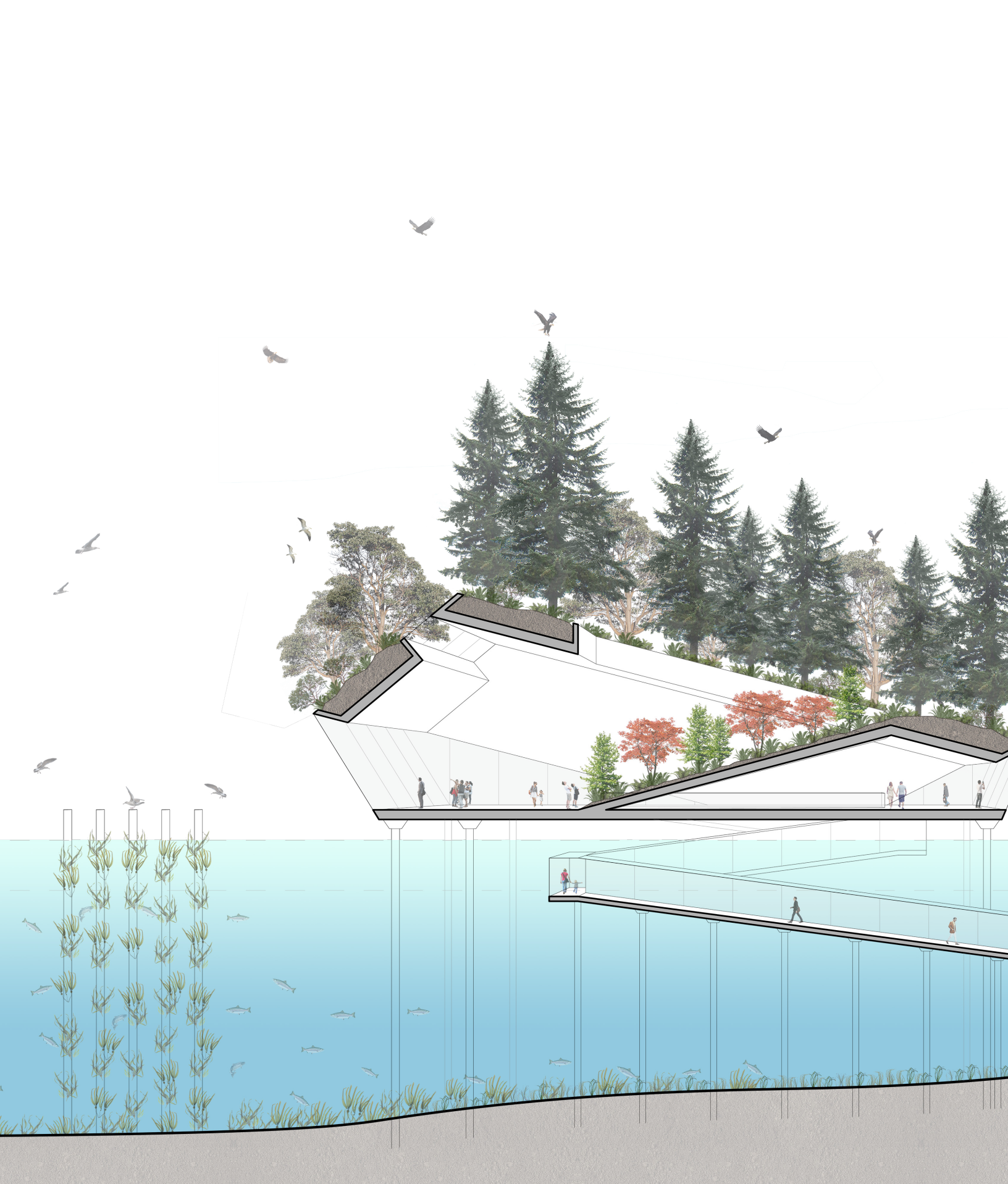




Figure 17 - A section perspective of the INTERTIDAL STUDIO depicting the spatial connection with the water with Madrone and Shore Pine trees in the background having their branches overhanging the bluff onto the water. The leaves and seeds fallen from these branches are a good source of nutrients for the fishes below. The studio space provides views towards the city, bluff 48 and the Sound. This space also steps down into the tidal zone allowing visitors to experience the change in the water level. Especially at low tide, when the water is near the base of the steps, one can easily reach the base of the bluff while exploring the various plants, insects and intertidal species like sea urchins, mussels and clams.



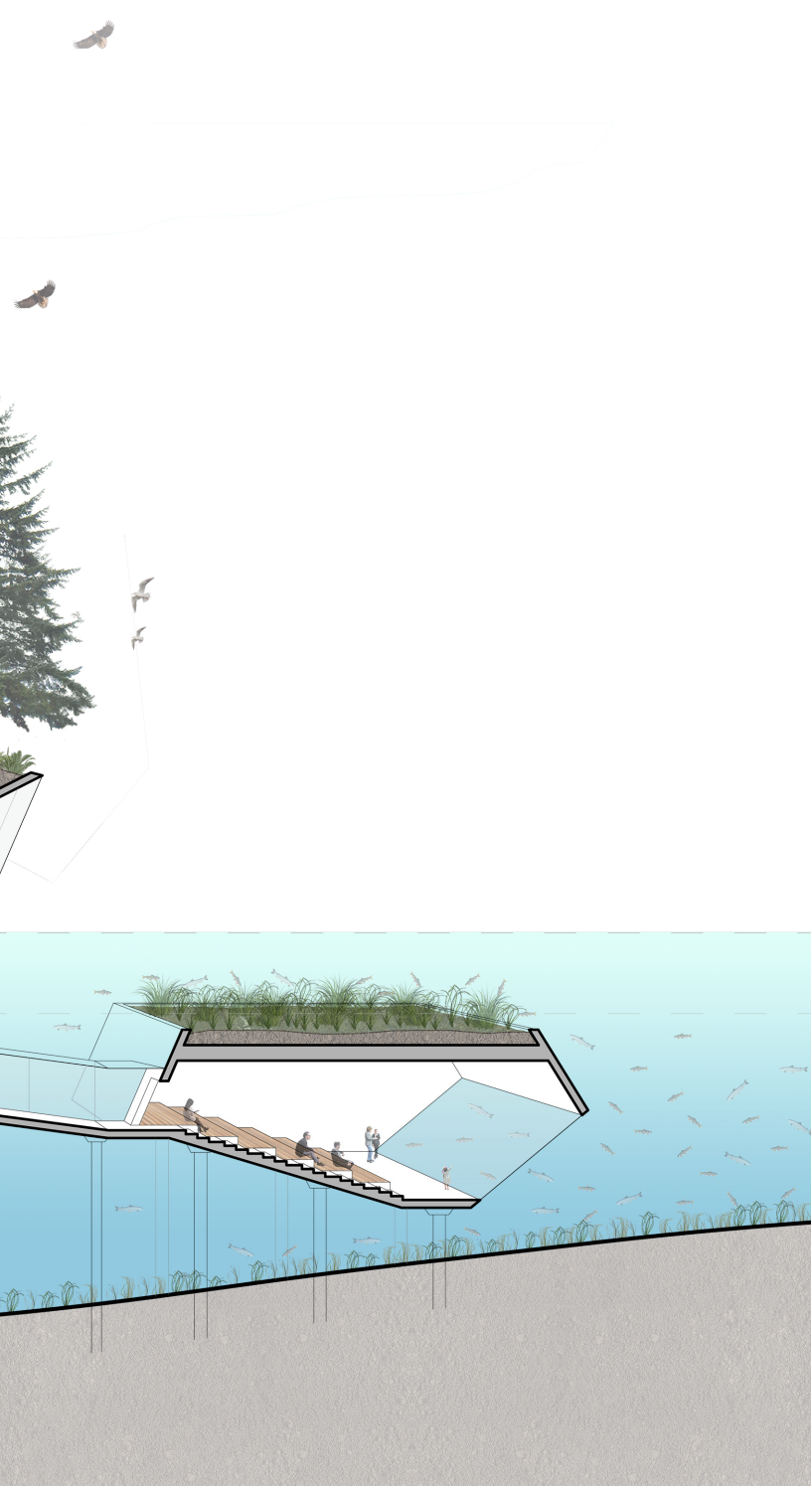


Figure 18 - The project culminates in the LANDSCAPE STUDIO where the natural beauty of the Puget Sound region is framed. With the help of the transparent facade, views can be generated towards the scenic environment, consisting of lush green islands, hills and the great snowcapped Olympic mountains. The form and layout of the space represents the mountainous landforms of the area with crests and valleys, bluffs and slopes. The inward sloped portion of the roof allows the roof landscape to come into the building maintaining the vital connection between man and nature. The green roof acts as a sponge, absorbing the rain and later using it for the vegetation. The high ceiling, with the tall Douglas Fir trees sitting on top, makes the project stand out from its industrial and commercial environment and act as a green landmark providing shelter to the birds while attracting public towards the water. The interior space is mainly an exhibition space, displaying the magnificent geography of the Puget Sound through pictures and 3D models. The lighting for the exhibits within the structure will allow the project to become an urban lantern glowing in the night. Furthermore, the space also gives an opportunity to go into the depth of the waters to explore the various marine habitats for which Puget Sound is known for. The SUBTIDAL STUDIO with its sloping form creates a seminar room with wide platforms encouraging the public to sit and gaze into the wilderness of the sea. Being in close proximity of the shallow seabed, which has enough illumination to have eelgrass fostering small invertebrates and fish species, like Salmonids, one can visually connect to the dynamic lifestyle of the sea.

Figure 19 - Considering the ecological impact this project is bringing to the site, while improving the terrestrial and marine habitat conditions and the connection between the city and its water, it is essential to understand and propose a FUTURE DEVELOPMENT PLAN that involves its expansion towards the south of the present site, over the years. Though the effects of this transformation will happen over time, the city can start by converting the streets with the main underground drainage and CSO pipes into green streets that retain and filter the water before discharging into the Puget Sound. Looking at the present day changes in technology and the need of improvement of the habitat, the Seattle Port needs to be relocated. The vacated space can be converted into shallow nearshore zone with bluffs having dense vegetation, which in return can prevent erosion and provide food to the habitat. Looking into the future, in about a century, the whole shoreline can be modified as a soft shoreline with a habitat reserve providing a more scenic and environmental friendly connection between land and sea.





Figure 20 - View looking northwest towards Bluff 48, an island with dense vegetation, with Bainbridge Island in the background.





Figure 01 - Deception pass, WA

5. CONCLUSION

Throughout time, the Seattle waterfront has always been the hub of economic and cultural activities. From being the hunting grounds for coast Salish Indians to becoming the nucleus of lumber industry then the hub of ferry terminals followed by the port and now once again become the cultural center for the area, the city edge has experienced numerous transformation. But all came at the cost of one thing; that is the exploitation of Puget Sound's naturally available resources. Though the city is now in the midst of revitalization of the waterfront with focus towards the public connection with the water while improving the water edge, the developments tend to ignore the ecological aspect of Elliot Bay shoreline. Therefore, this thesis takes an unconventional approach towards the treatment of the water edge as a place of entwining of two complex ecosystems; man and marine.

This thesis proposal began with the investigation that, "there should not be any sea wall and let the water come up to the city," with the removal of large overhead structures and transforming the existing city infrastructure that best responds to the site's ecology, this thesis puts in perspective a new view towards the waterfront development. Though this approach is not the only solution towards an ecological development of the waterfront but does presents an argument that nature can play an important role in harboring the city edge, while fostering the living beings around it. Thus creating a functioning habitat, that was once present a century ago, with the present day thriving city, Seattle.

The design incorporates both architecture and landscape in linking the city with its water. A series of interventions that caters to both the urban fabric and natural surroundings respectively, has allowed the creation of an experiential project that teaches the public about the Puget Sound ecosystem while performing their daily tasks. The space celebrates the transition from one realm to the other by depicting the natural process of shoreline ecology. The strategic locations of the proposed structures over the delicate fabric of the seabed depicts the sensitivity towards the fragile marine and terrestrial habitat. The use of native vegetation for supporting the basic utilities of the city also creates a landscape that is vernacular to the region.

The exploration of sustainability through a passive approach, that is the usage of natural process for water filtration and daylight for interior space and seabed illumination, demonstrates an ecologically responsive design on the waterfront. The elements of design and the way they have been proposed increases the longevity of the project, giving it a new appearance in the future. Thus presenting the design as model for a long lasting human intervention which matures with existence of nature.



Figure 02 - Deception pass, WA

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FIGURE LIST

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FIGURE A - Seattle City Profile

FIGURE B - Jack Williamson. "Nisqually National Wildlife Refuge." Web 27 Nov, 2017. < <http://www.jack-n-jill.net/blog/2013/4/nisqually-national-wildlife-refuge>>

FIGURE C - U.S. Department of the Interior. "Billy Frank Jr. Nisqually National Wildlife Refuge." 21 Excellent Side Trips for Your Next National Park Visit. Web 27 Nov, 2017. <<https://www.doi.gov/blog/21-excellent-side-trips-your-next-national-park-visit>>

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Figure 02 - Newport Beach CA. Web 27 Nov, 2017 <[https://en.wikipedia.org/wiki/Newport_Bay_\(California\)](https://en.wikipedia.org/wiki/Newport_Bay_(California))>

Figure 03 - Vicksburg Landing. Steamboat times. Web 27 Nov, 2017 < http://steamboattimes.com/levee_scenes.html>

Figure 04 - Convergence of Land and Marine life

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Figure 01 - Cork & Click. "Seattle Night Shoot." Web 27 Nov, 2017 < <https://corkandclick.com/seattle-areas-best-night-shoot-photography-class/>>

Figure 02 - Claude-Joseph Vernet. "Rochefort Arsenal." The Townsends Blog. Web 27 Nov, 2017. < <http://www.townsends.us/blog/rochefort-arsenal-joseph-vernet-1761/>>

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Figure 05 - Wikimedia Commons. "Museo Guggenheim Bilbao, distant view from Artxanda mountain, Bilbao, Spain." 31 Oct, 2011. Web 27 Nov, 2017. < https://commons.wikimedia.org/wiki/File:Museo_Guggenheim_Bilbao-distant_view.jpg>

Figure 06 - Environmentally Friendly Erosion Protection: Seawalls (Fish Friendly Marine Infrastructure). "Schematic diagrams of natural estuarine shoreline showing wide gradation across zones (top) and modified shoreline where intertidal zone is greatly reduced in size and width (bottom). Images courtesy of Office of Environment and Heritage." Fish Habitat Network. Web 27 Nov, 2017. < <http://www.fishhabitatnetwork.com.au/projects/environmentally-friendly-seawalls-fish-friendly-marine-infrastructure>>

Figure 07 - A diagram depicting the relationship of water depth to the fish sizes.

Figure 08 - Shoreline's natural process that plays a major role in supporting an ecosystem.

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Figure 01 - Geographicus Rare Antique Maps. "1867 U.S. Coast Survey Map or Chart of Puget Sound, Washington." Web 27 Nov, 2017. <<https://www.geographicus.com/P/AntiqueMap/PugetSound-uscs-1867>>

Figure 02 - An Estuary formation diagram

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Figure 05 - Coast Salish Artist Joe Jack. "Canoes." Traditional history of the Coast Salish people. Web 27 Nov, 2017. <<http://www.joejack.com/coastsalishhistory.html>>

Figure 06 - A sketch depicting the start of the impacts of human interventions after the European settlement settled in Seattle around 1860's.

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Figure 08 - A sketch depicting the present day Elliot Bay edge condition, with wide piers and a developed city infrastructure.

Figure 09 - James Corner Field Operations. "Seattle Central Waterfront." Web 27 Nov, 2017. <<http://www.fieldoperations.net/project-details/project/seattle-central-waterfront.html>>

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Figure 11 - The Urbanized Edge.

Figure 12 - Habitat Circulation.

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Figure 14 - Cross sections through the various types of edge conditions in Elliot Bay.

Figure 15 - MIG|SVR. "Green Street." High Point Redevelopment, Seattle WA. Dec, 2010. Web 27 Nov, 2017. <<http://www.svrdesign.com/high-point-redevelopment/vnhxvn3e7i21f0nwc81qhxb00qcmc>>

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Figure 17 - A cyclical pattern of the various types of Salmonid and Adult Salmons present in the Waters of Elliott Bay.

Figure 18 - James Corner Field Operations. "Sustainability" Honor Award Waterfront Seattle. Analysis and Planning: 2013 ASLA Professional Awards. Web 27 Nov, 2017. <<https://www.asla.org/2013awards/501.html>>

Figure 19 - Central Waterfront Committee & James Corner Field Operations. "Waterfront Seattle". Concept Design. July, 2012. Print, 3:30

Figure 20 - A programmatic diagram explaining the relationship between city and water through a soft edge.

Figure 21 - Thesis project's site, Pier 48, looking into Elliot Bay while having Seattle port towards the South, Ferry terminal (Colman Dock) to the north, a bustling city in the south.

Figure 22 - Elliot Bay with the study area highlighted in yellow

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Figure 24 - National Oceanic and Atmospheric. "Sea Level Rise Viewer." Seattle. Web 27 Nov, 2017. <<https://coast.noaa.gov/slr/>>

DESIGN PROPOSAL

Figure 01 - Convergence of Land and Marine life.

Figure 02 - The transformation from a rigid grid system towards a more flexible irregular system.

Figure 03 - Conceptual Section.

Figure 04 - A conceptual representation of the above surface structures with visual connection with the surrounding landscape.

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Figure 06 - A diagrammatic section of a green street that prevents water from running off quickly into the Sound.

Figure 07 - A conceptual representation of the intertidal zone with dense vegetation preventing erosion and opportunities for habitat to exist.

Figure 08 - Site Plan

Figure 09 - Vegetation Plan

- Figure 10 - Site Section
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- Figure 12 - S Main Street - Flooded
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Figure 01 - Patrick_McNally. "Deception Pass, Puget Sound, Washington State." Panoramio: Google Maps. 12 Jan, 2012. Web 27 Nov, 2017. <<http://www.panoramio.com/photo/64834767>>

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